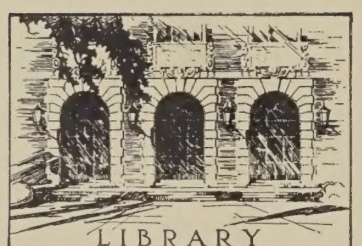

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Lacy-Hulbert & Co., Ltd.	91, Victoria Street, S.W.
Manlove, Alliott & Co., Ltd.	Nottingham
Murray, Workman & Co., Ltd.	Glasgow
Parsons, C. A., & Co.	Heaton Works, Newcastle-on-Tyne
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Worthington Pump Co., Ltd.	153, Queen Victoria Street, E.C.

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Belliss & Morcom, Ltd.	Ledsam St. Works, Birmingham
British Westinghouse Electric and Manufacturing Co., Ltd.	Trafford Park, Manchester
Brush Electrical Engineering Co., Ltd.	Falcon Works, Loughborough
Caird & Rayner	777, Commercial Road, Limehouse, E.
Carruthers, J. H., & Co., Ltd.	Polmadie Ironworks, Glasgow
Contraflo Condenser & Kinetic Air Pump Co., Ltd.	3, Central Buildings, Westminster, S.W.
Dawson & Downie	Clydebank
Friedenthal, F.	River Engine Works, Preston
Hall, J. P., & Sons, Ltd.	Peterborough
Lacy-Hulbert & Co., Ltd.	91, Victoria Street, S.W.
Manlove, Alliott & Co., Ltd.	Nottingham
Mirrlees, Watson Co., Ltd.	Scotland Street, Glasgow
Potter, A. C., & Co.	Lant Street, S.E.
Rees Roturbo Manufacturing Co., Ltd.	Wolverhampton, Eng.
Stott, S. S., & Co.	Hasiingden, near Manchester
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Alloys.—*(See Metals, &c.)*

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British Aluminium Co., Ltd.	109, Queen Victoria St., E.C.
British Insulated & Helsby Cables, Ltd.	Prescot, Lancashire
Gabriel & Co.	A.B. Row, Birmingham
Le Bas, Edward, & Co.	Dock House, Billiter St., E.C.
Ward, Thos. W., Ltd.	Albion Works, Sheffield

Ammunition.

Firth, Thos., & Sons, Ltd.	Norfolk Works, Sheffield
Vickers Limited	Sheffield

Anchors.

Spencer, John, & Sons, Ltd.	Newburn Steel Works, Newcastle-on-Tyne
Steel Co. of Scotland, Ltd.	23, Royal Exchange Square, Glasgow
Wood, Henry, & Co., Ltd.	Saltney, near Chester

Arbitrators.

Kirk, W., Price & Co.	46, Watling Street, E.C.; and Albert Square, Manchester

Armour Plates.

Beardmore, William, & Co., Ltd.	Parkhead Forge Rolling Mills and Steel Works, Glasgow
Brown, John, & Co., Ltd.	Sheffield
Cammell Laird & Co. Ltd.	Cyclops Steel & Iron Works, Sheffield
Vickers Limited	[Sheffield

Armoured Concrete.—*(See Concrete—Reinforced).*

Asbestos Goods, &c.—*(See also Jointing Materials, and Packings—Engines & Hydraulic.)*

Bell's United Asbestos Co., Ltd.	59½, Southwark Street, S.E.
Billington & Newton, Ltd.	Longport, Staffordshire

Ash Ejectors.

Trewent, F. J., & Proctor, Ltd.	43, Billiter Buildings, E.C.

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Fuller, Horsey, Sons & Cassell	11, Billiter Square, E.C.
Kirk W., Price & Co.	46, Watling Street, E.C.; and Albert Square, Manchester
Radford, R. Heber, Son & Squire	15, St. James Row, Sheffield

Axles.

Beardmore, William, & Co., Ltd.	Parkhead Forge Rolling Mills and Steel Works, Glasgow
Bessemer, Henry, & Co., Ltd.	Sheffield
Birmingham Railway Carriage and Wagon Co., Ltd.	Smethwick, Birmingham
Brown, Bayley's Steel Works, Ld.	Sheffield
Brown, John, & Co., Ltd.	Sheffield
Firth, Thos., & Sons, Ltd.	Norfolk Works, Sheffield
Glasgow Railway Eng. Co., Ltd.	Govan, Glasgow
Hadfields Limited	Hecla Works, Sheffield
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Alley & MacLellan, Ltd.	Sentinel Works, Glasgow
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Vospel & Co., Ltd.	Broad Street, Portsmouth
Watson, J. S.	Gainsborough
Werf Conrad, N.V.	Haarlem, Holland
White, Samuel J., & Co., Ltd.	East Cowes, I.o.W.

Barrows.

Ash, Joseph, & Son	Rea Street South, Birmingham
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Allen, Edgar, & Co., Ltd.	Sheffield
Beardmore, William, & Co., Ltd.	Parkhead Ironworks, Glasgow
Bessemer, Henry, & Co., Ltd.	Sheffield
Brown, Bayley's Steel Works, Ld.	Sheffield
Colville, David & Sons, Ltd.	Motherwell, near Glasgow
Ebbw Vale Steel Iron & Coal Co., Ltd.	Ebbw Vale, Mon.
Glasgow Iron & Steel Co., Ltd.	Wishaw Iron & Steel Works, Wishaw
Hadfields Limited	Hecla Works, Sheffield
Leeds Forge Co., Ltd.	Leeds
Motherwell Iron & Steel Co.	Motherwell, N.B.
Patent Shaft & Axletree Co., Ld.	Wednesbury
Scott, Walter, Ltd.	Leeds Steel Works, Leeds
Spencer, John, & Sons, Ltd.	Newburn Steel Works, Newcastle-on-Tyne
Steel Co. of Scotland, Ltd.	23, Royal Exchange Sq., Glasgow

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Broom & Wade, Ltd.	High Wycombe
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Hoffmann Manufacturing Co., Ld.	Chelmsford
Imperial Motor Industries, Ltd.	11, Denmark Street, Charing Cross Road, W.C.
Ransome, A., & Co., Ltd.	Stanley Wks., Newark-on-Trent
Skefko Ball Bearing Co., Ltd.	28, Victoria Street, Westminster, S.W.

Bearings (Thrust and Footstep).

Broom & Wade, Ltd.	High Wycombe
Croft & Perkins, Ltd.	Empire Works, Bradford

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London & Lancashire Fire Insurance Co., Ltd.	155, Leadenhall Street, E.C.
Manchester Steam Users' Association	9, Mount Street, Manchester
National Boiler and General Insurance Co., Ltd.	St, Mary's Parsonage, Manchester

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Chaplin, Alex., & Co.	Govan, Glasgow
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Clayton, Son, & Co., Ltd.	Hunslet, Leeds
Cochran & Co., Annan, Ltd.	Annan, N.B.
Coltman, Walter W., & Co., Ltd.	Central Boiler Works, Loughborough
Cradley Boiler Co.	Cradley Heath, near Birmingham
Craig, A. F., & Co., Ltd.	Paisley, N.B.
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Davey, Paxman & Co., Ltd.	Polloksnaws, Glasgow
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Day, Summers & Co., Ltd.	Sheffield
Dodman, Alfred, & Co., Ltd.	Northam Ironworks, Southampton
Escher Wyss & Co.	King's Lynn
Fowler, J., & Co. (Leeds), Ltd.	109, Victoria Street, S.W.
Galloways Ltd.	Leeds
Garrett, R., & Sons, Ltd.	Manchester
Grantham Boiler & Crank Co., Ld.	Leiston Works, Suffolk
Hanna, Donald & Wilson	Grantham
Hawthorn, R. & W., Leslie & Co., Ltd.	Paisley, N.B.
Hayes, Edward	Newcastle-on-Tyne
Hindley, E. S., & Sons	Stony Stratford, Wolverton
Hudson, Thomas, Ltd.	Bourton, Dorset; and 11, Queen Victoria Street, E.C.
Lees, T. & R.	Coatbridge, N.B.
Lumby, Son & Wood, Ltd.	Hollinwood, by Manchester
Manlove, Alliott & Co., Ltd.	Halifax
Marriott & Graham	Nottingham
Marshall, Sons & Co., Ltd.	Plantation Boiler Works, Glasgow
McKie & Baxter	Gainsborough
Merryweather & Sons	Copland Wks., Govan, Glasgow
Mumford, A. G., Ltd.	63, Long Acre, W.C.
North-Eastern Marine Engineering Co., Ltd.	Culver St. Iron w'ks, Colchester
Penman & Co., Ltd.	Northumberland Works, Wallsend-on-Tyne
Piggott, Thos., & Co., Ltd.	Strathclyde Street, Glasgow
Plenty & Son, Ltd.	Birmingham
Ransomes, Sims & Jefferies, Ltd.	Eagle Ironworks, Newbury, Berks.
Robey & Co., Ltd.	Ipswich [Berks.
Ross & Duncan	Lincoln
Rowan, David, & Co.	Glasgow
Ruston, Proctor & Co., Ltd.	Glasgow
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Smulders, A. F.	Dartmouth, S. Devon
Sulzer Bros.	Schiedam, Holland
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Vosper & Co., Ltd.	Southampton
Wallsend Slipway & Engineering Co., Ltd.	Portsmouth
White, J. Samuel, & Co., Ltd.	Wallsend
Wilson, William, & Co.	East Cowes, Isle of Wight
Yarrow & Co., Ltd.	Lilybank Boiler Wks., Glasgow
Yates & Thom, Ltd.	Glasgow
	Canal Works, Blackburn

Boilers (Water-tube).

Babcock & Wilcox, Ltd.	Oriel House, Farringdon Street, E.C.
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Smulders, A. F.	Schiedam, Holland
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Beebee, A.	Wednesbury
Dunford & Elliott (Sheffield), Ld.	Attercliffe Wharf, Sheffield
Grover & Co., Ltd.	Wharf Road, N.
Kirby Banks Screw Co., Ltd.	Meadow Lane, Leeds
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Marsden, S., & Son, Ltd.	London Road, Manchester
Patent Shaft & Axletree Co., Ld.	Wednesbury
Phœnix Bolt & Nut Co.	Handsworth, nr. Birmingham
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New Calyx Drill & Boring Co. Ltd.	120, East Ferry Road, Millwall E.
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Brake and Clutch Lining.

Herbert Frood Co., Ltd.	Sovereign Mills, Chapel-en-le-Frith

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Birmingham Railway Carriage and Wagon Co., Ltd.	Smethwick, Birmingham
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Davies & Metcalfe, Ltd.	Romiley, near Manchester
Herbert Frood Company, Ltd.	Sovereign Mills, Chapel-en-le-Frith
Vacuum Brake Co., Ltd.	32, Queen Victoria Street, E.C.
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Brake Solenoids.—*(See Solenoids—Brake).*

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Bell's United Asbestos Co., Ltd.	59½, Southwark Street, S.E.
Billington & Newton, Ltd.	Longport, Staffordshire
Bodley Brothers & Co.	Exeter
Broughton Copper Co., Ltd.	Manchester
Crosby Valve & Engineering Co., Ltd.	147, Queen Victoria St., E.C.
Delta Metal Co., Ltd.	East Greenwich, S.E.
France & Morgan	Whitefield Brass Wks., Govan, Glasgow
Gabriel & Co.	A.B. Row, Birmingham
Hurst, Nelson & Co., Ltd.	Motherwell, N.B.
Lunken Company, Ltd.	35, Great Dover Street, S.E.
North-Eastern Marine Engineering Co., Ltd.	Northumberland Wks., Wallsend-on-Tyne
Piggott, Thos., & Co., Ltd.	Springhill, Birmingham
Pulsometer Engineering Co., Ltd.	Nine Elms Ironworks, Reading
Stewart, Duncan, & Co., Ltd.	London Rd. Ironwks., Glasgow
Storey, I., & Sons, Ltd.	Empress Foundry, Manchester
Thornycroft, J. I., & Co., Ltd.	Southampton
United Brassfounders & Engineers, Ltd.	Empress Foundry, Manchester
Wallsend Slipway & Engineering Co., Ltd.	Wallsend

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Delta Metal Co., Ltd.	East Greenwich, S.E.
McKechnie Brothers	Rotton Park St., Birmingham

Brewery Plant.

Blair, Campbell & McLean, Ltd.	Woodville St., Govan, Glasgow
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Brick and Tile-Making Machinery.

Bodley Bros. & Co.	Exeter
Bradley & Craven, Ltd.	Westgate Common Foundry, Wakefield
Brightside Foundry & Eng. Co., Ltd.	Sheffield

Bridge Foundation Cylinders.—*(See also Structural Engineering.)*

Clay Cross Co., Ltd.	Clay Cross, near Chesterfield
Hanna, Donald & Wilson	Paisley
Head, Wrightson & Co., Ltd.	Teesdale Ironworks, Thornaby-on-Tees

Bridges.—*(See Structural Engineering.)*

Buffers.

A.B.C. Coupler, Ltd.	Queen Anne's Chambers, S.W.
Acieries et Fonderies d'Art, Ltd.	Caxton House, Westminster, S.W.
Brown, John, & Co., Ltd.	Sheffield
Cammell Laird & Co., Ltd.	Sheffield
Hurst, Nelson & Co., Ltd.	Motherwell, N.B.
Midland Railway Carriage and Wagon Co., Ltd.	Midland Works, Birmingham
Spencer, John, & Sons, Ltd.	Newburn Steel Works, Newcastle-on-Tyne
Turton, T., & Sons, Ltd.	Sheaf Works, Sheffield

Buildings (Iron & Steel).—*(See Structural Engineering).*

Buoys (Iron and Steel).

Bellamy, John, Ltd.	Millwall, E.
Towaru, T., & Co., Ltd.	9, Ouseburn, Newcastle-on-Tyne

Cable Laying Machinery.

Clarke, Chapman & Co., Ltd.	Victoria Works, Gateshead-on-Tyne

Cables (Electric Light, Telegraph and Telephone).

British Insulated and Helsby Cables, Ltd.	Prescot, Lancashire
India Rubber, Gutta Percha & Telegraph Works, Co., Ltd.	Silvertown, E.

Capstans (Steam, Hydraulic & Electric).

Berry, Henry, & Co., Ltd.	Croydon Works, Hunslet, Leeds
Booth, Joseph, & Bros., Ltd.	Rodley, Leeds
Campbell & Calderwood	Sobo Engine Works, Paisley
Clarke, Chapman & Co., Ltd.	Gateshead-on-Tyne
Mirrlees Watson Co., Ltd.	Scotland Street, Glasgow
Sandycroft Limited	Chester

Carburetters and Vaporisers.
Thornycroft, J. I., & Co., Ltd. Basingstoke

Carriage (Railway) Builders.
Birmingham Railway Carriage and Wagon Co., Ltd. .. .. Smethwick, Birmingham
Brush Electrical Engineering Co., Ltd. .. .. Falcon Works, Loughborough
Cuthill, King & Co. .. .. 56, Moorgate Street, E.C.
Glasgow Railway Eng. Co., Ltd. Govan, Glasgow
Hurst, Nelson & Co., Ltd. .. Glasgow Rolling Stock and Plant Works, Motherwell
MacLellan, P. & W., Ltd. .. Clutha Works, Glasgow
Metropolitan Carriage, Wagon and Finance Co., Ltd. .. .. Saltley, Birmingham
Midland Railway Carriage and Wagon Co., Ltd. .. .. Midland Works, Birmingham
Pickering, R. Y., & Co., Ltd. .. Wishaw, nr. Glasgow

Carriage (Railway) Fittings.
Kaye, Joseph, & Sons, Ltd. .. 93, High Holborn, W.C.

Cartridge Making Machinery.
Taylor & Challen, Ltd. .. .. Birmingham

Case-Hardening Materials.
Palfreyman, W. H. & Co. .. 17, Goree-Piazzas, Liverpool

Cask Making Machinery.
Ransome, A., & Co., Ltd. .. Newark-on-Trent

Castings (Aluminium).
Reliance (Coventry), Ltd. .. Coventry

Castings (Iron).—*(See also Pipe Founders.)*
Alley & MacLellan, Ltd. .. Sentinel Works, Glasgow
Ashmore, Benson, Pease & Co., Ltd. Stockton-on-Tees
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Bodley Brothers & Co. .. .. Exeter
Brandon Bridge-Building Co., Ltd. .. .. Brandon Works, Motherwell
Clay Cross Co., Ltd. .. .. Clay Cross, near Chesterfield
Craig, A. F., & Co., Ltd... .. Paisley, N.B.
Daniell, S. A., Ltd. .. .. Birmingham
Darlington Forge Co., Ltd. .. Darlington
Entwisle & Gass, Ltd. .. .. Bolton
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Herbert, Alfred, Ltd. .. .. Coventry
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Mackies Limited .. .. .. Berks Ironworks, Reading
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Midland Railway Carriage and Wagon Co., Ltd. .. .. Midland Works, Birmingham
North-Eastern Marine Engineering Co., Ltd. .. .. .. } Northumberland Wks., Wallsend-on-Tyne
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Ransome, A., & Co., Ltd. .. Stanley Wks., Newark-on-Trent
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
Shaw, W., & Co. .. .. Wellington Cast Steel Foundry, Middlesbro'-on-Tees
Thornycroft, J. I., & Co., Ltd... Southampton
Unbreakable Pulley & Mill Gearing Co., Ltd. .. .. .. 48, West Gorton, Manchester
Vickers Limited .. .. .. Sheffield
Walker Bros. (Wigan), Ltd. .. Pagefield Ironworks, Wigan
Wallsend Slipway & Engineering Co., Ltd. .. .. Wallsend
Wallwork, Henry, & Co., Ltd... Manchester

Castings (Malleable Iron).
Bagshawe & Co., Ltd. .. .. Dunstable Works, Dunstable
Hadfields Limited .. .. Hecla Works, Sheffield
Le Bas, Edward, & Co. .. .. Dock House, Billiter St., E.C.
Parker Foundry Co., Ltd. .. Derby
Tangyes Limited .. .. .. Cornwall Works, Birmingham
Vickers Limited .. .. .. Sheffield
Wallwork, Henry, & Co., Ltd... Manchester

Castings (Steel).—*(See also Manganese Steel Castings & Forgings.)*
Acieries et Fonderies d'Art, Ltd. Caxton House, Westminster, S.W.
Allen, Edgar, & Co., Ltd. .. Imperial Steel Works, Sheffield
Ashmore, Benson, Pease & Co., Ltd. Stockton-on-Tees
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Bessemer, Henry, & Co., Ltd. .. Sheffield
Brandon Bridge-Building Co., Ltd. .. .. Brandon Works, Motherwell
Brown, Bayley's Steel Works, Ltd. Sheffield
Brown, John, & Co., Ltd. .. Sheffield
Cammell Laird & Co. Ltd. .. Cyclops Steel & Iron Works, Sheffield
Colville, David, & Sons, Ltd. .. Motherwell, near Glasgow
Darlington Forge Co., Ltd .. Darlington
Ebbw Vale Steel Iron & Coal Co., Ltd. .. .. Ebbw Vale, Mon.
Fairley, James, & Sons .. .. Shadwell Street, Birmingham
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Ghion, J. .. .. Finsbury Pavement Hse., E.C.
Hadfields Limited .. .. Hecla Works, Sheffield
Lysaght, John, Ltd. .. .. Orb Works, Newport, Mon.
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Parker Foundry Co., Ltd. .. Derby
Shaw, W., & Co. .. .. .. Wellington Cast Steel Foundry, Middlesbro'-on-Tees
Spencer, John, & Sons, Ltd. .. Newburn Steel Wks., Newcastle-on-Tyne
Steel Co. of Scotland, Ltd. .. 23, Royal Exchange Square, [Glasgow
Vickers Limited .. .. .. Sheffield

Cement.
Greaves, Bull & Lakin, Ltd. .. Harbury, Leamington
Kaye & Co., Ltd. .. .. .. Southam Works, Rugby
Maxted & Knott, Ltd. .. .. Burnett Avenue, Hull
Smooth-on Manufacturing Co... 8, White Street, Moorfields, E.C.
Thomas & Bishop .. .. .. 119-125, Finsbury Pavement, E.C.

Cement-Making Plant.
Aveling & Porter, Ltd. Rochester
Fletcher, Geo., & Co., Ltd. .. Derby
Newell, Ernest, & Co., Ltd. Misterton, Gainsboro'
Rochester Engineering Co., Ltd. Wickham, Rochester
Stamm, W... .. .. 25, College Hill, E.C.

Centrifugal Drying Machines.—*(See also Cream-Separators, and Hydro-Extractors.)*
Broadbent, Thos., & Sons, Ltd .. Chapel Hill, Huddersfield
Manlove, Alliott & Co., Ltd. .. Nottingham
Pott, Cassells & Williamson .. Motherwell, near Glasgow
Tullis, D. & J., Ltd. .. .. Kilbowie Ironworks, Glasgow
Watson, Laidlaw & Co., Ltd. .. 98, Dundas St. (South), Glasgow

Cesspool Exhauster.
Merryweather & Sons .. .. Greenwich Road, S.E.

Chains and Cables.
Wood, Henry, & Co., Ltd. .. Saltney, near Chester

Chains (Gearing).
Bagshawe & Co., Ltd. .. .. Dunstable Works, Dunstable
Brampton Bros., Ltd. .. .. Birmingham
Coventry Chain Co., Ltd. .. Coventry
Renold, Hans, Ltd. .. .. Progress Works, Manchester
Westinghouse Brake Co., Ltd. 82, York Road, N.

Chemical Works (Plant for).
Alley & MacLellan, Ltd. .. Sentinel Works, Glasgow
Blair, Campbell & McLean, Ltd. Woodville Street, Govan, [Glasgow
Dowson & Mason Gas Plant Co., Ltd. .. .. Levenshulme, Manchester
Manlove, Alliott & Co., Ltd. .. Nottingham
Piggott, Thos., & Co., Ltd. .. Birmingham

Chimneys.
Babcock & Wilcox, Ltd. .. .. Oriel House, Farringdon St., E.C.
Bellamy, John, Ltd. .. .. Millwall, E.
Clayton, Son, & Co., Ltd. .. Hunslet, Leeds
Steel Pipe Company, Ltd. .. Kirkcaldy, N.B.

Chucks.—*(See also Machine Tools.)*
Crown Works .. .. .. London New Road, Chelmsford
Rapid Magnetting Machine Co., Ltd. .. .. .. Crescent, Birmingham
Taylor, Charles (Birm'ham), Ld. Bartholomew Sq., Birmingham

Clocks.—*(See Watches & Clocks.)*

Cloth Finishing Machinery.
Craig, A. F., & Co., Ltd.. .. Paisley, N.B.

Clutches (Friction).
Bever, Dorling & Co., Ltd. .. Bowling Ironworks, Bradford
British Hele-Shaw Patent Clutch Co., Ltd. .. .. Suthers Street, Oldham
Broadbent, Thos., & Sons., Ltd. Chapel Hill, Huddersfield
Croft & Perkins, Ltd. Empire Works, Bradford
Edmeston, A., & Sons, Ltd. . Patricroft, nr. Manchester
Entwisle & Gass, Ltd. .. .. Bolton
Herbert Frood Company, Ltd... Sovereign Mills, Chapel-en-le-Frith
Kay, James C., & Co., Ltd. .. Barnbrook Works, Bury, Lancs.
King, H. J. H., & Co., Ltd. .. Nailsworth, Glos.
Mackies, Ltd. .. .. .. Reading
Reddaway, F., & Co., Ltd .. Pendleton, Manchester
Unbreakable Pulley and Mill Gearing Co., Ltd. .. .. 48, West Gorton, Manchester
Wigglesworth, Frank, & Co., Ld. Clutch Works, Shipley, near Bradford

CO2 Recorders.
Cambridge Scientific Instrument Co., Ltd. .. .. Cambridge

Coal Handling Plant.—*(See also Conveyors & Elevators.)*
Allen, Edgar, & Co., Ltd. Sheffield
Dempster, Robert, & Sons, Ltd. Elland, Yorkshire
Goodall, Clayton & Co., Ltd. .. Leeds
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Jenkins, W. J., & Co., Ltd. .. Beehive Works, Retford
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Strachan & Henshaw, Ltd. .. Bristol
Werf Conrad, N.V. .. .. Haarlem, Holland

Cocks.—*(See Valves, Gas, Steam, Water, &c.)*

Coining Machinery.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Taylor & Challen, Ltd. .. .. Birmingham

Coke Rams.
Ransomes & Rapier, Ltd. .. Waterside Ironworks, Ipswich

Colliery Plant.—*(See also Haulage Plant, Mining Machinery, and Pumps.)*
Alley & MacLellan, Ltd. .. Sentinel Works, Glasgow
Barclay, Andrew, Sons & Co., Ltd. Caledonia Works, Kilmarnock
Bennis, Ed., & Co., Ltd. .. .. Bolton
Brown Hoisting Machinery Co. Cleveland, Ohio, U.S.A.
Carron Company .. .. .. Stirlingshire, N.B.
Clay Cross Co., Ltd. .. .. Clay Cross, near Chesterfield
Clayton, Son, & Co., Ltd. .. Hunslet, Leeds
Fletcher, Geo., & Co. Ltd. .. Derby
Goodall, Clayton & Co., Ltd. .. Leeds
Hadfields Limited.. .. .. Hecla Works, Sheffield
Hathorn, Davey & Co., Ltd. .. Leeds [on-Tees
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-
Heenan & Froude, Ltd. .. .. Worcester Engineering Works,
Hornsby, R., & Sons, Ltd. .. Grantham [Worcester
King, H. J. H., & Co., Ltd. .. Nailsworth, Glos.
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster,
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester [S.W.
Sandycroft Limited .. .. Chester
Siemens Brothers Dynamo Wks., Ltd. .. .. } Caxton House, Westminster, S.W.
Walker Bros. (Wigan), Ltd. .. Pagefield Ironworks, Wigan

Colliery Proprietors.
Brown, John, & Co., Ltd. .. Sheffield
Clay Cross Co., Ltd. .. .. Clay Cross, near Chesterfield
Ebbw Vale Steel Iron & Coal Co., Ltd. .. .. Ebbw Vale, Mon.
Glasgow Iron & Steel Co., Ltd... Wishaw Iron & Steel Works, Wishaw

Compasses.
Negretti & Zambra .. .. 38, Holborn Viaduct, E.C.

Composition for Covering Boilers, &c.—*(See Non-Conducting Compositions.)*

Concrete Mixers.
Koehring Machine Company .. Milwaukee, Wisconsin
Ransome-verMehr Machinery Co., Ltd. .. .. } 505, Brunswick House, Westminster, S.W.
Stothert & Pitt, Ltd. .. .. Bath

Concrete (Reinforced).
Expanded Metal Co., Ltd. .. York Mansions, York Street, Westminster, S.W.
Stewart, J. & W. .. .. .. Caxton House, Westminster, S.W.

Condensers (Evaporative).
Deane, Edwd., & Beal, Ltd. .. 676, Old Kent Road, S.E.
Ledward & Beckett, Ltd. .. Broadway Chambers, Westminster, S.W.

Condensers (Fresh Water).—*(See Distilling (Water) Apparatus.)*

Condensers (for Steam Engines).
Allen, W. H., Son, & Co., Ltd... Queen's Eng. Works, Bedford
Belliss & Morcom Ltd. .. .. Ledsam St. Works, Birmingham
British Westinghouse Electric and Manufacturing Co., Ltd. Trafford Park, Manchester
Brush Electrical Engineering Co., Ltd. .. .. .. Falcon Works, Loughborough
Caird & Rayner .. .. .. 777, Commercial Road, E.
Campbell & Calderwood .. Soho Engine Works, Paisley
Carruthers, J. H., & Co., Ltd. .. Polmadie Ironworks, Glasgow
Contraflo Condenser & Kinetic Air Pump Co., Ltd. .. .. } 3, Central Buildings, Westminster, S.W.
Craig, A. F., & Co., Ltd... .. Paisley
Escher Wyss & Co. .. .. 109, Victoria Street, S.W.
Fraser Limited .. .. .. Arbroath, Scotland
Friedenthal, F. .. .. .. River Engine Works, Preston
Hall, J. F., & Sons, Ltd. .. Peterborough
Harris Patent Feed-Water Filter (1910), Ltd. .. .. .. 82, Victoria Street, S.W.
Harris Patent Feed-Water Filter (1910), Ltd. .. .. .. } 24, Grainger Street West, Newcastle-on-Tyne
Hayward-Tyler & Co., Ltd. .. 99, Queen Victoria Street, E.C.
Klein Engineering Co. (1908), Ld. 94, Market Street, Manchester
Korting Brothers, Ltd... .. 53, Victoria Street, S.W.

Condensers for Steam Engines.—*Continued.*
Ledward & Beckett, Ltd. .. Broadway Chambers, Westminster, S.W.
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Parsons, C. A., & Co., Ltd. .. Newcastle-on-Tyne
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Premier Cooler & Engineering Co., Ltd. .. .. .. } Broadway Court, Broadway, Westminster, S.W.
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Richardsons, Westgarth & Co., Ltd. Hartlepool Engine Works, Hartlepool
Royles Limited .. .. .. Irlam, near Manchester
Simpson, James, & Co., Ltd. .. 101, Grosvenor Road, S.W.
Storey, I., & Sons .. .. .. Manchester
Stott, S. S., & Co. .. .. .. Haslingden, near Manchester
Thornycroft, J. I., & Co., Ltd. .. Southampton
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.
Wright's Forge & Engineering Co., Ltd. .. .. Tipton, Staffordshire

Constructional.—*(See Structural Engineering.)*

Controllers (Electrical).—*(See Motor Starters.)*

Conveyors and Elevators.—*(See also Coal Handling Plant.)*
Allen, Edgar, & Co., Ltd. .. Sheffield
Babcock & Wilcox, Ltd. .. .. Oriel House, Farringdon St., E.C.
Bagshawe & Co., Ltd. .. .. Dunstable Works, Dunstable
Barry, Henry & Co., Ltd. .. Aberdeen
Bennis, Ed., & Co., Ltd... .. Bolton
Brown Hoisting Machinery Co. Cleveland, Ohio, U.S.A.
Bullivant & Co., Ltd. .. .. 72, Mark Lane, E.C.
Conveyor and Elevator Co. .. Accrington, Lancashire
Dempster, Robert, & Sons, Ltd. Elland, Yorkshire
Figee .. .. Haarlem, Holland
Fletcher, Geo., & Co., Ltd. .. Derby
Goodall, Clayton & Co., Ltd. .. Leeds
Gutta Percha & Rubber, Ltd. .. Toronto, Canada
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Heenan & Froude, Ltd. .. .. Worcester Engineering Works, Worcester
Jenkins, W. J., & Co., Ltd. .. Beehive Works, Retford
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster,
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds [S.W.
Newell, Ernest, & Co., Ltd. .. Misterton, Gainsboro'
Pott, Cassels & Williamson .. Motherwell, near Glasgow
Ransome-ver Mehr Machinery Co., Ltd. .. .. } 505, Brunswick House, Westminster, S.W.
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Rochester Engineering Co., Ltd. Wickham, Rochester
Selson Engineering Co, Ltd. .. 85, Queen Victoria Street, E.C.
Strachan & Henshaw, Ltd. .. Bristol

Cooling Towers.—*(See Water Cooling Plant.)*

Copper Ingots, Bars and Sheets.
Broughton Copper Co., Ltd. .. Manchester

Coppersmiths.
Birmingham Battery & Metal Co. Birmingham [Glasgow
Blair, Campbell & McLean, Ltd. Woodville Street, Govan,
Delta Metal Co., Ltd. .. .. East Greenwich, S.E.
North-Eastern Marine Engineering Co., Ltd. .. .. .. } Northumberland Wks., Wallsend-on-Tyne
Storey, I., & Sons, Ltd. .. .. Empress Foundry, Manchester

Copying Presses.
Daniell, S. A., Ltd. .. .. Edward Street, Parade, Birmingham

Corrugated Boiler Furnaces.
Leeds Forge Co., Ltd. .. .. Leeds

Cotton Presses.—*(See also Hydraulic Presses.)*
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Fawcett, Preston & Co., Ltd. .. 17, York Street, Liverpool
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Naesmyth, Wilson & Co., Ltd. .. Bridgewater Foundry, Patricroft, near Manchester
Piggott, Thos., & Co., Ltd. .. Birmingham
Rice & Co. (Leeds), Ltd. .. .. Neville Wks., Elland Rd., Leeds
Stewart, Duncan, & Co., Ltd. .. London Road Ironworks, Glasgow
Tangyes Limited .. .. .. Cornwall Works, Birmingham

Counters for Revolutions.
Butler, Theo., Ltd. .. .. 149, Queen Victoria St., E.C.

Couplings (Railway).
A.B.C. Coupler, Ltd. .. .. Queen Anne's Chambers, S.W.
Acieries et Fonderies d'Art, Ltd. Caxton House, Westminster, S.W.
Birmingham Railway Carriage and Wagon Co., Ltd. .. .. Smethwick, Birmingham
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.

Couplings (Shaft).
Boving & Co., Ltd. .. .. 9½, Union Court, Old Broad Street, E.C.
Mackies, Limited.. .. .. Berks Ironworks, Reading
Platt, Samuel, Ltd. .. .. Wednesbury
Power Plant Co., Ltd . .. West Drayton, Middlesex
Richards, George, & Co., Ltd. .. Broadheath, near Manchester
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Smith & Grace Screw Boss Pulley Co., Ltd. .. .. Thrapston
Taylor & Challen, Ltd. .. .. Birmingham
Unbreakable Pulley and Mill Gearing Co., Ltd. .. .. 48, West Gorton, Manchester
Wigglesworth, Frank, & Co., Ld. Clutch Works, Shipley, near Bradford

Cranes, Hoisting Machines, Travellers, Winches, &c.—*(See also Lifts.)*
Arrol, Sir William, & Co., Ltd. Dalmarnock Ironwks., Bridgeton, Glasgow
Babcock & Wilcox, Ltd. .. .. Oriel House, Farringdon St., E.C.
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Booth, Joseph, & Bros., Ltd. .. Rodley, Leeds
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
Brecknell, Munro & Rogers, Ltd. Thrissell Street, Bristol
Broadbent, Thos., & Sons, Ltd. Chapel Hill, Huddersfield
Brown Hoisting Machinery Co. Cleveland, Ohio, U.S.A.
Butters Brothers & Co. .. 20, Waterloo Street, Glasgow
Chambers, Scott & Co., Ltd. .. Motherwell
Chaplin, Alex., & Co., Ltd. .. Govan, Glasgow
Clarke, Chapman & Co., Ltd. .. Gateshead-on-Tyne
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Cowans, Sheldon & Co., Ltd. .. Carlisle
Craven Brothers, Ltd. .. .. Osborne Street, Manchester
Derome Brothers .. .. .. 348, Victoria Street, S.W.
East Ferry Road Engineering Works Co., Ltd. .. .. Millwall, E.
Electromotors Ltd. .. .. Openshaw, Manchester
Fair, Walter D., & Co. .. .. 14, Leicester Street, W.C.
Figee .. .. Haarlem, Holland
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Godfrey Mfg. Co., Ltd. .. .. Old Crane Works, St. John St., Leicester
Grafton & Co. .. .. .. Bedford
Grieve, John, & Co. .. .. Motherwell, Scotland
Hanna, Donald & Wilson .. Paisley, N.B.
Higginbottom & Mannock, Ltd. West Gorton, Manchester
Jack, Alexander, & Co. .. .. Whitegates Engineering Wks. Motherwell
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster S.W.
Link-Belt Company .. .. 299, Broadway, New York City
Marshall, Fleming & Co. .. Motherwell, N.B.

Cranes, Hoisting Machines, Travellers, Winches, &c.—*(See also Lifts).—Continued*
Musgrave Bros. .. .. .. Crown Point Foundry Leeds
Northern Engineering Works .. 6, Chene Street, Detroit, Mich., U.S.A.
Priestman Brothers, Ltd. .. Holderness Foundry, Hull
Ransomes & Rapier, Ltd. .. Waterside Ironworks, Ipswich
Rice & Co. (Leeds), Ltd. .. .. Neville Wks., Elland Rd. Leeds
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
Royce Ltd. .. .. Trafford Park, Manchester
Russell, Geo., & Co., Ltd. .. Motherwell, near Glasgow
Sellers, William, & Co., Incorp.) Philadelphia, Penn., U.S.A.
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Smith, Thos., & Sons .. .. Rodley, near Leeds
Smulders, A. F. .. .. .. Schiedam, Holland
Stamm, W. .. .. 25, College Hill, E.C
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironwks., Glasgow
Stothert & Pitt, Ltd. .. .. Bath
Strachan & Henshaw, Ltd. .. Bristol
Sunderland Forge & Eng. Co., Ltd. .. .. Pallion, Sunderland
Tangyes Limited .. .. .. Birmingham
Taylor & Hubbard .. .. Leicester
Terry & Tench Co. (The) Inc. .. Graud Central Terminal, New York City
Vaughan & Son, Ltd. .. .. Manchester
Waygood-Otis, Ltd. .. .. Falmouth Road, S.E.
Werf Conrad, N.V. .. .. Haarlem, Holland
Whitakers (Engineers), Ltd. .. Horsforth, Leeds
Willetts, Charles, Junr... .. Colonial Wks., Cradley Heath, Staffs.
Youngs .. .. Ryland St. Wks., Birmingham

Crank Axles.
Bessemer, Henry, & Co., Ltd. .. Sheffield
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Hadfields Limited .. .. Hecla Works, Sheffield
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Vickers Limited .. .. .. Sheffield

Crankshafts.
Beardmore, William, & Co., Ld. Parkhead Ironworks, Glasgow
Bessemer, Henry, & Co., Ltd. .. Sheffield
Brown, John, & Co., Ltd. .. Sheffield
Cammell Laird & Co., Ltd. .. Sheffield
Dennystown Forge Co. .. .. Dumbarton
Fife Forge Co. .. .. .. Kirkcaldy, Scotland
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Hadfields Limited .. .. Hecla Works, Sheffield
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Thornycroft, J. I., & Co., Ltd... Southampton
Vickers Limited .. .. .. Sheffield

Cream Separators.
Pott, Cassells & Williamson .. Motherwell, nr. Glasgow

Crucibles.
Doulton & Co., Ltd. .. .. Lambeth, S.E.

Crushing Machinery.—*(See Disintegrators, Grinding Mills, and Stonebreakers.)*

Cupolas.
Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham

Cutting-off Machines.
Cox & Sons, Company (The) .. Bridgeton, N. J., U.S.A.
Taylor Charles (Birmingham), Ltd. .. .. } Bartholomew Square, Birmingham
Winn, Charles, & Co. .. .. Granville Place, Birmingham

Destructors.
Dowson & Mason Gas Plant Co., Ltd. .. .. Levenshulme, Manchester
Heenan & Froude, Ltd. .. .. Worcester Engineering Works
Manlove, Alliott & Co., Ltd. .. Nottingham
Meldrums, Limited .. .. Canal Works, Timperley, nea Manchester

Disincrustants.
Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E
Cumberland Engineering Co. .. Lloyd's House, 6, Lloyd Avenue, E.C
Dampney, J., & Co., Ltd. .. Bute Docks, Cardiff
Robey & Co., Ltd. .. .. Lincoln
Zynkara Co., Ltd. .. .. .. 34-36, Side, Newcastle-on-Tyn

Disinfectors.
Manlove, Alliott & Co., Ltd. .. Nottingham
Tullis, D. & J., Ltd. .. .. Kilbowie Ironwks., nr. Glasgo

Disintegrators.—*(See also Grinding Mills, Ore Crushing, and Stonebreakers.)*
Allen, Edgar, & Co., Ltd. .. Sheffield
Bradley Pulverizer Co. .. .. 37, Walbrook, E.C.
Goodall, Clayton & Co., Ltd. .. Leeds
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hadfields Limited .. .. Hecla Works, Sheffield
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Patent Lightning Crusher Co., Ltd. .. .. } 14a, Rosebery Avenue, Gray's Inn Road, E.C.
Pratchitt Brothers .. .. Denton Ironworks, Carlisle
Stamm W. .. .. 25, College Hill, E.C
Sturtevant Engineering Co., Ltd. 147, Queen Victoria Street, E.C.

Distillery Plant.
Blair, Campbell & McLean, Ltd. Woodville St., Govan, Glasgow
Dowson & Mason Gas Plant Co., Ltd. .. .. Levenshulme, Manchester
Fawcett, Preston & Co., Ltd. .. Liverpool
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Pontifex & Wood, Ltd. .. .. Union Foundry, Derby

Distilling (Water) Apparatus.—*(See also Evaporators.)*
Caird & Rayner .. .. .. 777, Commercial Road,
Chaplin, Alex., & Co. .. .. Govan, Glasgow
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Royles Limited .. .. .. Irlam, nr. Manchester

Diving Apparatus.
Siebe, Gorman & Co., Ltd. .. Neptune Works, S.E.

Doors (Watertight).
Stone, J., & Co., Ltd. .. .. Deptford, S.E.

Draught.—*(See Forced and Induced Draught.)*

Draw Benches.
Platt, Samuel, Ltd. .. .. Wednesbury

Drawing Instruments.
Dargue Bros., Ltd. .. .. Simplon Works, Bedford St Halifax
Halden, J., & Co., Ltd. .. .. 8, Albert Square, Manchester
Hall, B. J., & Co., Ltd. .. .. Chalfont House, Great Peter Street, Westminster, S.W.
Kern & Co. .. .. Aarau, Switzerland
Negretti & Zambra .. .. 38, Holborn Viaduct, E.C.
Stanley, W. F., & Co., Ltd. .. 286, High Holborn, W.C.

Drawings, Tracings, &c.—*(See also Photography and Materials, &c.*
Halden, J., & Co., Ltd. .. .. 8, Albert Square, Manchester
Stanley, W. F., & Co., Ltd. .. Railway Approach, London Bridge S.E.
Westinghouse Cooper Hewitt Co., Ltd. .. .. } 80, York Road, Kings Cross N.

Dredgers (Suction).

Ferguson Brothers (Port Glasgow), Ltd. .. Newark Works, Port-Glasgow
Gwynnes Ltd. .. Hammersmith Ironworks, W.
Lobnitz & Co., Ltd. .. Renfrew
Simons, W., & Co., Ltd. .. Renfrew, Scotland

Dredging Machines.

Bucyrus Company .. Caxton Hse, Westminster, S.W.
Coles, H. J., Ltd. .. London Crane Works, Derby
Dublin Dockyard Co., Ltd. .. North Wall, Dublin
Ferguson Brothers (Port-Glasgow), Ltd. .. Newark Works, Port-Glasgow
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Gwynnes Ltd. .. Hammersmith Ironworks, W.
Hadfields Limited .. Hecla Works, Sheffield
Hanna, Donald & Wilson .. Paisley, N.B.
Link-Belt Company .. 299, Broadway, New York City
Lobnitz & Co., Ltd. .. Renfrew, Scotland
Priestman Bros., Ltd. .. Holderness Foundry, Hull
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
Simons, W., & Co., Ltd. .. Renfrew, N.B.
Smit, L., & Zoon .. Kinderdijk, Holland
Smulders, A. F. .. Schiedam, Rotterdam, Holland
Stothert & Pitt, Ltd. .. Bath
Vickers Limited .. Barrow-in-Furness
Werf Conrad, N.V. .. Haarlem, Holland
Western Wheeled Scraper Co. .. Aurora, Illinois, U.S.A.
Westwood, Joseph, & Co., Ltd. Napier Yard, Millwall, E.

Drop Forgings.—*(See Forgings, Drop.)*

Drop Hammers.—*(See Hammers, Drop.)*

Drying Apparatus.—*(See also Centrifugal Drying Machines, and Hydro-Extractors.)*

Electro-Metals Ltd. .. .. 9½, Union Court, Old Broad Street, E.C.
Keith, James, & Blackman Co., Ltd. .. 27, Farringdon Avenue, E.C.
Lacy-Hulbert & Co., Ltd. .. 91, Victoria Street, S.W.
Manlove, Alliott & Co., Ltd. .. Nottingham
Musgrave & Co., Ltd. .. .. St. Ann's Ironworks, Belfast
Sturtevant Engineering Co., Ltd. 147, Queen Victoria St., E.C.

Dust Collectors *(Mills, Factories, Breweries, &c.).*

Keith, James, & Blackman Co., Ltd. .. .. 27, Farringdon Avenue, E.C.
Ransome, A., & Co., Ltd. .. Stanley Wks., Newark on-Trent
Rochester Engineering Co., Ltd. Wickham, Rochester
Sturtevant Engineering Co., Ltd. 147, Queen Victoria Street, E.C.

Dust Shields for Bearings.

Vickers, Benjn. R., & Sons, Ltd. Leeds

Dynamometers.

Heenan & Froude, Ltd. .. .. Worcester

Dynamos.—*(See Electric Lighting and Power Plant.*

Ebonite.—*(See also Indiarubber Goods, and Woodite for Steam, &c., Packings.)*

India-Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, E.
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester

Economisers (Fuel).

Clay Cross Co., Ltd. .. .. Clay Cross, near Chesterfield
Lowcock, A., Ltd. .. .. .. Shrewsbury

Electric Bells and Signals.

Bailey, Sir W. H., & Co., Ltd. .. Albion Wks. Salford, Manchester

Electric Cables.—*(See also Telegraph Wire & Cables.)*

British Insulated and Helsby Cables, Ltd. .. .. Prescot, Lancashire
India Rubber, Gutta Percha & Telegraph Works Co., Ltd. .. Silvertown, E.

Electric Lighting and Power Plant.—*(See also Motor Starters & Accessories, and Switchboards & Accessories.)*

Allen, W. H., Son, & Co., Ltd. .. Queen's Eng. Works, Bedford
Alley & Macllellan, Ltd. .. .. Sentinel Works, Glasgow
Belliss & Morcom Ltd. .. .. Ledsam St. Works, Birmingham
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
brecknell, Munro & Rogers, Ltd. Thrissell Street, Bristol
British Insulated and Helsby Cables, Ltd. .. .. Prescot, Lancashire
British Thomson-Houston Co., Ltd. .. .. .. Rugby
Brush Electrical Engineering Co., Ltd. .. .. Falcon Works, Loughborough
Clarke, Chapman & Co., Ltd. .. Gateshead-upon-Tyne
Crown Works .. .. London New Road, Chelmsford
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street, [E.C.
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham
Electromotors Ltd. .. .. Openshaw, Manchester
Fowler, J., & Co. (Leeds), Ltd. .. Leeds
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hall, J. P., & Co., Ltd. .. Oldham
Hartnell, Wilson, & Co., Ltd. .. Kirkstall Road, Leeds
Holmes, J. H., & Co. .. .. Portland Road, Newcastle-on-Tyne
Howden, James, & Co. .. .. Scotland Street, Glasgow
India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, E.
Jandus Arc Lamp & Electric Co., Ltd. .. .. Hartham Road, Holloway, N.
Lister, R. A., & Co., Ltd. .. Dursley, Glos.
Mavor & Coulson, Ltd. .. .. 47, Broad St., Mile End, Glasgow
Parsons, C. A., & Co. .. .. Heaton Works, Newcastle
Paul, Matthew, & Co., Ltd. .. Levenford Works, Dumbarton
Phœnix Dynamo Mfg. Co., Ltd. Thornbury Works, Bradford
Royce Ltd. .. .. Trafford Park, Manchester
Siemens Brothers Dynamo Wks., Ltd. .. .. .. Caxton House, Westminster, S.W.
Sturtevant Engineering Co., Ltd. 147, Queen Victoria St., E.C.
Sunderland Forge & Eng. Co., Ltd. .. .. .. Pallion, Sunderland
Thornycroft, J. I., & Co., Ltd. .. Caxton Hse., Westminster, S.W.
Vickers Limited .. .. .. Sheffield

Electric Motors.

Allen, W. H., Son & Co., Ltd. .. Queen's Eng. Works, Bedford
Beyer, Peacock & Co., Ltd. .. Gorton Foundry, Manchester
Booth, Joseph, & Bros., Ltd. .. Rodley, Leeds
British Thomson-Houston Co., Ltd. .. .. Rugby
British Westinghouse Electric and Manufacturing Co., Ltd. Trafford Park, Manchester
Brush Electrical Engineering Co., Ltd. .. .. Falcon Works, Loughborough
Clarke, Chapman & Co., Ltd. .. Gateshead-on-Tyne
Electric & Ordnance Accessories Co., Ltd. .. .. .. Aston, Birmingham
Electric Control, Ltd. .. .. Bridgeton, Glasgow
Electromotors Ltd. .. .. Openshaw, Manchester
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hall, J. P., & Co., Ltd. .. .. Oldham
Hartnell, Wilson, & Co., Ltd. Kirkstall Road, Leeds
Holmes, J. H., & Co. .. .. Portland Road, Newcastle-on-[Tyne
India Rubber, Gutta Percha & Telegraph Works Co., Ltd. .. Silvertown, E.
Mavor & Coulson, Ltd. .. .. 47, Broad St., Mile End, Glasgow
Parsons, C. A., & Co .. .. Heaton Works, Newcastle
Phœnix Dynamo Mfg. Co., Ltd. Thornbury Works, Bradford
Sandycroft Limited .. .. Chester
Siemens Brothers Dynamo Wks., Ltd. .. .. .. Caxton House, Westminster, S.W.
Sturtevant Engineering Co., Ltd. 147, Queen Victoria St., E.C.
Vickers Limited .. .. .. Sheffield

Electric Tools.

Consolidated Pneumatic Tool Co., Ltd. .. .. Palace Chambers, 9, Bridge Street, Westminster, S.W.
Westminster Tool & Electric Co. Suffolk House, Laurence Pountney Hill, E.C.

Electrical Engineers.

Allen, W. H., Son, & Co., Ltd. .. Queen's Eng. Works, Bedford
Barry, Henry, & Co., Ltd. .. Aberdeen
Belliss & Morcom Ltd. .. .. Ledsam St. Works, Birmingham
Beyer, Peacock & Co., Ltd. .. Gorton Foundry, Manchester
Brecknell, Munro & Rogers, Ltd. Thrissell Street, Bristol
British Insulated and Helsby Cables, Ltd. .. .. Prescot, Lancashire
British Thomson-Houston Co., Ltd. .. .. Rugby
Brush Electrical Engineering Co., Ltd. .. .. .. Falcon Works, Loughborough
Clarke, Chapman & Co., Ltd. .. Gateshead upon-Tyne
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street, [E.C.
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham
Electric Contr l, Ltd. .. .. Bridgeton, Glasgow
Electromotors Ltd. .. .. Openshaw, Manchester
Ferranti Ltd. .. .. .. Central House, Kingsway, W.C.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hall, J. P., & Co., Ltd. .. .. Oldham
Hartnell, Wilson & Co., Ltd. .. Kirkstall Road, Leeds
Haywa d-Tyler & Co., Ltd. .. 99, Queen Victoria Street, E.C. Road Station W
Holmes, J. H., & Co. .. .. Portland Road, Newcastle-on-Tyne
Igranic Electric Co., Ltd. .. 147, Queen Victoria Street, E.C.
India Rubber, Gutta Percha & Telegraph Works Co., Ltd. .. Silvertown, E.
Mavor & Coulson, Ltd. .. .. 47, Broad St., Mile End, Glasgow
Parsons, C. A., & Co. .. .. Heaton Works, Newcastle
Phœnix Dynamo Mfg. Co., Ltd. Thornbury Works, Bradford
Record Electrical Co., Ltd. .. Caxton House, Westminster, S.W.
Royce Ltd. .. .. Trafford Park, Manchester
Sandycroft Limited .. .. Chester
Siemens Brothers Dynamo Wks., Ltd. .. .. .. Caxton House, Westminster, S.W.
Vickers Limited .. .. .. Sheffield
Westinghouse Cooper Hewitt Co., Ltd. .. .. 80, York Road, Kings' Cross, N.
Westminster Tool & Electric Co. Suffolk House, Laurence Pountney Hill, E.C.

Elevators (Grain, Coal, &c.).—*(See also Coal Handling Plant, and Conveyors & Elevators.)*

Bagshawe & Co., Ltd. .. .. Dunstable Works, Dunstable
Barry, Henry, & Co., Ltd. .. Aberdeen
Bennis, Ed., & Co., Ltd. .. .. Bolton
Coles, H. J., Ltd. .. .. London Crane Works, Derby
Conveyor and Elevator Co. .. Accrington, Lancashire
East Ferry Road Engineering Works Co., Ltd. .. .. Millwall, E.
Goodall, Clayton & Co., Ltd. .. Leeds
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees [Worcester
Heenan & Froude, Ltd. .. .. Worcester Engineering Works,
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Newell, Ernest, & Co., Ltd. .. Misterton, Gainsboro'
Pott, Cassels & Williamson .. Motherwell, near Glasgow
Priestman Bros., Ltd. .. Holderness Foundry, Hull
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Rochester Engineering Co., Ltd. Wickham, Rochester
Smulders, A. F. .. .. .. Schiedam, Rotterdam, Holland

Emery and Emery Cloth, &c.

Davies, W. J., & Sons, Ltd. .. 109, Weston Street, S.E.
London Emery Works Co .. Park, Tottenham, N.
Mitchell's Emery Wheel Co. .. Bradford, Manchester
Oakey, John, & Sons, Ltd. .. Westminster Bridge Road, S.E.

Emery Grinding & Polishing Machinery.

Beyer, Peacock & Co., Ltd. .. Gorton Foundry, Manchester
Consolidated Pneumatic Tool Co., Ltd. .. .. Palace Chambers, 9, Bridge Street, Westminster, S.W.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Lush, Robert H. .. .. .. 31, Carburton Street, Portland Road Station, W.
London Emery Works Co. .. Park, Tottenham, N.
Luke & Spencer, Ltd. .. .. Broadheath, near Manchester
Mitchell's Emery Wheel Co. .. Bradford, Manchester
Muir, Wm., & Co. .. .. .. Sherbourne Street, Manchester
Rowland, B. R., & Co., Ltd. .. Reddish, near Manchester
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Sterne, L., & Co., Ltd. .. .. Crown Ironworks, Glasgow
Ward, H. W., & Co., Ltd. .. Lionel Street, Birmingham

Emery Wheels.

Greenwood & Batley, Ltd. .. Albion Works, Leeds
London Emery Works Co. .. Park, Tottenham, N.
Luke & Spencer, Ltd. .. .. Broadheath, near Manchester
Mitchell's Emery Wheel Co. .. Mill St., Bradford, Manchester
Rowland, B. R., & Co., Ltd. .. Reddish, near Manchester
Sterne, L., & Co., Ltd. .. .. Crown Ironworks, Glasgow
Tatterall, A. A., & Co. .. .. Blackburn

Engine and Boiler Fittings.

Bailey, Sir W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Barclay, Andrew, Sons & Co., Ld. Caledonia Works, Kilmarnock
Bell's United Asbestos Co., Ltd. 5½, Southwark Street, S.E.
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Fletcher Bros. .. .. Ozells Street North, Birmingham
Green & Boulding, Ltd. .. .. 28, New Bridge Street, E.C.
Hopkinson, J., & Co., Ltd. .. Huddersfield
Hunt & Mitton, Ltd. .. .. Ozells St. North, Birmingham
Lunken Company, Ltd. .. .. 35, Great Dover Street, S.E.
M'Neil, C. .. .. Kinning Park Ironworks and Hydraulic Forge, Glasgow
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Royles Limited .. .. .. Irlam, near Manchester
Schäffer & Budenberg, Ltd. .. Broadheath, near Manchester
Tangyes Limited .. .. .. Birmingham
United Brassfounders & Engineers, Ltd. .. .. .. Empress Foundry, Manchester
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow

Engineers (Consulting and Inspecting).

Armfield, Joseph J., & Co. .. 20, Mark Lane, E.C.
Davis, E. J. .. .. Gt. Eastern Road, Stratford, E.
Jennings, Edward J. .. .. West Walls, Newcastle-on-Tyne
Naish & Croft .. .. .. 150, Alma Street, Birmingham

Engines (Air).

Bailey, Sir W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Belliss & Morcom Ltd. .. .. Ledsam St. Works, Birmingham

Engines (Blowing).—*(See also Fans and Blowers, and Ventilators.)*

Belliss & Morcom Ltd. .. .. Ledsam St. Works, Birmingham
British Westinghouse Electric and Manufacturing Co., Ltd. Trafford Park, Manchester
Davy Brothers, Ltd. .. .. Sheffield
Diamond Blower Co., Ltd. .. 75a, Queen Victoria St., E.C.
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker, [Glasgow, W.
Fullerton, Hodgart, & Barclay, Ltd. .. .. Paisley, Scotland
Fraser & Chalmers, Ltd. .. .. 3, London Wall Buildings, E.C.
Gwynnes Ltd. .. .. .. Hammersmith Ironworks, W.
Walker Bros. (Wigan), Ltd. .. Pagefield Ironworks, Wigan

Engines (Gas).

Allen, W. H., Son & Co., Ltd. .. Bedford
Bates, W. J., & Co., Ltd. .. Denton, Manchester
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
British Westinghouse Electric and Manufacturing Co., Ltd. Trafford Park, Manchester
Cameron, John, Ltd. .. .. Salford, Manchester
Campbell Gas Engine Co., Ltd. Halifax, England
Crossley Bros., Ltd. .. .. Manchester
Davey, Paxman & Co., Ltd. .. Colchester
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street, E.C
Dudbridge Iron Works, Ltd. .. Dudbridge, near Stroud
Fielding & Platt, Ltd. .. .. Gloucester
Gardner, L., & Sons, Ltd. .. Patricroft, Manchester
Haslam Foundry & Engineering Co., Ltd. .. .. Derby
Hindley, E. S., & Sons .. .. Bourton, Dorset
Hornsby, Richard, & Sons, Ltd. Grantham
Kerting Brothers .. .. 53, Victoria St., Westminster,
Lister, R. A., & Co., Ltd. .. Dursley, Glos. [S.W.
Mather & Platt, Ltd .. .. Park Wks., Manchester [ter
National Gas Engine Co., Ltd. .. Ashton-under-Lyne, Manches-
Premier Gas Engine Co., Ld. .. Sandiacre, Nottingham
Robey & Co., Ltd. .. .. Lincoln
Robson, John (Shipley), Ltd. .. Shipley, Yorks
Ruston, Proctor & Co., Ltd. .. Lincoln
Smulders, A. F. .. .. .. Schiedam, Holland
Stamm, W. .. .. 25, College Hill, E.C.
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironworks, Glasgow
Sulzer Brothers .. .. 30, Norfolk Street, W.C.
Tangyes Limited .. .. .. Birmingham
Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster, S.W.

Engines (Locomotive).

Avonside Engine Co., Ltd. .. Bristol
Bagnall, W. G. Ltd. .. .. Castle Engine Works, Stafford
Baldwin Locomotive Works, The 34, Victoria Street, S.W.
Barclay, Andrew, Sons & Co., Ld. Kilmarnock, N.B.
Bell Locomotive Works (Inc.). Yonkers, N.Y., U.S.A.
Beyer, Peacock & Co., Ltd. .. Gorton Foundry, Manchester
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street, [E.C.
Fowler, J., & Co. (Leeds), Ltd. .. Leeds
Hawthorn, R. & W., Leslie & Co., Ltd. .. .. Newcastle-on-Tyne
Hudswell, Clarke & Co., Ltd. .. Leeds
Hunslet Engine Co., Ltd. .. .. Leeds
Kerr, Stuart & Co., Ltd. .. .. 1, Broad Street Place, E.C.
Lima Locomotive Corporation .. Lima, Ohio, U.S.A.
Manning, Wardle & Co., Ltd. .. Boyne Engine Works, Leeds
Nasmyth, Wilson & Co., Ltd. .. Bridgewater Foundry, Patricroft, near Manchester
North British Locomotive Co., Ltd. .. .. Administration Building, 110, Flemington St., Springburn, Glasgow
Peckett & Sons, Ltd. .. .. Atlas Loco. Works, Bristol
Robey & Co., Ltd. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Stephenson, Robert, & Co., Ltd. Darlington
Yorkshire Engine Co., Ltd. .. 16, Finsbury Circus, E.C.

Engines (Marine).

Ailsa Shipbuilding Co., Ltd. .. Troon, N.B.
Bergius Launch & Engine Co. .. Dobbies Loan, Glasgow
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
Burrell, C., & Sons, Ltd. .. Thetford
Campbell & Calderwood .. .. Soho Engine Works, Paisley
Chaplin, Alex., & Co. .. .. Govan, Glasgow
Cochran & Co., Annan, Ltd. .. Annan, N.B.
Crabtree & Co., Ltd. .. .. Great Yarmouth
Day, Summers & Co., Ltd. .. Northam Ironworks, South-
Dodman, Alfred, & Co., Ltd. .. King's Lynn [ampton
Fair, Walter D. & Co. .. .. 14, Leicester Street, W.C.
Fawcett, Preston & Co., Ltd. .. Liverpool
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Hanna, Donald & Wilson .. Paisley, N.B.
Hawthorn, R. & W., Leslie & Co., Ltd. .. .. Newcastle-on-Tyne
Hayes, Edward .. .. .. Stony Stratford, Wolverton
Kermath Mfg. Co. .. .. .. (Dept. E.), Detroit, Mich.,
Lobnitz & Co., Ltd. .. .. Renfrew, Scotland [U.S.A.
Mckie & Baxter .. .. .. Govan, Glasgow
Mumford, A. G., Ltd. .. .. Culver St. Ironwks., Colchester
North-Eastern Marine Engineering Co., Ltd. .. .. .. Northumberland Wks., Wallsend-on-Tyne
Paul, Matthew, & Co., Ltd. .. Levenford Works, Dumbarton
Plenty & Son, Ltd. .. .. Eagle Ironwks., Newbury, Berks
Richardsons, Westgarth & Co., Ld. Hartlepool Engine Works, Hartlepool
Ross & Duncan .. .. .. Whitefield Works, Glasgow
Rowan, David, & Co. .. .. Glasgow
Savery, T. A., & Co., Ltd. .. Newcomen Wks., Birmingham
Simons, W., & Co., Ltd. .. .. Renfrew, N.B.
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Smit, L., & Zoon .. .. .. Kinderdijk, Holland
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironworks, Glasgow
Sulzer Brothers .. .. .. 30, Norfolk Street, W.C.
Thornycroft, J. I., & Co., Ltd. .. Chiswick, W., & Southampton
Vickers Limited .. .. .. Barrow-in-Furness
Vosper & Co., Ltd. .. .. Portsmouth
Wallsend Slipway & Engineering Co., Ltd. .. .. Wallsend
White, J. Samuel, & Co., Ltd. .. East Cowes, Isle of Wight
Yarrow & Co., Ltd. .. .. Glasgow

Engines (Oil).

Allen, W. H., Son & Co., Ltd. .. Bedford
Bates, W. J., & Co., Ltd. .. Denton, Manchester
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Bergius Launch & Engine Co. .. Dobbies Loan, Glasgow
Blackstone & Co., Ltd. .. .. Rutland Works, Stamford
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
Broom & Wade, Ltd. .. .. High Wycombe
Campbell Gas Engine Co., Ltd. Halifax, England
Crossley Bros., Ltd. .. .. Manchester
Dudbridge Iron Works, Ltd. .. Dudbridge, near Stroud
Fair, Walter D. & Co. .. .. 14, Leicester Street, W.C.
Fielding & Platt, Ltd. .. .. Gloucester
Gardner, L., & Sons, Ltd. .. Patricroft, Manchester
Hornsby, R., & Sons, Ltd. .. Grantham
Kermath Mfg. Co. .. .. .. (Dept. E.), Detroit, Mich.,
Lister, R. A., & Co., Ltd. .. Dursley [U.S.A.
Marshall, Sons & Co., Ltd. .. Gainsborough
Mirrlees, Bickerton & Day, Ltd. Hazel Grove, near Stockport
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
National Gas Engine Co., Ltd. .. Ashton-under-Lyne, Manchester
Normand, Augustin .. .. 67, Rue du Perrey, Le Havre, France
Petters Limited .. .. .. Nautilus Works, Yeovil
Plenty & Son, Ltd. .. .. Newbury, Berkshire
Reavell & Co., Ltd. .. .. Ipswich
Robey & Co., Ltd. .. .. Lincoln
Robson, John (Shipley), Ltd. .. Shipley, Yorks
Ruston, Proctor & Co., Ltd. .. Sheaf Iron Works, Lincoln
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Smulders, A. F. .. .. .. Schiedam, Holland
Sulzer Brothers .. .. .. 30, Norfolk Street, W.C.
Tangyes Limited .. .. .. Birmingham
Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster, S.W.
Vosper & Co., Ltd. .. .. Portsmouth [S.W.
Westinghouse Brake Co., Ltd. .. 82, York Rd., King's Cross, N.
White, J. Samuel, & Co., Ltd. .. East Cowes, Isle of Wight
Willans & Robinson, Ltd. .. Rugby, Warwickshire
Wolseley Motors Ltd. .. .. York Street, Westminster, S.W.

Engines (Portable).

Blackstone & Co., Ltd. .. .. Rutland Works, Stamford
Davey, Paxman & Co., Ltd. .. Colchester
Garrett, R., & Sons, Ltd. .. Leiston Works, Suffolk
Hindley, E. S., & Sons .. .. Bourton, Dorset; and 11, Queen Victoria Street, E.C.
Hornsby, R., & Sons, Ltd. .. Grantham
Marshall, Sons & Co., Ltd. .. Gainsborough
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Ransomes, Sims & Jefferies, Ltd. Ipswich
Robey & Co., Ltd. .. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Smedley Brothers, Ltd. .. .. Belper, Derbyshire
Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster, S.W.

Engines (Pumping).

Bailey, Sir W. H., & Co., Ltd. .. Albion Wks., Salford, Manchester
Barclay, Andrew, Sons & Co., Ltd. .. .. Caledonia Works, Kilmarnock, Scotland
Belliss & Morcom Ltd. .. .. Ledsam St. Works, Birmingham
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
Caird & Rayner .. .. .. 777, Commercial Road, Limehouse, E.
Carruthers, J. H., & Co., Ltd. .. Polmadie Ironworks, Glasgow
Clarke, Chapman & Co., Ltd. .. Gateshead on-Tyne
Davey, Paxman & Co., Ltd. .. Colchester
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker, [Glasgow, W.
East Ferry Road Engineering Works Co., Ltd. .. .. .. Millwall, E.
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Fullerton, Hodgart & Barclay, Ltd. .. .. Vulcan Foundry and Engine Works, Paisley
Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Gwynnes Ltd. .. .. Hammersmith Ironworks, W
Hathorn, Davey & Co., Ltd. .. Leeds
McOnie, A. & P. W. .. .. Govan, Glasgow
Manlove, Alliott & Co., Ltd. .. Nottingham
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Pratchitt Brothers .. .. Denton Ironworks, Carlisle
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Rice & Co (Leeds), Ltd. .. .. Elland Road, Leeds
Robey & Co., Ltd. .. .. Lincoln
Simpson, James, & Co., Ltd. .. 101, Groswenor Road, S.W.
Smith, Hugh, & Co. .. .. Possil Engine Works, Glasgow
Stott, S. S., & Co. .. .. .. Haslingden, near Manchester
Tangyes Limited .. .. .. Birmingham
Worthington Pump Co., Ltd. .. 163, Queen Victoria Street, E.C.
Yates & Thom, Ltd. .. .. Canal Works, Blackburn

Engines (Stationary).

Allen, W. H., Son, & Co., Ltd. .. Queen's Eng. Works, Bedford
Alley & Macllellan, Ltd. .. .. Sentinel Works, Glasgow
Anderston Foundry Co., Ltd. .. Glasgow; and at Middlesboro'
Bailey, Sir W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Belliss & Morcom Ltd. .. .. Ledsam St. Works, Birmingham
Bever, Dorling & Co., Ltd. .. Bowling Ironworks, Bradford
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
Brotherhood, P., Ltd. .. .. 53, Parliament Street, S.W.
Browett, Lindley & Co., Ltd. .. Patricroft, Manchester
Brown Bros. & Co., Ltd. .. .. Rosebank Ironwks., Edinburgh, N.B.
Campbell & Calderwood .. .. Soho Engine Works, Paisley
Chaplin, Alex., & Co., Ltd. .. Govan, Glasgow
Clarke, Chapman & Co., Ltd. .. Gateshead-upon-Tyne
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Craig, A. F., & Co., Ltd. .. .. Paisley, N.B.
Davey, Paxman & Co., Ltd. .. Colchester
Davy Brothers, Ltd. .. .. Sheffield
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Donkin Co., Ltd. (The Bryan) .. Chesterfield
Douglas & Grant, Ltd. .. .. Dunnikier Foundry, Kirkcaldy, N.B.
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker, [Glasgow, W.
East Ferry Road Engineering Works Co., Ltd. .. .. .. Millwall, E.
Fawcett, Preston & Co., Ltd. .. Liverpool
Fowler, J., & Co. (Leeds), Ltd. .. Leeds
Fullerton, Hodgart & Barclay, Ltd. .. .. Vulcan Foundry and Engine Works, Paisley
Galloways Ltd. .. .. .. Manchester
Garrett, R., & Sons, Ltd. .. Leiston Works, Suffolk
Grantham Boiler & Crank Co., Ld. Grantham
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Gwynnes Ltd. .. .. Hammersmith Ironworks, W.
Harvey Engineering Co., Ltd. .. Scotland Street Engine Works, Scotland
Hathorn, Davey & Co., Ltd. .. Leeds [Glasgow
Heenan & Froude, Ltd. .. .. Worcester Engineering Works, Worcester
Hindley, E. S., & Sons .. .. Bourton, Dorset; and 11, Queen Victoria Street, E.C.
Hornsby, R., & Sons, Ltd. .. Grantham
Howden, James, & Co. .. .. Scotland Street, Glasgow
King, H. J. H., & Co., Ltd. .. Nailsworth, Glos.
Lees, T. & R. .. .. Hollinwood, by Manchester
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster,
Marshall, Sons & Co., Ltd. .. Gainsborough [S.W.
Pratchitt Brothers .. .. Denton Ironworks Carlisle
Ransomes, Sims & Jefferies, Ltd. Ipswich
Robey & Co., Ltd. .. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Sandycroft Limited .. .. Chester
Siemens Brothers Dynamo Wks., Ltd. .. .. .. Caxton House, Westminster, S.W.
Tangyes Limited .. .. .. Birmingham
Walker Bros. (Wigan), Ltd. .. Pagefield Ironworks, Wigan
Yates & Thom, Ltd. .. .. Canal Works, Blackburn

Engines (Traction).

Aveling & Porter, Ltd. .. .. Rochester
Avonside Engine Co., Ltd. .. Bristol
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
Burrell, C., & Sons, Ltd. .. Thetford
Davey, Paxman & Co., Ltd. .. Colchester
Fowler, J., & Co. (Leeds), Ltd. .. Leeds
Garrett, R., & Sons, Ltd. .. Leiston Works, Suffolk
Hornsby, R., & Sons, Ltd. .. Grantham
Marshall, Sons & Co., Ltd. .. Gainsborough
Pratchitt Brothers .. .. Denton Ironworks, Carlisle
Ransomes, Sims & Jefferies, Ltd. Ipswich
Robey & Co., Ltd. .. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Thornycroft, J. I., & Co., Ltd. .. Basingstoke
Wolseley Motors, Ltd. .. .. York Street, Westminster, S.W.

Engines (Winding).—*(See also Haulage Plants.)*

Barclay, Andrew, Sons & Co., Ltd. .. .. Caledonia Works, Kilmarnock, Scotland
Bever, Dorling & Co., Ltd. .. Bowling Works, Bradford
Chaplin, Alex., & Co., Ltd. .. Govan, Glasgow
Clarke, Chapman & Co., Ltd. .. Gateshead-on-Tyne
Davey, Paxman & Co., Ltd .. Colchester
East Ferry Road Engineering Works Co., Ltd. .. .. Millwall, E.
Fawcett, Preston & Co., Ltd. .. Liverpool
Galloways Ltd. .. .. .. Manchester
Heenan & Froude, Ltd. .. .. Worcester Engineering Works, Worcester
Hindley, E. S., & Sons .. .. Bourton, Dorset; and 11, Queen Victoria Street, E.C.
King, H. J. H., & Co., Ltd. .. Nailsworth, Glos.
Lees, T. & R. .. .. Hollinwood, by Manchester
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster,
Marshall, Sons & Co., Ltd. .. Gainsborough [S.W.
Pratchitt Brothers .. .. Denton Ironworks Carlisle
Ransomes, Sims & Jefferies, Ltd. Ipswich
Robey & Co., Ltd. .. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Sandycroft Limited .. .. Chester
Siemens Brothers Dynamo Wks., Ltd. .. .. .. Caxton House, Westminster, S.W.
Tangyes Limited .. .. .. Birmingham
Walker Bros. (Wigan), Ltd. .. Pagefield Ironworks, Wigan
Yates & Thom, Ltd. .. .. Canal Works, Blackburn

Evaporators.—*(See also Distilling (Water) Apparatus.)*

Blair, Campbell & McLean, Ltd. — Woodville St., Govan, Glasgow
Burnet, L., & Co. .. — Govan, Glasgow
Caird & Rayner .. .. — 777, Commercial Road, E.
Fullerton, Hodgart & Barclay, Ltd. .. .. .. — Vulcan Foundry and Engine Works, Paisley
Harvey Engineering Co., Ltd. .. — Scotland Street Engine Works, Glasgow
Mirrlees Watson Co., Ltd. .. — Scotland Street, Glasgow
Richardsons, Westgarth & Co., Ltd. .. .. — Hartlepool
Royles Limited .. .. .. — Irlam, near Manchester
Weir, G. & J., Ltd. .. .. — Cathcart, Glasgow

Excavators.

Bucyrus Company .. .. — Caxton House, Westminster,
Chaplin, Alex., & Co., Ltd. .. — Govan, Glasgow [S.W.
Coles, H. J., Ltd. .. .. .. — London Crane Works, Derby
Figee .. .. — Haarlem, Holland
Fleming & Ferguson, Ltd. .. — Paisley, N.B.
Link-Belt Company .. .. — 299, Broadway, New York City
Lobnitz & Co., Ltd. .. .. — Renfrew, Scotland
Priestman Bros., Ltd. .. .. — Holderness Foundry, Hull
Rose, Downs & Thompson, Ltd. — Old Foundry, Hull
Rubery, Owen & Co. .. .. — Darlaston, South Staffordshire
Ruston, Proctor & Co., Ltd. .. — Sheaf Ironworks, Lincoln
Smulders, A. F. .. .. — Schiedam, Rotterdam, Holland
Strachan & Henshaw, Ltd. .. — Bristol
Western Wheeled Scraper Co. .. — Aurora, Illinoi , U.S.A.
Westwood, Joseph, & Co., Ltd. — Napier Yard, Millwall, E.
Whitakers (Engineers), Ltd. .. — Horsforth, Leeds

Exhausters.—*(See also Gas Exhausters.)*

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. — Birmingham
Donkin Co., Ltd. (The Bryan) .. — Chesterfield
Gwynnes Ltd. .. .. .. — 81, Cannon Street, E.C.
Korting Bros., Ltd. .. .. — 53, Victoria St., Westminster, S.W.
Samuelson & Co., Ltd. .. .. — Britannia Wks, Banbury, Oxon.
Standard Engineering Co., Ltd. — Leicester

Expanded Metal.

Expanded Metal Co., Ltd. .. — York Mansion, York Street, Westminster, S.W.

Fans and Blowers.—*(See also Engines—Blowing, and Ventilators.)*

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. — Birmingham
Allen, W. H., Son, & Co., Ltd. .. — Queen's Eng. Works, Bedford
Barclay, Andrew, Sons & Co., Ltd. .. .. — Caledonia Works, Kilmarnock, Scotland
Belliss & Morcom Ltd. .. .. — Ledsam St. Wks., Birmingham
Brotherhood, P., Ltd. .. .. — 53, Parliament Street, S.W.
Churchill, Chas., & Co., Ltd. .. — 9 to 15, Leonard Street, E.C.
Davidson & Co., Ltd. .. .. — Sirocco Engin'r'g. Wks., Belfast
Diamond Blower Co., Ltd. .. — 75B, Queen Victoria Street, E.C.
Donkin Co., Ltd. (The Bryan) .. — Chesterfield
Electric & Ordnance Accessories Co., Ltd. .. .. .. — Aston, Birmingham
Electromotors Ltd. .. .. — Openshaw, Manchester
Fraser & Chalmers, Ltd. .. .. — 3, London Wall Buildings, E.C.
Gibbs, John, & Son .. .. — 722-6, Duke Street, Liverpool
Günther, W , & Sons .. .. — Central Works, Oldham
Gwynnes Ltd. .. .. .. — Hammersmith Ironworks, W.
Heenan & Froude, Ltd. .. .. — Worcester Engineering Works, Worcester
Howden, James, & Co. .. .. — Scotland St., Glasgow
Keith, James, & Blackman Co., Ltd. .. .. — 27, Farringdon Avenue, E.C.
Korting Bros. .. .. .. — 53, Victoria Street, S.W.
Musgrave & Co., Ltd. .. .. — St. Ann's Ironworks, Belfast
Parsons, C. A., & Co, ... — Heaton Works, Newcastle
Paul, Matthew, & Co., Ltd. .. — Levenford Works, Dumbarton
Samuelson & Co., Ltd. .. .. — Banbury, Oxon
Simpson, Strickland & Co., Ltd. — Dartmouth
Standard Engineering Co., Ltd. — Leicester
Sturtevant Engineering Co., Ld. — 147, Queen Victoria Street, E.C.
Walker Bros. (Wigan), Ltd. .. — Pagefield Ironworks, Wigan
Westminster Tool & Electric Co. — Suffolk House, Laurence Pountney Hill, E.C.

Feed Check Valves (Combination).

Green & Boulding, Ltd. .. .. — 28, New Bridge Street, E.C.
Hopkinson, J., & Co., Ltd. .. — Huddersfield
Weir, G. & J., Ltd. .. .. — Cathcart, Glasgow

Feed Water Filters.—*(See also Filtering Apparatus.)*

Carruthers, J. H., & Co., Ltd. .. — Polmadie Ironworks, Glasgow
Harris Patent Feed-Water Filter (1910), Ltd. .. .. .. — 82, Victoria Street, S.W.
Harris Patent Feed-Water Filter (1910), Ltd. .. .. .. — 24, Grainger Street West, Newcastle-on-Tyne
Mather & Platt, Ltd. .. .. — Park Works, Manchester

Feed-Water Heaters.

Babcock & Wilcox, Ltd. .. .. — Oriel House, Farringdon St., E.C.
Bailey, Sir W. H., & Co., Ltd. .. — Albion Wks. Salford, Manchest'r
Burnet, L., & Co. .. .. .. — Govan, Glasgow
Caird & Rayner .. .. .. — 777, Commercial Road, E.
Clarke, Chapman & Co., Ltd. .. — Gateshead-on-Tyne
Hall, J. P., & Sons, Ltd. .. .. — Peterborough
North-Eastern Marine Engineering Co., Ltd. .. .. .. — Northumberland Wks., Wallsend-on-Tyne
Paterson Engineering Co., Ltd. — 21, Amberley House, Norfolk Street, Strand, W.C.
Royles Limited .. .. .. — Irlam, near Manchester
Shore, T., & Sons .. .. .. — Etruria, Stoke-on-Trent
Storey I., & Sons, Ltd. .. .. — Manchester
Tangyes Limited .. .. .. — Birmingham
Weir, G. & J., Ltd. .. .. — Cathcart, Glasgow
Worthington Pump Co., Ltd. .. — 153, Queen Victoria Street, E.C.
Wright's Forge & Engineering Co., Ltd. .. .. — Tipton, Staffordshire

Feed-Water Regulators.

Kater & Ankersmit .. .. — 34, Fenchurch Street, E.C.
Thornycroft, J. I., & Co., Ltd. .. — Basingstoke
Trist, Ronald, & Co., Ltd. .. — 4, Lloyd's Avenue, E.C.
White, J. Samuel, & Co., Ltd. .. — East Cowes, Isle of Wight
Yarrow & Co., Ltd. .. .. — Glasgow

Fencing.

Bayliss, Jones & Bayliss, Ltd. .. — Wolverhampton
Rubery, Owen & Co. .. .. — Darlaston, South Staffordshire

Ferro-Concrete.—*(See Concrete—Reinforced).*

Files.

Allen, Edgar, & Co., Ltd. .. — Imperial Steel Works, Sheffield
Cammell Laird & Co., Ltd. .. — Cyclops Steel & Iron Works, Sheffield
Firth, Thos., & Sons, Ltd. .. — Norfolk Works, Sheffield
Hadfields Limited .. .. — Hecla Works, Sheffield
Spencer, John, & Sons, Ltd. .. — Newburn Steel Works, Newcastle-on-Tyne
Turton, T., & Sons, Ltd. .. .. — Sheaf Works, Sheffield

Filtering Apparatus.—*(See also Feed-water Filters.)*

Buhring's Patent Water Purifying Co. .. .. — 60, Wilson Street, E.C.
Caird & Rayner .. .. .. — 777, Commercial Road, E.
Carruthers, J. H., & Co., Ltd. .. — Polmadie Ironworks, Glasgow
Cochburns Limited .. .. — Clydesdale Works, Cardonald,
Harris Patent Feed-Water Filter (1910), Ltd. .. .. .. — [near Glasgow 82, Victoria Street, S.W.
Harris Patent Feed-Water Filter (1910), Ltd. .. .. .. — 24, Grainger Street West, Newcastle-on-Tyne
Manlove, Alliott & Co., Ltd. .. — Nottingham
Mather & Platt, Ltd. .. .. — Park Works, Manchester
Mirrlees Watson Co., Ltd. .. — Scotland Street, Glasgow
Paterson Engineering Co., Ltd. — 21, Amberley House, Norfolk Street, Strand, W.C.
Pulsometer Engineering Co., Ltd. — Nine Elms Ironworks, Reading
Royles Limited .. .. .. — Irlam, near Manchester
Rubery, Owen & Co. .. .. — Darlaston, South Staffordshire
United Water Softeners, Ltd. .. — Imperial Hse., Kingsway, W.C.
Wells, A. C., & Co. .. .. — 102, Midland Rd., N.W.
Wrights' Forge & Engineering Co., Ltd. .. .. — Tipton, Staffordshire

Filters (Air).

Premier Cooler & Engineering Co., Ltd. .. .. — Broadway Court, Broadway, Westminster, S.W.
Heenan & Froude, Ltd. .. .. — Worcester Engineering Works, Worcester

Fire Bars.

Barclay, Andrew, Sons & Co., Ltd. .. .. — Caledonia Works, Kilmarnock
Rose, Downs & Thompson, Ltd. — Old Foundry, Hull

Fire-Extinguishing Apparatus.

Merryweather & Sons .. .. — 63, Long Acre, W.C.
Reddaway, F., & Co., Ltd. .. — Pendleton, Manchester
Worthington Pump Co., Ltd. .. — 153, Queen Victoria Street, E.C.

Flour Mill Machinery.—*(See Mill Machinery—Flour, Corn and Rice.)*

Forced and Induced Draught Apparatus.

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. — Birmingham
Benuis, Ed., & Co., Ltd. .. .. — Bolton
Davidson & Co., Ltd. .. .. — Sirocco Engineering Works, Belfast
Davy Bros., Ltd. .. .. .. — Sheffield
Electric & Ordnance Accessories Co., Ltd. .. .. — Aston, Birmingham
Heenan & Froude, Ltd. .. .. — Worcester Engineering Works, Worcester
Howden, James, & Co. .. .. — Scotland Street, Glasgow
Keith, James, & Blackman Co., Ltd. .. .. — , Farringdon Avenue, E.C.
Mechan & Sons, Ltd. .. .. — Scotstoun Iron Works, Glasgow
Meldrums Ltd. .. .. .. — Canal Works, Timperley, near Manchester
Musgrave & Co., Ltd. .. .. — St. Ann's Ironworks, Belfast
Prat, Louis .. .. — 29, Rue de l'Arcade, Paris
Standard Engineering Co., Ltd. — Leicester
Sturtevant Engineering Co., Ld. — 147, Queen Victoria St., E.C.
Utting, S. (Prat System) .. — 4, St. Mary Axe, E.C.

Forges (Portable).

Sturtevant Engineering Co., Ld. — 147, Queen Victoria Street, E.C.
Standard Engineering Co., Ltd. — Leicester

Forging Machines and Plant.

Berry, Henry, & Co., Ltd. .. — Croydon Works, Hunslet, Leeds
Brett's Patent Lifter Co., Ltd. .. — Coventry
Davis & Primrose, Ltd. .. .. — Bangor Road, Leith
Davy Brothers, Ltd. .. .. — Sheffield
Greenwood & Batley, Ltd. .. — Albion Works, Leeds
Player, W. & J. .. .. .. — Birmingham
Rice & Co. (Leeds), Ltd. .. — Elland Road, Leeds
Ryder, Thomas, & Son, Ltd. .. — Turner Bridge Ironwks., Bolton
Smith, Hugh, & Co., Ltd. .. — Possil Engine Works, Glasgow
Taylor & Challen, Ltd. .. .. — Birmingham

Forging Presses.—*(See also Hydraulic Presses.)*

Berry, Henry, & Co., Ltd. .. — Croydon Works, Hunslet, Leeds
Davy Brothers, Ltd. .. .. — Sheffield
McOnie, A. & P. W. .. .. — Govan, Glasgow
Rice & Co. (Leeds), Ltd. .. .. — Elland Road, Leeds
Smith, Hugh, & Co., Ltd. .. — Possil Engine Works, Glasgow
Stewart, Duncan, & Co, Ltd. .. — London Road Ironworks, Glasgow

Forgings (Brass, Bronze, Copper, &c.).

Delta Metal Co., Ltd. .. .. — East Greenwich, S.E.

Forgings (Drop).

Armstrong, Stevens & Son Ltd. — Whittall Street, Birmingham
Carron Company .. .. .. — Carron, Stirlingshire, N.B.
Head, Wrightson & Co., Ltd. .. — Teesdale Iron works, Thornaby-on-Tees
Hurst, Nelson & Co., Ltd. .. — Motherwell, N.B.
Vickers Limited .. .. — Sheffield
Wiley, James, & Sons, Ltd. .. — Darlaston

Forgings (Iron and Steel).

Beardmore, William, & Co., Ltd. — Parkhead Ironworks, Glasgow
Bessemer, Henry, & Co., Ltd. .. — Sheffield
Brown, Bayley's Steel Works, Ld. — Sheffield
Brown, John, & Co., Ltd. .. — Sheffield
Cammell Laird & Co. Ltd. .. — Cyclops Steel & Iron Works, Sheffield
Carron Company .. .. .. — Carron, Stirlingshire, N.B.
Colville, David, & Sons, Ltd. .. — Motherwell, near Glasgow
Darlington Forge Co., Ltd. .. — Darlington
Dennystown Forge Co. .. .. — Dumbarton
Fairley, James, & Sons .. .. — Shadwell Street, Birmingham
Fife Forge Co. .. .. .. — Kirkcaldy, Scotland
Firth, Thos., & Sons, Ltd. .. — Norfolk Works, Sheffield
Hadfields Limited .. .. .. — Hecla Works, Sheffield
Hawthorn, R. & W., Leslie & Co., Ltd. .. .. — Newcastle-on-Tyne
Hurst, Nelson & Co., Ltd. .. — Glasgow Rolling Stock and Plant Works, Motherwell
Kirkstall Forge Co., Ltd. .. — Near Leeds
Leeds Forge Co., Ltd. .. .. — Leeds
Midland Railway Carriage and Wagon Co., Ltd. .. .. — Midland Works, Birmingham
North-Eastern Marine Engineering Co., Ltd. .. .. .. — Northumberland Wks., Wallsend-on-Tyne
Richards, Edwin, & Sons .. — Portway Works, Wednesbury
Spencer, John, & Sons, Ltd. .. — Newburn Steel Works, Newcastle-on-Tyne
Steel Co. of Scotland, Ltd. .. — 23, Royal Exchange Square, Glasgow
Thornycroft, J. I., & Co., Ltd. .. — Southampton
Vickers Limited .. .. .. — Sheffield

Foundry Plant.—*(See also Crucibles, Cupolas, Ladles, Moulding Machines, and Sand Blast Machines.)*

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. — Birmingham
London Emery Works Co. .. — Park, Tottenham, N.
Pridmore, Henry E. (Inc.) .. — 19th and Rockwell Streets, Chicago, Ill., U.S.A.

Furnaces for Destroying Refuse.—*(See Disinfectors and Destructors.)*

Furnaces and Furnace Fittings.

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. — Birmingham
August's Muffle Furnaces, Ltd. — Thorn Tree Work King Cross, Halifax
Beardmore, William, & Co., Ltd. — Parkhead Forge Rolling Mills and Steel Works, Glasgow
Bennis, Ed., & Co., Ltd. .. — Lancashire Stoker Works, Bolton
Brett's Patent Lifter Co., Ltd .. — Coventry
Brown, John, & Co., Ltd. .. — Sheffield
Churchill, Chas., & Co., Ltd. .. — 9 to 15, Leonard Street, E.C.
Dowson & Mason Gas Plant Co., Ltd. .. .. — Levenshulme, Manchester
Howden, James, & Co. .. .. — Scotland Street, Glasgow
Leeds Forge Co., Ltd. .. .. — Leeds
Meldrums Ltd. .. .. .. — Canal Works, Timperley, near Manchester
Monometer Manufacturing Co., Ltd. .. .. — Whitehouse Street, Aston, Birmingham
Piggott, Thos., & Co., Ltd. .. — Birmingham
Underfeed Stoker Co., Ltd. .. — Coventry House, South Place,
Wallsend Slipway & Engineering Co., Ltd. .. .. .. — [E.C. Wallsend

Furnaces (Gas and Oil Heated).

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. — Birmingham

Furnaces (Hardening).

August's Muffle Furnaces, Ltd. — Thorn Tree Works, King Cross, Halifax
Wright, John, & Co. .. .. — Eureka Works, Birmingham

Fusible Plugs.

Lunken Company, Ltd. .. .. — 35, Great Dover Street, S.E.
National Boiler and General Insurance Co., Ltd. .. .. — St. Mary's Parsonage, Manchester

Galvanized Ironwork.

Ash, Joseph, & Son .. .. — Rea Street South, Birmingham
Baldwins, Ltd. .. .. .. — 5, Fenchurch Street, E.C
Braby, Fred., & Co., Ltd. .. — Fitzroy Wks., 352 to 364, Euston Road, N.W.
Harvey, G. A., & Co. (London), Ltd. .. .. — Greenwich Metal Works, Woolwich Road, S.E.
Ramshay & Marshall, Ltd. .. — Birmingham

Galvanizers.

Ash, Joseph, & Son .. .. — Rea Street South, Birmingham
Braby, Fred., & Co., Ltd. .. — Fitzroy Wks., 352 to 364, Euston Road, N.W.
Ebbw Vale Steel Iron & Coal Co., Ltd. .. .. — Ebbw Vale, Mon.
Harvey, G.A., & Co. (London), Ld. — Greenwich Metal Works, Woolwich Road, S.E.

Gas Engines.—*(See Engines, Gas.)*

Gas Exhausters.—*(See also Exhausters.)*

Allen, W. H., Son, & Co., Ltd. .. — Queen's Eng. Works, Bedford
Donkin Co., Ltd. (The Bryan) .. — Chesterfield
Gwynnes Ltd. .. .. .. — 81, Cannon Street, E.C.
Korting Brothers, Ltd. .. .. — 53, Victoria St., Westminster, S.W.
Samuelson & Co., Ltd. .. .. — Britannia Works, Banbury, Oxon.
Sturtevant Engineering Co., Ltd. — 147, Queen Victoria Street, E.C.

Gas Producers.

Bellamy, John, Ltd. .. .. — Millwall, E.
Cameron, John, Ltd. .. .. — Salford, Manchester
Campbell Gas Engine Co., Ltd. — Halifax, England
Clayton, Son, & Co., Ltd. .. — Hunslet, Leeds
Crossley Bros., Ltd. .. .. — Openshaw, Manchester
Daniels, T. H. & J., Ltd. .. — Stroud, Glos.
Davey, Paxman & Co., Ltd. .. — Colchester
Dempster, E. & J., Ltd. .. .. — Newton Heath, Manchester
Dowson & Mason Gas Plant Co., Ltd. .. .. — 39, Victoria Street, Westminster, S.W.
Dowson & Mason Gas Plant Co., Ltd. .. .. — Levenshulme, Manchester
Fielding & Platt, Ltd. .. .. — Gloucester
Gas Power & By-Products Co., Ltd. .. .. — 116, Hope Street, Glasgow
Hornsby, Richard, & Sons, Ltd. — Grantham
Pierson, J. & O. G. .. .. — 47, Rue Lafayette, Paris
Power Gas Corporation, Ltd. .. — Stockton-on-Tees
Robson, John (Shipley), Ltd. .. — Shipley, Yorks
Rodger, A., & Co. .. .. .. — St. Helen's Engine Works, Govan, Glasgow
Ruston, Proctor & Co., Ltd. .. — Lincoln
Stewart, Duncan, & Co., Ltd. .. — London Rd. Ironwks., Glasgow
Tangyes Limited .. .. .. — Birmingham

Gas Works (Plant for).—*(See also Coke Rams, and Exhausters.)*

Ashmore, Benson, Pease & Co., Ld. — Stockton-on-Tees
Clarke, Chapman & Co., Ltd. .. — Victoria Works, Gateshead-on-Tyne
Clayton, Son, & Co., Ltd. .. — Hunslet, Leeds [Tyne
Donkin Co., Ltd. (The Bryan) .. — Chesterfield
Goodall, Clayton & Co., Ltd. .. — Leeds
Hanna, Donald & Wilson .. .. — Paisley, N.B.
Head, Wrightson & Co., Ltd. .. — Teesdale Ironworks, Thornaby-on-Tees
Jenkins, W. J., & Co., Ltd. .. — Beehive Works, Retford
Patent Shaft & Axletree Co., Ltd. — Wednesbury
Piggott, Thos., & Co., Ltd. .. — Springhill, Birmingham

Gases (Oxygen, &c.)

British Oxygen Co., Ltd. .. — Elverton Street, S.W.
Imperial Light Limited .. .. — 123, Victoria Street, S.W.

Gauge Glasses.

Butterworth Bros., Ltd. .. — Newton Heath Glass Wks., Manchester
Guilbert-Martin .. .. .. — 9, Edmund Place, Aldersgate, E.C.
Klinger, Richard, & Co. .. .. — 56, Fenchurch St., E.C.
Lunken Company, Ltd. .. .. — 35, Great Dover Street, S.E.
Schäffer & Budenberg, Ltd. .. — Broadheath, near Manchester
Tomey, Joseph, & Sons, Ltd. .. — Aston, Birmingham
Treasure, J. B., & Co., Ltd. .. — 8, Vauxhall Road, Liverpool

Gauges (Measuring).

Newall Engineering Co. .. — Blackhorse Lane, Walthamstow, E.

Gauges (Pressure, Vacuum & Hydraulic).

Bailey, Sir W. H., & Co., Ltd. .. — Albion Wks. Salford, Manchest'r
Brady & Martin, Ltd. .. .. — Newcastle-on-Tyne
Dobbie McInnes, Ltd. .. .. — 57, Bothwell Street, Glasgow
Fletcher Bros. .. .. .. — Ozo-ils St. North, Birmingham
Hannan & Buchanan .. .. — 75, Robertson Street, Glasgow
Hopkinson, J., & Co., Ltd. .. — Huddersfield
Hulburd Engineering Co., Ltd. — St. Benet Chambers, Fenchurch Street, E.C.
Hunt & Mitton, Ltd. .. .. — Ozolls St. North, Birmingham
Lunken Company, Ltd. .. .. — 35, Great Dover Street, S.E.
Negretti & Zambra .. .. — 38, Holborn Viaduct, E.C.
Salter, Geo., & Co. .. .. — West Bromwich
Schäffer & Budenberg, Ltd. .. — Broadheath, near Manchester
Treasure, J. B., & Co , Ltd. .. — 8, Vauxhall Road, Liverpool
United Brassfounders & Engineers, Ltd. .. .. .. — Empress Foundry, Manchester

Gear Cutters.

British Insulated & Helsby Cables, Ltd. .. .. .. — Prescot, Lancashire
Lang, John, & Sons .. .. — Johnstone, nr. Glasgow
Power Plant Co., Ltd. .. .. — West Drayton, Middlesex
Reid Gear Co. .. .. .. — Linwood, near Paisley
Wallwork, Henry, & Co., Ltd. .. — Manchester

Gearing.—*(See Wheels, Geared.)*

Gearing (Speed Reducing).

Citroen Gear Co., Ltd. .. .. — 27, Queen Victoria St., E.C.
Reid Gear Co. .. .. .. — Linwood, near Paisley

Gears (Rawhide, &c.).

Angus, George, & Co., Ltd. .. — Newcastle-on-Tyne

Girders.

Arrol, Sir William, & Co., Ltd. — Dalmarnock Ironwks., Bridgeton, Glasgow
Clyde Structural Iron Co., Ltd. — Clydeside Ironworks, Scotstoun, Glasgow
Craig, A. F., & Co., Ltd. .. .. — Paisley, N.B.
Heenan & Froude, Ltd. .. .. — Newton Heath Ironworks, near Manchester
Lysaght, John, Ltd. .. .. — St. Vincent Ironworks, Bristol
Mechan & Sons Ltd. .. .. — Scotstoun Ironworks, Glasgow
Piggott, Thos., & Co., Ltd. .. — Springhill, Birmingham
Scott, Walter, Ltd. .. .. — Leeds Steel Works, Leeds

Glazing.

Grover & Co., Ltd. .. .. — Britannia Works, Wharf Rd., N
Mellowes & Co., Ltd. .. .. — Sheffield

Gold-Crushing & Amalgamating Machinery.

Allen, Edgar, & Co., Ltd. .. — Sheffield
Davey, Paxman & Co., Ltd. .. — Colchester
Hadfields Limited .. .. .. — Hecla Works, Sheffield
Marsden, H. R., Ltd. .. .. — Soho Foundry, Leeds
Robey & Co., Ltd. .. .. — Lincoln
Sandycroft Limited .. .. — Chester
Stamm, W. .. .. — 25, College Hill, E.C.

Gold Dredgers.

Bucyrus Co. .. .. — 507, Caxton House, Westminster, S.W.
Lobnitz & Co., Ltd. .. .. — Renfrew, Scotland
Simons, W., & Co., Ltd. .. .. — Renfrew, Scotland

Governors (Engine).

Braithwaite, Isaac, & Son, Engineers, Ltd. .. .. .. — 200, Upper Thames Street, E.C
Escher Wyss & Co. .. .. — 109, Victoria Street, S.W.
Hartnell, Wilson, & Co., Ltd. .. — Volt Works, Kirkstall Road, Leeds
Mason Regulator Co. .. .. — Boston, Mass., U.S.A.
Pollock, Macnab & Highgate .. — Shettleston, Glasgow
Pitman, Percy .. .. .. — 5, Willcott Road, Acton, W.
Storey, I., & Sons Ltd. .. — Empress Foundry, Manchester
Tangyes Limited .. .. .. — Birmingham

Graphite (Lubricating, &c.).

Dampney, J., & Co., Ltd. .. — Cardiff
Graphite Products, Ltd. .. .. — 218-220, Queen's Road, Battersea, S.W.

Grinding Mills.—*(See also Disintegrators.)*

Allen, Edgar, & Co., Ltd. .. — Sheffield
Fletcher, Geo., & Co., Ltd. .. — Derby
Hadfields Limited .. .. — Hecla Works, Sheffield
Hardy Patent Pick Co., Ltd. .. — Sheffield
Marsden, H. R., Ltd. .. .. — Soho Foundry, Leeds
Marshall, Sons & Co., Ltd. .. — Gainsborough
Newell, Ernest, & Co., Ltd. .. — Misterton, Gainsboro'
Patent Lightning Crusher Co., Ltd. .. .. — 14a, Rosebery Avenue, Gra Inn Road, E.C.
Stamm, W. .. .. — 25, College Hill, E.C

Grinding & Polishing Machinery.—*(See Emery Grinding Machinery.)*

Grinding and Polishing Wheels.—*(See Wheels.)*

Gunpowder and Gun-Cotton Machinery.

Greenwood & Batley, Ltd. .. — Armley Road, Leeds
Stamm, W. .. .. — 25, College Hill, E.C.
Taylor & Challen, Ltd. .. .. — Birmingham

Guns and Gun Forgings.

Brown, John, & Co., Ltd. .. — Sheffield
Firth, Thos., & Sons, Ltd. .. — Norfolk Works, Sheffield
Stamm, W. .. .. — 25, College Hill, E.C.
Vickers Limited .. .. .. — Sheffield

Hammers (Drop).

Brett's Patent Lifter Co., Ltd. .. — Coventry
Massey, B. & S., Ltd. .. .. — Openshaw, Manchester
Platt, Samuel, Ltd. .. .. — Wednesbury
Ross, R. G., & Son, Ltd. .. .. — Glasgow

Hammers (Power).—*(See also Steam Hammers.)*

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. — Birmingham
Consolidated Pneumatic Tool Co., Ltd. .. .. — Palace Chambers, 9, Bridge Street, Westminster
Globe Pneumatic Eng. Co., Ltd. — 1, Victoria Street., S.W.
Greenwood & Batley, Ltd. .. — Albion Works, Leeds
Ingersoll-Rand Co. .. .. — 165, Queen Victoria St.
Judson-Jackson Co., Ltd. .. — 59, Marsham Street, minster, S.W.
Massey, B. & S., Ltd. .. .. — Openshaw, Manchester
Nasmyth, Wilson & Co., Ltd. .. — Bridgewater Foundry, Patcroft, near Manchester
Newbold, Walter, & Co. .. .. — 107, Upper Thames St.,
Player, W. & J. .. .. .. — Birmingham
Ross, R. G., & Son, Ltd. .. .. — Glasgow [B
Ryder, Thos., & Son, Ltd. .. — Turner Bridge Iron
Walker, W. A., & Co. .. .. — 38, Victoria Street, S.W.

Hammers (Steam).—*(See Steam Hammers).*

Haulage Plants.—*(See also Engines, Winding.)*

Barclay, Andrew, Sons & Co., Ltd. .. .. — Caledonia Works, Kilmarnock, Scotland
Brazil, Straker & Co., Ltd. .. — Vulcan Works, Bristol
Bullivant & Co., Ltd. .. .. — 72, Mark Lane, E.C.
Carron Company .. .. .. — Carron, Stirlingshire, N.
Heenan & Froude, Ltd. .. .. — Worcester
Higginbottom & Mannock, Ltd. — Crown Ironworks, West Manchester
King, H. J. H., & Co., Ltd. .. — Nailsworth, Glos.
Lidgerwood Manufacturing Co. — Caxton House, West
Marshall, Sons & Co., Ltd. .. — Gainsborough
Ross, R. G., & Son, Ltd. .. .. — Glasgow
Ruston, Proctor & Co., Ltd. .. — Sheaf Ironworks, Lincoln
Yates & Thom, Ltd. .. .. — Canal Works, Blackburn

Heating Apparatus.

Buffalo Forge Company .. .. — Caxton House, West S.W.
Davidson & Co., Ltd. .. .. — Sirocco Engin'ring Wks.,
Ferranti, Ltd. .. .. .. — Central House, Kingsway
Horne Engineering Co. .. .. — St. Peters Lane,
Keith, James, & Blackman Co., Ltd. .. .. — 27, Farringdon Avenue
Korting Brothers, Ltd. .. .. — 53, Victoria Street, S.W.
Musgrave & Co., Ltd. .. .. — St. Ann's Ironworks, Belfast
Royles Limited .. .. .. — Irlam, nr. Manchester
Standard Engineering Co., Ltd. — Leicester
Sturtevant Engineering Co., Ld. — 147, Queen Victoria St., E.C.
Tullis, D. & J., Ltd. .. .. — Kilbowie Ironwks., nr. Glasgow
Westinghouse Brake Co., Ltd. — 82, York Road, N.
Wright's Forge & Engineering Co., Ltd. .. .. — Tipton, Staffordshire

Hinges.

Whitley & Valiant, Ltd. .. — Ashton-in-Makerfield

Hoisting Machinery.—*(See also Cranes.)*

Babcock & Wilcox, Ltd. .. .. — Oriel House, Farringdon E.C.
Bailey, Sir W. H., & Co., Ltd. .. — Albion Wks. Salford, Manchest
Berry, Henry, & Co., Ltd. .. — Croydon Works, Hunslet,
Brown Hoisting Machinery Co. — Cleveland, Ohio, U.S.A.
Chaplin, Alex., & Co. .. .. — Govan, Glasgow
Clarke, Chapman & Co., Ltd. .. — Gateshead-on-Tyne
Coles, H. J., Ltd. .. .. .. — London Crane Works, Derby
Consolidated Pneumatic Tool Co., Ltd. .. .. — Palace Chambers, 9, Bridge Street, Westminster, S.W.
Cornforth, Ernest E. .. .. — Stoke-on-Trent
Craig, A. F., & Co., Ltd. .. .. — Paisley, N.B.
Craven Brothers, Ltd. .. .. — Osborne Street, Manchester
Davey, Paxman & Co., Ltd. .. — Colchester
Electromotors Ltd. .. .. — Openshaw, Manchester
Figee .. .. — Haarlem, Holland
Gibbins, R. C., & Co. .. .. — Berkley Street, Birmingham
Godfrey Mfg. Co., Ltd. .. .. — Old Crane Works, St. John St., Leicester
Goodall, Clayton & Co., Ltd. .. — Leeds
Head, Wrightson & Co., Ltd. .. — Teesdale Ironworks, Thornaby-on-Tees
Higginbottom & Mannock, Ltd. — West Gorton, Manchester
Jack, Alexander, & Co. .. .. — Whitegates Engineering Works, Motherwell
Lidgerwood Mfg. Co. .. .. — Caxton House, Westminster, S.W.

Hoisting Machinery.—*(See also Cranes).—Continued.*

Northern Engineering Works .. 6, Chene Street, Detroit, Mich., U.S.A.
Priestman Brothers, Ltd. .. Holderness Foundry, Hull
Ransomes, Sims & Jefferies, Ltd. Ipswich
Rice & Co. (Leeds), Ltd. .. .. Elland Road, Leeds
Robey & Co., Ltd. .. .. .. Lincoln
Ross, R. G., & Son. Ltd. .. .. Glasgow
Royce Ltd. .. .. .. Trafford Park, Manchester
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Shamm, W. .. .. 25, College Hill, E.C.
Tangyes Limited .. .. .. Birmingham
Terry & Tench Co. (The) Inc. .. Grand Central Terminal, New York City
Vaughan & Son, Ltd. .. .. West Gorton, Manchester
Waygood-Otis, Ltd. .. .. Falmouth Road, S.E.
Whitakers (Engineers), Ltd. .. Horsforth, Leeds
Willetts, Charles, Junr. .. .. Colonial Wks., Cradley Heath, Staffs.
Youngs .. .. Ryland St. Wks., Birmingham

Hose Pipes.

Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Gutta Percha & Rubber, Ltd. .. Toronto, Canada
India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, E.
Interlock Metal Hose Co. .. River Park Rd., Wood Green, N.
Merryweather & Sons .. .. 63, Long Acre, W.C.
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Tullis, John, & Son .. .. St. Ann's Leather Wks., Glasgow
Willcox, W. H., & Co., Ltd. .. 23, Southwark Street, S.E.
Woodite Works .. .. .. Mitcham Common, Surrey
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Hydrants.

Alley & Macllellan, Ltd. .. .. Sentinel Works, Glasgow
Blakeborough, J., & Sons, Ltd. Woodhouse Works, Brighouse
Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B.

Hydraulic Machinery.

Arrol, Sir William, & Co., Ltd. Dalmarnock Ironwks., Bridgeton, Glasgow
Bailey, Sir W. H., & Co., Ltd. .. Albion Wks., Salford, Manchester
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Brown Bros. & Co., Ltd. .. Rosebank Ironwks., Edinburgh, N.B.
Campbell & Calderwood .. .. Soho Engine Works, Paisley
Carruthers, J. H., & Co., Ltd. .. Polmadie Ironworks, Glasgow
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Cowans, Sheldon & Co., Ltd. .. Carlisle
Craig, A. F., & Co., Ltd. .. Paisley, N.B.
Craven Brothers, Ltd. .. .. Osborne Street, Manchester
Davy Brothers, Ltd. .. .. Sheffield
Drysdale & Co., Ltd. .. .. Bon Accord Works Yoker, [Glasgow, W.
East Ferry Road Engineering Works Co. Ltd. .. .. Millwall, E.
Fullerton, Hodgart & Barclay, Ltd. .. .. .. } Vulcan Foundry and Engine Works, Paisley
Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B.
Greenwood & Batley, Ltd. .. Leeds
Hathorn, Davey & Co., Ltd. .. Leeds
Hayward-Tyler & Co., Ltd. .. 99, Queen Victoria Street, E.C.
Marshall, Fleming & Co. .. Motherwell, N.B.
McOnie, A. & P. W. .. .. Govan, Glasgow
Middleton, Robert, & Co. .. Sheepscar Foundry, Leeds
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Nasmyth, Wilson & Co., Ltd. .. Bridgewater Foundry, Patricroft, near Manchester
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Rice & Co. (Leeds), Ltd. .. .. Neville Wks., Elland Rd., Leeds
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow
Stewart, Duncan, & Co., Ltd. .. London Road Ironworks, Glasgow
Stothert & Pitt, Ltd. .. .. Bath [Glasgow
Tangyes Limited .. .. .. Birmingham
Taylor & Challen, Ltd. .. .. Birmingham
Waygood-Otis, Ltd. .. .. Falmouth Road, S.E.

Hydraulic Rams.

Bailey, Sir W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Keith, James, & Blackman Co., Ltd. .. .. 27, Farringdon Avenue, E.C.

Hydro-Extractors.—*(See Centrifugal Drying Machines.)*

Hydrokineters and Temperature Equalisers.

Brundrit, Joseph .. .. .. 14, Water Street, Liverpool
Weir, G. & J., Ltd. .. .. Holm Foundry, Cathcart, Glasgow

Ice-Making Machines.—*(See also Refrigerating Machinery.)*

Allen, W. H., Son, & Co., Ltd. .. Queen's Eng. Works, Bedford
Escher, Wyss & Co. .. .. 109, Victoria Street, S.W.
Hall, J. & E., Ltd. .. .. Dartford Ironworks, Kent
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Pontifex & Wood, Ltd. .. .. Union Foundry, Derby
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Seagers, Ltd. .. .. .. Dartford
Sterne, L., & Co., Ltd. .. .. Crown Ironworks, Glasgow

Igniters (Electric).

Lodge Bros. & Co. .. .. Wrentham Street, Birmingham

Incandescent Lamps.

British-Thomson Houston Co., Ltd. .. .. Rugby

India-rubber Goods.—*(See also Ebonite, and Woodite for Steam, &c., Packings.)*

Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Gutta Percha & Rubber, Ltd. .. Toronto, Canada
India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, E.
Ingram, J. G., & Son .. .. Hackney Wick, N.E.
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Woodite Works .. .. .. Mitcham Common, Surrey

Indicators and Indicator Gear (Steam and Gas Engine).

Bailey, Sir W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Crosby Valve & Engineering Co., Ltd. .. .. 147, Queen Victoria St., E.C.
Dobbie McInnes, Ltd. .. .. 57, Bothwell Street, Glasgow
Fletcher Bros. .. .. .. Oozells St. North, Birmingham
Hannan & Buchanan .. .. 75, Robertson Street, Glasgow
Negretti & Zambra .. .. 38, Holborn Viaduct, E.C.
Trist, Ronald, & Co., Ltd. .. 4, Lloyd's Avenue, E.C.

Injectors.

Bailey, Sir W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Davies & Metcalfe, Ltd. .. .. Romiley, Manchester
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Fletcher Bros. .. .. .. Oozells St. North, Birmingham
Green & Boulding, Ltd. .. .. 28, New Bridge Street, E.C.
Gresham & Craven, Ltd. .. .. Manchester
Holden & Brooke, Ltd. .. .. Sirius Works, West Gorton, Manchester
Jenkins Bros., Ltd. .. .. 95, Queen Victoria Street, E.C.
Hunt & Mitton, Ltd. .. .. Oozells St. North, Birmingham
Klinger, Richard, & Co. .. .. 66, Fenchurch Street, E.C.
Korting Brothers, Ltd. .. .. 53, Victoria St., S.W.
Lunken Company, Ltd. .. .. 35, Great Dover Street, S.E.
Manlove, Alliott & Co., Ltd. .. Nottingham
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Willcox, W. H., & Co., Ltd. .. 23, Southwark Street, S.E.

Inks.

Halden, J., & Co., Ltd. .. .. 8, Albert Square, Manchester
Higgins, C. M., & Co. .. .. 11, Farringdon Avenue, E.C.
Stanley, W. F., & Co., Ltd. .. 286, High Holborn, W.C.

Instruments (Electrical, Surveying, Testing, &c.).

British Thomson Houston Co., Ltd. .. .. Rugby
Cambridge Scientific Instrument Co., Ltd. .. .. Cambridge
Engineering Supplies, Ltd. .. 28, Victoria Street, S.W.
Halden, J., & Co., Ltd. .. .. 8, Albert Square, Manchester
Kern & Co. .. .. Aarau, Switzerland
Lea Recorder Co., Ltd. .. .. 28, Deansgate, Manchester
Negretti & Zambra .. .. 38, Holborn Viaduct, E.C.
Schäffer & Budenberg, Ltd. .. Broadheath, near Manchester
Shore Instrument & Mfg. Co. .. New York
Stanley, W. F., & Co., Ltd. .. 286, High Holborn, W.C.

Insulating Materials.

Micanite & Insulators Co., Ltd. Walthamstow, E.
Newalls Insulation Co., Ltd. .. Mosley St., Newcastle-on-Tyne
Wiggins, F., & Sons .. .. 102 & 103, Minories, E.
Woodite Works .. .. .. Mitcham Common, Surrey

Insurance Companies.—*(See Boiler Inspection & Insurance Societies.)*

Iron Founders.—*(See Castings, Iron.)*

Iron Merchants.

Birch, John, & Co., Ltd. .. .. 2, London Wall Buildings, E.C.
Cooke, William, & Co., Ltd. .. Tinsley Steel, Iron & Wire Rope Works, Sheffield
Henderson & Glass .. .. Liverpool
MacLellan, P. & W., Ltd. .. Clutha Works, Glasgow

Iron (Pig).

Brown, John, & Co., Ltd. .. Sheffield
Clay Cross Co., Ltd. .. .. Clay Cross, Derbyshire
Glasgow Iron & Steel Co., Ltd. .. Wishaw Iron & Steel Works, [Wishaw
Metropolitan Carriage, Wagon and Finance Co., Ltd. .. .. Saltley, Birmingham

Iron & Steel Buildings.—*(See Structural Engineering).*

Iron and Steel Works (Plant for).—*(See also Crucibles, Cupolas, Forging Machines, Hammers—Power, Presses—Power.)*

Ashmore, Benson, Pease & Co., Ltd. Stockton-on-Tees
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Craig & Donald, Ltd. .. .. Johnstone, near Glasgow
Dalglish, A. & W. .. .. Pollokshaws, Glasgow
Davy Brothers, Ltd. .. .. Sheffield
Dawson & Mason Gas Plant Co., Ltd. .. .. 39, Victoria Street, S.W.
Galloways Ltd. .. .. .. Manchester
Goodall, Clayton & Co., Ltd. .. Leeds
Harvey Engineering Co., Ltd. .. Scotland Street Engine Works, Glasgow
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Heenan & Froude, Ltd. .. .. Newton Heath Ironworks, near Manchester
Lysaght, John, Ltd. .. .. Orb Works, Newport, Mon.
Marsden, H. R. .. .. .. Soho Foundry, Leeds
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Rice & Co. (Leeds), Ltd. .. .. Neville Wks., Elland Rd., Leeds
Siemen's Bros. Dynamo Works, Ltd. .. .. } Caxton House, Westminster, S.W.
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow
Yates & Thom, Ltd. .. .. Canal Works, Blackburn

Jacks (Lifting).

Dempster, Moore & Co. .. .. 49, Robertson Street, Glasgow
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Godfrey Mfg. Co., Ltd. .. .. Old Crane Works, St. John St., Leicester
Tangyes Limited .. .. .. Birmingham
Willetts, Charles, Junr. .. .. Colonial Wks., Cradley Heath, Staffs.
Youngs .. .. Ryland St. Wks., Birmingham

Jointing Materials.—*(See also Asbestos Goods, &c., India-rubber Goods, and Packing—Engine & Hydraulic.)*

Beldam Packing & Rubber Co. .. 1 & 2, Gracechurch St., E.C.
Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Graphite Products, Ltd. .. .. 218-220, Queen's Road, Battersea, S.W. [E.
Hobdell, Way & Co., Ltd. .. St. John's House, 124-5, Minories.
Hulburd Engineering Co., Ltd. St. Benet Chambers, Fenchurch Street, E.C.
Jenkins Bros., Ltd. .. .. 95, Queen Victoria Street, E.C.
Klinger, Richard, & Co. .. .. 66, Fenchurch Street, E.C.
Metallic Manufacturing Co., Ld. Ardrossan
Smooth-on Manufacturing Co 8, White Street, Moorfields, E.C.
Thomas & Bishop .. .. .. 119-125, Finsbury Pavement, E.C.
Walton & Co. .. .. .. 66 & 68, Slaney St., Birmingham

Joists, Rolled (Iron and Steel).

Lanarkshire Steel Co., Ltd. .. Motherwell
Scott, Walter, Ltd. .. .. Leeds Steel Works, Leeds

Kilns.

Fletcher, Geo., & Co., Ltd. .. Derby

Ladles.

Clayton Son, & Co., Ltd. .. Hunslet, Leeds
McNeil, C. .. .. Kinning Park Ironworks and Hydraulic Forge, Glasgow

Lamps.—*(See also Electric Lighting & Power Plant, and Incandescent Lamps.)*

British Thomson-Houston Co., Ltd. .. .. Rugby
Jandus Arc Lamp & Electric Co., Ltd. .. .. Hartham Road, Holloway, N.
Wells, A. C., & Co. .. .. 102, Midland Road, St. Pancras, N.W.

Lathes.—*(See Machine Tools.)*

Launches and Yachts.—*(See also Motor Boats.)*

Alley & Macllellan, Ltd. .. .. Sentinel Works, Glasgow
Boulton & Paul, Ltd. .. .. Norwich
Burnet, L., & Co. .. .. .. Govan, Glasgow
Chaplin, Alex., & Co. .. .. Cranstonhill Engine Works, Glasgow
Cochran & Co., Annan, Ltd. .. Annan, N.B.
Crabtree & Co., Ltd. .. .. Great Yarmouth
Day, Summers & Co., Ltd. .. Northam Ironworks, Southampton
Escher, Wyss & Co .. .. 109, Victoria Street, S.W.
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Hanna, Donald & Wilson .. Paisley, N.B.
Hayes, Edward .. .. .. Stony Stratford, Wolverton
McKie & Baxter .. .. .. Copland Wks., Govan, Glasgow
Normand, Augustin .. .. 67, Rue du Perrey, Le Havre, France
Ross & Duncan .. .. .. Whitefield Works, Glasgow
Simons, W., & Co., Ltd. .. .. Renfrew, N.B.
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Smit, L., & Zoon .. .. .. Kinderdijk, Holland
Thornycroft, J. I., & Co., Ltd. .. Southampton, and Caxton House, Westminster, S.W.
Vosper & Co., Ltd. .. .. Portsmouth
Yarrow & Co., Ltd. .. .. Glasgow

Laundry Machinery.—*(See also Centrifugal Drying Machines, and Drying Apparatus.)*

Braithwaite, Isaac, & Son, Engineers, Ltd. .. .. .. 200, Upper Thames Street, E.C.
Manlove, Alliott & Co., Ltd. .. Nottingham
Tullis, D. & J., Ltd. .. .. Kilbowie Ironwks. nr. Glasgow

Leathers (Hydraulic, &c.)

Walton & Co. .. .. .. 66 & 68, Slaney St., Birmingham

Lifts.

Bailey, Sir W. H. & Co. Ltd. .. Albion Wks. Salford, Manchest'r
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Hall, J. & E., Ltd. .. .. Dartford Ironworks, Kent
Otis Elevators Co., Ltd. .. .. 4, Queen Victoria Street, E.C.
Rice & Co. (Leeds), Ltd. .. .. Elland Road, Leeds
Stannah, J. .. .. 4, Skin Market Place, Bankside, S.E.
Tangyes Limited .. .. .. Birmingham
Waygood-Otis Ltd .. .. Falmouth Road, S.E.
Willetts, Charles, Junr. .. .. Colonial Wks., Cradley Heath, Staffs.

Light Railways.—*(See Railways, Light and Portable.)*

Lighters.—*(See Barges.)*

Lighting Apparatus.—*(See also Electric Lighting Plant.)*

Cottage Lighting Co. .. .. Robertsbridge, England
India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, E.
Imperial Light, Limited .. .. 123, Victoria Street, S.W.
Jandus Arc Lamp & Electric Co., Ltd. .. .. Hartham Rd., Holloway, N.
Keith, James, & Blackman Co., Ltd. .. .. 27, Farringdon Avenue, E.C.
Wells, A. C., & Co. .. .. 102, Midland Road, St. Pancras, N.W.

Lightning Conductors.

Bailey, Sir W. H., & Co., Ltd. .. Albion Wks. Salford, Manchester

Liquid Fuel.

Kermodes, Ltd. .. .. .. 35, The Temple, Dale Street, Liverpool

Lock Nuts and Nut-Locking Appliances.

Bayliss, Jones & Bayliss, Ltd. .. Wolverhampton
Grover & Co., Ltd. .. .. Wharf Road, N.
Positive Lock Washer Co. .. 2-8, James Watt St., Glasgow

Locomotive Engines.—*(See Engines, Locomotive.)*

Locomotives (Mountings for).

Bailey, Sir W. H., & Co., Ltd. .. Albion Wks. Salford, Manchester
Hopkinson, J., & Co., Ltd. .. Huddersfield
Lunken Company, Ltd. .. .. 35, Great Dover Street, S.E.
Storey, I., & Sons, Ltd. .. .. Empress Foundry, Manchester

Looms.

Craig, A. F., & Co., Ltd. .. .. Paisley, N.B.

Lubricants and Oils.

Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Graphite Products, Ltd. .. 218-220, Queen's Road, Battersea, S.W.
Keystone Lubricating Co. .. Wittles Croft, Ducie Street (City) Manchester
Prices' Company, Ltd. .. .. Battersea, S.W.
Thomas & Bishop .. .. .. 119-125, Finsbury Pavement, E.C.
Trier Bros., Ltd. .. .. .. Caxton House, Westminster, S.W.
Wells, Henry, Oil Co. .. .. Salford, W., near Manchester
Willcox, W. H., & Co., Ltd. .. 32 to 38, Southwark Street, E.C.

Lubricators.

Bailey, Sir W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Butterworth Bros., Ltd. .. .. Newton Heath Glass Wks., Manchester
Crosby Valve & Engineering Co., Ltd. .. .. 147, Queen Victoria St., E.C.
Fletcher Bros. .. .. .. Oozells St. North, Birmingham
Hulburd Engineering Co., Ltd. St. Benet Chambers, Fenchurch Street, E.C.
Hunt & Mitton, Ltd. .. .. Oozells St. North, Birmingham
Klinger, Richard, & Co. .. .. 66, Fenchurch Street, E.C.
Korting Brothers, Ltd. .. .. 53, Victoria St., S.W.
Lubricators, Ltd. .. .. .. Leeds Place, Tollington Park, N.
Lunken Company, Ltd. .. .. 35, Great Dover Street, S.E.
Partridges, Limited .. .. 131, Northwood Street, Birmingham
Piggott, Thos., & Co. .. .. Springhill, Birmingham
Steam Cylinder Lubricator Co., Ltd. .. .. } Gordon Works, Lower Broughton, Manchester
Tangyes Limited .. .. .. Birmingham
Trier Bros., Ltd. .. .. .. Caxton House, Westminster, [S.W.
United Brassfounders & Engineers, Ltd. .. .. Empress Foundry, Manchester
Vickers, Benjn. R., & Sons .. Leeds
Willcox, W. H., & Co., Ltd. .. 32 to 38, Southwark Street, E.C.

Machine Tools.—*(See also Chucks, Second-hand Tools, &c., and Tools—Hand and Small.)*

Archdale, Jas., & Co., Ltd. .. Ledsam Street, Birmingham
Asquith, William, Ltd. .. .. Park Works, Halifax
Barker, Spink, Lease & Co. .. Roose Works, Shipley, Yorks.
Berry, F., & Sons .. .. .. Calderdale Ironworks, Sowerby Bridge
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Beyer, Peacock & Co., Ltd. .. Gorton Foundry, Manchester
Buck & Hickman, Ltd. .. .. 2 & 4, Whitechapel Road, E.
Buckton, Joshua, & Co., Ltd. .. Leeds
Burton, C. W., Griffiths & Co. .. 1, 2 & 3, Ludgate Square, E.C.
Butler, J., & Co. .. .. .. Victoria Ironworks, Halifax
Cameron, John, Ltd. .. .. Oldfield Road Ironwks., Salford
Carron Company .. .. .. Carron, Stirlingshire, N.B.
Chambers, Scott & Co., Ltd. .. Motherwell
Churchill, Chas. & Co., Ltd. .. 9 to 15, Leonard St., E.C
Clifton & Waddell .. .. .. Johnstone, near Glasgow
Consolidated Pneumatic Tool Co., Ltd. .. .. } Palace Chambers, 9, Bridge Street, Westminster, S.W.
Craig & Donald, Ltd. .. .. Johnstone, near Glasgow
Craven Brothers, Ltd. .. .. Osborne Street, Manchester
Crown Works .. .. .. London Rd., Chelmsford
Darling & Sellers, Ltd. .. .. Keighley
Davis & Primrose .. .. .. Ætna Ironworks, Bangor Road, Leith, N.B.
Dean, Smith & Grace (1908), Ld. Keighley
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Drummond Brothers, Ltd. .. Engel Works, near Guildford
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Harvey, G. & A., Ltd. .. .. Govan, Glasgow, W.
Heap, Joshua, & Co., Ltd. .. Ashton-under-Lyne
Herbert, Alfred, Ltd. .. .. Coventry
Hill, Joseph .. .. .. Woods Lane, Derby
Hilles & Jones Company .. Wilmington, Delaware, U.S.A.
Holbrook & Sons .. .. .. Stratford, E.
Jones, A. A., & Shipman, Ltd. East Park Road, Leicester
Jones & Lamson Machine Co. .. Jubilee Buildings, 97, Queen Victoria Street, E.C.
Judson-Jackson Co., Ltd. .. 50, Marsham Street, Westminster, S.W.
Kearns, H. W., & Co., Ltd. .. Broadheath, near Manchester
Lash, Robert H. .. .. .. 31, Carburton Street, Portland Road Station, W.
Lang, J., & Sons .. .. .. Johnstone, N.B.
Lees-Bradner Co. .. .. .. Cleveland, Ohio
Loudon Brothers, Ltd. .. .. 39, West Campbell St., Glasgow
MacLellan, P. & W., Ltd. .. Clutha Works, Glasgow
McOnie, A. & P. W. .. .. Govan, Glasgow
Muir, Wm. & Co., Ltd. .. .. Sherbourne Street, Manchester
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Newbold, Walter, & Co. .. .. 107, Upper Thames Street, E.C.
Niles-Bement-Pond Co. .. .. 111, Broadway, New York, U.S.A.
Niles-Bement-Pond Co. .. .. 23 & 25, Victoria Street, S.W.
Noble & Lund, Ltd. .. .. Felling, nr. Newcastle-on-Tyne
Parkinson, J., & Son .. .. Shipley, Yorkshire
Pfeil & Co. .. .. 145-9, St. John Street, Clerkenwell, E.C.
Phœnix Dynamo Mfg. Co., Ltd. Thornbury Works, Bradford
Pratt & Whitney Co. .. .. Hartford, Conn., U.S.A.
Redman, C., & Sons .. .. Dunkirk, Halifax
Rice & Co. (Leeds), Ltd. .. .. Neville Wks., Elland Rd., Leeds
Richards, Geo., & Co., Ltd. .. Broadheath, near Manchester
Scott Bros. .. .. West Mount, Halifax
Scriven & Co. .. .. Leeds Old Foundry, Marsh Lane, Leeds
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Shanks, Thomas, & Co. .. .. Union Ironworks, Johnstone
Smith Brothers & Co. (Glasgow), Ltd. .. .. Kinning Park, Glasgow
Smith & Coventry, Ltd. .. .. Ordsall Lane, Mancheste
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow
Spencer James, & Co .. .. Chamber Iron Works, Hollin-
Stirk, John, & Sons, Ltd. .. Halifax [wood, M'chester.
Swift, George, & Sons .. .. Range Bank, Halifax
Swiss Oerlikon Machine Tool Co. Oerlikon, near Zurich, Switzerland
Tangyes Limited .. .. .. Birmingham
Taylor, Charles (Birm'ghm.), Ltd. Bartholomew Sq., Birmingham
Timbrell & Wright Machine Tool and Eng. Co., Ltd. .. .. Birmingham
Tullis, D. & J., Ltd. .. .. Kilbowie Ironwks., nr. Glasgow
Walker, W. A., & Co. .. .. 33, Victoria Street, S.W.
Wallace Supply Co. (Mfrs.) .. 415, Orleans Street, Chicago, U.S.A.
Ward, Haggas & Smith .. .. Eastwood, Keighley
Ward, H. W., & Co., Ltd. .. Lionel Street, Birmingham
Ward, Thos. W., Ltd. .. .. Albion Works, Sheffield
Webster & Bennett, Ltd. .. Coventry
Wilkinson, G., & Sons .. .. Keighley
Winn, Charles, & Co. .. .. Grauville Place, Birmingham
Wolseley Motors, Ltd. .. .. York Street, Westminster, S.W.

Magnets.—*(See Separators, Magnets, &c).*

Manganese Steel Castings and Forgings.

Allen, Edgar, & Co., Ltd. .. Sheffield
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Ghion, J. .. .. Finsbury Pavement House, E.C.
Hadfields Limited .. .. Hecla Works, Sheffield

Manhole Doors.—*(See also Boiler Manholes.)*

McNeil, C. .. .. Kinning Park Ironworks and Hydraulic Forge, Glasgow

Manufacturers.—*(See Patent Law.)*

Mathematical Instrument Makers.—*(See Drawing Instruments.)*

Measuring Machines.—*(See Micrometers.)*

Mechanical Engineers (Consulting).

Davey, Paxman & Co., Ltd. .. Colchester
Armfield, J., & Co. .. .. 20, Mark Lane, E.C.

Merchants (Machinery, &c.)

Birch, John, & Co., Ltd. .. 2, London Wall Buildings, E.C.
Jennings, Edward J. .. .. West Walls, Newcastle-on-Tyne
MacLellan, P. & W., Ltd. .. Clutha Works, Glasgow
Noyes Bros. (Melbourne) Propy., Ltd. .. .. 499, Bourke Street, Melbourne
Noyes Bros. (Sydney), Ltd. .. 115, Clarence Street, Sydney
Willcox, W. H., & Co., Ltd. .. 32 to 38, Southwark Street, E.C

Metallic Packing.

Green & Boulding, Ltd. .. .. 28, New Bridge Street, E.C.
Hulburd Engineering Co., Ltd. St. Benet Chambers, Fenchurch Street, E.C.
Lancaster & Tonge, Ltd. .. Pendleton, near Manchester
Oldham, Alex., & Sons .. .. Dukinfield
United States Metallic Packing Co., Ltd. .. .. } Soho Works, Allerton Road, Bradford

Metals (Phosphor Alloys, &c.).

Atlas Metal & Alloys Co., Ltd. .. 52, Queen Victoria Street, E.C
Billington & Newton, Ltd. .. Longport, Staffordshire
Bull's Metal & Melloid Co., Ltd. Yoker, nr. Glasgow
Delta Metal Co., Ltd. .. .. East Greenwich, S.E.
Gabriel & Co. .. .. A B. Row, Birmingham
Gemmell, W., & Co. .. .. 492, Argyle Street, Glasgow
Glacier Anti-Friction Metal Co., Ltd. .. .. } Waldo Road., Willesden Junction, N.
Lunken Company, Ltd. .. .. 35, Great Dover Street, S.E.
McKechnie Brothers .. .. Rotton Park St., Birmingham
Magnolia Anti-Friction Metal Co. of Gt. Britain, Ltd. .. .. 49, Queen Victoria Street, E.C.
Muntz, P. H., & Co., Ltd. .. Alexandra Works, West Bromwich
National Alloys, Ltd. .. .. Ilford, E.
Saunders, J. T., & Co. .. .. 1, Victoria Street, Westminster, S.W.
Vickers Limited .. .. .. Vickers House, Broadway, Westminster, S.W.

Meters.

Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B.
Lea Recorder Co., Ltd. .. .. 28, Deansgate, Manchester
Siemens Bros. & Co., Ltd. .. Caxton House, Westminster, S.W.
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Mica Merchants.

Wiggins, F., & Sons .. .. 102, 103 & 104, Minories, E.

Micrometers.

Shore Instrument & Mfg. Co. .. New York

Mill Gearing.—*(See Wheels, Geared; also Shafting and Shaft Fittings.*

Mill Machinery (Flour, Corn & Rice).
Armfield, Joseph J., & Co. .. 20, Mark Lane, E.C.
Blackstone & Co., Ltd. .. .. Rutland Works, Stamford
Marshall, Sons & Co., Ltd. .. Gainsborough
Ransomes, Sims & Jefferies, Ltd. Ipswich
Robey & Co., Ltd. .. .. .. Lincoln
Robinson, T., & Son, Ltd. .. Rochdale
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Stamm, W. .. .. 25, College Hill, E.C.

Milling Cutters and Cutter Blanks.
Chatwin, Thomas, Ltd. .. .. Great Tindal St., Birmingham
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Muir, Wm., & Co., Ltd. .. .. Sherbourne Street, Manchester

Mills (Paint, Oil, Mortar, &c.).
Blackstone & Co., Ltd. .. .. Rutland Works, Stamford
Fratchitt Brothers .. .. Denton Ironworks, Carlisle
Smedley Bros., Ltd. .. .. Belper, Derbyshire

Mining Machinery.—*(See also Colliery Plant.)*
Allen, Edgar, & Co., Ltd. .. Sheffield
Allen, W. H., Son & Co., Ltd. .. Bedford
Bailey, Sir W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Barclay, Andrew, Sons & Co., Ltd. .. .. Caledonia Works, Kilmarnock, Scotland
Carron Company .. .. .. Carron, Stirlingshire, N.B.
Clay Cross Co., Ltd. .. .. Clay Cross, near Chesterfield
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Consolidated Pneumatic Tool Co., Ltd. .. .. Palace Chambers, 9, Bridge Street, Westminster, S.W.
Davey, Paxman & Co., Ltd. .. Colchester
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Fletcher, Geo., & Co., Ltd. .. Derby
Fowler, J., & Co. (Leeds), Ltd. .. Leeds
Hadfields Limited .. .. .. Hecla Works, Sheffield
Hardy Patent Pick Co., Ltd. .. Sheffield
Hathorn, Davey & Co., Ltd. .. Leeds
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Heenan & Froude, Ltd. .. .. Worcester Engineering Works, Worcester
Hornsby, R., & Sons, Ltd. .. Grantham
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Marshall, Sons & Co., Ltd. .. Gainsborough
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Ransomes, Sims & Jefferies, Ltd. Ipswich
Robey & Co., Ltd. .. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Lincoln
Sandycroft Limited .. .. Chester
Stamm, W. .. .. 25, College Hill, E.C.
Standard Engineering Co., Ltd. Leicester
Tangyes Limited .. .. Birmingham
Walker Bros. (Wigan), Ltd. .. Pagefield Ironworks, Wigan
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Mint Machinery.
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Taylor & Challen, Ltd. .. .. Birmingham

Mixers.
Davy Brothers, Ltd. .. .. Sheffield

Model Makers.
Rosser & Russell, Ltd. .. .. Queen's Wharf, Hammersmith, W.

Motor Boats.—*(See also Launches and Yachts.)*
Boulton & Paul, Ltd. .. .. Norwich
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster, S.W.
Vosper & Co., Ltd. .. .. Portsmouth
White, J. Samuel, & Co., Ltd. .. East Cowes, Isle of Wight
Wolseley Motors, Ltd. .. .. York Street, Westminster, S.W.

Motor Cars.—*(See Motor Vehicles.)*

Motor Starters and Accessories.
Booth, Joseph, & Bros., Ltd. .. Rodley, Leeds
British Thomson-Houston Co., Ltd. .. .. Rugby
British Westinghouse Electric and Manufacturing Co., Ltd. Trafford Park, Manchester
Electric & Ordnance Accessories Co., Ltd. .. .. .. Aston, Birmingham
Electric Control, Ltd. .. .. Bridgeton, Glasgow
Electromotors Ltd. .. .. Openshaw, Manchester
Ellison, George .. .. .. Victoria Wks., Warstone Lane, Birmingham
Ferranti, Ltd. .. .. .. Central House, Kingsway, W.C.
Holmes, J. H., & Co., Ltd. .. Newcastle-on-Tyne
Igranic Electric Co., Ltd. .. 147, Queen Victoria Street, E.C.
Record Electrical Co., Ltd. .. Caxton House, Westminster, S.W.
Sandycroft Limited .. .. Chester

Motor Vehicles.
Alley & Maclellan, Ltd. .. .. Sentinel Works, Glasgow
Avonside Engine Co., Ltd. .. Bristol
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol
Broom & Wade, Ltd. .. .. High Wycombe
Brush Electrical Engineering Co., Ltd. .. .. .. Falcon Works, Loughborough
Hall, J. & E., Ltd. .. .. .. 10, St. Swithin's Lane, E.C.
Maudslay Motor Co., Ltd. .. Parkside, Coventry
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironworks, Glasgow
Talbot, Clement, Ltd. .. .. Barlby Rd, Ladbroke Grove, W.
Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster, S.W.
Wolseley Motors, Ltd. .. .. York Street, Westminster, S.W.

Motors.—*(See Electric Motors.)*

Moulding Machines.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
London Emery Works Co. .. Park, Tottenham, N.
Murray, Workman & Co., Ltd. Glasgow
Pridmore, Henry E. (Inc.) .. 19th and Rockwell Streets, Chicago, Ill., U.S.A.
Samuelson & Co., Ltd. .. .. Britannia Wks, Banbury, Oxon.

Name Plates.
Barns, W., & Son .. .. .. Queensland Road, Holloway, N.
Fryer, Edward, & Son .. .. 68, West Street, Sheffield
Naughtons, Ltd. .. .. .. Livery Street, Birmingham

Non-Conducting Compositions.
Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Keenan, Matthew, & Co., Ltd. .. Tredegar Road, Bow, E.
Kenyon, Wm., & Sons, Ltd. .. Dukinfield, Manchester
Leroy, F., & Co. .. .. .. 20, Gray St., Commercial Rd, E.
Newalls Insulation Co., Ltd. .. Mosley St., Newcastle-on-Tyne

Nut-Making Machines.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Platt, Samuel, Ltd. .. .. Wednesbury
Taylor & Challen, Ltd. .. .. Birmingham

Office Fittings, Furniture and Appliances.
Calden, J., & Co., Ltd. .. .. 8, Albert Square, Manchester

Oil Cans.
Braime, T. F., & Co., Ltd. .. Hunslet, Leeds
Hayes, Jos., & Sons, Ltd. .. Lock Works, Leeds

Oil Extractors.
Alley & Maclellan, Ltd. .. .. Sentinel Works, Glasgow
Bakers (Leeds), Ltd. .. .. Union Works, Hunslet, Leeds
Diamond Blower Co., Ltd. .. 75a, Queen Victoria Street E.C.
Holden & Brooke, Ltd. .. .. 28, Sirius Works, West Gorton, Manchester
Kater & Ankersmit .. .. 34, Fenchurch Street, E.C.
Paterson Engineering Co. .. 21, Amberley House, Norfolk Street, Strand, W.C.
Premier Cooler & Engineering Co., Ltd. .. .. Broadway Court, Broadway, Westminster, S.W.
Princeps & Co. .. .. .. Sheffield
Royles Limited .. .. .. Irlam, near Manchester
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Oil Filters.
Wells, A. C., & Co. .. .. 102, Midland Road, N.W.

Oil Fuel.
Anglo-Mexican Petroleum Products Company, Ltd. .. .. Finsbury Court, E.C.

Oil Mill and Refining Machinery.
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Craig, A. F., & Co., Ltd. .. Paisley
Manlove, Alliott & Co., Ltd. .. Nottingham
Middleton, Robert .. .. Sheepscar Foundry, Leeds
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
Stamm, W. .. .. 25, College Hill, E.C.

Oils.—*(See Lubricants.)*

Ore Crushing Machinery.—*(See also Disintegrators, and Stonebreakers.)*
Allen, Edgar, & Co., Ltd. .. Sheffield
Bradley Pulverizer Co. .. .. 37, Walbrook, E.C.
Davey, Paxman & Co., Ltd. .. Colchester
Hadfields Limited .. .. Hecla Works, Sheffield
Hornsby, R., & Sons, Ltd. .. Grantham
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Robey & Co., Ltd. .. .. .. Lincoln
Sandycroft Limited .. .. Chester
Stamm, W. .. .. 25, College Hill, E.C.
Sturtevant Engineering Co., Ltd. .. .. 147, Queen Victoria Street, E.C.

Overalls for Engineers & Boiler Inspectors.
Paisleys Ltd. .. .. .. 82/96, Jamaica Street, Glasgow

Oxygen.—*(See Gases, Oxygen, &c., & Welding & Cutting Plant.)*

Packing Cases and Packing Materials.
Southern, James W., & Son, Ld. Store Street, Manchester

Packing (Engine and Hydraulic).—*(See also Jointing Materials, and Metallic Packing.)*
Beldam Packing & Rubber Co. .. 1 & 2, Gracechurch St., E.C.
Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Davey, Paxman & Co., Ltd. .. Colchester
Green & Boulding, Ltd. .. .. 28, New Bridge Street, E.C.
Greene, Tweed & Co. .. .. Queen Anne's Chambers, Tothill Street, S.W.
Gutta Percha & Rubber, Ltd. .. Toronto, Canada
Jenkins Brothers, Ltd. .. .. 95, Queen Victoria Street, E.C.
Klinger, Richard, & Co. .. .. 66, Fenchurch Street, E.C.
Lindsay, R. B., & Co. .. .. 28, Mair Street, Plantation, Glasgow
Metallic Manufacturing Co., Ld. Ardrossan
Reddaway, F., & Co., Ltd. .. Pendleton, Manchester
Rose, Downs & Thompson, Ltd. Old Foundry, Hull
Trist, Ronald, & Co., Ltd. .. 4, Lloyd's Avenue, E.C.
United States Metallic Packing Co., Ltd. .. .. Soho Works, Allerton Road, Bradford
Walker, James, & Co. .. .. Lion Works, Garford Street, Poplar, E.
Willcox, W. H., & Co., Ltd. .. 23, Southwark Street, S.E.
Woodite Works .. .. .. Mitcham Common, Surrey

Paint Mill.—*(See Mills—Paint, Oil, Motor, &c.)*

Paints, Varnishes, &c.
Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Dampney, J., & Co., Ltd. .. Cardiff
Davison, H., & Sons, Ltd. .. Magull Street, Liverpool
Metropolitan Carriage, Wagon and Finance Co., Ltd. .. Saltley, Birmingham
Palfreyman, W. H., & Co. .. Goree-Piazzas, Liverpool
Wailes, Dove & Co., Ltd. .. Newcastle-on-Tyne

Patent Agents.
Alexander, F. P., & Son .. .. 306, High Holborn, W.C.
Cruikshank & Fairweather, Ld. 62, St. Vincent Street, Glasgow
Harris & Mills .. .. .. 34 & 35, High Holborn, W.C.
Jensen & Son .. .. .. 77, Chancery Lane, W.C.
Radford, E. Heber, Son & Squire 15, St James Row, Sheffield
Raworth, John E. .. .. .. 70/71, Queen Anne's Chambers, Tothill St., Westminster, S.W.
Thomson, W. R. M., & Co. .. 96, Buchanan Street, Glasgow
Vaughan & Son .. .. .. 57, Chancery Lane, W.C.
Wilson, John G., & Co. .. .. 55, Market Street, Manchester
Wise, Lloyd, & Co. .. .. 10, New Court, Lincoln's Inn, W.C.
Withers, J. S., & Spooner .. Staple House, 51 & 52, Chancery Lane, W.C.

Patent Law (Manufacturers under).
Rosser & Russell, Ltd. .. .. Queen's Wharf, Hammersmith

Patternmakers.
Woodmansey & Co. .. .. Madeley Street, Hull

Perforated Metals.
Barns, W., & Son .. .. .. Queensland Road, Holloway, N.
Harvey, G. A., & Co. (London), Ltd. .. .. Greenwich Metal Works, Woolwich Road, S.E.
Hudson, Thomas, Ltd. .. .. Sheepford Works, Coatbridge, [N.B.

Permanent Way.—*(See also Rails—Steel & Iron, and Railway & Contractors' Plant.)*
Bagnall, W. G., Ltd. .. .. Castle Engine Works, Stafford
Birch, John, & Co., Ltd. .. .. 3, London Wall Buildings, E.C.
Bolling & Lowe .. .. .. Laurence Pountney Hill, E.C.
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street, E.C.

Petrol Storage.
Baldwins, Ltd. .. .. .. 5, Fenchurch Street, E.C.
Boulton & Paul, Ltd. .. .. Norwich

Photography and Materials, &c., and Appliances for Photographic Printing and Copying Processes.
Dargue Bros., Ltd. .. .. Simplon Works, Bedford St., Halifax
Halden, J., & Co., Ltd. .. .. 8, Albert Square, Manchester
Hall, B. J., & Co., Ltd. .. .. Chalfont House, Great Peter Street, Westminster, S.W.
Herbert, Alfred, Ltd. .. .. Coventry
Pease, C. F., Company .. .. 166, W. Adams Street, Chicago
Stanley, W. F., & Co., Ltd. .. Railway Approach, London Bridge, S.E
Westinghouse Cooper Hewitt Co., Ltd. .. .. 80, York Road, Kings' Cross, N.

Picks, Shovels and Spades.
Hadfields Limited .. .. .. Hecla Works, Sheffield
Hardy Patent Pick Co., Ltd. .. Sheffield

Pile Drivers.
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Lidgerwood Mfg. Co. .. .. Caxton Hse., Westminster, S.W.
Whitakers (Engineers), Ltd. .. Horsforth, Leeds

Piles, Sheet-Steel Piling and Pile Shoes.
Le Grand & Sutcliff .. .. 125, Bunhill Row, E.C.
Ransome-ver Mehr Machinery Co., Ltd. .. .. 505, Brunswick House, Westminster, S.W.
Stewart, J. & W. .. .. .. Caxton House, Westminster, S.W.

Pins (Taper).
Mountford, Fredk. .. .. Fremo Works, Granville St., Birmingham

Pipe Founders.—*(See also Tubes.)*
Ashmore, Benson, Pease & Co., Ld. Stockton-on-Tees
Clay Cross Co., Ltd. .. .. Clay Cross, near Chesterfield
Lowcock, A., Ltd. .. .. .. Shrewsbury
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading

Pipe Screwing and Cutting Machinery.
Heap, Joshua, & Co., Ltd. .. Ashton-under-Lyne
Platt, Samuel, Ltd. .. .. Wednesbury
Tangyes Limited .. .. .. Birmingham

Pipes (Sanitary, Drain, Reinforced and Stoneware).
Doulton & Co., Ltd. .. .. Lambeth, S.E.

Pipes (Wood Lined).
Bristol Engineering Co., Ltd. .. Fishponds, Bristol

Pipes (Wrought-iron and Steel).—*(See also Tubes—Iron & Steel.)*
Ashmore, Benson, Pease & Co., Ld. Stockton-on-Tees
Bellamy, John, Ltd. .. .. Millwall, E.
Clayton, Son & Co., Ltd. .. .. Hunslet, Leeds
Dempster, R. & J., Ltd. .. .. Newton Heath, Manchester
Howell & Co., Ltd. .. .. Brook Steel Works, Sheffield
Lysaght, John, Ltd. .. .. St. Vincent Ironworks, Bristol
Mechan & Sons, Ltd. .. .. Scotstoun Ironworks, Glasgow
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Russell, James, & Sons, Ltd. .. Crown Tube Wks., Wednesbury
Steel Pipe Company, Ltd. .. Kirkcaldy, N.B.
Stewarts & Lloyds, Ltd. .. .. 41, Oswald St., Glasgow; & Broad St. Chambers, Birmingham

Pistons and Piston Rings.
Edmeston, A. & Sons .. .. Patricroft, nr. Manchester
Lancaster & Tonge, Ltd. .. Pendleton, Manchester
Lockwood & Carlisle, Ltd. .. Eagle Foundry, Sheffield
McNeil, C. .. .. Kinning Park Ironworks and Hydraulic Forge, Glasgow
Oldham, Alex., & Sons .. .. Dukinfield
Trist, Ronald, & Co., Ltd. .. 4, Lloyd's Avenue, E.C.

Planing Machines.—*(See Machine Tools.)*

Plates (Dished and Flanged).
Abbott & Co. (Newark) Ltd. .. Newark-on-Trent
Hudson, Thomas, Ltd. .. .. Coatbridge, N.B.

Plates (Iron and Steel).
Beardmore, William, & Co., Ltd. Parkhead Ironworks, Glasgow
Brown, Bayley's Steel Works, Ld. Sheffield
Brown, John, & Co., Ltd. .. Sheffield
Colville, David, & Sons, Ltd. .. Motherwell, near Glasgow
Ebbw Vale Steel Iron & Coal Co., Ltd. .. .. Ebbw Vale, Mon.
Glasgow Iron & Steel Co., Ltd. .. Wishaw Iron & Steel Works, Motherwell, N.B. [Wishaw
Lanarkshire Steel Co., Ltd. .. Motherwell, N.B. [Wishaw
Leeds Forge Co., Ltd. .. .. Leeds
Lysaght, John, Ltd. .. .. Orb Works, Newport, Mon.
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Steel Co. of Scotland, Ltd. .. 23, Royal Exchange Square, Glasgow

Plummer Blocks.—*(See also Bearings.)*
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Jardine, John .. .. .. Deering Street, Nottingham
Mackies Limited .. .. .. Berks Ironworks, Reading
Platt, Samuel, Ltd. .. .. Wednesbury
Richards, Geo., & Co., Ltd. .. Broadheath, near Manchester
Smith & Grace Screw Boss Pulley Co., Ltd. .. .. Thrapston
Taylor & Challen, Ltd. .. .. Birmingham
Unbreakable Pulley and Mill Gearing Co., Ltd. .. .. 48, West Gorton, Manchester

Pneumatic Tools.
Bristol Engineering Co., Ltd. .. Fishponds, Bristol
Consolidated Pneumatic Tool Co., Ltd. .. .. Palace Chambers, 9, Bridge Street, Westminster, S.W.
Diamond Blower Co., Ltd. .. 75B, Queen Victoria Street, E.C.
Globe Pneumatic Eng. Co., Ltd. 1, Victoria Street, S.W.
Howard Pneumatic Engineering Co., Ltd. .. .. 11, Tothill Street, Westminster, S.W.
Ingersoll-Rand Co. .. .. .. 165, Queen Victoria Street, E.C.
Ross, R. G., & Son, Ltd. .. .. Glasgow

Poles, Posts and Standards.
Stewarts & Lloyds, Ltd. .. .. 41, Oswald Street, Glasgow; Broad St. Chambers, Birmingham

Portable Engines.—*(See Engines, Portable.)*

Portable Railways.—*(See Railways, Light and Portable.*

Pottery and Encaustic Tile Machinery.—*(See Brick & Tile-Making Machinery.)*

Pressed Steel and Metal Work.
Birmingham Railway Carriage and Wagon Co., Ltd. .. .. Smethwick, Birmingham
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Leeds Forge Co., Ltd. .. .. Leeds
Metropolitan Carriage, Wagon and Finance Co., Ltd. .. .. Saltley, Birmingham
Patent Shaft & Axletree Co., Ld. Wednesbury
Vaughtons, Ltd. .. .. .. Livery Street, Birmingham

Presses (Hydraulic).—*(See Hydraulic Presses.)*

Presses (Power).
Brett's Patent Lifter Co., Ltd. .. Coventry
Fawcett, Preston & Co., Ltd. .. Liverpool
Glover, W. T., & Co., Ltd. .. Trafford Park, Manchester
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hands, John, & Sons, Ltd. .. Cardigan Works, Birmingham
Platt, Samuel, Ltd. .. .. Wednesbury
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironworks, Glasgow
Taylor & Challen, Ltd. .. .. Birmingham

Propellers.—*(See Screw Propellers.)*

Propellers (Air).—*(See also Fans and Blowers, and Ventilators.)*
Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Donkin Co., Ltd. (The Bryan) Chesterfield
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham
Sturtevant Engineering Co., Ltd. 147, Queen Victoria Street, E.C.

Publishers.
Arnold, Edward .. .. .. 41 & 43, Maddox Street, W.
Atkinson, Robert (London), Ld. 19, Ludgate Hill, E.C.
Baker, E. .. .. John Bright St., Birmingham
Bateford, B. T. .. .. .. 94, High Holborn, E.C.
Chapman & Hall, Ltd. .. .. 11, Henrietta Street, W.C.
Constable, A., & Co., Ltd. .. 10, Orange Street, Leicester Square, W.C.
"Engineering" Ltd. .. .. 35 & 36, Bedford Street, W.C.
Griffin, Charles, & Co., Ltd. .. Exeter Street, Strand, W.C.
Lockwood, Crosby, & Son .. 7, Stationers' Hall Court, E.C.
Longmans, Green & Co. .. .. 39, Paternoster Row, E.C
Scott, Greenwood, & Son .. 8, Broadway, Ludgate, E.C.
Spon, E. & F. N., Ltd. .. .. 57, Haymarket, S.W.
Whittaker & Co. .. .. .. White Hart Street, Paternoster Square, E.C.

Pulley Blocks.
Bailey, Sir W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Bullivant & Co., Ltd. .. .. 72, Mark Lane, E.C.
Derome Bros. .. .. .. 34B, Victoria Street, S.W.
Gibbins, R. C., & Co. .. .. Berkley Street, Birmingham
Godfrey Mfg. Co., Ltd. .. .. Old Crane Works, St. John St., Leicester
Tangyes Limited .. .. .. Birmingham
Vaughan & Son, Ltd. .. .. West Gorton, Manchester
Willetts, Charles, Junr. .. .. Colonial Wks., Cradley Heath, Staffs.
Youngs .. .. Ryland St. Wks., Birmingham

Pulleys (Cast Iron).
Bodley Brothers & Co. .. .. Exeter
Croft & Perkins, Ltd. .. .. Power Works, Bradford
Fraser, Ltd. .. .. .. Arbroath, Scotland
Kay, James C., & Co., Ltd. .. Barnbrook Works, Bury, Lancs.
Mackies Ltd. .. .. .. Caversham Road, Reading
Platt, Samuel, Ltd. .. .. Wednesbury
Richards, Geo., & Co., Ltd. .. Broadheath, near Manchester
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A
Smith & Grace Screw Boss Pulley Co., Ltd. .. .. .. Thrapston
Taylor & Challen, Ltd. .. .. Birmingham
Thompson & Southwick, Ltd. .. Tamworth, Staffs.
Unbreakable Pulley and Mill Gearing Co., Ltd. .. .. .. 48, West Gorton, Manchester
Urquhart, Lindsay & Co., Ltd. .. Blackness Foundry, Dundee
Wigglesworth, Frank, & Co., Ld. Clutch Works, Shipley, near Bradford

Pulleys (Wood).
Buck & Hickman, Ltd. .. .. 2 & 4, Whitechapel Road, E.
Gandy Belt Mfg. Co., Ltd. .. Wheatland Works, Seacombe, Cheshire

Pulleys (Wrought Iron and Steel).
Barry, Henry & Co., Ltd. .. Aberdeen
Croft & Perkins, Ltd. .. .. Power Works, Bradford
Douglas, Lawson & Co. .. .. Birstall, near Leeds
Fraser, Douglas, & Son, Ltd. .. Arbroath, Scotland
Hudswell, Clarke & Co., Ltd. .. Railway Foundry, Leeds
Mackies Ltd. .. .. .. Caversham Road, Reading
Platt, Samuel, Ltd. .. .. Wednesbury
Richards, Geo., & Co., Ltd. .. Broadheath, near Manchester
Skerne Works, Ltd. .. .. Darlington
Smith & Grace Screw Boss Pulley Co., Ltd. .. .. Thrapston
Thompson & Southwick, Ltd. .. Tamworth, Staffs
Unbreakable Pulley and Mill Gearing Co., Ltd. .. .. .. 48, West Gorton, Manchester
Urquhart, Lindsay & Co., Ltd. Blackness Foundry, Dundee
Warden, A., & Co. .. .. .. 44-46, Shepherdess Walk, City Road, E.C.
Wigglesworth, Frank, & Co., Ld. Clutch Works, Shipley, near Bradford

Pulverizers.—*(See also Disintegrators).*
Allen, Edgar, & Co., Ltd. .. Sheffield
Armfield, Joseph J., & Co. .. 20, Mark Lane, E.C.
Bradley Pulverizer Co. .. .. 37, Walbrook, E.C.
Patent Lightning Crusher Co., Ltd. .. .. 14a, Rosebery Avenue, Gray Inn Road, E.C.
Stamm, W. .. .. 25, College Hill, E.C.

Pumps (Air).—*(See Air Pumps.)*

Pumps (Centrifugal).
Allen, W. H., & Co., Ltd. .. Queen's Eng. Works, Bedford
Bailey, Sir W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Belliss & Morcom Ltd. .. .. Ledsam Street Works, B'ham
Campbell & Calderwood .. .. Soho Engine Works, Paisley
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker Glasgow, W.
Entwisle & Gass, Ltd. .. .. Bolton
Escher, Wyss & Co. .. .. 109, Victoria Street, S.W.
Eureka Pump Co. .. .. .. 53, Bothwell Street, Glasgow
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Günther, W., & Sons .. .. Central Works, Oldham
Gwynnes Ltd. .. .. .. Hammersmith Ironworks, W
Hathorn, Davey & Co., Ltd. .. Leeds
Lobnitz & Co., Ltd. .. .. Renfrew
Paul, Matthew, & Co., Ltd. .. Levenford Works, Dumbarton
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Rees Roturbo Manufacturing Co., Ltd .. .. Nine Elms Ironworks, Reading
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Simons, W., & Co., Ltd. .. .. Renfrew, N.B.
Stereophagus Pump & Engineering Co., Ltd. .. .. .. 39, Victoria Street, S.W.
Sulzer Bros. .. .. 30, Norfolk St., Strand, W.C.
Tangyes Limited .. .. .. Birmingham
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Pumps (Colonial).
Bailey, Sir W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Caird & Rayner .. .. .. 777, Commercial Road, Limehouse, E.
Eureka Pump Co. .. .. .. 53, Bothwell Street, Glasgow
Evans, Joseph, & Sons (Wolverhampton), Ltd. .. .. .. Wolverhampton
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Pumps (Donkey).
Bailey, Sir W. H., & Co., Ltd. .. Albion Wks. Salford, Manchest'r
Braithwaite, Isaac, & Son, Engineers, Ltd. .. .. 200, Upper Thames Street, E.C.
Caird & Rayner .. .. .. 777, Commercial Road, Limehouse, E.
Cameron John, Ltd. .. .. Oldfield Rd. Ironworks, Salford
Carruthers, J. H., & Co., Ltd. .. Polmadie Ironworks, Glasgow
Clarke, Chapman & Co., Ltd. .. Gateshead-upon-Tyne
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Dawson & Downie .. .. .. Elgin Works, Clydebank
Evans, Joseph, & Sons (Wolverhampton), Ltd. .. .. .. Wolverhampton
Friedenthal, F. .. .. .. River Engine Works, Preston
Hall, J. P., & Sons, Ltd. .. .. Peterborough
Hathorn, Davey & Co., Ltd. .. Leeds
Mumford, A. G., Ltd. .. .. Culver Street Ironworks, Colchester
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Robey & Co., Ltd. .. .. .. Lincoln
Simpson, James, & Co., Ltd. .. 101, Grosvenor Road, S.W.
Tangyes Limited .. .. .. Birmingham
Toward, T., & Co., Ltd. .. .. 9, Quayburn, Newcastle-on-Tyne
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Pumps and Pumping Machinery.
Allen, W. H., Son & Co., Ltd. .. Queen's Eng. Works, Bedford
Bailey, Sir W. H., & Co., Ltd. .. Albion Wks, Salford, M'chester
Barclay, Andrew, Sons & Co., Ltd. .. .. Caledonia Works, Kilmarnock, Scotland
Belliss & Morcom Ltd. .. .. Ledsam Street Works, B'ham
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Bever, Dorling & Co., Ltd. .. Bowling Ironworks, Bradford
Brazil, Straker & Co., Ltd. .. Vulcan Works, Bristol

Pumps and Pumping Machinery.—*Continued.*

Brotherhood, Peter, Ltd. .. 53, Parliament Street, S.W.
Brooke Tool Mfg. Co., Ltd. .. Birmingham
Caird & Rayner .. .. .. 777, Commercial Road, Limehouse, E.
Cameron, John, Ltd. .. .. Oldfield Rd. Ironworks, Salford
Campbell Gas Engine Co., Ltd. Halifax, England
Carruthers, J. H., & Co., Ltd. .. Polmadie Iron Works, Glasgow
Chaplin, Alex., & Co .. Govan, Glasgow
Clarke, Chapman & Co., Ltd. .. Gateshead-on-Tyne
Davey, Paxman & Co., Ltd. .. Colchester
Davy Brothers, Ltd. .. .. Sheffield
Dawson & Downie .. .. Elgin Works, Clydebank
Drum Engineering Co. .. .. 33, Brook Street, Bradford
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker, Glasgow, W.
East Ferry Road Engineering Works Co., Ltd. .. .. .. Millwall, E.
Ellison, W. T. & Co., Ltd. .. Irlams-o'-th'-Height, Manchester
Escher, Wyss & Co .. .. .. 109, Victoria Street, S.W.
Eureka Pump Company.. .. 53, Bothwell Street, Glasgow
Evans, Joseph, & Sons (Wolverhampton, Ltd. .. .. .. Wolverhampton
Fawcett, Preston & Co., Ltd. .. Liverpool
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Friedenthal, F. .. .. .. River Engine Works, Preston
Fullerton, Hodgart & Barclay, Ltd. .. .. Vulcan Foundry and Engine Works, Paisley
Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B.
Glover & Hobson, Ltd. .. .. Albert Ironworks, Chelmsford
Greenwood & Batley, Ltd. .. Leeds
Gwynnes Ltd. .. .. Hammersmith Ironworks, W.
Hall, J. F., & Sons, Ltd. .. Peterborough
Hanna, Donald & Wilson .. Paisley
Hathorn, Davey & Co., Ltd. .. Leeds
Hayward-Tyler & Co., Ltd. .. 99, Queen Victoria Street, E.C.
Holden & Brooke, Ltd. .. .. Sirius Wks., West Gorton, Manchester
Hornsby, R., & Sons, Ltd. .. Grantham
Hughes & Lancaster .. .. 47, Victoria St. S.W.
Isler, C., & Co., Ltd. .. .. Artesian Wks., Bear Lane, S.E.
Korting Brothers, Ltd. .. .. 53, Victoria Street, S.W.
Lancaster & Tonge, Ltd. .. Pendleton, near Manchester
Le Grand & Sutcliff .. .. 125, Bunhill Row, E.C.
Lister, R. A.. & Co., Ltd. .. Dursley, Glos.
Lunken Company, Ltd. .. .. 35, Great Dover Street, S.E.
Manlove, Alliott & Co., Ltd. .. Nottingham
Mason Regulator Co. .. .. Boston, Mass., U.S.A.
Mather & Platt, Ltd. .. .. Park Works, Manchester
Merryweather & Sons .. .. 63, Long Acre, W.C.
Metallic Manufacturing Co., Ltd. Ardrossan [ter
Mumford, A. G., Ltd. .. .. Culver St. Ironworks, Colches-
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Parsons, C. A., & Co. .. .. Heaton Works, Newcastle
Paul, Matthew, & Co., Ltd. .. Levenford Works, Dumbarton
Pearn, Frank, & Co., Ltd. .. Manchester
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Potter, A. C. & Co. .. .. Lant Street, S.E.
Pratchitt Brothers .. .. Denton Ironworks, Carlisle
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Pumps Limited .. .. .. 14, Broad Street, Birmingham
Ransomes & Rapier, Ltd. .. Waterside Ironworks, Ipswich
Ransomes, Sims & Jefferies, Ltd. Ipswich
Rees Roturbo Manufacturing Co., Ltd. .. .. .. Wolverhampton, Eng.
Rice & Co. (Leeds), Ltd. .. .. Neville Wks., Elland Rd., Leeds
Robey & Co., Ltd. .. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks Lincoln
Samuelson & Co., Ltd. .. .. Britannia Wks, Banbury, Oxon.
Sandycroft Limited .. .. Chester
Shore, T., & Sons .. .. Albion Foundry, Etruria, Stoke-on-Trent
Simpson, James, & Co., Ltd. .. 101, Grosvenor Road, S.W.
Stereophagus Pump & Engineering Co., Ltd. .. .. .. 39, Victoria Street, S.W.
Storey, I., & Sons, Ltd. .. .. Empress Foundry, Manchester
Stothert & Pitt, Ltd. .. .. Bath
Stott, S. S., & Co. .. .. .. Haslingden, near Manchester
Sulzer Bros. .. .. 30, Norfolk Street, Strand, W.C.
Tangyes Limited .. .. .. Birmingham
Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster, S.W.
Toward, T., & Co., Ltd. .. .. 9, Ouseburn, Newcastle-on-
Weir, G. & J., Ltd. .. .. Cathcart, Glasgow
Westinghouse Brake Co., Ltd. .. York Road, King's Cross, N.
Willcox, W. H., & Co., Ltd. .. 32 to 38, Southwark Street, S.E.
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Pumps (Turbine).

Allen, W. H., Son & Co., Ltd. .. Queen's Engineering Works, Bedford
Boving & Co., Ltd. .. .. .. 9½, Union Court, Old Broad Street, E.C.
British Westinghouse Electric and Manufacturing Co., Ltd. Trafford Park, Manchester
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker, Glasgow, W.
Mather & Platt, Ltd. .. Park Works, Manchester
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Pumps Limited .. .. .. 14, Broad Street, Birmingham
Rees Roturbo Manufacturing Company, Ltd. .. .. .. Wolverhampton, Eng.

Pumps (Vacuum).

Blair, Campbell & McLean, Ltd. Woodville St., Govan, Glasgow
Broom & Wade, Ltd. .. .. High Wycombe
Evans, Joseph, & Sons (Wolverhampton), Ltd. .. .. .. Wolverhampton
Lacy-Hulbert & Co., Ltd. .. 91, Victoria Street, S.W.
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Reavell & Co., Ltd. .. .. Ipswich
Siebe, Gorman & Co., Ltd. .. Neptune Works, S.E.

Punching and Shearing Machines.

Berry, F., & Sons .. .. .. Calderdale Ironworks, Sowerby Bridge
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Cameron, John, Ltd. .. .. Oldfield Rd. Ironwks., Salford
Craig & Donald, Ltd. .. .. Johnstone, near Glasgow
Davy Brothers, Ltd. .. .. Sheffield
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hands, John, & Sons, Ltd. .. Cardigan Works, Birmingham
Hilles & Jones Company .. Wilmington, Delaware, U.S.A.
MacLellan, P. & W., Ltd. .. Clutha Works, Glasgow
McOnie, A. & P. W. .. .. Govan, Glasgow
Musgrave Bros. .. .. .. Crown Point Foundry, Leeds
Pollock, MacNab & Highgate .. Shettleston, Glasgow
Rice & Co. (Leeds), Ltd. .. Eiland Road, Leeds
Scott Bros. .. .. West Mount, Halifax
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Smith Brothers & Co. (Glasgow), Ltd. .. .. Kinning Park, Glasgow
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow
Tangyes Limited .. .. .. Birmingham

Pyrometers and Thermometers.

Cambridge Scientific Instrument Co., Ltd. .. .. .. Cambridge
Foster Instrument Co. .. .. Letchworth, Herts.
Horne Engineering Co. .. .. St. Peters Lane, Glasgow
Negretti & Zambra .. .. 38, Holborn Viaduct, E.C.
Schaffer & Budenberg, Ltd. .. Broadheath, near Manchester
Shore Instrument & Mfg. Co. .. New York
Sugden, T., Ltd. .. .. .. 189, Fleet Street, E.C.

Rail Benders.

Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Gibbins, E. C., & Co. .. .. Berkley Street, Birmingham
Tangyes Limited .. .. .. Birmingham
Youngs .. .. Ryland St. Wks., Birmingham

Rail Lifters.

Gibbins, E. C., & Co. .. .. Berkley Street, Birmingham
Youngs .. .. Ryland St. Wks., Birmingham

Rails (Steel and Iron).—*(See also Permanent Way, and Switches & Crossings.)*

Bolling & Lowe .. .. 2, Laurence Pountney Hill, E.C.
Cammell Laird & Co., Ltd .. Cyclops Steel & Iron Works, Sheffield
Colville, David, & Sons, Ltd. .. Motherwell, near Glasgow
Kerr, Stuart & Co., Ltd. .. .. 1 & 2, Broad Street Place, E.C.
Steel Co. of Scotland, Ltd. .. 23, Royal Exchange Square, Widnes, Lancs. [Glasgow
White, Ed., & Sons

Railway & Other Carriage Fittings.

Gabriel & Co. .. .. .. A.B. Row, Birmingham

Railway and Contractors' Plant.

Alley & MacLellan, Ltd. .. Sentinel Works, Glasgow
Bagnall, W. G., Ltd. .. Castle Engine Works, Stafford
Bell Locomotive Works (Inc.) .. Youkers, N.Y., U.S.A.
Beyer, Peacock & Co., Ltd. .. Gorton Foundry, Manchester
Birch, John, & Co., Ltd. .. .. 3, London Wall Buildings, E.C
Bolling & Lowe .. .. .. 2, Laurence Pountney Hill, E.C
Brown, Bayley's Steel Works, Ltd. Sheffield
Bucyrus Co. .. .. .. 507, Caxton House, Westminster, S.W.
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street, E.C.
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Fowler, J., & Co. (Leeds), Ltd. .. Leeds
Gibbins, E. C., & Co. .. .. Berkley Street, Birmingham
Hadfields Limited .. .. .. Hecla Works, Sheffield
Heenan & Froude, Ltd. .. .. Worcester Engineering Works, Worcester
Hurst, Nelson & Co., Ltd. .. Glasgow Rolling Stock and Plant Works, Motherwell
Leeds Forge Co., Ltd. .. .. Leeds [S.W.
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster,
MacLellan, P. & W., Ltd. .. Clutha Works, Glasgow
McLachlan & Co., Ltd. .. .. Darlington
Murray, Workman & Co., Ltd. Glasgow
Patent Shaft & Axletree Co., Ltd. Wednesbury
Ruberg, Owen & Co. .. .. Darlaston, South Staffordshire
Stanuu, W. .. .. 25, College Hill, E.C.
Stone, J. B., & Co., Ltd. .. .. 135, Finsbury Pavement, E.C.
Western Wheeled Scraper Co. .. Aurora, Illinois, U.S.A.

Railway Rolling Stock.—*(See Carriage, Wagon and Engine—Locomotive.)*

Railway Signals.

McKenzie & Holland, Ltd. .. 58, Victoria Street, S.W
McKenzie, Holland & Westinghouse Power Signal Co., Ltd. .. 58, Victoria Street, S.W.

Railway Wheels.—*(See Wheels, Railway.)*

Railways (Light and Portable).

Bagnall, W. G., Ltd. .. .. Castle Engine Works, Stafford
Birch, John, & Co., Ltd. .. .. 2, London Wall Buildings, E.C.
Bolling & Lowe .. .. .. 2, Laurence Pountney Hill, E.C.
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street, E.C.
Fowler, J., & Co. (Leeds), Ltd. .. Leeds
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Kerr, Stuart & Co., Ltd. .. .. 1, Broad Street Place, E.C.

Rawhide Wheels.—*(See Wheels, Rawhide.)*

Reducing Valves.—*(See Valves, Reducing.)*

Refrigerating Machinery.—*(See also Ice-Making Machines.)*

Hall, J. & E., Ltd. .. .. .. Dartford Ironworks, Kent
Haslam Foundry & Eng. Co., Ltd. Union Foundry, Derby
Liverpool Refrigeration Co., Ld. Colonial House, Liverpool
Mirrlees, Watson Co., Ltd. .. Scotland Street, Glasgow
Pontifex & Wood, Ltd. .. .. Union Foundry, Derby
Pulsometer Engineering Co., Ltd. Nine Elms Ironworks, Reading
Seagers, Ltd. .. .. .. Dartford
Sterne, L., & Co., Ltd. .. .. Crown Ironworks, Glasgow

Reversing Gears (Motor Boat).

Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster, S.W.

Rice-Dressing Machinery.

Douglas & Grant .. .. .. Kirkcaldy, N.B.

Riveting Machines.

Arrol, Sir William, & Co., Ltd. Dalmarnock Ironwks., Bridgeton, Glasgow
Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Drysdale & Co., Ltd. .. .. Bon Accord Works, Yoker, Glasgow, W.
Globe Pneumatic Eng. Co., Ltd. 1, Victoria Street, S.W.
McOnie, A. & P. W. .. .. Govan, Glasgow
Musgrave Bros., ... Crown Point Foundry, Leeds
Rice & Co. (Leeds), Ltd. .. .. Neville Wks., Elland Rd., Leeds
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Smith, Hugh, & Co., Ltd. .. Possil Engine Works, Glasgow

Rivets.—*(See Bolts, Rivets, &c.)*

Road Rollers (Steam, &c.).

Aveling & Porter, Ltd. .. .. Rochester
Fowler, J., & Co. (Leeds), Ltd. Leeds
Marshall, Sons, & Co., Ltd. .. Gainsborough
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln

Rockbreaker (Mechanical under Water).

Lobnitz & Co., Ltd. .. .. Renfrew, Scotland

Rock Drills.—*(See also Boring Tools & Machinery, and Well Engineers.)*

Coles H. J., Ltd. .. .. .. London Crane Works, Derby
Consolidated Pneumatic Tool Co., Ltd. .. .. 9, Bridge Street, Westminster, S.W.
Ingersoll-Rand Co. .. .. 165, Queen Victoria Street, E.C.

Roller Bearings.—*(See Bearings—Ball & Roller.)*

Rolling Mill Machinery.—*(See Iron and Steel Works, Plant for.)*

Rolling Mills (for Metals).—*(See also Iron and Steel Works, Plant for.)*

Rolls (Chilled and Grain).

Bayliss, Jones & Bayliss, Ltd. .. Wolverhampton
Lysaght, John, Ltd. .. .. Orb Works, Newport, Mon.
Stanuu, W. .. .. 25, College Hill, E.C.

Roofs (Iron, Steel and Zinc).—*(See Structural Engineering.)*

Rope Tramways.

Bullivant & Co., Ltd. .. .. 72, Mark Lane, E.C.
Lidgerwood Mfg. Co. .. .. Caxton House, Westminster, S.W.
White, Ed., & Sons .. .. Widnes, Lancs.

Ropes (Driving).

Hart, Thomas .. .. .. Blackburn
Kenyon, Wm., & Sons, Ltd. .. Dukinfield, Manchester

Ropes (Wire).—*(See Wire & Wire Rope Makers.)*

Rubber Machinery.

Entwistle & Gass, Ltd. .. .. Bolton

Runways.

Derome Brothers .. .. .. 34B, Victoria Street, S.W.
Godfrey Mfg. Co., Ltd. .. .. Old Crane Works, St. John St., Leicester
Higginbottom & Mannock, Ltd. Crown Ironworks, West Gorton, Manchester
Strachan & Henshaw, Ltd. Bristol
Vaughan & Son, Ltd. .. .. West Gorton, Manchester

Rust Preventive.

Palfreyman, W. H., & Co. .. 17, Goree-Piazzas, Liverpool

Safety Apparatus.

King, H. J. H., & Co., Ltd. .. Nailsworth, Glos.
Klinger, Richard, & Co. .. .. 66, Fenchurch Street, E.C.

Sand Blast Machines.

London Emery Works Co. .. Park, Tottenham, N.
Tilghman's Patent Sand Blast Co., Ltd. .. .. Broadheath, near Manchester

Sand (Moulding).

Arnold, Joseph .. .. Camden Town, N.W.
Mansfield Sand Co., Ltd. .. Mansfield, Notts.

Sanitary Appliances.

Doulton & Co., Ltd. .. .. Lambeth, S.E.
Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B. [S.W.
Hughes & Lancaster .. .. 47, Victoria St., Westminster,

Saw Makers.

Allen, Edgar, & Co., Ltd. .. Sheffield
Beardshaw, J., & Son, Ltd. .. Baltic Steel Works, Sheffield
Buckton, Joshua, & Co., Ltd. .. Leeds
Carron Company .. .. Carron, Stirlingshire, N.B.
Chambers, Scott & Co., Ltd. .. Motherwell
Davy Brothers, Ltd. .. .. Sheffield
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Mounninger, C. D., Ltd. .. .. 124, Clerkenwell Road, E.C.

Saw Mill Machinery.—*(See Wood-Working Machinery.)*

Scientific Instruments.—*(See Boiler Mountings, Drawing Instruments, and Pyrometers & Thermometers.)*

Screens.

Goodall, Clayton & Co., Ltd. .. Leeds

Screw Propellers and Propeller Blades.

Billington & Newton, Ltd. .. Longport, Stoke-on-Trent
Brown, John, & Co., Ltd. .. Sheffield
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Friedenthal, F. .. .. .. River Engine Works, Preston
Hadfields Limited .. .. .. Hecla Works, Sheffield
North-Eastern Marine Engineering Co., Ltd. .. .. .. Northumberland Wks., Wallsend-on-Tyne
Ross & Duncan .. .. .. Glasgow
Spencer, John, & Sons, Ltd. .. Newburn Steel Works Newcastle-on-Tyne
Thornycroft, J. I., & Co., Ltd. .. Southampton
Vickers Limited .. .. .. Sheffield

Screwing Machines.

Armstrong Manufacturing Co. 338, Knowlton Street, Bridgeport, Conn., U.S.A.
Chatwin, Thos., Ltd. .. .. Gt. Tindall St., Birmingham
Cox & Sons, Company (The) .. Bridgeton, N. J., U.S.A.
Daniell, S. A., Ltd. .. .. Edward St., Parade, Birming
Heap, Joshua, & Co., Ltd. .. Ashton-under-Lyne [ham
Niles-Bement-Pond Co. .. .. Hamilton, Ohio, U.S.A.
Oster Manufacturing Co. .. Cleveland, Ohio, U.S.A.
Platt, Samuel, Ltd. .. .. Wednesbury
Shanks, Thomas, & Co. .. .. Union Ironworks, Johnstone
Tangyes Limited .. .. .. Birmingham
Winn, Chas., & Co. .. .. Granville Place, Birmingham

Search Lights.

British Thomson-Houston Co., Ltd. .. .. Rugby
Clarke, Chapman & Co., Ltd. .. Gateshead-upon-Tyne
Siemens Brothers Dynamo Wks., Ltd. .. .. Caxton House, Westminster, S.W.

Second-hand Tools, &c.

Butters Bros. & Co. .. .. 20, Waterloo Street, Glasgow
Gemmell, W., & Co. .. .. 492, Argyle Street, Glasgow
Hurst, Nelson & Co., Ltd. .. Motherwell, N.B.
Macnab, John .. .. .. Hyde
Ward, Thos. W., Ltd. .. .. Albion Works, Sheffield

Separators, Magnets, &c.

Consolidated Pneumatic Tool Co., Ltd. .. .. Palace Chambers, 9, Bridge Street, Westminster, S.W.
Rapid Magnetting Machine Co., Ltd. .. .. Birmingham
Westminster Tool & Electric Co. Suffolk House, Laurence Pountney Hill, E.C.

Shafting & Shaft Fittings.—*(See also Clutches—Friction, Couplings—Shaft, and Plummer Blocks & Bearings.*

Barry, Henry, & Co., Ltd. .. Aberdeen
Beardmore, William, & Co , Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Bessemer, Henry, & Co., Ltd. .. Sheffield
Bodley Bros. & Co. .. .. Old Quay Foundry, Exeter
Brown, Bayley's Steel Wrks., Ltd. Sheffield
Brown, John, & Co., Ltd. .. Sheffield
Coles, H. J., Ltd. .. .. .. London Crane Works, Derby
Craig, A. F., & Co., Ltd. .. Paisley, N.B.
Craven Brothers, Ltd. .. .. Osborne Street, Manchester
Croft & Perkins, Ltd. .. .. Power Works, Bradford
Douglas, Lawson & Co. .. .. Birstall, near Leeds
Dunfold & Elliott (Sheffield), Ld. Attercliffe Wharf, Sheffield
Entwisle & Gass, Ltd. .. .. Bolton
Escher, Wyss & Co. .. .. 109, Victoria Street, S.W.
Fife Forge Co. .. .. .. Kirkcaldy, Scotland
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Hadfields Limited .. .. .. Hecla Works, Sheffield
Hawthorn, R. & W., Leslie and Co., Ltd. .. .. Newcastle-on-Tyne
Hudswell, Clarke & Co., Ltd. .. Leeds
Jardine, John .. .. .. Deering Street, Nottingham
Kay, James C., & Co., Ltd. .. Barnbrook Works, Bury, Lancs.
Kirkstall Forge Co., Ltd. .. Leeds
Mackie, Ltd. .. .. Caversham Road, Reading
Platt, Samuel, Ltd. .. .. Wednesbury
Richards, Geo., & Co., Ltd. .. Broadheath, near Manchester
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Smith & Grace Screw Boss Pulley Co., Ltd. .. .. Tarapeton [castle-on-Tyne
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Taylor & Challen, Ltd. .. .. Birmingham
Trier Bros., Ltd. .. .. .. Caxton House, Westminster.
Unbreakable Pulley and Mill Gearing Co., Ltd. .. .. [S.W.
Vickers Limited .. .. .. 48, West Gorton, Manchester
Warden, A., & Co. .. .. Sheffield
Wigglesworth, Frank, & Co., Ltd. 44-48, Shepherdess Walk, City Road, E.C.
Yates & Thom, Ltd. .. .. Clutch Works, Shipley, near Bradford
Canal Works, Blackburn

Shearing Machines.—*(See Punching & Shearing Machines.)*

Sheerlegs.

Day, Summers & Co., Ltd. .. Northam Ironwks., Southampton

Sheet-Metal Work, and Machinery.

Braime, T. F., & Co., Ltd. .. Hunslet, Leeds
Standard Engineering Co., Ltd. Leicester
Taylor & Challen, Ltd. .. .. Birmingham

Sheet-Metal Work (Welded).

Ash, Joseph, & Son .. .. Bea St. South, Birmingham

Shipbuilders.—*(See also Barges & Lighters, Dredgers—Suction, Motor Boats, and Torpedo Boats.)*

Ailsa Shipbuilding Co., Ltd. .. Troon, N.B.
Alley & Macleilan, Ltd. .. Sentinel Works, Glasgow
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Boulton & Paul, Ltd. .. .. Norwich
Brown, John, & Co., Ltd. .. Sheffield
Cammell Laird & Co., Ltd. .. Sheffield
Crabtree & Co., Ltd. .. .. Great Yarmouth
Day, Summers & Co., Ltd. .. Northam Ironwks., Southampton
Dublin Dockyard Co., Ltd. .. North Wall, Dublin [ton
Ferguson Brothers (Port-Glasgow), Ltd... .. .. Newark Works, Port-Glasgow
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Hawthorn, R. & W., Leslie & Co., Ltd. .. .. Newcastle-on-Tyne
Hayes, Edward .. .. .. Stony Stratford, Wolverton
Isherwood, J. W. .. .. .. 4, Lloyd's Avenue, E.C.
Lobnitz & Co., Ltd. .. .. Renfrew, Scotland
McKie & Baxter .. .. .. Copland Wks., Govan, Glasgow
Normand, Augustin .. .. 67, Rue du Perrey, Le Havre, France
Ross & Duncan .. .. .. Glasgow
Simons, W., & Co., Ltd. .. .. Renfrew, N.B.
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Smit, L., & Zoon .. .. .. Kinderdijk, Holland
Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster,
Vickers Limited .. .. .. Barrow-in-Furness [S.W.
Wallsend Slipway & Engineering Co., Ltd. .. .. Wallsend
Watson, J. S. .. .. .. Gainsborough
White, J. Samuel, & Co., Ltd. .. East Cowes, I. o. W.
Yarrow & Co., Ltd. .. .. Glasgow

Shovels and Spades.—*(See Picks, &c.)*

Sirens and Whistles.

France & Morgan .. .. .. Whitefield Brass Wks., Govan Glasgow
Lunken Company, Ltd. .. .. 35, Great Dover Street, E.C.

Sites (Industrial).

Great Western Railway Co. .. Paddington Station, W.

Sleepers (Railway).—*(See also Permanent Way.)*

Slotting & Shaping Machines.—*(See Machine Tools.)*

Sluices.

Ransomes & Rapier, Ltd. .. Waterside Ironworks, Ipswich

Smiths' Fires.

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham

Smoke Helmets, &c.

Siebe, Gorman & Co., Ltd. .. Neptune Works, Westminster Bridge Road, S.E.

Solders.

McKechnie Brothers .. .. Rotton Park St., Birmingham

Solenoids (Brake).

Ellison, George .. .. .. Victoria Wks., Warstone Lane, Birmingham

Speed Indicators and Counters.

Butler, Theodore, Ltd. .. .. 149, Queen Victoria Street, E.C.
Dobbie, McInnes, Ltd. .. .. 57, Bothwell Street, Glasgow

Springs.

A.B.C. Coupler, Ltd. .. .. Queen Anne's Chambers, S.W.
Brown, Bayley's Steel Wrks., Ltd. Sheffield
Brown, John, & Co., Ltd. .. Sheffield [nr. Glasgow
Cockburns Limited .. .. Clydesdale Works, Cardonald,
Cottam, Edwin, & Co., Ltd. .. Cardiff; & Masboro' Rotherham
Ebbw Vale Steel Iron & Coal Co., Ltd. .. .. Ebbw Vale, Mon.
Salter, Geo., & Co. .. .. .. West Bromwich
Skinner, J. P., & Co., Ltd. .. Lowfields, Sheffield
Spencer John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Sterne, L., & Co., Ltd. .. Crown Ironworks, Glasgow
Terry, Herbert, & Sons, Ltd. .. Redditch
Turton, Thos., & Sons, Ltd. .. Sheaf Works, Sheffield

Stamping Machinery.

Berry, Henry, & Co., Ltd. .. Croydon Works, Hunslet, Leeds
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Hands, John, & Sons, Ltd. .. Cardigan Works, Birmingham
Massey, B. & S., Ltd. .. .. Openshaw, Manchester
Platt, Samuel, Ltd. .. .. Wednesbury
Taylor & Challen, Ltd. .. .. Birmingham

Stampings (Brass, Bronze, Copper, &c.).

Delta Metal Co., Ltd. .. .. East Greenwich, S.E.
Gabriel & Co. .. .. .. A.B. Row, Birmingham

Stampings (Iron and Steel).

Armstrong, Stevens & Son, Ltd. Whittall Street, Birmingham
Braime, T. F., & Co., Ltd. .. Hunslet, Leeds
Fowler, John, & Co. (Leeds), Ld. Leeds
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby
Hadley, Salop [on-Tees
Sankey, Joseph, & Sons, Ltd. .. Darlington
Skerne Works, Ltd. .. .. Livery Street, Birmingham
Vaughtons, Ltd. .. .. .. 32A, Liverpool Street, E.C.
Yetton & Brockett .. .. .. 32A, Liverpool Street, E.C.

Steam Cultivating Machines.

Aveling & Porter, Ltd. .. .. Rochester
Fowler, John & Co. (Leeds), Ltd. Leeds
Marshall, Sons & Co., Ltd. .. Gainsborough

Steam Hammers.—*(See also Hammers—Power.)*

Brett's Patent Lifter Co., Ltd. Coventry
Davis & Primrose, Ltd. .. .. Etna Ironworks, Bangor Road, Leith, Edinburgh
Davy Brothers, Ltd. .. .. Sheffield
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Massey, B. & S., Ltd. .. .. Openshaw, Manchester
Nasmyth, Wilson & Co., Ltd. .. Bridgewater Foundry, Patricroft, near Manchester
Pollock, MacNab & Highgate .. Shettleston, Glasgow
Ross, R. G., & Son, Ltd. .. .. Glasgow
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.

Steam Pipes.—*(See Pipes—Wrought Iron and Steel, and Tubes—Brass, Iron, &c.)*

Steam Rollers.—*(See Road Rollers.)*

Steam Separators.

Alley & Macellan, Ltd. .. .. Sentinel Works, Glasgow
Holden & Brooke, Ltd. .. .. Sirius Works, West Gorton,
Hopkinson, J., & Co., Ltd. .. Huddersfield [Manchester
Kater & Ankersmit .. .. 34, Fenchurch Street, E.C.
Kay, James C., & Co., Ltd. .. Barnbrook Works, Bury, Lancs.
North-Eastern Marine Engineering Co. Ltd. .. .. .. } Northumberland Wks., Wallsend-on-Tyne
Princeps & Co. .. .. .. Sheffield
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Steam Traps.

Alley & McLellan, Ltd. .. .. Sentinel Works, Glasgow
British Steam Specialties, Ltd. Bedford Street, Leicester
Cockburns Limited .. .. Clydesdale Works, Cardonald, near Glasgow
Edmeston, A., & Sons .. .. Patricroft, nr. Manchester
Gaipel, Wm., & Co. .. .. Vulcan Works, St. Thomas St., S.E. [E.
Hobdell, Way & Co., Ltd. .. St. John's House, 124-5, Minories,
Holden & Brooke, Ltd. .. .. Sirius Works, West Gorton,
Hopkinson, J., & Co., Ltd. .. Huddersfield [Manchester
Kater & Ankersmit .. .. 34, Fenchurch Street, E.C.
Klein Engineering Co. (1908), Ltd. 94, Market Street, Manchester
Lancaster & Tonge, Ltd. Pendleton, Manchester
Premier Cooler & Engineering Co., Ltd. .. .. } Broadway Court, Broadway, Westminster, S.W.
Royles Limited .. .. .. Irlam, near Manchester
United Brassfounders & Engineers, Ltd. .. .. Empress Foundry, Manchester
Yetton & Brockett .. .. .. 32a, Liverpool Street, E.C.

Steam Turbines and Fittings.

Allen, W. H., Son & Co., Ltd. .. Bedford
Bellias & Morcom, Ltd. .. .. Birmingham
British Thomson-Houston Co., Ltd. .. .. .. Rugby
British Westinghouse Electric and Manufacturing Co., Ltd. Trafford Park, Manchester
Brush Electrical Engineering Co., Ltd. .. .. Falcon Works, Loughborough
Cockburns Limited .. .. Clydesdale Works, Cardonald near Glasgow
Davison & Partner .. .. 11, Carteret Street, S.W.
Dick, Kerr & Co. Ltd. .. .. Abchurch Yard, Cannon St., E.C.
Escher, Wyss & Co. .. .. 109, Victoria Street, S.W.
Fraser & Chalmers, Ltd .. .. 3, London Wall Buildings, E.C.
Howden, James, & Co. .. .. Scotland Street, Glasgow
Parsons, C. A., & Co. .. .. Heaton Works, Newcastle-on-Tyne
Thornycroft, J. I., & Co., Ltd. .. Southampton [Tyne
Vickers Limited .. .. .. Sheffield
Wallsend Slipway & Engineering Co., Ltd. .. .. Wallsend
White, J. Samuel, & Co., Ltd. .. East Cowes, Isle of Wight
Willans & Robinson, Ltd. .. Rugby, Warwickshire

Steel and Iron Makers.

Allen, Edgar, & Co., Ltd. .. Imperial Steel Wks., Sheffield
Beardmore, William, & Co., Ltd. Parkhead Ironworks, Glasgow
Bessemer, Henry, & Co., Ltd. .. Sheffield
Brown, Bayley's Steel Works, Ltd. Sheffield
Brown, John, & Co., Ltd. .. Sheffield
Cammell Laird & Co., Ltd. .. Sheffield
Colville, David, & Sons, Ltd. .. Motherwell, near Glasgow
Cradock, Geo., & Co., Ltd. .. Wakefield, England
Darlington Forge Co., Ltd. .. Darlington
Fairley, James, & Sons .. Shadwell Street, Birmingham
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Glasgow Iron & Steel Co., Ltd. Wishaw, N.B.
Hadfields Limited .. .. .. Hecla Works, Sheffield
Howell & Co., Ltd. .. .. Brook Steel Works, Sheffield
Lanarkshire Steel Co., Ltd. .. Motherwell
Leeds Forge Co., Ltd. .. .. Leeds
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Motherwell Iron & Steel Co. .. Motherwell, N.B.
Patent Shaft & Axletree Co., Ltd. Wednesbury
Ramshay & Marshall, Ltd. .. Birmingham
Scott, Walter, Ltd. .. .. Leeds Stee. Works, Leeds
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne [Glasgow
Steel Co. of Scotland, Ltd. .. 23, Royal Exchange Square,
Stewarts & Lloyds, Ltd. .. .. 41, Oswald St., Glasgow; & Broad St. Chambers, Birmingham
Turton, T., & Sons, Ltd. .. .. Sheaf Works, Sheffield
Vickers Limited .. .. .. Sheffield

Steel and Iron Works (Plant for).—*(See Iron and Steel Works.)*

Steel (Tool, Special and High-Speed).

Allen, Edgar, & Co., Ltd. .. Sheffield
Armstrong, Sir W. G., Whitworth & Co., Ltd. .. .. .. Openshaw, Manchester
Beardshaw, J., & Son, Ltd. .. Baltic Steel Works, Sheffield
Cammell Laird & Co., Ltd. .. Sheffield
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Vickers Limited .. .. .. Sheffield

Steering Gear.

Alley & Macellan, Ltd. .. .. Sentinel Works, Glasgow
Brown Bros. & Co., Ltd. .. Rosebank Ironwks., Edinburgh, [N.B.
Carron Company .. .. .. Carron, Stirlingshire, N.B.
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham

Stokers (Mechanical).

Babcock & Wilcox, Ltd. .. .. Oriel House, Farringdon Street, E.C. [Bolton
Beanis, Ed., & Co., Ltd. .. .. Lancashire Stoker Works,
Meldrums, Ltd. .. .. .. Canal Works, Timperley, near Manchester
Proctor, J., Ltd. .. .. .. Burnley, Lancashire
Underfeed Stoker Co., Ltd. .. Coventry House, South Place, E.C.

Stonebreakers.—*(See also Disintegrators.)*

Allen, Edgar, & Co., Ltd. .. Sheffield
Baxter, W. H., Ltd .. .. Leeds
Hadfields Limited .. .. .. Hecla Works, Sheffield
Marsden, H. R., Ltd. .. .. Soho Foundry, Leeds
Tobey & Co., Ltd. .. .. .. Lincoln
Ttamm, W. .. .. 25, College Hill, E.C.
Western Wheeled Scraper Co. .. Aurora, Illinois, U.S.A.

Structural Engineering.

Anderson, D., & Son, Ltd. Lagan Felt Works, Belfast
Arrol, Sir William, & Co, Ltd. Dalmarnock Ironworks, Bridgeton, Glasgow
Ash, Joseph, & Son .. .. Rea Street South, Birmingham
Ashmore, Benson, Pease & Co., Ltd. Stockton-on-Tees
Baldwins Ltd. .. .. .. 5, Fenchurch Street, E.C.
Bellamy, John, Ltd. .. .. Millwall, S.E.
Boulton & Paul, Ltd. .. .. Norwich
Brandon Bridge-Building Co. Ltd. .. .. Brandon Works, Motherwell
Clayton, Son, & Co., Ltd. .. Hunslet, Leeds
Cleveland Bridge and Engineering Co., Ltd .. .. .. Darlington
Clyde Structural Iron Co., Ltd. Clydeside Ironworks, Scotstoun, Glasgow
Craig, A. F., & Co., Ltd. .. Paisley, N.B. [toun, Glasgow
Findlay, Alex., & Co., Ltd. .. Motherwell, near Glasgow
Fredk. Hall, Clayton & Co., Ltd. Leeds
Hanna, Donald & Wilson .. Paisley [on-Tees
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-
Heenan & Froude, Ltd. .. .. Newton Heath Ironworks, Manchester
Isherwood, J. W. .. .. .. Zetland Bldgs., Middlesbrough
Lysaght, John, Ltd. .. .. St. Vincent Ironworks, Bristol
Maclellan, P. & W., Ltd. .. Clutha Works, Glasgow
Maxwell & Page .. .. .. 49, Sefton Street, Liverpool
Mechan & Sons, Ltd. .. .. Scotstoun Ironworks, Glasgow
Metropolitan Carriage, Wagon and Finance Co., Ltd. .. .. Saltley, Birmingham
Motherwell Bridge Co., Ltd. .. Motherwell, N.B.
Newton, Chambers & Co., Ltd. Thorncliffe Ironworks, near Sheffield
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Ransomes & Rapier, Ltd. .. Waterside Ironworks, Ipswich
Toward, T., & Co., Ltd. .. .. 9, Ouseburn, Newcastle-on-Tyne

Tanners and Curriers.

Tullis, John, & Son, Ltd. .. St. Ann's Leather Wks., Glasgow
Webb & Son (Combs.), Ltd. .. Stowmarket

Taper Pins.—*(See Pins, Taper.)*

Tea-Dressing Machinery.

Marshall, Sons & Co., Ltd. .. Gainsborough
Ransomes, Sims & Jefferies, Ltd. Ipswich

Telegraph Cable-Laying Machines.—*(See Cable-Laying Machinery.)*

Telegraph Instruments.

British Insulated and Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, E.

Telegraph Wire & Cables.—*(See also Electric Cables.)*

British Insulated and Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
India-Rubber Gutta-Percha and Telegraph Works Co., Ltd. .. Silvertown, E.

Telegraphs (Engine and Steering).

Brown Bros. & Co., Ltd. .. Rosebank Ironwks., Edinburgh, [N.B.
Chadburn's (Ship) Telegraph Co., Ltd. .. .. Cyprus Road, Bootle, Lancs.

Telephones.

British Insulated and Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham

Testing Machines.

Avery, W. & T., Ltd. .. .. Soho Foundry, Birmingham
Bailey, Sir W. H. & Co., Ltd. Albion Works, Salford, Manchester
Cambridge Scientific Instrument Co., Ltd. .. .. .. Cambridge
Denison, Saml., & Son, Ltd. .. Far Hunslet, Leeds, S.
Foster Instrument Co. .. .. Letchworth, Herts.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Smith, Hugh & Co., Ltd. .. Possil Engine Works, Glasgow
Tangyes Limited .. .. .. Birmingham

Thermometers.—*(See Pyrometers.)*

Timber.

Hughes, Bolckow, & Co., Ltd. .. Blyth, Northumberland
Jennings, C., & Co. .. .. Pennywell Road, Bristol

Time-Checking Machines and Registers.

Bailey, Sir W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Buck & Hickman, Ltd. .. .. 2 & 4, Whitechapel Road, E.

Tools (Hand and Small).—*(See also Chucks, Files, and Machine Tools.)*

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Armstrong Mfg. Co. .. .. 338, Kingsland Street, Bridgeport, Conn., U.S.A.
Armstrong, Stevens & Son, Ltd. Whittall Street, Birmingham
Beardshaw, J., & Son, Ltd., .. Baltic Steel Works, Sheffield
Bristol Engineering Co., Ltd .. Fishponds, Bristol
Brunton & Trier .. .. .. Caxton House, Westminster, S.W.
Buck & Hickman, Ltd. .. .. 2 & 4, Whitechapel Road, E.

Sugar Machinery.

Blair, Campbell & McLean, Ltd. Woodville St., Govan, Glasgow
Craig, A. F., & Co., Ltd. .. .. Paisley, N.B.
Davis & Primrose, Ltd. .. .. Etna Ironworks, Bangor Road, Leith, Edinburgh
Fawcett, Preston & Co., Ltd. .. Liverpool
Harvey Engineering Co., Ltd. .. Scotland Street Engine Works, Glasgow
Manlove, Alliott & Co., Ltd. .. Nottingham
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Pott, Cassels & Williamson .. Motherwell, near Glasgow
Robey & Co., Ltd. .. .. Lincoln
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Stamm, W. .. .. 25, College Hill, E.C.
Stewart, Duncan, & Co., Ltd. .. London Rd. Ironworks, Glasgow
Watson, Laidlaw & Co. Ltd. .. 98, Dundas St. (South), Glasgow

Superheaters.

Babcock & Wilcox, Ltd. .. .. Oriel House, Farringdon St., E.C.
Davey, Paxman & Co., Ltd. .. Colchester [E.C.
Galloways Ltd. .. .. .. Manchester
Garrett, R., & Sons, Ltd. .. Leiston Works, Suffolk
Heenan & Froude, Ltd. .. .. Worcester
McPhail & Simpson, Ltd. .. Wakefield
Mechan & Sons, Ltd. .. .. Scotstoun Iron Wks., Glasgow
Schmidt's Superheating Co. (1910), Ltd. .. .. 28, Victoria Street, S.W.
Sugden, T., Ltd. .. .. .. 180, Fleet Street, E.C.
Superheater Units Ltd. .. .. 4, Castle Square, Swansea

Surveyors.—*(See Auctioneers, &c.)*

Switchboards & Accessories.—*(See also Electric Lighting & Power Plant, and Instruments — Electrical, Surveying, &c.)*

British Thomson-Houston Co., Ltd. .. .. Rugby
Electric Control, Ltd. .. .. Bridgeton, Glasgow
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham
Ellison, George .. .. .. Victoria Wks., Warstone Lane, Birmingham

Switches and Crossings.

Cammell Laird & Co., Ltd. .. Sheffield
Heenan & Froude, Ltd. .. .. Worcester
McKenzie & Holland, Ltd. .. 58, Victoria Street, S.W.
McKenzie, Holland & Westinghouse Power Signal Co., Ltd. .. 58, Victoria Street, S.W.
Vickers Limited .. .. .. Sheffield
White, Rd., & Sons .. .. Widnes, Lancs.

Tanks.

Ash, Joseph, & Son .. .. Rea Street South, Birmingham
Baldwins, Ltd. .. .. .. 5, Fenchurch Street, E.C.
Bellamy, John, Ltd. .. .. Millwall, E.
Braby, Fredk., & Co., Ltd. .. Fitzroy Works, 352 to 362, Euston Road, N.W.
Brandon Bridge-Building Co., Ltd. .. .. Brandon Works, Motherwell
Clay Cross Co. .. .. .. Clay Cross, near Chesterfield
Clayton, Son, & Co., Ltd. .. Hunslet, Leeds
Clyde Structural Iron Co., Ltd. Clydeside Ironwks., Scotstoun,
Craig, A. F., & Co., Ltd. .. Paisley, N.B. [Glasgow
Hanna, Donald & Wilson .. Paisley, N.B.
Harvey, G. A., & Co. (London) Ltd. Greenwich Metal Works, Woolwich Road, S.E.
Head, Wrightson & Co., Ltd. .. Teesdale Ironworks, Thornaby-on-Tees
Jenkins, R., & Co., Ltd. .. .. Rotherham, Eng.
Lysaght, John, Ltd. .. .. St. Vincent Ironworks, Bristol
Mechan & Sons, Ltd. .. .. Scotstoun Ironworks, Glasgow
Metropolitan Carriage, Wagon and Finance Co., Ltd. .. .. Saltley, Birmingham
Motherwell Bridge Co., Ltd. .. Motherwell, N.B.
Newton, Chambers & Co., Ltd. Thorncliffe Ironworks, near Sheffield
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Ransomes & Rapier, Ltd. .. Waterside Ironworks, Ipswich
Toward, T., & Co., Ltd. .. .. 9, Ouseburn, Newcastle-on-Tyne

Tanners and Curriers.

Tullis, John, & Son, Ltd. .. St. Ann's Leather Wks., Glasgow
Webb & Son (Combs.), Ltd. .. Stowmarket

Taper Pins.—*(See Pins, Taper.)*

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India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, E.

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India-Rubber Gutta-Percha and Telegraph Works Co., Ltd. .. Silvertown, E.

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Chadburn's (Ship) Telegraph Co., Ltd. .. .. Cyprus Road, Bootle, Lancs.

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British Insulated and Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
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Avery, W. & T., Ltd. .. .. Soho Foundry, Birmingham
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Cambridge Scientific Instrument Co., Ltd. .. .. .. Cambridge
Denison, Saml., & Son, Ltd. .. Far Hunslet, Leeds, S.
Foster Instrument Co. .. .. Letchworth, Herts.
Greenwood & Batley, Ltd. .. Albion Works, Leeds
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.
Smith, Hugh & Co., Ltd. .. Possil Engine Works, Glasgow
Tangyes Limited .. .. .. Birmingham

Thermometers.—*(See Pyrometers.)*

Timber.

Hughes, Bolckow, & Co., Ltd. .. Blyth, Northumberland
Jennings, C., & Co. .. .. Pennywell Road, Bristol

Time-Checking Machines and Registers.

Bailey, Sir W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Buck & Hickman, Ltd. .. .. 2 & 4, Whitechapel Road, E.

Tools (Hand and Small).—*(See also Chucks, Files, and Machine Tools.)*

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
Armstrong Mfg. Co. .. .. 338, Kingsland Street, Bridgeport, Conn., U.S.A.
Armstrong, Stevens & Son, Ltd. Whittall Street, Birmingham
Beardshaw, J., & Son, Ltd., .. Baltic Steel Works, Sheffield
Bristol Engineering Co., Ltd .. Fishponds, Bristol
Brunton & Trier .. .. .. Caxton House, Westminster, S.W.
Buck & Hickman, Ltd. .. .. 2 & 4, Whitechapel Road, E.

Tools (Hand and Small).—*(See also Chucks, Files, and Machine Tools.).—Continued.*

Burton, C. W., Griffiths & Co. .. 1, 2 & 3, Ludgate Square, E.C.
Chatwin, Thos., Ltd. .. .. Gt. Tindall St., Birmingham
Churchill, Chas., & Co., Ltd. .. 9 to 15, Leonard St., Finsbury, E.C.
Consolidated Pneumatic Tool Co., Ltd. .. .. .. } Palace Chambers, 9, Bridge St., Westminster, S.W.
Coventry Ordnance Works, Ltd. Ordnance Works, Coventry
Crown Works .. .. .. London New Road, Chelmsford
Daniell, S. A., Ltd. .. .. Edward St., Parade, Birmingham
Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Gilman, Frank .. .. .. 62, Lightwoods Hill, Birmingham
Heap, Joshua, & Co., Ltd. .. Ashton under-Lyne
Lash, Robert H. .. .. .. 31, Carburton Street, Portland Road Station, W.
Lewitt Machine Co. .. .. .. Orange, Mass., U.S.A.
Nicholson, W. T., & Clipper Co., Ltd. .. .. } Clipper Works, King Street, Salford, Manchester
Oster Manufacturing Co. .. Cleveland, Ohio, U.S.A.
Pryor, Edward, & Son .. .. 63, West Street, Sheffield
Selson Engineering Co., Ltd. .. 85, Queen Victoria Street, E.C.
Stone, J. B., & Co., Ltd. .. 135, Finsbury Pavement, E.C.
Taylor, Charles (Birm'm.), Ltd. Bartholomew Sq., Birmingham
United States Metallic Packing Co., Ltd. .. .. Soho Works, Bradford
Vickers Limited .. .. .. Vickers House, Broadway Westminster, S.W.
Wallace Supply Co. (Mfrs.) .. 415, Orleans Street, Chicago U.S.A.
Ward, H. W., & Co., Ltd. .. Lionel Street, Birmingham
Wells, A. C., & Co. .. .. 102, Midland Road, St. Pancras,
Widdowson, John H. .. .. Salford, Manchester [N.W.
Wilkinson & Co. .. .. .. Spring Gardens Works, Dudley
Yetton & Brockett .. .. .. 32a, Liverpool Street, E.C.

Tools (Pneumatic).—*(See Pneumatic Tools.)*

Torpedo Boats.

Hanna, Donald & Wilson .. Paisley [France
Normand, Augustin .. .. 67, Rue du Perrey, Le Havre,
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Smit, L., & Zoon .. .. .. Kinderdijk, Holland [S.W.
Thornycroft, J. I., & Co., Ltd. .. Caxton House, Westminster,
White, J. Samuel, & Co., Ltd. .. East Cowes, Isle of Wight
Yarrow & Co., Ltd. .. .. Glasgow

Torsion Meters.

Chadburn's (Ship) Telegraph Co. Ltd. .. .. Cyprus Road, Bootle, Lancs.

Tractors (Oil, Steam, &c.).

Marshall, Sons & Co., Ltd. .. Gainsborough

Tramways and Tramway Plant.

Allen, Edgar, & Co., Ltd. .. Sheffield
Birch, John, & Co., Ltd. .. .. 10 & 11, Queen St. Place, E.C.
Bolling & Lowe .. .. .. 2, Laurence Pountney Hill, E.C.
Brecknell, Munro & Rogers, Ltd. Thrissell Street, Bristol
Brush Electrical Engineering Co., Ltd. .. .. Falcon Works, Loughborough
Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon Street,
Hadfields Limited .. .. Hecla Works, Sheffield [E.C.
Hawthorn, R. & W., Leslie & Co., Ltd. .. .. Newcastle-on-Tyne
Hornsby, R., & Sons, Ltd. .. Grantham
Hurst, Nelson & Co., Ltd. .. Glasgow Rolling Stock and Plant Works, Motherwell
Kerr, Stuart & Co., Ltd. .. .. 1, Broad Street Place, E.C.
Russell, James, & Sons, Ltd. .. Crown Tube Works, Wednesbury

Transporters.

Arrol, Sir Wm., & Co., Ltd. .. Bridgeton, Glasgow
Brown Hoisting Machinery Co. Cleveland, Onio, U.S.A.
Dempster, Robert, & Son, Ltd. Elland, Yorkshire
Higginbottom & Mannock, Ltd. West Gorton, Manchester
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln

Tubes (Brass and Copper).—*(See also Pipes.)*

Birmingham Battery & Metal Co., Ltd. .. .. Birmingham
Broughton Copper Co., Ltd. .. Manchester
Delta Metal Co., Ltd. .. .. Dartmouth St., Birmingham
Grice, Grice & Son, Ltd. .. Sheepcote Street, Birmingham
Munts, P. H., & Co., Ltd. .. Alexandra Works, West Bromwich
Royles Limited .. .. .. Irlam, near Manchester
Yorkshire Copper Works, Ltd. Leeds

Tubes (Iron and Steel).

Brown, John, & Co., Ltd. .. Sheffield
Clayton, Son & Co., Ltd. .. .. Hunslet, Leeds
Ebbw Vale Steel Iron & Coal Co., Ltd. .. .. Ebbw Vale, Mon.
Foster Brothers, Ltd. .. .. Wednesbury
Howell & Co., Ltd .. .. Brook Steel Works Sheffield
Le Bas, Edward, & Co. .. .. Dock House, Billiter Street, E.C.
Lewis, E., & Sons .. .. .. Wolverhampton
Mechan & Sons, Ltd. .. .. Scotstoun Ironworks, Glasgow
Muntz, P. H., & Co., Ltd. .. Alexandra Works, West Bromwich
Piggott, Thos., & Co., Ltd. .. Springhill, Birmingham
Russell, James, & Sons, Ltd. .. Crown Tube Wks., Wednesbury
Russell, John, & Co., Ltd. .. Alma Tube Works, Walsall
Spencer, John, Ltd. .. .. Wednesbury
Steel Pipe Company, Ltd. .. Kirkcaldy, N.B.
Stewarts & Lloyds, Ltd. .. .. 41, Oswald Street, Glasgow; and Broad Street Chambers, Birmingham
Tubes Ltd. .. .. Birmingham
Weldless Steel Tube Co., Ltd. .. Icknield Port Rd., Birmingham

Tube-Making Machinery.

Platt, Samuel, Ltd. .. .. Wednesbury

Tube Wells.—*(See Well Engineers.)*

Tug Boats.

Day, Summers & Co. .. .. Northam Ironworks, South [ampton
Ferguson Brothers (Port-Glasgow), Ltd. .. .. .. Newark Works, Port-Glasgow
Fleming & Ferguson, Ltd. .. Paisley, N.B.
Hayes, Edward .. .. .. Stony Stratford, Wolverton
Lobnitz & Co., Ltd. .. .. Renfrew
McKie & Baxter .. .. Copland Wks., Govan, Glasgow
Ross & Duncan .. .. .. Glasgow
Simpson, Strickland & Co., Ltd. Dartmouth, S. Devon
Smit, L., & Zoon .. .. .. Kinderdijk, Holland
Thornycroft, J. I., & Co., Ltd. .. Southampton, and Caxton House, Westminster, S.W.
White, J. Samuel, & Co., Ltd. .. East Cowes, Isle of Wight

Turbine Pumps.—*(See Pumps, Turbine.)*

Turbines (Water).—*(See also Steam Turbines.)*

Allen, W. H., Son, & Co., Ltd. .. Queen's Eng. Works, Bedford
Armfield, Joseph J., & Co. .. 20, Mark Lane, E.C.
Boving & Co., Ltd .. .. .. 9½, Union Court, Old Broad Street, E.C.
British Thomson-Houston Co., Ltd. .. .. Rugby
Escher, Wyss & Co. .. .. 109, Victoria Street, S.W.
Gunther, W., & Sons .. .. Central Works, Oldham
King, H. J. H., & Co., Ltd. .. Nailsworth, Glos.
Pitman, Percy .. .. .. 5, Willcott Road, Acton, W.
Thornycroft, J. I., & Co., Ltd. .. Southampton
Vickers Limited .. .. .. Sheffield

Turnstiles.

Ellison, W. T., & Co., Ltd. .. Irlams-o'-th'-Height, Manchester [S.E.
Isler, C., & Co., Ltd. .. .. Artesian Works, Bear Lane
Le Grand & Sutcliff .. .. 125, Bunhill Row, E.C.

Turntables.

Ashmore, Benson, Pease & Co., Ltd. Stockton-on-Tees
Cowans, Sheldon & Co., Ltd. .. Carlisle [Manchester
Heenan & Froude, Ltd. .. .. Newton Heath Ironworks, near
Kerr, Stuart & Co., Ltd. .. .. 5, Broad Street Place, E.C.
Patent Shaft & Axletree Co., Ltd. Wednesbury
Ransomes & Rapier, Ltd. .. Waterside Ironworks Ipswich
Sellers, William, & Co. (Incorp.) Philadelphia, Penn., U.S.A.

Tyres (Railway).

Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
Bessemer, Henry, & Co., Ltd. .. Sheffield
Brown, Bayley's Steel Works, Ltd. Sheffield
Brown, John, & Co., Ltd. .. Sheffield
Cammell Laird & Co. Ltd. .. Sheffield
Firth, Thos., & Sons, Ltd. .. Sheffield
Patent Shaft & Axletree Co., Ltd. Wednesbury
Vickers Limited .. .. .. Sheffield

Valuers.—*(See Auctioneers, &c.)*

Valve Gear.

Lees, T. & R. .. .. .. Hollinwood, near Manchester

Valves (Gas, Steam, Water, &c.).

Alley & MacLellan, Ltd. .. Sentinel Works, Glasgow
Auld, David, & Sons, Ltd. .. Whitevale Foundry, Glasgow
Bailey, Sir W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Baldwin, James, & Co. .. .. Keighley [chester
Bell's United Asbestos Co., Ltd. 59½, Southwark Street, S.E.
Berry, Henry, & Co. Ltd. .. Croydon Works, Hunslet, Leeds
Blair, Campbell & McLean, Ltd. Woodville St., Govan, Glasgow
Blakeborough, J., & Sons .. Brighouse
British Steam Specialties, Ltd. Bedford Street, Leicester
Cockburns Limited .. .. Clydesdale Works, Cardonald, near Glasgow
Crosby Valve & Engineering Co., Ltd. .. .. 147, Queen Victoria St., E.C.
Davies & Metcalfe, Ltd. .. .. Romiley, near Manchester
Donkin Co., Ltd. (The Bryan) .. Chesterfield
East Ferry Road Engineering Works Co., Ltd. .. .. Millwall, E.
Fletcher Bros. .. .. .. Oozells St. North, Birmingham
Glenfield & Kennedy, Ltd. .. Kilmarnock, N.B.
Gutta Percha & Rubber, Ltd. .. Toronto, Canada
Hanna, Donald & Wilson .. Paisley, N.B.
Holden & Brooke, Ltd. .. .. Sirius Works, West Gorton,
Hopkinson, J., & Co., Ltd. .. Huddersfield [Manchester
Hulburd Engineering Co., Ltd. St. Benet Chambers, Fenchurch Street, E.C.
Hunt & Mitton, Ltd. .. .. Oozells St. North, Birmingham
Jenkins Bros., Ltd. .. .. 95, Queen Victoria Street, E.C.
Lunken Company, Ltd. .. .. 35, Great Dover Street, S.E.
Metallic Valve Co. .. .. Colonial House, Water Street,
Piggott, Thos., & Co., Ltd. .. Birmingham [Liverpool
Rice & Co. (Leeds), Ltd. .. .. Elland Road, Leeds
Royles Limited .. .. .. Irlam, near Manchester
Turnbull, Alex., & Co., Ltd. .. Bishopbriggs, Glasgow
United Brassfounders & Engineers, Ltd. .. .. .. Empress Foundry, Manchester
Woodite Works .. .. .. Mitcham Common, Surrey
Worthington Pump Co., Ltd. .. 153, Queen Victoria Street, E.C.

Valves (Reducing).

Auld, David, & Sons, Ltd. .. Whitevale Foundry, Glasgow
Bailey, Sir W. H., & Co., Ltd. .. Albion Works, Salford, Manchester
Blakeborough, J., & Sons .. Brighouse [chester
Cockburns Ltd. .. .. .. Clydesdale Engineering Works, Cardonald, near Glasgow
Hopkinson, J., & Co., Ltd .. Huddersfield
Mason Regulator Co. .. .. Boston, U.S.A.
Royles Limited .. .. .. Irlam, near Manchester
Sugden, T., Ltd. .. .. .. 180, Fleet Street, E.C.
Turnbull, Alex., & Co., Ltd. .. Bishopbriggs, Glasgow

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Bailey, Sir W. H., & Co., Ltd. .. Albion Wks., Salford, Manchester
Blakeborough, J., & Sons .. Brighouse
Cockburns Ltd. .. .. .. Clydesdale Engineering Works, Cardonald, near Glasgow
Crosby Valve & Engineering Co., Ltd. .. .. 147, Queen Victoria Street, E.C.
Hobdell, Way & Co., Ltd. .. St. John's House, 124-5, Minories,
Hopkinson, J., & Co., Ltd. .. Huddersfield [E.
Klinger, Richard, & Co. .. .. 66, Fenchurch Street, E.C.
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Royles Limited .. .. .. Irlam, near Manchester
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Ventilators.—*(See also Fans and Blowers.)*

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Boyle, R., & Son .. .. .. 64, Holborn Viaduct, E.C.
Buffalo Forge Company .. .. Caxton House, Westminster S.W.
Electric & Ordnance Accessories Co., Ltd. .. .. Aston, Birmingham
Heenan & Froude, Ltd. .. .. Worcester Engineering Works,
Keith, James, & Blackman Co., Ltd. .. .. [Worcester
Musgrave & Co., Ltd. .. .. 27, Farringdon Avenue, E.C.
Royce Ltd. .. .. St. Ann's Ironworks, Belfast
Standard Engineering Co., Ltd. Trafford Park, Manchester
Sturtevant Engineering Co., Ltd. Leicester
147, Queen Victoria St., E.C.

Vices.

Alldays & Onions (Pneumatic Engineering) Co., Ltd. .. Birmingham
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Vulcanite and Vulcanised Fibre.—*(See also India Rubber Goods.)*

India Rubber, Gutta Percha and Telegraph Works Co., Ltd. .. Silvertown, Essex
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Bagnall, W. G., Ltd. Castle Engine Works, Stafford
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Midland Railway Carriage and Wagon Co., Ltd. .. .. .. Midland Works, Birmingham
Patent Shaft & Axletree Co., Ltd. Wednesbury
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Wagons (Self-propelled).—*(See Motor Vehicles)*

Wagons (Tip).

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Dick, Kerr & Co., Ltd. .. .. Abchurch Yard, Cannon St, E.C.
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Kerr, Stuart & Co., Ltd. .. 5, Broad Street Place, E.C.
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Watches and Clocks.

Bailey, Sir W. H., & Co., Ltd. .. Salford, Manchester
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Water Cooling Plant.

Kater & Ankersmit .. .. 34, Fenchurch Street, E.C.
Klein Engineering Co. (1908), Ld. 94, Market Street, Manchester
Premier Cooler & Engineering Co., Ltd. .. .. Broadway Court, Broadway, Westminster, S.W.

Water-Purifying Apparatus. — *(See Feed-Water Filters.)*

Babcock & Wilcox, Ltd. .. Oriel Hse., Farringdon St., E.C.
Baker (Leeds), Ltd. .. .. Union Works, Hunslet, Leeds
Bellamy, John, Ltd. .. .. Millwall, E.
Buhring's Patent Water Purifying Co. .. .. 60, Wilson Street, E.C.
Harris Patent Feed-Water Filter (1910), Ltd. .. .. 81, Victoria Street, S.W.
Harris Patent Feed-Water Filter (1910), Ltd. .. .. .. Newcastle-on-Tyne
Kennicott Water Softener Co. Ettingshall Works, Wolverhampton
Mather & Platt, Ltd. .. .. Salford Ironworks, Manchester
Paterson Engineering Co., Ltd. 21, Amberley House, Norfolk Street, Strand, W.C.
Pulsometer Engineering Co., Ld. Nine Elms Ironworks, Reading
Royles Limited .. .. .. Irlam, near Manchester
Rubery, Owen & Co. .. .. Darlaston, South Staffordshire
Underfeed Stoker Co., Ltd. .. Coventry House, South Place, E.C.
United Water Softeners, Ltd .. Imperial Hse., Kingsway, W.C.
Wright's Forge & Engineering Co., Ltd. .. .. Tipton, Staffordshire

Water Wheels. — *(See also Turbines—Water.)*

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Bodley Brothers & Co. .. .. Exeter
Davis & Primrose, Ltd. .. .. Bangor Rd., Leith, Edinburgh
King, H. J. H., & Co., Ltd. .. Nailsworth, Glos.
Stothert & Pitt, Ltd. .. .. Bath

Weighing Machines.

Avery, W. & T., Ltd. .. .. Soho Foundry, Birmingham
Bennis, Ed., & Co., Ltd. .. .. Bolton
Danison, Saml., & Son, Ltd. .. Far Hunslet, Leeds, S.
East Ferry Road Engineering Works, Co., Ltd. .. .. Millwall, E.
Klein Engineering Co. (1908), Ltd. 94, Market Street, Manchester

Welding and Cutting Plant.

Acetylene Corporation, Ltd. .. 49, Victoria Street, S.W.
Acetylene Illuminating Co., Ld. 268 and 270, South Lambeth Road, S.E.
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British Oxygen Co., Ltd. .. Elverton Street, Westminster
Imperial Light Limited .. .. 123, Victoria Street, S.W.
McGowan, Wild & Co. .. .. Hurst Street, Birmingham
Naish & Croft .. .. .. 150, Alma Street, Birmingham
Sirius Autogenous Works Co. .. 85-7, High Street, Stratford, E.
Thorn & Hoddle Acetylene Co., Ld. 151, Victoria St., S.W.
Warden, A., & Co. .. .. 44, 46, 48, Shepherdess Walk, City Road, N.

Well Engineers. — *(See also Boring & Sinking Tools & Machinery for Shafts & Wells.)*

Isler, C., & Co., Ltd. .. .. Artesian Wks, Bear Lane, S.E.
Lacy-Hulbert & Co., Ltd. .. 91, Victoria Street, S.W.
Le Grand & Sutcliff .. .. 125, Bunhill Row, E.C.
New Calyx Drill & Boring Co., Ltd. .. .. 120, East Ferry Road, Millwall, E.
Potter, A. C., & Co. .. .. Lant Street, S.E.

Wheel-Cutting Machinery. — *(See Gear Cutters.)*

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Angus, George, & Co., Ltd. .. Newcastle-on-Tyne
Barry, Henry & Co., Ltd. .. Aberdeen
Bessemer, Henry, & Co., Ltd. .. Sheffield
Bodley Brothers & Co. .. .. Exeter
British Insulated & Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
Brown, Bayley's Steel Works, Ld. Sheffield
Citroen Gear Co., Ltd. .. .. 27, Queen Victoria Street, E.C.
Craig, A. F., & Co., Ltd. .. Paisley, N.B.
Entwisle & Gass, Ltd. .. .. Atlas Foundry, Bolton
Hadfields Limited .. .. Hecla Works, Sheffield
Hawthorn, R. & W., Leslie and Co., Ltd. .. .. Newcastle-on-Tyne
Kay, James C., & Co., Ltd. .. Barnbrook Works, Bury, Lancs.
King, H. J. H., & Co., Ltd. .. Nailsworth, Glos.
Kirkstall Forge Co., Ltd. .. Leeds
Lang, John, & Sons .. .. Johnstone, nr. Glasgow
Mackie, Ltd. .. .. .. Caversham Road, Reading

Wheels (Geared). — *Continued.*

Manlove, Alliott & Co., Ltd. .. Nottingham
Moss Gear Co., Ltd .. .. Aston Manor, Birmingham
Power Plant Co., Ltd. .. .. West Drayton, Middlesex
Reid Gear Co. .. .. .. Linwood, near Paisley
Richards, Geo. & Co., Ltd. .. Broadheath, near Manchester
Rodgers Bros. .. .. .. Baker Street, Brixton, S.W.
Ross, R. G., & Son, Ltd. .. .. Glasgow
Shaw, W., & Co. .. .. .. Wellington Cast Steel Foundry Middlesbro'-on-Tees
Spencer, John, & Sons, Ltd. .. Newburn Steel Works, Newcastle-on-Tyne
Thornycroft, J. I., & Co., Ltd. .. Basingstoke
Unbreakable Pulley & Mill Gearing Co., Ltd. .. .. .. 48, West Gorton, Manchester
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Acieries et Fonderies d'Art, Ltd. Caxton House, Westminster, S.W.
Beardmore, William, & Co., Ltd. Parkhead Forge Rolling Mills and Steel Works, Glasgow
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Firth, Thos., & Sons, Ltd. .. Norfolk Works, Sheffield
Glasgow Railway Engineering Co., Ltd. .. .. Govan, Glasgow
Hadfields Limited .. .. Hecla Works, Sheffield
Hurst, Nelson & Co., Ltd. .. Glasgow Rolling Stock and Plant Works, Motherwell
Metropolitan Carriage, Wagon and Finance Co., Ltd. .. .. Saltley, Birmingham
Midland Railway Carriage and Wagon Co., Ltd. .. .. Midland Works, Birmingham
Patent Shaft & Axletree Co., Ld. Wednesbury
Pickering, R. Y., & Co., Ltd. .. Wishaw, near Glasgow
Sankey, Joseph, & Sons, Ltd. .. Hadley, Salop

Wheels (Rawhide, &c.).

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British Thomson-Houston Co., Ltd. .. .. Rugby
Rodgers Bros. .. .. .. Baker Street, Brixton, S.W.

Whitewashing and Painting Machines.

Wells, A. C., & Co. .. .. 102, Midland Road, N.W.

Winches. — *(See Cranes.*

Windlasses.

Clarke, Chapman & Co., Ltd. .. Gateshead-upon-Tyne
Mirrlees Watson Co., Ltd. .. Scotland Street, Glasgow

Wire and Wire Rope Makers.

Birmingham Battery & Metal Co., Ltd. .. .. Birmingham
British Insulated & Helsby Cables, Ltd. .. .. .. Prescot, Lancashire
Brown, W. B., & Co. (Bankhall), Ltd. .. .. .. Globe Works, Bankhall, Liverpool
Bullivant & Co., Ltd. .. .. 72, Mark Lane, E.C.
Cooke, William, & Co., Ltd. .. Tinsley Steel, Iron & Wire Rope Works, Sheffield
Cousland, A., & Son .. .. 3, Mitchell Street, Glasgow
Cradock, Geo., & Co., Ltd. .. Wakefield
Delta Metal Co., Ltd. .. .. Dartmouth St., Birmingham
Dennis, W. F., & Co. .. .. 49, Queen Victoria St., E.C.
Elliot, George, & Co., Ltd. .. 16, Great George Street, Westminster
Fowler, J., & Co. (Leeds), Ltd. Leeds

Woodite for Steam, Electrical and Hydraulic Packings.

Woodite Works .. .. .. Mitcham Common, Surrey

Wood-Wool Machinery.

Ransome, A., & Co., Ltd. .. Stanley Wks, Newark-on-Trent

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Dempster, Moore & Co., Ltd. .. 49, Robertson Street, Glasgow
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Lees, T. & R. .. .. .. Hollinwood, near Manchester
Marshall, Sons & Co., Ltd. .. Gainsborough
Pollock, Macnab & Highgate .. Shettleston, Glasgow
Ransome, A., & Co., Ltd. .. Stanley Wks., Newark-on-Trent
Richards, Geo., & Co., Ltd. .. Broadheath, near Manchester
Robey & Co., Ltd. .. .. .. Lincoln
Robinson, Thos., & Son, Ltd. .. Rochdale
Ruston, Proctor & Co., Ltd. .. Sheaf Ironworks, Lincoln
Wadkin & Co. .. .. .. London Street, Leicester

Worm Gearing.

Bodley Bros. & Co. .. .. Old Quay Foundry, Exeter
Wallwork, Henry, & Co., Ltd. .. Manchester

Yachts. — *(See Launches and Yachts.)*

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Abbott & Co. (Newark), Ltd., Newark-on-Trent	**Abbott, Newark**
Acetylene Corporation, Ltd., 49, Victoria Street, Westminster, S.W.	**Flamma, London**
Acetylene Illuminating Co., Ltd., 268 and 270, South Lambeth Road, S.W.	**Endazzle, London**
Aciéries et Fonderies d'Art, Ltd., Caxton House, Westminster, S.W.	**Westeelite, London**
Ailsa Shipbuilding Co., Ltd., Troon, N.B.	**Shipyard, Troon**
Alexander, E. P., & Son, 306, High Holborn, W.C.	**Epa, London**
Alldays & Onions (Pneumatic Engineering) Co., Ltd., Birmingham	**Alldays, Birmingham**
Alldays & Onions (Pneumatic Engineering) Co., Ltd., 58, Holborn Viaduct, E.C.	**Typhoon, London**
Allen, Edgar, & Co., Ltd., Imperial Steel Works, Sheffield	**Allen, Sheffield**
Allen, W. H., Son, & Co., Ltd., Queen's Eng. Works, Bedford	**Pump, Bedford**
Allen, W. H., Son, & Co., Ld., 1, Queen Anne's Chambers, Westminster, S.W.	**Pump, London**
Alley & Maclellan, Ltd., Sentinel Works, Glasgow	**Alley, Glasgow**
Anderson, D., & Son, Ltd., Lagan Felt Works, Belfast	**Anderson, Belfast**
Anderston Foundry Co., Ltd., Glasgow	**Afco, Glasgow**
Anglo-Mexican Petroleum Products Company, Ltd., Finsbury Court, E.C.	**Mexprodux, Ave., London**
Angus, George, & Co., Ltd., Newcastle-on-Tyne	**Angus, Newcastle**
Archdale, Jas., & Co., Ltd., Ledsam Street, Birmingham	**Archdale, Birmingham**
Armfield, Joseph J., & Co., 20, Mark Lane, E.C.	**Transformation, London**
Armstrong Mfg. Co., 338, Knowlton Street, Bridgeport, Conn., U.S.A.	
Armstrong, Stevens & Son, Ltd., Whittall Street, Birmingham	**Armstrongs, Birmingham**
Armstrong, Sir W. G., Whitworth & Co., Ltd., Openshaw, Manchester	**Whitworth, Openshaw**
Arnold, Edward, 41 & 43, Maddox Street, W.	**Scholarly, London**
Arnold, Joseph, 32, St. Paul's Road, N.W.	**Sandbags, London**
Arrol, Sir William, & Co., Ltd., Dalmarnock Iron Works, Bridgeton, Glasgow	**Tay, Glasgow**
Ash, Joseph, & Son, Rea Works, Rea Street South, Birmingham	**Tanks, Birmingham**
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Asquith, William, Ltd., Park Works, Halifax	**Drill, Halifax**
Atkinson, Robert (London), **Ltd.**, 19, Ludgate Hill, E.C.	**Findings, London**
Atlas Metal & Alloys Co., Ltd., 52, Queen Victoria Street, E.C.	**Aloyau, Cannon, London**
August's Muffle Furnaces, Ltd., Thorn Tree Works, King Cross, Halifax	**August, Halifax**
Auld, David, & Sons, Ltd., Whitevale Foundry, Glasgow	**Reducing, Glasgow**
Aveling & Porter, Ltd., Rochester	**Aveling, Rochester**
Avery, W. & T., Ltd., Soho Foundry, Birmingham	**Avery, Birmingham**
Avonside Engine Co., Ltd., Bristol	**Loco, Bristol**
Babcock & Wilcox, Ltd., Oriel House, Farringdon Street, E.C.	**Babcock, London**
Bagnall, W. G., Ltd., Castle Engine Works, Stafford	**Bagnall, Stafford**
Bagshawe & Co., Ltd., 3, Tower Royal, Cannon Street, E.C.	**Outburst, London**
Bagshawe & Co., Ltd., Dunstable Works, Dunstable	**Bagshawe, Dunstable**
Bailey, Sir W. H., & Co., Ltd., Albion Wks., Salford, Manchester	**Beacon, Salford**
Baker, E., John Bright Street, Birmingham	
Baker's (Leeds), Ltd. Union Works, Hunslet, Leeds	**Exhaust, Leeds**
Baldwin, James, & Co., Devonshire Brass Works, Keighley	**Baldwin, Engineers, Keighley**
Baldwin Locomotive Works, The, 34, Victoria Street, S.W.	**Fribald, London**
Baldwin Locomotive Works, The, 500, North Broad Street, Philadelphia, Pa., U.S.A.	**Baldwin, Philadelphia**
Baldwins Ltd., 5, Fenchurch Street, E.C.	**Promptitude, London**
Baldwins Ltd., Orchard Place, Blackwall, E.	**Silverine, London**
Barclay, Andrew, Sons & Co., Ltd., Caledonian Works, Kilmarnock	**Barclayson, Kilmarnock**
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Barns, W., & Son, Queensland Road, Holloway, N.	**Perforation, London**
Barry, Henry & Co., Ltd., Aberdeen	**Barry, Aberdeen**
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Batsford, B. T., 94, High Holborn, E.C.	
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Beardshaw, J., & Son, Ltd., Baltic Steel Works, Sheffield	**Beardshaw, Sheffield**
Beardshaw, J., & Son, Ltd., 38, Victoria Street, S.W.	**Vilvalle, London**
Beebee, A., Wednesbury	**Beebee, Fallings Heath, [Wednesbury**
Beeley, Thomas, & Son, Ltd., Hyde Junction Ironwks., Hyde, near Manchester	**Beeley, Hyde**
Beldam Packing & Rubber Co., 1 & 2, Gracechurch Street, E.C.	**Corrugated, London**

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Bell's United Asbestos Co., Ltd., 59½, Southwark Street, S.E.	**Belfry or Asbestos, London**
Bennis, Ed., & Co., Ltd., Little Hulton, Bolton	**Bennis, Little Hulton, Bolton**
Bergius Launch & Engine Co., Dobbies Loan, Glasgow	**Bergius, Glasgow**
Berry, F., & Sons, Sowerby Bridge, Yorkshire	**Berrys, Sowerby Bridge**
Berry, Henry, & Co., Ltd., Croydon Works, Derby	**Rivetter, Leeds**
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Birmingham Railway Carriage & Wagon Co., Ltd., Smethwick, Birmingham	**Carriage, Smethwick, Birmingham**
Blackstone & Co., Ltd., Rutland Works, Stamford	**Blackstones, Stamford**
Blair, Campbell & McLean, Ld., Woodville St., Govan, Glasgow	**Blazon, Glasgow**
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Bodley Bros., & Co., Old Quay Foundry, Exeter	**Bodley, Exeter**
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Bradley & Craven, Ltd., Westgate Common Foundry, Wakefield	**Craven, Wakefield**
Bradley Pulveriser Co., 37, Walbrook, E.C.	**Equestrian, London**
Braime, T. F., & Co., Ltd., Hunslet, Leeds	**Braime, Hunslet, Leeds**
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Brampton Bros., Ltd., Birmingham	**Brampton, Birmingham**
Brandon Bridge-Building Co., Ltd., Brandon Works, Motherwell	**Girder, Motherwell**
Brazil, Straker & Co., Ltd., Vulcan Ironworks, Bristol	**Hydraulic, Bristol**
Brecknell, Munro & Rogers, Ltd., Thrissell Street, Bristol	**Brecknell, Bristol**
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Brightside Foundry & Eng. Co., Ltd., Sheffield	**Castings, Sheffield**
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British Aluminium Co., Ltd., 109, Queen Victoria Street, E.C.	**Cryolite, London**
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British Steam Specialties, Ltd., Bedford Street, Leicester	**Boss, Leicester**
British Thomson-Houston Co., Ltd., Rugby	**Asteroidal, Rugby**
British Westinghouse Electric & Manufacturing Co., Ltd., 2, Norfolk Street, W.C.	**Multiphase, London**
British Westinghouse Electric & Manufacturing Co., Ltd., Trafford Park, Manchester	**Westinghouse, Manchester**
Broadbent, Thos., & Sons, Ltd., Chapel Hill, Huddersfield	**Broadbent, Huddersfield**
Brooke Tool Manufacturing Co., Ltd., Belgrave Road, Birmingham	**Saws, Birmingham**
Broom & Wade, Ltd., High Wycombe	**Broom, High Wycombe**
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Broughton Copper Co., Ltd., 6, Broad Street Place, E.C.	**Copper Co., London**
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Brown, Bayley's Steel Works Ltd., Sheffield	**Bayley, Sheffield**
Brown Bros., & Co., Ltd., Rosebank Ironworks, Edinburgh, N.B.	**Hydraulic, Edinburgh**
Brown Hoisting Machinery Co., Cleveland, Ohio, U.S.A.	**Brownhoist, Cleveland, [U.S.A.**
Brown, John, & Co., Ltd., Sheffield	**Atlas, Sheffield**
Brown, W. B., & Co. (Bankhall), Ltd., Globe Works, Bankhall, Liverpool	**Vires, Liverpool**
Brundrit, Joseph, 14, Water Street, Liverpool	**Segment, Liverpool**
Brunton & Trier, Caxton House, Westminster, S.W.	**Viscosity, Vic., London**
Brush Electrical Engineering Co., Ltd., Falcon Works, Loughborough	**Falcon, Loughborough**
Brush Electrical Engineering Co., Ltd., 1, Kingsway, W.C.	**Magneto, London**
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Buckton, Joshua, & Co., Ltd., Leeds	**Bucktons, Leeds**
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Buffalo Forge Company, Caxton House, Westminster, S.W.	
Buhring's Patent Water Purifying Co., 60, Wilson St., E.C.	**Aquapurco, London.**
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Bull's Metal & Melloid Co., Ltd., Yoker, nr. Glasgow	**Melloid, Yoker**
Burnet, Lindsay, & Co., Moor Park Boiler Works, Govan, Glasgow	**Burnet, Glasgow**
Burrell, Chas., & Sons, Ltd., St. Nicholas Works, Thetford, Norfolk	**Burrell, Thetford**

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Butler, Theodore, Ltd., 149, Queen Victoria Street, E.C.	**Scythes, London**
Butters Bros. & Co., 20, Waterloo Street, Glasgow	**Butters, Glasgow**
Butterworth Bros., Ld., Newton Heath Glass Works, Manchester	**Glasses, Newton Heath**
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Cambridge Scientific Instrument Co., Ltd., Cambridge	**Instrument, Cambridge**
Cameron, John, Ltd., Oldfield Road Iron Works, Salford	**Original, Manchester**
Cammell Laird & Co., Ltd., Cyclops Steel and Iron Works, Sheffield	**Cammell, Sheffield**
Cammell Laird & Co., Ltd., 3, Central Buildings, Westminster, S.W.	**Cammellaco, London**
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Carron Company, Carron, Stirlingshire, N.B.	**Carronade, Falkirk**
Carruthers, J. H., & Co., Ltd., Polmadie Ironworks, Glasgow	**Hoisting, Glasgow**
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Chambers, Scott & Co., Ltd., Motherwell	**Energy, Motherwell**
Chaplin, Alex., & Co., Ltd., Govan, Glasgow	**Chaplin, Glasgow**
Chatwin, Thos., Ltd., Great Tindal Street, Birmingham	**Chatwin, Birmingham**
Churchill, Chas., & Co., Ltd., 9 to 15, Leonard Street, Finsbury, E.C.	**Opodeldoc, London**
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Cleveland Bridge & Engineering Co., Ltd., Darlington	**Cleveland, Darlington**
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Cochran & Co., Annan, Ltd., Annan	**Multitube, Annan, N.B.**
Cockburns Ltd., Clydesdale Works, Cardonald, near Glasgow	**Cockburn, Glasgow**
Cole, Henry A., & Co., Ltd., Coronet Works, Liverpool	**Satisfactory, Liverpool**
Coles, H. J., Ltd., London Crane Works, Derby	**Coles, Derby**
Coltman, Walter W., & Co., Ltd., Central Boiler Works, Loughborough	**Boilers, Loughborough**
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Cottam, Edwin, & Co., Ltd., Don Steel Foundry, Rotherham	**Solidity, Rotherham**
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Cowans, Sheldon & Co., Ltd., Carlisle	**St. Nicholas, Carlisle**
Cox & Sons (Company) The, Bridgeton, N.J., U.S.A.	
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Cradock, Geo., & Co., Ltd., Wire Rope Works, Wakefield	**Cradock, Wakefield**
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Davis & Primrose, Ltd., Etna Iron Works, Bangor Road, Leith, Edinburgh	**Etna, Leith**
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Dowson & Mason Gas Plant Co., Ld., Levenshulme, M'chester	**Gasify, Levenshulme**
Drum Engineering Co., 33, Brook Street, Bradford	**Drum, Bradford**
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Gandy Belt Mfg. Co., Ltd., 97, Queen Victoria Street, E.C.	**Gandy, London**
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Kenyon, Wm., & Sons, Dukinfield, Manchester	**Kenyon, Dukinfield**
Kermath Mfg. Co., (Dept. E.), Detroit, Mich., U.S.A.	
Kermodes Ltd., 35, The Temple, Dale Street, Liverpool	**Warmth, Liverpool**
Kern & Co., Aarau, Switzerland	**Kern, Aarau**
Kern & Co., Peninsular House, 28, Monument Street, E.C.	**Kernamat, London**
Kerr, Stuart & Co., Ltd., 5, Broad Street Place, E.C.	**Meliss, London**
Kerr, Stuart & Co., Ltd., Stoke-on-Trent	**California, Stoke-on-Trent**
Keystone Lubricating Co., Wittles Croft, Ducie Street (City) Manchester	**Densities, Manchester**
King, H. J. H., & Co., Ltd., Nailsworth, Glos.	**King, Nailsworth**
Kirby Banks Screw Co., Ltd., Meadow Lane, Leeds	**Hexagon, Leeds**
Kirchner & Co., 21, 23 & 25, Tabernacle Street, E.C.	**Kirchner, London**
Kirk, Wheatley, Price & Co., 46, Watling Street, E.C.	**Indices, London**
Kirk, Wheatley, Price & Co., Albert Square, Manchester	**Indicator, Manchester**
Kirkstall Forge Co., Ltd., Leeds	**Forge, Kirkstall**
Klein Engineering Co. (1908), Ltd., 94, Market St., Manchester	**Modernize, Manchester**
Klinger, Richard, & Co., 66, Fenchurch Street, E.C.	**Sustained, London**
Koehring Machine Company, Milwaukee, Wisconsin	
Korting Bros., Ltd., 53, Victoria Street, Westminster, S.W.	**Korting, London**
Lacy-Hulbert & Co., Ltd., 91, Victoria Street, S,W.	**Percussive, London**
Lanarkshire Steel Co., Ltd., Motherwell	**Siemens, Motherwell**
Lancaster & Tonge, Ltd., Pendleton, near Manchester	**Pistons, Manchester**
Lang, John, & Sons, Lathe Makers, Johnstone, N.B.	**Lang, Johnstone**
Lash, Robert H., 31, Carburton Street, Portland Road Station, W.	**Outillage, London**
Lea Recorder Co., Ltd., 28, Deansgate, Manchester	**Recording, Manchester**
Leavitt Machine Co., Orange, Mass., U.S.A.	**Beforetime, Orange, Mass.**
Le Bas, Edward, & Co., Dock House, Billiter Street, E.C.	**Gramercy, London**
Le Grand & Sutcliff, 125, Bunhill Row, E.C.	**Abyssinian, London**
Ledward & Beckett, Ltd., Broadway Chambers, Westminster S.W.	**Preferment, London**
Leeds Forge Co., Ltd., Leeds	**Vulpes, Leeds**
Lees, T. & R., Hollinwood by Manchester	**Lees, Hollinwood**
Leroy, F., & Co., 20, Gray Street, Commercial Road, E.	**Efficiency, London**

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Lewis, E., & Sons, Wolverhampton	**Lewis, Wolverhampton**
Lewis & Tylor, Ltd., Cardiff	**Belting, Cardiff**
Lidgerwood Mfg. Co., Caxton House, Westminster, S.W.	**Lidgerwood, London**
Lima Locomotive Corporation, Lima, Ohio, U.S.A.	**Shayloco, New York**
Lindsay, R. B., & Co., 38, Mair Street, Plantation, Glasgow	**Conical, Glasgow**
Link-Belt Company, 299, Broadway, New York City	**Linkbelt, Chicago**
Lister, R. A., & Co., Ltd., Dursley, Glos.	**Machinery, Dursley**
Liverpool Refrigeration Co., Ltd., Colonial House, Liverpool	**Polar, Liverpool**
Lobnitz & Co., Ltd., Renfrew, Scotland	**Lobnitz, Renfrew**
Lockwood & Carlisle, Ltd., Eagle Foundry, Sheffield	**Piston, Sheffield**
Lockwood, Crosby, & Son, 7, Stationer's Hall Court, E.C.	**Crosby Lockwood, London**
Lodge Bros. & Co., Wrentham Street, Birmingham	**Igniter, Birmingham**
London & Lancashire Fire Insurance Co., Ltd., 155, Leadenhall Street, E.C.	**Policy, Led., London**
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Longmans, Green & Co., 39, Paternoster Row, E.C.	**Longmans, London**
London Brothers Ltd., 39, West Campbell Street, Glasgow	**Achilles, Glasgow**
Lowcock A., Ltd., Shrewsbury	**Triton, Shrewsbury**
Lubricators, Ltd., Leeds Place, Tollington Park, N.	**Agreascup, London**
Luke & Spencer, Ltd., Broadheath, near Manchester	**Emery, Altrincham**
Lumby, Son & Wood, Ltd., Greetland, near Halifax	**Lumby, Greetland**
Lunken Company, Ltd., 35, Great Dover Street, S.E.	**Lunken, London**
Lysaght, John, Ltd., St. Vincent Ironworks, Bristol	**Lysaght, Bristol**
Lysaght, John Ltd., Orb Works Newport, Mon.	**Lysaght, Newport, Mon.**
Mackies Ltd., Caversham Road, Reading	**Machinery, Reading**
MacLellan, P. & W., Ltd., Clutha Works, Glasgow	**MacLellan, Glasgow**
MacLellan, P. & W., Ltd., 108a, Cannon Street, E.C.	**MacLellan, London**
Macnab, John, Mary Street, Hyde	**Lathes, Hyde**
McGowan, Wild & Co., Hurst Street, Birmingham	**Logic, Birmingham**
McKechnie Brothers, Rotton Park Street, Birmingham	**McKechnie, Birmingham**
McKenzie, Holland, & Westinghouse Power Signal Co., Ltd., 58, Victoria Street, S.W.	**Powersig, Sowest, London**
McKenzie & Holland, Ltd., 58, Victoria Street, S.W.	**Macksig, London**
McKie & Baxter, Copland Works, Govan, Glasgow	**Calidad, Glasgow**
McLachlan & Co., Ltd., Darlington	**Railway, Darlington**
McNeil, C., Kinning Park Iron Works and Hydraulic Forge, Glasgow	**Macneil, Glasgow**
McOnie, A. & P. W., Cessnock Engine Works, Govan, Glasgow	**Melada, Glasgow**
McPhail & Simpson, Ltd., Wakefield	**Saving, Wakefield**
Magnolia Anti-Friction Metal Co. of Gt. Britain, Ltd., 49, Queen Victoria Street, E.C.	**Magnolier, London**
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Manlove, Alliott & Co., Ltd., 41 & 42, Parliament Street, S.W.	**Manloves, London**
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Mansfield Sand Co., Ltd., Mansfield, Notts.	
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Marshall, Sons & Co., Ltd., Gainsborough	**Marshall, Gainsborough**
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Mason Regulator Co., Boston, Mass., U.S.A.	**Masonica, Boston, U.S.A.**
Massey B. & S., Ltd., Openshaw, Manchester	**Masseys, Openshaw**
Mather & Platt, Ltd., Park Works, Manchester	**Mather or Sprinkler, Manchester**
Maudslay Motor Co., Ltd., Parkside, Coventry	**Maudslay, Coventry**
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Maxwell & Fage, 49, Sefton Street, Liverpool	**Galvanizer, Liverpool**
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Mellowes & Co., Sheffield	**Eclipse, Sheffield**
Merryweather & Sons, 63, Long Acre, W.C.	**Merywether, London**
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Metropolitan Carriage, Wagon & Finance Co., Ltd., Saltley, Birmingham	**Metro, Birmingham**
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Middleton, Robt., & Co., 22, Martins Lane, Cannon Street, E.C.	**Intensifier, London**
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Mirrlees Watson Co., Ltd., Scotland Street, Glasgow	**Mirrlees, Glasgow**
Mitchell's Emery Wheel Co., Mill Street, Bradford, Manchester	**Diameter, Manchester**
Monninger, C. D., Ltd., 124, Clerkenwell Road, E.C.	**Cedyem, Smith, London**
Monometer Manufacturing Co., Ltd., Whitehouse Street, Aston, Birmingham	**Monometer, Birmingham**
Moss Gear Co., Ltd., Aston Manor, Birmingham	**Mosgear, Birmingham**
Motherwell Bridge Co., Ltd., Motherwell, N.B.	**Bridge, Motherwell**
Motherwell Iron & Steel Co., Motherwell, N.B.	**Hoops, Motherwell**
Mountford, Fredk., Ld., Fremo Wks., Granville St., Birmingham	**Everything, Birmingham**
Muir, Wm., & Co., Ltd., Sherbourne Street, Manchester	**Britannia, Manchester**
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Muntz, P. H., & Co., Ltd., Alexandra Works, West Bromwich	**Muntz, Westbromwich**
Murray, Workman & Co., Ltd., Jura St., Cardonald, Glasgow	**Effectual, Glasgow**
Musgrave Bros., Crown Point Foundry, Leeds	**Tools, Leeds**
Musgrave & Co., Ltd., St. Ann's Ironworks, Belfast	**Musgrave Limited, Belfast**
Naish & Croft, 160, Alma Street, Birmingham	
Nasmyth, Wilson & Co., Ltd., Bridgewater Foundry, Patricroft, near Manchester	**Nasmyth, Patricroft**
National Alloys, Ltd., Ilford, E.	**Altior, Ilford**
National Boiler & General Insurance Co., Ltd., St. Mary's Parsonage Manchester	**National, Manchester**
National Gas Engine Co., Ld., Ashton-under-Lyne, Manchester	**National, Ashton-under-Lyne**
Negretti & Zambra, 38, Holborn Viaduct, E.C.	**Negretti, London**
New Calyx Drill & Boring Co., Ltd., 120, East Ferry Road, Millwall, E.	**Calyx, London**
Newalls Insulation Co., Ltd., Scottish Provident Buildings, Mosley Street, Newcastle-on-Tyne	**Newalls, Newcastle-on-Tyn**
Newbold, Walter, & Co., 107, Upper Thames Street, E.C.	**Newbold, London**
Newell, Ernest, & Co., Ltd., Misterton, Gainsboro'	**Newells, Misterton, Gainsb'r**
Newton, Chambers & Co., Ltd., Thorncliffe Ironworks, near Sheffield	**Newton, Sheffield**
Nicholson, W. T., & Clipper Co., Ltd., Clipper Works, King Street, Salford, Manchester	**Clipper, Manchester**
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Niles-Bement-Pond Co., 23 & 25, Victoria Street, S.W.	**Niliacus, London**
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North British Locomotive Co., Ltd., Administration Bld'g., 110, Flemington Street, Springburn, Glasgow	**Loco, Glasgow**
North-Eastern Marine Engineering Co., Ltd., Northumberland Works, Wallsend-on-Tyne	**News, Wallsend**
Northern Engineering Works, 6, Chene Street, Detroit, Mich., U.S.A.	**Newcrane, Detroit**
Noyes Bros. (Melbourne) Propy., Ltd., 499, Bourke Street, Melbourne	
Noyes Bros. (Sydney), Ltd., 115, Clarence Street, Sydney	
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Otis Elevator Co., Ltd., 4, Queen Victoria Street, E.C.	**Lyndentree, London**
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Parker Foundry Co., Ltd., Derby	**Parker, Derby**
Parkinson, J., & Son, Shipley, Yorkshire	**Temples, Shipley**
Parsons, C. A., & Co., Heaton Works, Newcastle-on-Tyne	**Turbo, Newcastle-on-Tyne**
Parsons, C. A., & Co., 8, Victoria Street, S.W.	**Silently, London**
Partridges, Limited, 131, Northwood Street, Birmingham	
Patent Lightning Crusher Co., Ltd., 14a, Rosebery Avenue Gray's Inn Road, E.C.	**Agenciador (10), London**
Patent Shaft & Axletree Co., Ltd., Wednesbury	**Shaft, Wednesbury**
Paterson Engineering Co., Ltd., 21, Amberley House, Norfolk Street, Strand, W.C.	**Cumulative, London**
Paul, Matthew, & Co., Ltd., Levenford Works, Dumbarton	**Paul, Dumbarton**
Pearn, F., & Co., Ltd., West Gorton, Manchester	**Pumps, Manchester**
Pease, C. F., Company, 166, W. Adams, Street, Chicago	**Peaseco, Chicago**
Peckett & Sons, Ltd., Atlas Locomotive Works, Bristol	**Peckett, Bristol**
Penman & Co., Ltd., 377, Dalmarnock Road, Glasgow	**Penman, Glasgow**
Petters Limited, Nautilus Works, Yeovil	**Petters, Yeovil**
Pfeil & Co., 145-9, St. John Street, Clerkenwell, E.C.	**Pfeil, London**
Phœnix Bolt & Nut Co., Handsworth, nr. Birmingham	**Bolts, Birmingham**
Phœnix Dynamo Mfg. Co., Ltd., Thornbury Works, Bradford	**Dynamo, Bradford**
Pickering, R. Y., & Co., Ltd., Wishaw, near Glasgow	**Pickering, Wishaw**
Pickering, R. Y., & Co., Ltd., 3, Victoria Street, S.W.	**Wagonload, London**
Pierson, J. & O. G., 47, Rue Lafayette, Paris	**Luns, Paris**
Piggott, Thos., & Co., Ltd., Birmingham	**Atlas, Birmingham**
Piggott, Thos., & Co., Ltd., 63, Queen Victoria Street, E.C.	**Intersection, London**
Pitman, Percy, 5, Willcott Road, Acton, W.	**Hydromotor, Act, London**
Platt, Samuel, Ltd., Wednesbury	**Platt, Wednesbury**
Player, W. & J., Birmingham	**Method, Birmingham**
Plenty & Son, Ltd., Newbury, Berkshire	**Plenty, Newbury**
Pollock, MacNab & Highgate, Shettleston, Glasgow	**Highgate, Shettleston**
Pontifex & Wood, Ltd., Union Foundry, Derby	**Zero, Derby**
Pontifex & Wood, Ltd., 175-177, Salisbury House, London Wall, E.C.	**Ponfex, London**
Positive Lock Washer Co., 2-8, James Watt Street, Glasgow	**Keystone, Glasgow**
Pott, Cassels & Williamson, Motherwell, near Glasgow	**Pott, Motherwell**
Potter, A. C., & Co., Lant Street, S.E.	**Pyrula, London**
Power Gas Corporation, Ltd., Stockton-on-Tees	**Tetratomic, Stockton-on-**
Power Plant Co., Ltd., West Drayton, Middlesex	**Roc, West Drayton [Tees**
Prat, Louis, 29, Rue de la Arcade, Paris	**Tiragpra, Paris**
Pratchitt Brothers, Denton Ironworks, Carlisle	**Pratchitts, Engineers Carlisle**
Pratt & Whitney Co., Hartford, Conn., U.S.A.	**Pratwhit, Hartford, U.S.A.**
Premier Cooler & Engineering Co., Ltd., Broadway Court, Broadway, Westminster, S.W.	**Precooler, Vic., London**
Premier Gas Engine Co., Ltd., Sandiacre, Nottingham	**Premier, Sandiacre**
Prices' Company, Ltd., Belmont Works, Battersea, S.W.	**Belmont, London**
Prices' Company, Ltd., Bromborough Pool, Liverpool	**Prices, Birkenhead**
Pridmore, Henry E. (Inc.), 19th and Rockwell Streets, Chicago, Illinois, U.S.A.	**Henryeprid, Chicago**
Priestman Bros., Ltd., Holderness Foundry, Hull	**Priestman, Hull**
Priestman Bros., Ltd., 3, Laurence Pountney Hill, E.C.	**Priestman, London**
Princeps & Co., Sheffield	**Princeps, Sheffield**
Proctor, Jas., Ltd., Burnley, Lancashire	**Proctor, Burnley**
Pryor, Edward, & Son, 68, West Street, Sheffield	**Pryor, Sheffield**
Pulsometer Engineering Co., Ltd., 11, Tothill Street, S.W.	**Pulsometer, London**
Pulsometer Engineering Co., Ltd., Nine Elms Ironworks, Reading, Berks.	**Pulsometer, Reading**
Pulsometer Engineering Co., Ltd., 15, King Street, Leeds	**Pulsometer, Leeds**
Pulsometer Engineering Co., Ltd., 2, Strand St., Liverpool	**Pulsometer, Liverpool**
Pulsometer Engineering Co., Ltd., 160, St. Vincent Street, Glasgow	**Pulsometer, Glasgow**
Pulsometer Engineering Co., Ltd., 206, Corn Exchange Buildings, Manchester	**Pulsometer, Manchester**
Pumps Limited, 14, Broad Street, Birmingham	**Salvage, Birmingham**

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Ransomes, Sims & Jefferies, Ltd., Orwell Works, Ipswich	**Ransomes, Ipswich**
Ransomes, Sims & Jefferies, Ltd., Palmerston House, 34, Old Broad Street, E.C.	**Anglia, London**
Rapid Magnetting Machine Co., Ltd., 18, The Crescent, Birmingham	**Borings, Birmingham**
Raworth, John E., 70-71, Queen Anne's Chambers, Tothill Street, Westminster, S.W.	
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Reddaway, F., & Co., Ltd., 50 & 51, Lime Street, E.C.	**Reddaway, London**
Reddaway, F., & Co., Ltd., Pendleton, Manchester	**Anchorage, Manchester**
Redman, C., & Sons, Dunkirk, Halifax	**Redmans, Engineers, Halifax**
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Reid Gear Co., Linwood, near Paisley	**Reid, Linwood**
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Richards, Geo., & Co., Ltd., Broadheath, near Manchester	**Richards, Altrincham**
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Robey & Co., Ltd., Lincoln	**Robey, Lincoln**
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Robson, John (Shipley), **Ltd.,** Shipley, Yorks	**Robsons, Shipley**
Rochester Engineering Co., Ltd., Wickham, Rochester	**Rec, Rochester**
Rodgers Bros., Baker Street, Brixton, S.W.	**Racemiform, London**
Rose, Downs & Thompson, Ltd., Old Foundry, Hull	**Rose, Hull**
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Ross, R. G., & Son, Ltd., Glasgow	**Glenros, Glasgow**
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Rowan, David, & Co., Glasgow	**Rowan, Glasgow**
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Russell, G., & Co., Ltd., Motherwell, N.B.	**Russell, Motherwell**
Russell, James, & Sons, Ltd., Crown Tube Works, Wednesbury	**Russell, Wednesbury**
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Ruston, Proctor & Co., Ltd., Sheaf Iron Works, Lincoln	**Ruston, Lincoln**
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Samuelson & Co., Ltd., Banbury, Oxon	**Samuelson, Banbury**
Sandycroft Limited, Chester	**Sandycroft, Hawarden**
Sankey, Joseph, & Sons, Ltd., Hadley, Salop	**Sankey, Hadley**
Saunders, J. T., & Co., 1, Victoria Street, Westminster, S.W.	**Wilburtier, London**
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Scammell, G., & Nephew, Ltd., Spitalfields, E.	**Scamwheel, London**
Schäffer & Budenburg, Ltd., Broadheath, near Manchester	**Manometer, Altrincham**
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Scott, Walter, Ltd., Leeds Steel Works, Leeds	**Bessemer, Leeds**
Scriven & Co., Marsh Lane, Leeds	**Scriven, Leeds**
Scriven & Co., 38, Victoria Street, Westminster, S.W.	**Vilvalle, London**
Seagers, Ltd., Dartford	**Seagers, Dartford**
Sellers, Wm., & Co. (Incorp.), Philadelphia, Penn., U.S.A.	**Sellers, Philadelphia, U.S.A.**
Selson Engineering Co., Ltd., 85, Queen Victoria Street, E.C.	**Selig, London**
Shanks, Thomas, & Co., Union Iron Works, Johnstone, near Glasgow	**Shanks, Johnstone**
Shaw, W., & Co., Wellington Cast Steel Foundry, Middlesbro'-on-Tees	**Wellington, Middlesbro'**
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Simpson, James, & Co., Ltd., 101, Grosvenor Rd., Pimlico, S.W.	**Aquosity, London**
Simpson, Strickland & Co., Ltd., Dartmouth, S. Devon	**Engineers, Dartmouth**
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Smith Brothers & Co. (Glasgow), **Ltd.,** Kinning Park, Glasgow	**Planer, Glasgow**
Smith & Coventry, Ltd., Gresley Ironworks, Ordsal Lane, Manchester	**Gresley, Manchester**
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Spencer, John, & Sons, Ld., Ouseburn Wks, Newcastle-on-Tyne	**Tyne, Newcastle-on-Tyne**
Spencer, John, & Sons, Ltd., 32, Victoria Street, S.W.	**Newburn, London**
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Standard Engineering Co., Ltd., Leicester	**Standard, Leicester**
Standard Piston Ring & Engineering Co., Premier Works, Don Road, Sheffield	**Ocean, Sheffield**
Stanley, W. F., & Co., Ltd., 286, High Holborn, W.C.	**Turnstile, London**
Stanley, W. F., & Co., Ltd., Railway Approach, London Bridge, S.E.	**Tribrach, London**
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Steel Company of Scotland (Limited), 23, Royal Exchange Square, Glasgow	**Steel, Glasgow**
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Stephenson, Robert, & Co., Ltd., Darlington	**Rocket, Darlington**
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Storey, Isaac, & Sons, Ltd., Empress Foundry, Cornbrook, Manchester	**Stork, Manchester**
Stothert & Pitt, Ltd., Bath	**Stothert, Bath**
Stothert & Pitt, Ltd., 38, Victoria St., S.W.	**Stothert, London**
Stott, S. S., & Co., Haslingden, near Manchester	**Elevator, Haslingden**
Strachan & Henshaw, Ltd., Bristol	**Strashaw, Bristol**
Sturtevant Engineering Co., Ltd., 147, Queen Victoria Street, E.C.	**Sturtevant, London**
Sugden, T., Ltd., 180, Fleet Street, E.C.	**Tubularity, London**
Sulzer Bros., 30, Norfolk Street, Strand, W.C.	**Gebsulzer, London**
Sunderland Forge & Eng. Co., Ltd., Pallion, Sunderland	**Marr, Sunderland**
Superheater Units, Ltd., 4, Castle Square, Swansea	**Superunits, Swansea**
Swift, George, & Sons, Range Bank, Halifax	**Swiftly, Halifax**
Swiss Oerlikon Machine Tool Co., Oerlikon, near Zurich, Switzerland	**Outil, Oerlikon**
Talbot, Clement, Ltd., Barlby Road, Ladbroke Grove, W.	**Clemtal, London**
Tangyes Limited, Birmingham	**Tangyes, Birmingham**
Tangyes Limited, 35, Queen Victoria Street, E.C.	**Tangyes, London**
Tattersall, A. A., & Co., Blackburn	**Vitundum, Blackburn**
Taylor & Challen, Ltd., Derwent Foundry, Birmingham	**Derwent, Birmingham**
Taylor, Charles (Birmingham), Ltd., Bartholomew Square, Birmingham	**Lathes, Birmingham**
Taylor & Hubbard, Leicester	**Lifting, Leicester**
Terry, Herbert, & Sons, Ltd., Redditch	**Springs, Redditch**
Terry & Tench Co. (The) Inc., Grand Central Terminal, New York City	**Tertench, New York**
Thomas & Bishop, 119-125, Finsbury Pavement, E.C.	**Velcling, London**
Thompson, John, Wolverhampton, Eng.	**Boiler, Wolverhampton**
Thompson & Southwick, Ltd., Tamworth, Staffs.	**Pulleys, Tamworth**
Thomson, W. R. M., & Co., 96, Buchanan Street, Glasgow	**Inventions, Glasgow**
Thorn & Hoddle Acetylene Co., Ltd., 151, Victoria Street, Westminster, S.W.	**Incanto, London**
Thornycroft, J. I., & Co., Ltd., Caxton House, Westminster, S.W.	**Thornycroft, Vic., London**
Thornycroft, J. I., & Co., Ltd., 5-11, Vauxhall Bridge Rd., S.W.	**Manageable, London**
Thornycroft, J. I., & Co., Ltd., Basingstoke, Hants.	**Thornycroft, Basingstoke**
Thornycroft, J. I., & Co., Ltd., Woolston, Southampton	**Thornycroft, Southampton**
Tilghman's Patent Sand Blast Co., Ltd., Broadheath, near Manchester	**Tilghmans, Altrincham**
Timbrell & Wright Machine Tool & Engineering Co., Ltd., Birmingham	**Revolving, Birmingham**
Tomey, Joseph, & Sons, Ltd., Manor Glass Works, Aston, Birmingham	**Tomey, Birmingham**
Toward, T., & Co., Ltd., 9, Ouseburn, Newcastle-on-Tyne	**Towards, Newcastle-on-Tyne**
Treasure, J. B., & Co., Ltd., 8, Vauxhall Road, Liverpool	**Treasure, Liverpool**
Trewent, F. J., & Proctor, Ltd., 43, Billiter Buildings, Billiter Street, E.C.	**Trewent, London**
Trier Bros., Ltd., Caxton House, Westminster, S.W.	**Viscosity, London**
Trist, Ronald, & Co., Ltd., 4, Lloyd's Avenue, E.C.	**Resvalar, London**
Tubes, Ltd., Birmingham	**Cylinders, Birmingham**
Tullis, D. & J., Ltd., Kilbowie Ironworks, near Glasgow	**Tullis, Clydebank**
Tullis, D. & J., Ltd., 1, Southwark Bridge Buildings, S.E.	**Kilbowie, London**
Tullis, John, & Son, Ltd., St. Ann's Leather Works, Glasgow	**Tullis, Glasgow**
Turnbull, Alex., & Co., Ltd., Bishopbriggs, Glasgow	**Valve, Glasgow**
Turner & Co., 1-3, Stalbridge Street, Lisson Grove, N.W.	
Turton, T., & Sons, Ltd., Sheaf Works, Sheffield	**Turtons, Sheffield**

NAME AND ADDRESS OF ADVERTISER.	TELEGRAPHIC ADDRESS.
Unbreakable Pulley & Mill Gearing Co., Ltd., 56, Cannon Street, E.C.	**Horsepower, Cannon, London**
Unbreakable Pulley and Mill Gearing Co., Ltd., 48, West Gorton, Manchester	**Strength, Manchester**
Underfeed Stoker Co., Ltd., Coventry House, South Place, E.C.	**Underfeed, London**
United States Metallic Packing Co., Ltd., Soho Works, Allerton Road, Bradford	**Metallic, Bradford**
United Water Softeners, Ltd., Imperial House, Kingsway, W.C.	**Aquadolce, London**
Urquhart, Lindsay & Co., Ltd., Blackness Foundry, Dundee	**Engineers, Dundee**
Utting, S., 4, St. Mary Axe, E.C.	**Utting, Leadenhall Chambers London**
Vacuum Brake Co., Ltd., 32, Queen Victoria Street, E.C.	**Solution, London**
Vaughan & Son, 57, Chancery Lane, W.C.	
Vaughan & Son, Ltd., West Gorton, Manchester	**Vaunting, Manchester**
Vaughtons, Ltd., Livery Street, Birmingham	**Emblems, Birmingham**
Vibrocel Company, Ltd., Eldon Street, E.C.	**Vibrocello, London**
Vickers, Benjn. R., & Sons, Ltd., Leeds	**Vickers, Leeds**
Vickers Limited, River Don Works, Sheffield	**Vickers, Sheffield**
Vickers Limited, Vickers House, Broadway, Westminster, S.W.	**Vickers, London**
Vosper & Co., Ltd., Broad Street, Portsmouth	**Repsov, Portsmouth**
Wadkin & Co., Leicester	**Woodworker Leicester**
Wailes, Dove & Co., Ltd., Newcastle-on-Tyne	**Bitumastic, Newcastle-on [Tyne**
Walber, W. A., & Co., 38, Victoria Street, Westminster, S.W.	**Vilvalle, London**
Walker Brothers (Wigan), Ltd., Pagefield Ironworks, Wigan	**Pagefield, Wigan**
Walker, James, & Co., Ltd., Lion Wks. Garford St., Poplar, E.	**Lioncelle, London**
Wallace Supply Co. (Mfrs.), 415, Orleans Street, Chicago, U.S.A.	**Walsup, Chicago**
Wallsend Slipway & Engineering Co., Ltd., Wallsend	**Wall, Newcastle-on-Tyne**
Wallwork, Henry & Co., Ltd., Manchester	**Foundry, Manchester**
Walton & Co., 66 & 68, Slaney Street, Birmingham	**Walco, Birmingham**
Ward, Haggas & Smith, Eastwood, Keighley	**Planers, Keighley**
Ward, H. W., & Co., Ltd., Lionel Street, Birmingham	**Tudor, Birmingham**
Ward, T. W., Ltd., Albion Works, Sheffield	**Forward, Sheffield**
Warden, A., & Co., 44, 46, 48, Shepherdess Walk, City Road, N.	**Lytestrong, London**
Watson, J. S., Gainsborough	**Watson, Gainsborough**
Watson, Laidlaw & Co., Ltd., 98, Dundas Street (South), Glasgow	**Fugal, Glasgow**
Waygood-Otis Ltd., Falmouth Road, S.E.	**Waygood, Sedist, London**
Webb & Son (Combs.), **Ltd.,** Combs Tannery, Stowmarket	**Webb, Combs**
Webster & Bennett, Ltd., Foleshill, Coventry	**Profile, Coventry**
Weir, G. & J., Ltd., Holm Foundry, Cathcart, Glasgow	**Giweir, Glasgow**
Weldless Steel Tube Co. Ltd., Icknield Port Road, Birmingham	**Weldless, Birmingham**
Wells, A. C., & Co., 102, Midland Road, St. Pancras, N.W.	**Unbreakable, London**
Wells, A. C., & Co., Carnarvon Street, Cheetham, Manchester	**Unbreakable, Manchester**
Wells, Henry, Oil Co., Salford W., near Manchester	**Lubricant, Manchester**
Werf Conrad, N.V., Haarlem, Holland	**Werfconrad, Haarlem**
West, George F., & Co., Caxton House, Westminster, S.W.	**Westeelite, London**
Western Wheeled Scraper Co., Aurora, Illinois, U.S.A.	**Western, Aurora, Illinois**
Westinghouse Brake Co., 82, York Road, King's Cross, N.	**Westinghouse, London**
Westinghouse Cooper Hewitt Company, Ltd., 80, York Road, King's Cross, N.	**Hewittic-Kincross, London**
Westminster Tool & Electric Company, Suffolk House Laurence Pountney Hill, E.C.	**Aphasitic, Cannon, London**
Westwood, Joseph, & Co., Ltd., Napier Yard, Millwall, E.	**Westwood, London**
Whitakers (Engineers), Ltd., Horsforth, Leeds	**Excavator, Leeds**
White, J. Samuel, & Co., Ltd. East Cowes, Isle of Wight	**White, East Cowes**
White, Rd., & Sons, Widnes, Lancs.	**Rails, Widnes [field**
Whitley & Valiant, Ltd., Ashton-in-Makerfield, Lancashire	**Whitley, Ashton-in-Maker-**
Whittaker & Co., White Hart Street, Paternoster Square, E.C.	
Widdowson, John H., Britannia Works, Ordsall Lane, Salford Manchester	**Taps, Salford**
Wiggins, F., & Sons, 102, 103 & 104, Minories, E.C.	**Wiggins, Minories, London**
Wigglesworth, Frank, & Co., Ltd., Clutch Works, Shipley, near Bradford	**Clutch, Shipley**
Wiley, James, & Sons, Ltd., Darlaston	**Wiley, Darlaston**
Wilkinson & Co., Spring Gardens Works, Dudley	**Nayler, Dudley**
Wilkinson, G., & Sons, Keighley	**Wilkinsons, Engineers, [Keighley**
Willans & Robinson, Ltd., Rugby, Warwickshire	**Willans, Rugby**
Willetts, Charles, Junr., Colonial Works, Cradley Heath, Staffs.	**Willetts Junr., Cradley Heath**
Willcox, W. H., & Co., Ltd., 32 to 38, Southwark Street, S.E.	**Willcox, Southwark St., Lndn.**
Wilson, John G., & Co., 55, Market Street, Manchester	**Ingenuity, Manchester**
Wilson, William, & Co., Lilybank Boiler Works, Glasgow	**Boiler, Glasgow**
Winn, Charles, & Co., Granville Place, Birmingham	**Winn, Birmingham**
Wise, Lloyd & Co., 10, New Court, Lincoln's Inn, W.C.	
Withers, J. S., & Spooner, Staple House, 51 and 52, Chancery Lane, W.C.	**Improvably, Holb., London**
Wolseley Motors, Ltd., York Street, S.W.	**Autovent, Vic., London**
Wolseley Motors, Ltd., Adderley Park, Birmingham	**Exactitude, Birmingham**
Wood, Henry, & Co., Ltd., Saltney, near Chester	
Woodite Works, Mitcham Common, Surrey	**Woodite, Mitcham**
Woodmansey & Co., Madeley Street, Hull	
Worthington Pump Co., Ltd., 153, Queen Victoria Street, E.C.	**Pumping, London**
Wright's Forge & Engineering Co., Ld., Tipton, Staffordshire	**Wright, Tipton**
Wright's Forge & Engineering Co., Ld., 57, Bishopsgate, E.C.	**Penetration, London**
Wright, John, & Co., Eureka Works, Birmingham	
Yarrow & Co., Ltd., Glasgow	**Yarrow, Glasgow**
Yates & Thom, Ltd., Canal Works, Blackburn	**Yates, Blackburn**
Yetton & Brockett, 32A, Liverpool Street, E.C.	**Gripookeng, Ave., London**
Yorkshire Copper Works, Ltd., Leeds	**Tubes, Leeds**
Youngs, Ryland Street Works, Birmingham	**Oldens, Birmingham**
Zynkara Co., Ltd., 34-36, Side, Newcastle-on-Tyne	**Zynkara, Newcastle-on-Tyne**

KEY TO TELEGRAPHIC ADDRESSES.

TELEGRAPHIC ADDRESS.	NAME AND ADDRESS OF ADVERTISER.
Abbott, Newark	**Abbott & Co. (Newark), Ltd.,** Newark-on-Trent
Abyssinian, London	**Le Grand & Sutcliff,** 125, Bunhill Row, E.C.
Achilles, Glasgow	**Loudon Brothers Ltd.,** 39, West Campbell Street, Glasgow
Adopted, London	**Grover & Co., Ltd.,** Wharf Road, City Road, N.
Afco, Glasgow	**Anderston Foundry Co., Ltd.,** Glasgow
Agenciador (10), London	**Patent Lightning Crusher Co., Ltd.,** 14a, Rosebery Avenue, Gray's Inn Road, E.C.
Agreascup, London	**Lubricators, Ltd.,** Leeds Place, Tollington Park, N.
Albert, Chelmsford	**Glover & Hobson, Ltd.,** Albert Ironworks, Chelmsford
Alldays, Birmingham	**Alldays & Onions (Pneumatic Engineering) Co., Ltd.,** Birmingham
Allen, Sheffield	**Allen, Edgar, & Co., Ltd.,** Imperial Steel Works, Sheffield
Alley, Glasgow	**Alley & Maclellan, Ltd.,** Sentinel Works, Glasgow
Alma, Walsall	**Russell, John, & Co., Ltd.,** Alma Tube Works, Walsall
Aloyau, Cannon, London	**Atlas Metal & Alloys Co., Ltd.,** 52, Queen Victoria Street,
Altior, Ilford	**National Alloys, Ltd.,** Ilford, E. [E.C.
Aluminium, Coventry	**Reliance (Coventry), Ltd.,** Coventry
Amarilla, Derby	**Fletcher, George, & Co., Ltd.,** Flitwick, Derby
Anchorage, Manchester	**Reddaway, F., & Co., Ltd.,** Pendleton, Manchester
Anderson, Belfast	**Anderson, D., & Son, Ltd.,** Lagan Felt Works, Belfast
Anglia, London	**Ransomes, Sims & Jefferies, Ltd.,** Palmerston House, 34, Old Broad Street, E.C.
Angus, Newcastle	**Angus, George, & Co., Ltd.,** Newcastle-on-Tyne
Aphasitic, Cannon, London	**Westminster Tool & Electric Company,** Suffolk House, Laurence Pountney Hill, E.C.
Aquadolce, London	**United Water Softeners, Ltd.,** Imperial House, Kingsway, W.C.
Aquapurco, Fin., London	**Buhring's Patent Water Purifying Co.,** 60, Wilson St., E.C.
Aquilentus, Kirkcaldy	**Steel Pipe Company, Ltd.,** Kirkcaldy, N.B.
Aquosity, London	**Simpson, James, & Co., Ltd.,** 101, Grosvenor Road, Pimlico, S.W.
Archdale, Birmingham	**Archdale, Jas., & Co., Ltd.,** Ledsam Street, Birmingham
Armstrongs, Birmingham	**Armstrong, Stevens & Son, Ltd.,** Whittall Street, Birmingham
Asmulders, Schiedam	**Smulders, A. F.,** Schiedam, Rotterdam, Holland
Asteroidal, Rugby	**British Thomson-Houston Co., Ltd.,** Rugby
Atlas, Birmingham	**Piggott, Thos., & Co., Ltd.,** Birmingham
Atlas, Gloucester	**Fielding & Platt, Ltd.,** Gloucester
Atlas, Sheffield	**Brown, John, & Co., Ltd.** Sheffield
August, Halifax	**August's Muffle Furnaces, Ltd.,** Thorn Tree Works, King Cross, Halifax
Autobuff, Vic., London	**A.B.C. Coupler, Ltd.,** Queen Anne's Chambers, S.W.
Autovent, Vic., London	**Wolseleys Motors, Ltd.,** York Street, S.W.
Aveling, Rochester	**Aveling & Porter, Ltd.,** Rochester
Avery, Birmingham	**Avery, W. & T., Ltd.,** Soho Foundry, Birmingham
Babcock, London	**Babcock & Wilcox, Ltd.,** Oriel House, Farringdon Street, E.C.
Bagnall, Stafford	**Bagnall, W. G., Ltd.,** Castle Engine Works, Stafford
Bagshawe, Dunstable	**Bagshawe & Co., Ltd.,** Dunstable Works, Dunstable
Baldwin, Engineers, Keighley	**Baldwin, James, & Co.,** Devonshire Brass Works, Keighley
Baldwin, Philadelphia	**Baldwin Locomotive Works, The,** 500, North Broad Street, Philadelphia, Pa., U.S.A.
Barclayson, Kilmarnock	**Barclay, Andrew, Sons & Co., Ltd.,** Caledonian Works, Kil-
Barry, Aberdeen	**Barry, Henry & Co., Ltd.,** Aberdeen [marnock
Bates, Denton-Lancs	**Bates, W. J., & Co., Ltd.,** Denton, Manchester
Battery, Selly Oak	**Birmingham Battery & Metal Co., Ltd.,** Birmingham
Bayley, Sheffield	**Brown, Bayley's Steel Works, Ltd.,** Sheffield
Bayliss, Wolverhampton	**Bayliss, Jones & Bayliss, Ltd.,** Wolverhampton
Beacon, Salford	**Bailey, W. H., & Co., Ltd.,** Albion Works, Salford, Manchester
Beardmore, Glasgow	**Beardmore, William, & Co., Ltd.,** Parkhead Forge, Rolling Mills and Steel Works, Glasgow
Beardshaw, Sheffield	**Beardshaw, J., & Son, Ltd.,** Baltic Steel Works, Sheffield
Beaucoup, Kensal, London	**Glacier Anti-Friction Metal Co., Ltd.,** Waldo Road, Willesden Junction, N.W.
Beebee, Fallings Heath, Wednesbury	**Beebee, A.,** Wednesbury
Beeley, Hyde	**Beeley, Thomas, & Son, Ltd.,** Hyde Junction Ironworks, Hyde, near Manchester
Beforetime, Orange, Mass.	**Leavitt Machine Co.,** Orange, Mass., U.S.A.
Belfry or Asbestos, London	**Bell's United Asbestos Co., Ltd.** 59½, Southwark Street, S.E.
Bellamy, London	**Bellamy, John, Ltd.,** Millwall, E.
Belliss, Birmingham	**Belliss & Morcom Ltd.,** Ledsam Street Works, Birmingham
Belmont, London	**Prices' Company, Ltd.,** Battersea, S.W.
Belting, Cardiff	**Lewis & Tylor, Ltd.,** Cardiff
Bennis, Little Hulton, Bolton	**Bennis, Ed., & Co.,** Little Hulton, Bolton
Bergius, Glasgow	**Bergius Launch & Engine Co.,** Dobbies Loan, Glasgow
Berrys, Sowerby Bridge	**Berry, F., & Sons,** Sowerby Bridge, Yorkshire
Bessemer, Leeds	**Scott, Walter, Ltd.,** Leeds Steel Works, Leeds
Bessemer, Sheffield	**Bessemer, Hy., & Co., Ltd.,** Sheffield
Bird, London	**Bolling & Lowe,** 2, Laurence Pountney Hill, E.C.
Bitumastic, Newcastle-on-Tyne	**Wailes, Dove & Co., Ltd.,** Newcastle-on-Tyne
Blackstones, Stamford	**Blackstone & Co., Ltd.,** Rutland Works, Stamford
Blakeboroughs, Brighouse	**Blakeborough, J., & Sons,** Brighouse
Blazon, Glasgow	**Blair, Campbell & McLean, Ld.,** Woodville St., Govan, Glasgow
Blooms, Sheffield	**Dunford & Elliott** (Sheffield), **Ltd.,** Attercliffe Wharf, Sheffield

TELEGRAPHIC ADDRESS.	NAME AND ADDRESS OF ADVERTISER.
Bodley, Exeter	**Bodley Bros. & Co.,** Old Quay Foundry, Exeter
Boiler, Cradley Heath	**Cradley Boiler Co.,** Cradley Heath, near Birmingham
Boiler, Glasgow	**Wilson, William, & Co.,** Lilybank Boiler Works, Glasgow
Boilers, Wolverhampton	**Thompson, John,** Wolverhampton, Eng.
Boilers, Loughborough	**Coltman, Walter W., & Co., Ltd.,** Central Boiler Works, Loughborough
Bolts, Birmingham	**Phœnix Bolt & Nut Co.,** Handsworth, nr. Birmingham
Bolts, Manchester	**Marsden, S., & Son, Ltd.,** London Road, Manchester
Bonaccord, Glasgow	**Drysdale & Co., Ltd.,** Bon Accord Works, Yoker, Glasgow, W.
Borings, Birmingham	**Rapid Magnetting Machine Co., Ltd.,** 18, The Crescent, Birmingham
Boss, Leicester	**British Steam Specialties, Ltd.,** Bedford Street, Leicester
Boulton, Norwich	**Boulton & Paul, Ltd.,** Norwich
Braime, Hunslet, Leeds	**Braime, T. F., & Co., Ltd.,** Hunslet, Leeds
Brake, Manchester	**Gresham & Craven, Ltd.,** Salford, Manchester
Brampton, Birmingham	**Brampton Bros., Ltd.,** Birmingham
Brecknell, Bristol	**Brecknell, Munro & Rogers, Ltd.,** Thrissell Street, Bristol
Bridge, Motherwell	**Motherwell Bridge Co., Ltd.,** Motherwell, N.B.
Brins Oxygen, London	**British Oxygen Co., Ltd.,** Elverton Street, Westminster, S.W.
Britannia, Manchester	**Muir, Wm., & Co., Ltd.,** Sherbourne Street, Manchester
Broadbent, Huddersfield	**Broadbent, Thos., & Sons, Ltd.,** Chapel Hill, Huddersfield
Bronze, Longport	**Billington & Newton, Ltd.,** Longport, Stoke-on-Trent
Broom, High Wycombe	**Broom & Wade, Ltd.,** High Wycombe
Brotherhood, Parl., London	**Brotherhood, Peter, Ltd.,** 53, Parliament Street, S.W.
Brownhoist, Cleveland, U.S.A.	**Brown Hoisting Machinery Co.,** Cleveland, Ohio, U.S.A.
Bucktons, Leeds	**Buckton, Joshua, & Co., Ltd.,** Leeds
Budgett, Chelmsford	**Crown Works,** London New Road, Chelmsford
Bullivants, London	**Bullivant & Co., Ltd.,** 72, Mark Lane, E.C.
Burnet, Glasgow	**Burnet, Lindsay, & Co.,** Moor Park Boiler Works, Govan, Glasgow
Burrell, Thetford	**Burrell, Chas., & Sons, Ltd.,** St. Nicholas Wks., Thetford, Norfolk
Butler, Halifax, England	**Butler, J., & Co.,** Victoria Ironworks, Halifax
Butters, Glasgow	**Butters Bros. & Co.,** 20, Waterloo Street, Glasgow
Cables, Manchester	**Glover, W. T., & Co., Ltd.,** Trafford Park, Manchester
Calidad, Glasgow	**McKie & Baxter,** Copland Works, Govan, Glasgow
California, Stoke-on-Trent	**Kerr, Stuart & Co., Ltd.,** Stoke-on-Trent
Calyx, London	**New Calyx Drill & Boring Co., Ltd.,** 120, East Ferry Road, Millwall, E.
Camgas, Halifax	**Campbell Gas Engine Co., Ltd.,** Halifax, England
Cammell, Sheffield	**Cammell Laird & Co., Ltd.,** Cyclops Steel and Iron Works, Sheffield
Cammellaco, London	**Cammell Laird & Co., Ltd.,** 3, Central Buildings, Westminster, S.W.
Carriage, Smethwick, Birmingham	**Birmingham Railway Carriage & Wagon Co., Ltd.,** Smethwick, Birmingham
Carronade, Falkirk	**Carron Company,** Carron, Stirlingshire, N.B.
Castings, Sheffield	**Brightside Foundry & Eng. Co., Ltd.,** Sheffield
Caulking, Parl., London	**Consolidated Pneumatic Tool Co., Ltd.,** Palace Chambers 9, Bridge Street, Westminster, S.W.
Cedyem, Smith, London	**Monninger, C. D., Ltd.,** 124, Clerkenwell Road, E.C.
Chadburn, Liverpool	**Chadburn's (Ship) Telegraph Co., Ltd.,** Cyprus Road, Bootle, Lancs.
Chains, Coventry	**Coventry Chain Co., Ltd.,** Coventry
Chaplin, Glasgow	**Chaplin, Alex., & Co., Ltd.,** Govan, Glasgow
Chatwin, Birmingham	**Chatwin, Thos., Ltd.,** Great Tindal Street, Birmingham
Cheaper, Char., London	**Harvey, G. A., & Co. (London), Ltd.,** Greenwich Metal Works, Woolwich Road, S.E.
Chucks, Leicester	**Jones, A. A., & Shipman, Ltd.,** East Park Rd., Leicester
Clemtal, London	**Talbot, Clement, Ltd.,** Barlby Road, Ladbroke Grove, W.
Cleveland, Darlington	**Cleveland Bridge & Engineering Co., Ltd.,** Darlington
Clifdell, Johnstone	**Clifton & Waddell,** Johnstone, near Glasgow
Clipper, Manchester	**Nicholson, W. T., & Clipper Co., Ltd.,** Clipper Works, King Street, Salford, Manchester
Clutch, Shipley	**Wigglesworth, Frank, & Co., Ltd.,** Clutch Works, Shipley, near Bradford
Cockburn, Glasgow	**Cockburns Ltd.,** Clydesdale Works, Cardonald, near Glasgow
Coles, Derby	**Coles, H. J.,** Ltd., London Crane Works, Derby
Colville, London	**Colville, David, & Sons, Ltd.,** 54, Old Broad Street, E.C.
Colville, Motherwell	**Colville, David, & Sons, Ltd.,** Dalzell Steel and Iron Works, Motherwell, near Glasgow
Company, Ebbw Vale	**Ebbw Vale Steel Iron & Coal Co., Ltd.,** Ebbw Vale, Mon.
Compass, Glasgow	**Dobbie, McInnes, Ltd.,** 57, Bothwell Street, Glasgow
Compromet, Westrand, London	**Cumberland Engineering Co.,** Lloyd's House, Lloyd's Av., E.C.
Conical, Glasgow	**Lindsay, R. B., & Co.,** 38, Mair Street, Plantation, Glasgow
Conveyor, Accrington	**Conveyor & Elevator Co.,** Accrington, Lancashire
Control, Glasgow	**Electric Control, Ltd.,** Bridgeton, Glasgow
Cooke, Sheffield	**Cooke, William, & Co., Ltd.,** Tinsley Steel, Iron and Wire Rope Works, Sheffield
Copper Co., London	**Broughton Copper Co., Ltd.,** 122, Cannon Street, E.C.
Copper Co., Manchester	**Broughton Copper Co., Ltd.,** Manchester
Corrugated, Glasgow	**Clyde Structural Iron Co., Ld.,** Clydeside Ironworks, Scotstoun, Glasgow
Corrugated, London	**Beldam Packing & Rubber Co.,** 1 & 2, Gracechurch St., E.C.

TELEGRAPHIC ADDRESS.	NAME AND ADDRESS OF ADVERTISER.
Cotlite, Robertsbridge	**Cottage Lighting Co.,** Robertsbridge, England
Courteous, Eusroad, London	**Braby, Fredk., & Co., Ld.,** Fitzroy Works, 352 to 362, Euston Rd.,
Crabtree, Yarmouth	**Crabtree & Co., Ltd.,** Great Yarmouth [N.W.
Cradock, Wakefield	**Cradock, Geo., & Co., Ltd.,** Wire Rope Works, Wakefield
Craig-Donald, Johnstone	**Craig & Donald, Ltd.,** Johnstone, Renfrewshire, N.B.
Craig, Paisley	**Craig, A. F., & Co., Ltd.,** Paisley
Cranes, Leicester	**Godfrey Mfg. Co., Ltd.,** Old Crane Works, St. John Street, Leicester
Cranes, Motherwell	**Jack, Alexander, & Co.,** Whitegates Engineering Works, Motherwell, Scotland
Cranes, Rodley	**Booth, Joseph, & Bros., Ltd.,** Rodley, Leeds
Craven, Wakefield	**Craven & Craven,** Whetley Grove, Manningham, Bradford
Crosby Lockwood, London	**Lockwood, Crosby, & Son,** 7, Stationer's Hall Court, E.C.
Crosby, London	**Crosby Valve & Engineering Co., Ltd.,** 147, Queen Victoria Street, E.C.
Crown, Glasgow	**Sterne, L., & Co., Ltd.,** Crown Ironworks, Glasgow
Crown, Gortonbrook	**Higginbottom & Mannock, Ltd.,** Crown Ironworks, West Gorton, Manchester
Cryolite, London	**British Aluminium Co., Ltd.,** 109, Queen Victoria Street, E.C.
Cumulative, London	**Paterson Engineering Co., Ltd.,** 21, Amberley House, Norfolk Street, Strand, W.C.
Cyclops, Gateshead	**Clarke, Chapman & Co., Ltd.,** Gateshead-upon-Tyne
Cylinders, Birmingham	**Tubes, Ltd.,** Birmingham
Cymplecks, London	**Stewart, J. & W.,** Caxton House, Westminster, S.W.
Dampney, Cardiff	**Dampney, J., & Co., Ltd.,** Bute Docks, Cardiff
Daniell, Birmingham	**Daniell, S. A., Ltd.,** Edward Street, Parade, Birmingham
Daniels, Stroud	**Daniels, T. H. & J., Ltd.,** Stroud, Glos
Darling Sellers, Keighley	**Darling & Sellers, Ltd.,** Keighley
Davison, Wapping, Liverpool	**Davison, H., & Sons, Ltd.,** Magull Street, Liverpool
Day Summers, Southampton	**Day, Summers & Co., Ltd.,** Northam Ironworks, Southampton
Dellburn, Motherwell	**Marshall, Fleming & Co.,** Motherwell, N.B.
Delta, Eastgren., London	**Delta Metal Co., Ltd.,** East Greenwich, S.E.
Dempster, Elland	**Dempster, Robert, & Sons, Ltd.,** Elland, Yorkshire
Dempster, Glasgow	**Dempster, Moore & Co., Ltd.,** 49, Robertson Street, Glasgow
Densities, Manchester	**Keystone Lubricating Co.,** Wittles Croft, Ducie Street (City), Manchester
Derwent, Birmingham	**Taylor & Challen, Ltd.,** Derwent Foundry, Birmingham
Dhagoba, Westrand, London	**Constable & Co.,** 10, Orange Street, Leicester Square, W.C.
Diagram, Liverpool	**Hughes & Lancaster,** Liverpool
Diameter, Manchester	**Mitchell's Emery Wheel Co.,** Mill Street, Bradford, Manchester
Dicker, London	**Dick, Kerr & Co., Ltd.,** Abchurch Yard, Cannon Street, E.C.
Distend, Vic., London	**Expanded Metal Co., Ltd.,** York Mansion, York Street, S.W.
Dockyard, Dublin	**Dublin Dockyard Co., Ltd.,** North Wall, Dublin
Dodman, King's Lynn	**Dodman, Alfred, & Co. Ltd.,** Highgate Works, King's Lynn
Dogal, Bochurch, London	**Sirius Autogenous Work Co.,** 85-87, High Street, Stratford, E.
Donald, Paisley	**Hanna, Donald & Wilson,** Abercorn Foundry, Paisley
Donkin, Chesterfield	**Donkin Company, Ltd. (The Bryan),** Chesterfield
Douglas, Kirkcaldy	**Douglas & Grant, Ltd.,** Dunnikier Foundry, Kirkcaldy, N.B.
Doulton, London	**Doulton & Co., Ltd.,** Lambeth, S.E.
Dredger, Port Glasgow	**Ferguson Brothers** (Port-Glasgow), **Ltd.,** Newark Works, Port [Glasgow
Drill, Halifax	**Asquith, William, Ltd.,** Park Works, Halifax
Driving, Manchester	**Renold, Hans, Ltd.,** Progress Works, Manchester
Drum, Bradford	**Drum Engineering Co.,** 33, Brook Street, Bradford
Dynamo, Bradford	**Phœnix Dynamo Mfg. Co., Ltd.,** Thornbury Works, Bradford
Dynamo, Oldham	**Hall, J. P., & Co., Ltd.,** Oldham
Eclipse, Sheffield	**Mellowes & Co., Ltd.,** Sheffield
Economy, Hazel Grove	**Mirrlees, Bickerton & Day, Ltd.,** Hazel Grove, nr. Stockport
Edibrac, London	**Imperial Light Limited,** 123, Victoria Street, S.W.
Edmeston, Patricroft	**Edmeston, A., & Sons, Ltd.,** Patricroft, nr. Manchester
Effectual, Glasgow	**Murray, Workman & Co., Ltd.,** Jura St., Cardonald, Glasgow
Efficiency, London	**Leroy, F., & Co.,** 20, Gray Street, Commercial Road, E.
Elevator, Haslingden	**Stott, S. S., & Co.,** Haslingden, near Manchester
Elliot Company, Cardiff	**Elliot, George, & Co., Ltd.,** Cardiff
Elliot Company, London	**Elliot, George, & Co., Ltd.,** 16, Gt. George St., Westminster, S.W.
Ellisons Ltd., Irlams-o'-th'-Height	**Ellison, W. T., & Co., Ltd.,** Irlams-o'-th'-Height, Manchester
Elsterne, London	**Sterne, L., & Co., Ltd.,** Donington House, Norfolk Street, W.C.
Elyor, Cadishead	**Royles Limited,** Irlam, near Manchester
Emblems, Birmingham	**Vaughtons, Ltd.,** Livery Street, Birmingham
Emery, Altrincham	**Luke & Spencer, Ltd.,** Broadheath, near Manchester
Emery, Berm., London	**Davies, W. J., & Sons, Ltd.,** 109, Weston Street, S.E.
Endazzle, London	**Acetylene Illuminating Co., Ltd.,** 268 and 270, South Lambeth Road, S.W.
Endeavour, London	**Birch, John, & Co., Ltd.,** 2, London Wall Buildings, E.C.
Energy, Hull	**Maxted & Knott, Ltd.,** Burnett Avenue, Hull
Energy, Motherwell	**Chambers, Scott & Co., Ltd.,** Motherwell
Engine, Leeds	**Hunslet Engine Co., Ltd.,** Leeds
Engine, Smith, London	**Marshall, Sons & Co., Ltd.,** 79, Farringdon Road, E.C.
Engineering, Westrand, London	**"Engineering," Ltd.,** 35 and 36, Bedford Street, Strand, W.C.
Engineers, Dartmouth	**Simpson, Strickland & Co., Ltd.,** Dartmouth
Engineers, Dundee	**Urquhart, Lindsay & Co., Ltd.,** Blackness Foundry, Dundee
Ensulim, London	**Schmidt's Superheating Co.** (1910), **Ld.,** 28, Victoria St., S.E.
E.O.A., Birmingham	**Electric & Ordnance Accessories Co., Ltd.,** Aston, Birmingham
Epa, London	**Alexander, E. P., & Son,** 306, High Holborn, W.C.
Equestrian, London	**Bradley Pulverizer Co.,** 37, Walbrook, E.C.
Etna, Leith	**Davis & Primrose, Ltd.,** Bangor Road, Leith, Edinburgh
Evans, Wolverhampton	**Evans, Joseph, & Sons (Wolverhampton, Ltd.),** Wolverhampton
Evaporate, Pollokshaws	**Dalglish, A. & W.,** West of Scotland Boiler Works, Pollokshaws Glasgow
Everything, Birmingham	**Mountford, Fredk., Ltd.,** Fremo Wks., Granville St., Birmingham
Exactitude, Birmingham	**Wolseley Motors, Ltd.,** Adderley Park, Birmingham

TELEGRAPHIC ADDRESS.	NAME AND ADDRESS OF ADVERTISER.
Excavator, Leeds	**Whitakers (Engineers), Ltd.,** Horsforth, Leeds
Exhaust, Leeds	**Bakers (Leeds) Ltd.,** Union Works, Hunslet, Leeds
Exhaust, Romiley	**Davies & Metcalfe, Ltd.,** Romiley, Manchester
Expansion, Glasgow	**Glasgow Railway Engineering Co., Ltd.,** Govan, Glasgow
Explanatus, London	**Griffin, Charles, & Co., Ltd.,** Exeter Street, Strand, W.C.
Extrusion, Birmingham	**Delta Metal Co., Ltd.,** Dartmouth Street, Birmingham
Fairley, Birmingham	**Fairley, James, & Sons,** Old Mint, Shadwell Street, Birmingham
Falcon, Loughborough	**Brush Electrical Engineering Co., Ltd.,** Falcon Works,
Fawcett, Liverpool	**Fawcett, Preston, & Co., Ltd.,** Liverpool [Loughborough
Ferranti, Westcent, London	**Ferranti, Ltd.,** Central House, Kingsway, W.C.
Fife Forge, Kirkcaldy	**Fife Forge Co.,** Kirkcaldy, Scotland
Figee-Haarlem	**Figee,** Haarlem, Holland
Findings, London	**Atkinson, Robert** (London), **Ltd.,** 19, Ludgate Hill, E.C.
Findlay, Motherwell	**Findlay, Alex., & Co., Ltd.,** Motherwell, near Glasgow
Firmo, Glasgow	**Firth, Thos., & Sons, Ltd.,** 144, St. Vincent Street, Glasgow
Firosis, London	**Reddaway, F., & Co., Ltd.,** 212, Shaftesbury Avenue, W.C.
Firth, Sheffield	**Firth, Thos., & Sons, Ltd.,** Norfolk Works, Sheffield
Flamma, London	**Acetylene Corporation, Ltd.,** 49, Victoria Street, S.W.
Flueblower, London	**Diamond Blower Co., Ltd.,** 75B, Queen Victoria Street, E.C.
Forge, Darlington	**Darlington Forge Co., Ltd.,** Darlington
Forge, Dumbarton	**Dennystown Forge Co.,** Dumbarton
Forge, Kirkstall	**Kirkstall Forge Co., Ltd.,** Leeds
Forward, Sheffield	**Ward, T. W., Ltd.,** Albion Works, Sheffield
Foster Instrument, Letchworth	**Foster Instrument Co.,** Letchworth, Herts
Fosters, Wednesbury	**Foster Brothers, Ltd.,** Wednesbury
Foundry, Bolton	**Entwisle & Gass, Ltd.,** Bolton
Foundry, Manchester	**Wallwork, Henry, & Co., Ltd.,** Manchester
Fowler, Leeds	**Fowler, John & Co. (Leeds), Ltd.,** Steam Plough Wks., Leeds
France, Glasgow	**France & Morgan,** Whitefield Brass Works, Govan, Glasgow
Fraser, Arbroath	**Fraser, Douglas, & Sons, Ltd.,** Arbroath, Scotland
Fresco, Glasgow	**Gas Power & By-Products Co., Ltd.,** 116, Hope Street, Glasgow
Fribald, London	**Baldwin Locomotive Works, The,** 34, Victoria Street, S.W.
Friction, Chapel-en-le-Frith	**Herbert Frood Company, Ltd.,** Sovereign Mills, Chapel-en-le-Frith
Fugal, Glasgow	**Watson, Laidlaw & Co., Ltd.,** 98, Dundas St. (South), Glasgow
Fuller Horsey, London	**Fuller, Horsey, Sons & Cassell,** 11, Billiter Square, E.C.
Gabriel, Birmingham	**Gabriel & Co.,** A.B. Row, Birmingham
Galloway, Manchester	**Galloways Limited,** Manchester
Galvanizer, Liverpool	**Maxwell & Fage,** 49, Sefton Street, Liverpool
Gandah, Glasgow	**Harvey, G. & A., Ltd.,** Govan, Glasgow, W.
Gandy, Birkenhead	**Gandy Belt Mfg. Co., Ltd.,** Wheatland Works, Seacombe, Cheshire
Gandy, London	**Gandy Belt Mfg. Co., Ltd.,** 97, Queen Victoria Street, E.C.
Garrett, Leiston	**Garrett, R., & Sons, Ltd.,** Leiston Works, Suffolk
Gas, Leeds	**Clayton, Son, & Co., Ltd.,** Leeds City Boiler Works, Leeds
Gaseous, London	**Dowson & Mason Gas Plant Co., Ltd.,** 39, Victoria St., S.W.
Gasholder, Stockton-on-Tees	**Ashmore, Benson, Pease & Co., Ltd.,** Stockton-on-Tees
Gasify, Levenshulme	**Dowson & Mason Gas Plant Co., Ltd.,** Levenshulme, Manchester
Gebsulzer, London	**Sulzer Bros.,** 30, Norfolk Street, Strand, W.C.
Genuine, London	**Fair, Walter D., & Co.,** 14, Leicester Street, W.C.
Ghion, London	**Ghion, J.,** Finsbury Pavement House, E.C.
Gibbins, Birmingham	**Gibbins, R. C., & Co.,** Berkley Street, Birmingham
Giftedness, London	**Imperial Motor Industries, Ltd.,** 11, Denmark Street, Charing Cross Road, W.C.
Gilman, Lightwoods, Birmingham	**Gilman, Frank,** 62, Lightwoods Hill, Birmingham
Girder, Motherwell	**Brandon Bridge-Building Co., Ltd.,** Brandon Works, Motherwell
Giweir, Glasgow	**Weir, G. & J., Ltd.,** Holm Foundry, Cathcart, Glasgow
Glasses, Newton Heath	**Butterworth Bros., Ltd.,** Newton Heath GlassWorks, Manchester
Glenfield, Kilmarnock	**Glenfield & Kennedy, Ltd.,** Kilmarnock, N.B.
Glenros, Glasgow	**Ross, R. G., & Son, Ltd.,** Glasgow
Grace, Thrapston	**Smith & Grace Screw Boss Pulley Co., Ltd.,** Thrapston
Grafton, Bedford	**Grafton & Co.,** Bedford
Graftonian, London	**Grafton & Co.,** 120, Cannon Street, E.C.
Gramercy, London	**Le Bas, Edward, & Co.,** Dock House, Billiter Street, E.C.
Graysilver, Silver, London	**India Rubber, Gutta Percha & Telegraph Works Co., Ltd.,** Silvertown, E.
Greaves, Harbury	**Greaves, Bull & Lakin, Ltd.,** Harbury, Leamington
Greene, Quancham, London	**Greene, Tweed & Co.,** 15, Queen Anne's Chambers, Tothill Street, Westminster, S.W
Greenwood, Leeds	**Greenwood & Batley, Ltd.,** Albion Works, Leeds
Gresley, Manchester	**Smith & Coventry, Ltd.,** Gresley Ironworks, Ordsal Lane, Manchester
Grice, Birmingham	**Grice, Grice & Son, Ltd.,** Sheepcote Street, Birmingham
Grieve, Motherwell	**Grieve, John, & Co.,** Motherwell, Scotland
Gripookeng, Ave., London	**Yetton & Brockett,** 32A, Liverpool Street, E.C.
Günther, Oldham	**Günther, W., & Sons,** Central Works, Oldham
Guttaperch, Toronto	**Gutta Percha & Rubber Ltd.,** Toronto, Canada
Gwynne, London	**Gwynnes Ltd.,** Hammersmith Ironworks, W.
Hadfield, Sheffield	**Hadfields Limited,** Hecla Works, Sheffield
Halden, Manchester	**Halden, J., & Co., Ltd.,** 8, Albert Square, Manchester
Hall, Engineers, Peterboro'	**Hall, J. P., & Sons, Ltd.,** Peterborough
Hallford, London	**Hall, J. & E., Ltd.,** 10, St. Swithin's Lane, E.C.
Hallford, Dartford	**Hall, J. & E., Ltd.,** Dartford, Kent
Hardypick, Sheffield	**Hardy Patent Pick Co., Ltd.,** Sheffield
Hart, Blackburn	**Hart, Thomas,** Blackburn

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Hathorn, Leeds	**Hathorn, Davey & Co., Ltd.,** Sun Foundry, Leeds
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Heap, Ltd., Ashton-under-Lyne	**Heap, Jos., & Co., Ltd.,** Ashton-under-Lyne
Heenan, Manchester	**Heenan & Froude, Ltd.,** 4, Chapel Walks, Manchester
Heenan, Worcester	**Heenan & Froude, Ltd.,** Worcester Engineering Wks., Worcester
Helical, London	**Citröen Gear Co., Ltd.,** 27, Queen Victoria Street, E.C.
Henryeprid, Chicago	**Pridmore, Henry E. (Inc.),** 19th and Rockwell Streets, Chicago, Illinois, U.S.A.
Heroic, Reddish	**Rowland, B. R., & Co., Ltd.,** Climax Works, Reddish, near Manchester
Hewittic-Kincross, London	**Westinghouse Cooper Hewitt Company, Ltd.,** 80, York Road, King's Cross, N.
Hibou, London	**Burton, C. W., Griffiths & Co.,** 1, 2 & 3, Ludgate Square, E.C.
Highgate, Shettleston	**Pollock, MacNab & Highgate,** Shettleston, Glasgow
Hill, Derby	**Hill, Joseph,** Woods Lane, Derby
Hilljones, Wilmington	**Hilles & Jones Company,** Wilmington, Delaware, U.S.A.
Hindley, Bourton-Dorset	**Hindley, E. S., & Sons,** Bourton, Dorset
Hobnails, London	**Hobdell, Way & Co., Ltd.,** St. John's House, 124-5, Minories, E.
Hoffmann, Chelmsford	**Hoffmann Manufacturing Co., Ltd.,** Chelmsford
Hoisting, Glasgow	**Carruthers, J. H., & Co., Ltd.,** Polmadie Ironworks, Glasgow
Holmes, Newcastle-on-Tyne	**Holmes, J. H., & Co.,** Portland Road, Newcastle-on-Tyne
Hoops, Motherwell	**Motherwell Iron & Steel Co.,** Motherwell, N.B.
Hopkinson, Huddersfield	**Hopkinson, J., & Co., Ltd.,** Huddersfield
Hornsbys, Grantham	**Hornsby, R., & Sons, Ltd.,** Spittlegate Iron Works, Grantham
Hornsbys, London	**Hornsby, R., & Sons, Ltd.,** Hornsby House, 75B, Queen Victoria Street, E.C.
Horsepower, Cannon, London	**Unbreakable Pulley & Mill Gearing Co., Ld.,** 56, Cannon St.,
Howden, Glasgow	**Howden, James, & Co.,** Scotland Street, Glasgow [E.C.
Howell, Sheffield	**Howell & Co., Ltd.,** Brook Steel Works, Sheffield
Hudson, Coatbridge	**Hudson, Thomas, Ltd.,** Sheepford Works, Coatbridge, N.B.
Humpidge, Cainscross	**Dudbridge Iron Works, Ltd.,** Dudbridge, near Stroud
Hydraulic, Bristol	**Brazil, Straker & Co., Ltd.,** Vulcan Ironworks, Bristol
Hydraulic, Edinburgh	**Brown Bros. & Co., Ltd.,** Rosebank Ironworks, Edinburgh, N.B.
Hydraulic, Leeds	**Middleton, Robt., & Co.,** Sheepscar Foundry, Leeds
Hydromotor, Act., London	**Pitman, Percy,** 5, Willcott Road, Acton, W.
Hydrostatic, London	**East Ferry Road Engineering Works Co., Ltd.,** Millwall, E.
Hydroturbo, Wolverhampton	**Rees Roturbo Manufacturing Company, Ltd.,** Wolverhampton, Eng.
Hypostile, Glasgow	**Boyle, R., & Son,** 110, Bothwell Street, Glasgow
Hypostile, London	**Boyle, R., & Son,** 64, Holborn Viaduct, E.C.
Igniter, Birmingham	**Lodge Bros. & Co.,** Wrentham Street, Birmingham
Igranic, London	**Igranic Electric Co., Ltd.,** 147, Queen Victoria Street, E.C.
Improvably, London	**Withers, J. S., & Spooner,** Staple House, 51 and 52, Chancery Lane, W.C. [S.W.
Incanto, London	**Thorn & Hoddle Acetylene Co., Ltd.,** 151, Victoria Street,
Indicator, Manchester	**Kirk, Wheatley, Price & Co.,** Albert Square, Manchester
Indices, London	**Kirk, Wheatley, Price & Co.,** 46, Watling Street, E.C.
Induction, Birmingham	**Ellison, George,** Victoria Works, Warstone Lane, Birmingham
Influx, Manchester	**Holden & Brooke, Ltd.,** Sirius Works, West Gorton, Manchester
Infusion, Vic., London	**Record Electrical Co., Ltd.,** Caxton House, Westminster, S.W.
Ingenuity, Manchester	**Wilson, John G., & Co.,** 55, Market Street, Manchester
Ingersoll, London	**Ingersoll-Rand Co.,** 165, Queen Victoria Street, E.C.
Ingot, Wishaw	**Glasgow Iron & Steel Co., Ltd.,** Wishaw Iron and Steel Works, Wishaw
Inspect, London	**Hall, B. J., & Co., Ltd.,** Chalfont House, Great Peter Street, S.W.
Instrument, Cambridge	**Cambridge Scientific Instrument Co., Ltd.,** Cambridge
Insulator, Prescot	**British Insulated & Helsby Cables, Ltd.,** Prescot, Lancashire
Intensifier, London	**Middleton, Robt., & Co.,** 22, Martin's Lane, Cannon Street, E.C.
Intersection, London	**Piggott, Thos., & Co., Ltd.,** 63, Queen Victoria Street, E.C.
Inventions, Eastbourne	**Howard Pneumatic Engineering Co., Ltd.,** Fort Road, Eastbourne
Inventions, Glasgow	**Thomson, W. R. M., & Co.,** 96, Buchanan Street, Glasgow
Ironheads, London	**Smooth-on Manufacturing Co.,** 8, White St., Moorfields, E.C.
Isbercon, London	**Isherwood, J. W.,** 4, Lloyd's Avenue, E.C.
Isler, London	**Isler, C., & Co., Ltd.,** Artesian Works, Bear Lane, S.E.
Jackson, Claycross	**Clay Cross Co., Ltd.,** Claycross, near Chesterfield
James Keith, London	**Keith, James, & Blackman Co., Ld.,** 27, Farringdon Av., E.C
Jandunus, London	**Jandus Arc Lamp & Electric Co., Ltd.,** Hartham Road, Holloway, N.
Jardine, Nottingham	**Jardine, John,** Deering Street, Nottingham
Jenkins, Retford	**Jenkins, J. W., & Co., Ltd.,** Beehive Works, Retford
Jenorten, Ave., London	**Boving & Co., Ltd.,** 9½, Union Court, Old Broad St., E.C.
Kaye, Southam	**Kaye & Co., Ltd.,** Southam Works, Rugby
Kays, Bury 4	**Kay, James C., & Co., Ltd.,** Barnbrook Works, Bury, Lancs.
Kearns, Altrincham	**Kearns, H. W., & Co., Ltd.,** Broadheath, near Manchester
Keenanite, London	**Keenan, Matthew, & Co., Ltd.,** Tredegar Road, Bow, E.
Kenyon, Dukinfield	**Kenyon, Wm., & Sons,** Dukinfield, Manchester
Kern, Aarau	**Kern & Co.,** Aarau, Switzerland
Kernamat, London	**Kern & Co.,** Peninsular House, 28, Monument Street, E.C.
Keystone, Glasgow	**Positive Lock Washer Co.,** 2-8, James Watt Street, Glasgow
Kilbowie, London	**Tullis, D. & J., Ltd.,** 1, Southwark Bridge Buildings, S.E.
King, Nailsworth	**King, H. J. H., & Co., Ltd.,** Nailsworth, Glos.
Knapping, Leeds	**Baxter, W. H., Ltd.,** Leeds
Korting, London	**Korting Bros., Ltd.,** 53, Victoria Street, Westminster, S.W.
Laminated, Glasgow	**Hendry, James,** Laminated Leather Works, Bridgeton, Glasgow
Land, Grantham	**Grantham Boiler & Crank Co., Ltd.,** Grantham
Lang, Johnstone	**Lang, John, & Sons,** Johnstone, N.B.
Lapweld, Glasgow	**Stewarts & Lloyds, Ltd.,** 41, Oswald Street, Glasgow
Lathe, Coventry	**Herbert, Alfred, Ltd.,** Coventry
Lathe, Shipley	**Barker, Spink, Lease & Co.,** Rosse Works, Shipley, Yorkshire
Lathes, Birmingham	**Taylor, Charles** (Birm'm.), Ltd., Bartholomew Sq., Birmingham
Lathes, Felling	**Noble & Lund, Ltd.,** Felling, near Newcastle-on-Tyne
Lathes, Hyde	**Macnab, John,** Mary Street, Hyde
Lathes, Stoughton	**Drummond Brothers, Ltd.,** Engel Works, near Guildford
Lathes, Keighley	**Dean, Smith & Grace (1908), Ltd.,** Keighley
Lathookol, London	**Holbrook & Sons,** Stratford, E.
Lees, Hollinwood	**Lees, T. & R.,** Hollinwood, by Manchester
Lewis, Wolverhampton	**Lewis, E., & Sons,** Wolverhampton [N.W.
Lias, London	**Greaves, Bull & Lakin, Ltd.,** 9, Grove Rd. Bridge, Marylebone,
Lidgerwood, London	**Lidgerwood Mfg. Co.,** Caxton House, Westminster, S.W.
Lifter, Coventry	**Brett's Patent Lifter Co., Ltd.,** Coventry
Lifting, Leicester	**Taylor & Hubbard,** Leicester
Lignum, Manchester	**Southern, James W., & Son, Ltd.,** Store Street, Manchester
Linkbelt, Chicago	**Link-Belt Company,** 299, Broadway, New York City
Lioncelle, London	**Walker James, & Co., Ld.,** Lion Works, Garford St., Poplar, E.
Lloyds, Birmingham	**Stewart & Lloyds, Ltd.,** Broad Street Chambers, Birmingham
Lobnitz, Renfrew	**Lobnitz & Co., Ltd.,** Renfrew, Scotland
Lockencan, London	**Kaye, Jos., & Sons, Ltd.,** 93, High Holborn, W.C.
Lockett, Ave., London	**Cutbill, King & Co.,** 56/58, Moorgate Street, E.C.
Lockfast, London	**Bayliss, Jones & Bayliss, Ltd.,** 139 & 141, Cannon Street, E.C.
Loco, Bristol	**Avonside Engine Co.,** Bristol
Loco, Glasgow	**North British Locomotive Co., Ltd.,** Administration Bldg., 110, Flemington Street, Springburn, Glasgow
Loco, Gorton	**Beyer, Peacock & Co., Ltd.,** Gorton Foundry, Manchester
Loco, Leeds	**Hudswell, Clarke & Co., Ltd.,** Railway Foundry, Leeds
Locomotive, Newcastle	**Hawthorn, R. & W., Leslie & Co., Ltd.,** Newcastle-on-Tyne
Logic, Birmingham	**McGowan, Wild & Co.,** Hurst Street, Birmingham
Longmans, London	**Longmans, Green & Co.,** 39, Paternoster Row, E.C.
Lubricant, Manchester	**Wells, Henry, Oil Co.,** Salford, W., near Manchester
Lumby, Greetland	**Lumby, Son & Wood, Ltd.,** Greetland, near Halifax
Lunken, London	**Lunken Company, Ltd.,** 35, Great Dover Street, S.E.
Luns, Paris	**Pierson, J. & O. G.,** 47, Rue Lafayette, Paris
Lustroso, London	**Graphite Products, Ltd.,** 218-220, Queen's Road, Battersea, S.W.
Lyncean, London	**Contraflo Condenser & Kinetic Air Pump Co., Ltd.,** 3, Central Buildings, Westminster, S.W.
Lyndentree, London	**Otis Elevator Co., Ltd.,** 4, Queen Victoria Street, E.C.
Lysaght, Bristol	**Lysaght, John, Ltd.,** St. Vincent Ironworks, Bristol
Lysaght, Newport, Mon.	**Lysaght, John, Ltd.,** Orb Works, Newport, Mon.
Lytestrong, London	**Warden, A., & Co.,** 44, 46, 48, Shepherdess Walk, City Road, N.
Machinery, Birmingham	**Hands, John, & Sons, Ltd.,** Cardigan Works, Birmingham
Machinery, Dursley	**Lister, R. A., & Co., Ltd.,** Dursley, Glos.
Machinery, Reading	**Mackies Ltd.,** Berks Iron Works, Reading
McKechnie, Birmingham	**McKechnie Brothers,** Rotton Park Street, Birmingham
MacLellan, Glasgow	**MacLellan, P. & W., Ltd.,** Clutha Works, Glasgow
MacLellan, London	**MacLellan, P. & W., Ltd.,** 108A, Cannon Street, E.C.
Macksig, London	**McKenzie & Holland, Ltd.,** 58, Victoria Street, S.W.
Macneil, Glasgow	**McNeil, C.,** Kinning Park Iron Works and Hydraulic Forge, Glasgow
Maconie, Glasgow	**Harvey Engineering Co., Ltd.,** Scotland Street Engine Works,
Magnet, Manchester	**Electromotors Limited,** Openshaw, Manchester [Glasgow
Magneto, London	**Brush Electrical Engineering Co., Ld.,** 1, Kingsway, W.C.
Magnolier, London	**Magnolia Anti-Friction Metal Co. of Gt. Britain, Ltd.,** 49, Queen Victoria Street, E.C.
Manageable, London	**Thornycroft, J. I., & Co., Ltd.,** 5-11, Vauxhall Bridge Road, S.W.
Manloves, London	**Manlove, Alliott & Co., Ltd.,** 41 & 42, Parliament Street, S.W.
Manloves, Nottingham	**Manlove, Alliott & Co., Ltd.,** Nottingham
Manning, Leeds	**Manning, Wardle & Co., Ltd.,** Boyne Engine Works, Leeds
Manometer, Altrincham	**Schäffer & Budenberg, Ld.,** Whitworth St., London Rd., Manchester
Marr, Sunderland	**Sunderland Forge & Eng. Co., Ltd.,** Pallion, Sunderland
Marriott, Glasgow	**Marriott & Graham,** Plantation Boiler Works, Glasgow
Marsden, Leeds	**Marsden, H. R.,** Ltd., Soho Foundry, Leeds
Marshalls, Gainsborough	**Marshall, Sons & Co., Ltd.,** Gainsborough
Masonica, Boston, U.S.A.	**Mason Regulator Co.,** Boston, Mass., U.S.A.
Masseys, Openshaw	**Massey, B. & S., Ltd.,** Openshaw, Manchester
Mather or Sprinkler, Manchester	**Mather & Platt, Ltd.,** Park Works, Manchester
Maudslay, Coventry	**Maudslay Motor Co., Ltd.,** Parkside, Coventry
Melada, Glasgow	**McOnie, A. & P. W.,** Cessnock Engine Works, Govan, Glasgow
Meldrum, Altrincham	**Meldrums Ltd.,** Timperley, near Manchester
Meliss, London	**Kerr, Stuart & Co., Ltd.,** 1 & 2, Broad Street Place, E.C.
Melloid, Yoker	**Bull's Metal & Melloid Co., Ltd.,** Yoker, near Glasgow
Merywether, London	**Merryweather & Sons,** 63, Long Acre, W.C.
Mesmeric, London	**Firth, Thos., & Sons, Ltd.,** 8, The Sanctuary, Westminster, S.W.
Metallic Bradford	**United States Metallic Packing Co., Ltd.,** Soho Works, Allerton Road, Bradford
Metalose, Wood, London	**Interlock Metal Hose Co.,** River Park Road, Wood Green, N.
Meteorite, Glasgow	**Eureka Pump Company,** 53, Bothwell Street, Glasgow
Method, Birmingham	**Player, W. & J.,** Birmingham
Metro, Birmingham	**Metropolitan Carriage, Wagon and Finance Co., Ltd.,** Abbey Works, Shrewsbury
Mexprodux, Ave., London	**Anglo-Mexican Petroleum Products Company, Ltd.,** Finsbury Court, E.C.
Mirrlees, Glasgow	**Mirrlees Watson Co., Ltd.,** Scotland Street, Glasgow
Mitton, Birmingham	**Hunt & Mitton, Ltd.,** Oozells Street North, Birmingham
Mitton, Birmingham	**Fletcher Bros.,** Oozells Street North, Birmingham
Modernize, Manchester	**Klein Engineering Co., Ltd.,** 94, Market Street, Manchester
Monometer, Birmingham	**Monometer Manufacturing Co., Ltd.,** Whitehouse Street, Aston, Birmingham
Mosgear, Birmingham	**Moss Gear Co., Ltd.,** Aston Manor, Birmingham
Motor, Sheffield	**Davy Brothers, Ltd.,** Sheffield
Multiphase, London	**British Westinghouse Electric & Manufacturing Co. Ltd.,** 2, Norfolk Street, W.C.
Multitube, Annan	**Cochran & Co., Annan, Ltd.,** Annan, N.B.

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Mumford, Colchester	**Mumford, A. G., Ltd.,** Culver Street Ironworks, Colchester
Muntz, Westbromwich	**Muntz, P. H., & Co., Ltd.,** Alexandra Works, West Bromwich
Musgrave Limited, Belfast	**Musgrave & Co., Ltd.,** St. Ann's Ironworks, Belfast
Mytilite, London	**Micanite & Insulators Co., Ltd.,** Walthamstow, E.
Nasmyth, Patricroft	**Nasmyth, Wilson & Co., Ltd.,** Bridgewater Foundry, Patricroft, near Manchester
National, Ashton-under-Lyne	**National Gas Engine Co., Ld.,** Ashton-under-Lyne, Manchester
National, Manchester	**National Boiler & General Insurance Co., Ltd.,** St. Mary's Parsonage, Manchester
Nautical, Glasgow	**Mechan & Sons, Ltd.,** Scotstoun Iron Works, Glasgow
Naxium, London	**London Emery Works Co.,** Park, Tottenham, N.
Nayler, Dudley	**Wilkinson & Co.,** Spring Gardens Works, Dudley
Negretti, London	**Negretti & Zambra,** 38, Holborn Viaduct, E.C.
Nelson, Motherwell	**Hurst, Nelson & Co., Ltd.,** Glasgow Rolling Stock and Plant Works,
Neumuehle, London	**Escher, Wyss & Co.,** 109, Victoria Street, S.W. [Motherwell
Newalls, Newcastle-on-Tyne	**Newalls Insulation Co., Ltd.,** Scottish Provident Buildings, Newcastle-on-Tyne
Newbold, London	**Newbold, Walter, & Co.,** 107, Upper Thames Street, E.C.
Newburn, London	**Spencer, John, & Sons, Ld.,** 32, Victoria St., Westminster, S.W.
Newburn, Newcastle-on-Tyne	**Spencer, John, & Sons, Ltd.,** Newburn Steel Works, Newcastle-on-Tyne
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Newells, Misterton, Gainsboro'	**Newell, Ernest, & Co., Ltd.,** Misterton, Gainsboro
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Niliacus, London	**Niles-Bement-Pond Co.,** 23 & 25, Victoria St., Westminster, S.W.
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Ocean, Sheffield	**Standard Piston Ring & Engineering Co.,** Premier Works, Don Road, Sheffield
Olders, Birmingham	**Youngs,** Ryland Street Works, Birmingham
Opodeldoc, London	**Churchill, Chas., & Co., Ltd.,** 9 to 15, Leonard St., Finsbury, E.C.
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Otto, Manchester	**Crossley Bros. Ltd.,** Openshaw, Manchester
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Outfall, London	**Stereophagus Pump & Engineering Co., Ltd.,** 39, Victoria Street, Westminster, S.W.
Outfitter, Glasgow	**Paisleys Ltd.,** 82-96, Jamaica Street, Glasgow
Outil, Oerlikon	**Swiss Oerlikon Machine Tool Co.,** Oerlikon, near Zurich, Switzerland
Outillage, London	**Lash, Robert H.,** 31, Carburton Street, Portland Road Station, W.
Oxygen, Wolverhampton	**Knowles Oxygen Co., Ltd.,** Wolverhampton
Ozonistic, Vic., London	**Judson-Jackson Co., Ltd.,** 50, Marsham Street, Westminster, S.W.
Pagefield, Wigan	**Walker Brothers (Wigan), Ltd.,** Pagefield Ironworks, Wigan
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Patella, London	**Geipel, Wm., & Co.,** Vulcan Works, St. Thomas Street, S.E.
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Paul, Dumbarton	**Paul, Matthew, & Co., Ltd.,** Levenford Works, Dumbarton
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Paxman, London	**Davey, Paxman & Co., Ltd.,** 78, Queen Victoria Street, E.C.
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Peckett, Bristol	**Peckett & Sons, Ltd.,** Atlas Locomotive Works, Bristol
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Penman, Glasgow	**Penman & Co., Ltd.,** 377, Dalmarnock Road, Glasgow E.C.
Percussion, Fishponds	**Bristol Engineering Co., Ltd.,** Fishponds, Bristol
Percussive, London	**Lacy-Hulbert & Co., Ltd.,** 91, Victoria Street, S.W.
Perforation, London	**Barns, W., & Son,** Queensland Road, Holloway, N.
Petters, Yeovil	**Petters Limited,** Nautilus Works, Yeovil
Pfeil, London	**Pfeil & Co.,** 145-9, St. John Street, Clerkenwell, E.C.
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Photophore, London	**Guilbert-Martin,** 9, Edmund Place, Aldersgate, E.C.
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Planer, Glasgow	**Smith Brothers & Co.** (Glasgow), **Ltd.,** Kinning Park, Glasgow
Planers, Keighley	**Ward, Haggas & Smith,** Eastwood, Keighley
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Plenty, Newbury	**Plenty & Son, Ltd.,** Newbury, Berkshire
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Prices, Birkenhead	**Prices' Company, Ltd.,** Bromborough Pool, Liverpool
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Processes, London	**Electro-Metals, Ltd.,** 9½, Union Court, Old Broad Street, E.C.
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Pulsometer, Reading	**Pulsometer Engineering Co., Ltd.,** Nine Elms Ironworks, Reading, Berks.
Pulsometer, Glasgow	**Pulsometer Engineering Co., Ltd.,** 160, St. Vincent Street Glasgow
Pulsometer, Leeds	**Pulsometer Engineering Co., Ltd.,** 15, King Street, Leeds
Pulsometer, Liverpool	**Pulsometer Engineering Co., Ltd.,** 2, Strand St., Liverpool
Pulsometer, Manchester	**Pulsometer Engineering Co., Ltd.,** 206, Corn Exchange Buildings, Manchester [Bedford
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Pump, London	**Allen, W. H., Son, & Co., Ltd.,** 1, Queen Anne's Chambers, S.W.
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Rivetter, Leeds	**Berry, Henry, & Co., Ltd.,** Croydon Works, Leeds
Robey, Lincoln	**Robey & Co., Ltd.,** Lincoln
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Silverine, London	**Baldwins, Ltd.**, Orchard Street, Blackwall, E.
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Weldless, Birmingham	**Weldless Steel Tube Co., Ltd.**, Icknield Port Rd., Birmingham
Weldless, Dukinfield	**Oldham, Alexander, & Sons**, Dukinfield
Wellington, Middlesbro'	**Shaw, W., & Co.**, Wellington Cast Steel Foundry, Middlesbro'-on-
Werlconrad, Haarlem	**Werf Conrad, N.V.** Haarlem, Holland [Tees

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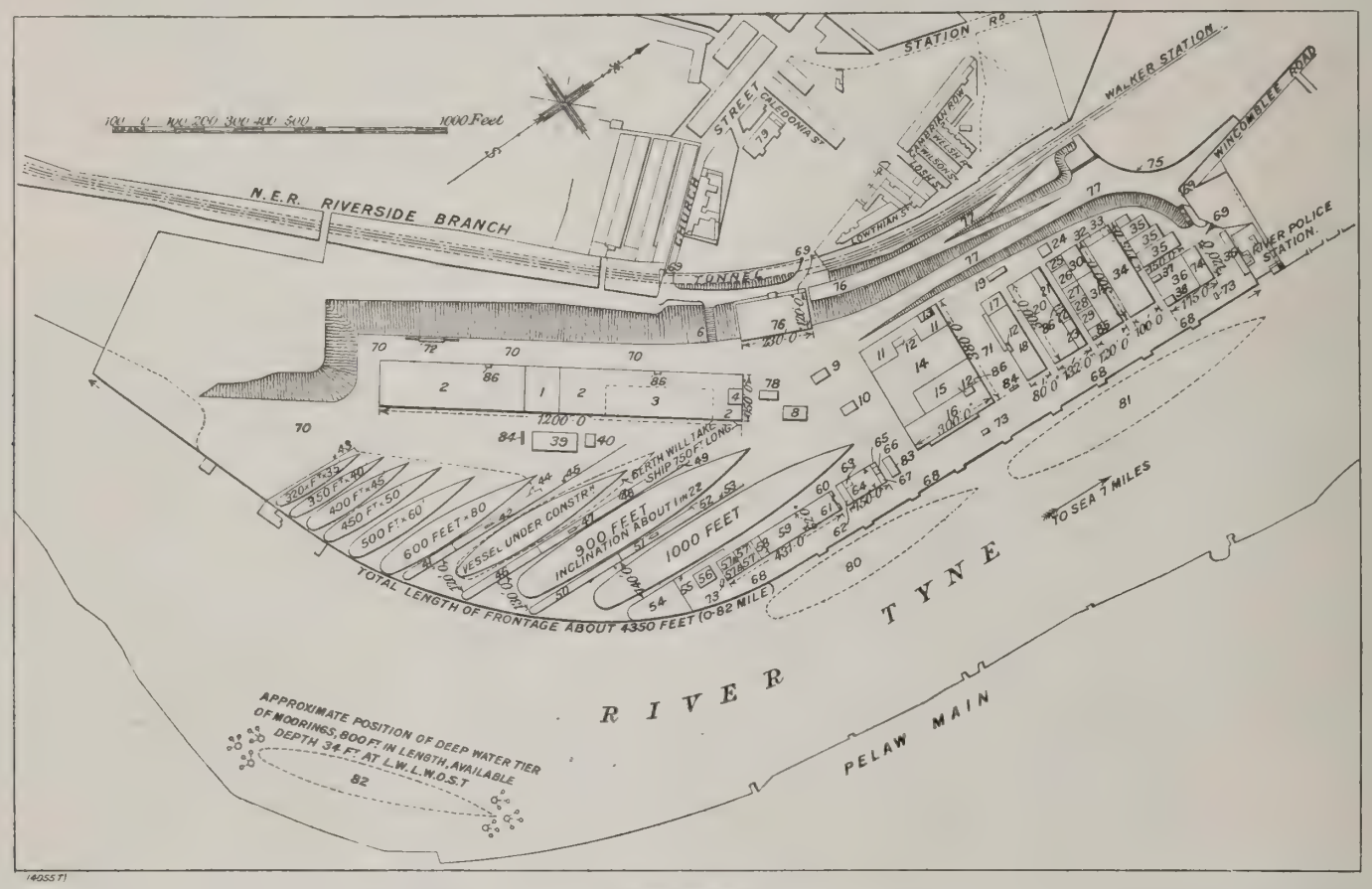
Westcelite, London	**Acieries et Fonderies d'Art, Ltd.,** Caxton House, Westminster, S.W.
Westeelite, London	**Bucyrus Company,** Caxton House, Westminster, S.W.
Westeelite, London	**West, George F., & Co.,** Caxton House, Westminster, S.W.
Western, Aurora, Illinois	**Western Wheeled Scraper Co.,** Aurora, Illinois, U.S.A.
Westinghouse, London	**Westinghouse Brake Co.,** 82, York Road, King's Cross, N.
Westinghouse, Manchester	**British Westinghouse Electric & Manufacturing Co., Ltd.,** Trafford Park, Manchester
Westwood, Milleast, London	**Westwood, Joseph, & Co,, Ltd.,** Napier Yard, Millwall, E.
Wheels, Darlington	**Skerne Works, Ltd.,** Darlington
White, East Cowes	**White, J. Samuel, & Co., Ltd.,** East Cowes, Isle of Wight
Whitefield, Glasgow	**Ross & Duncan,** Govan, Glasgow
Whitley, Ashton-in-Makerfield	**Whitley & Valiant, Ltd.,** Ashton-in-Makerfield
Whitworth, Openshaw	**Armstrong, Sir W. G., Whitworth & Co., Ltd.,** Openshaw, Manchester
Wiggins, Minories, London	**Wiggins, F., & Sons,** 102, 103 & 104, Minories, E.
Wiley, Darlaston	**Wiley, James, & Sons, Ltd.,** Darlaston
Wilburtier, London	**Saunders, J. T., & Co.,** 1, Victoria Street, Westminster, S.W.
Wilkinsons, Engineers, Keighley	**Wilkinson, G., & Sons,** Keighley
Willans, Rugby	**Willans & Robinson, Ltd.,** Rugby, Warwickshire
Willcox, Southwark Street, London	**Willcox, W. H., & Co., Ltd.,** 32-38, Southwark St., S.E.
Willetts Junr., Cradley Heath	**Willetts, Charles, Junr.,** Colonial Works, Cradley Heath, Staffs.
Windtight, London	**Harris Patent Feed-Water Filter** (1910), **Ltd.,** 82, Victoria St., S.W.
Windtight, Newcastle-on-Tyne	**Harris Patent Feed-Water Filter** (1910), **Ltd.,** 24, Grainger Street West, Newcastle-on-Tyne
Winn, Birmingham	**Winn, Charles, & Co.,** Granville Place, Birmingham
Woodite, Mitcham	**Woodite Works,** Mitcham Common, Surrey
Woodworker, Leicester	**Wadkin & Co.,** Leicester
Wright, Tipton	**Wright's Forge & Engineering Co., Ld.,** Tipton, Staffordshire
Yarrow, Glasgow	**Yarrow & Co., Ltd.,** Glasgow
Yates, Blackburn	**Yates & Thom, Ltd.,** Canal Works, Blackburn
Zero, Derby	**Haslam Foundry & Engineering Co., Ltd.,** Derby
Zero, Derby	**Pontifex & Wood, Ltd.,** Union Foundry, Derby
Zynkara, Newcastle-on-Tyne	**Zynkara Co. Ltd.,** 34-36, Side, Newcastle-on-Tyne

the requirements of Messrs. Armstrong, Messrs. Asquith have designed and provided machines carrying high-speed radial drills, supported on a bridge travelling on rails between which the plate to be drilled can be supported, so that the work can be completed on the longest of plates without any movement of the plate. Another notable tool is a plate-edge planer, which is designed so that the beam with hand-screw and hydraulic holding-down clamps can be raised, in order to enable turbine-lifting girders, up to 2 ft. 3½ in. deep, to be planed. The punching and shearing-machines, and any others where work has to be supported during operations, are provided with 8-ton cranes, of 23-ft. rake, and the smaller machines with 5-ton cranes, of 20-ft. rake. The practice is adopted of laying out and drilling

In the range of buildings behind the fitting-out wharf the blacksmiths' shop comes first. It is 300 ft. long by 80 ft. wide by 30 ft. high, and included in its equipment is a gas-fired reversing regenerative forging-furnace and an annealing furnace. At the west end of this building is the blacksmiths' fitting-shop for the manufacture of ladders, gratings, mess-racks, &c.

A very important department is the fitting-shop, a building 300 ft. long by 132 ft. wide. Under the same roof there is arranged a tool department, with stores and a valve-testing shop. Above these are the riggers' loft and sail-makers' shop. The remainder of the building is divided into three bays, the largest of 40 ft. 9 in. span. Two of the bays accommodating the larger machine-tools are

another to benches, while a third is given up to the erection of furniture, cabins, &c. In the galleries there are to be pattern and model-makers' shops. In close proximity to the joiners' shop is a saw-mill, which is now in process of erection. It is a building 120 ft. long, 82 ft. 6 in. wide, and 26 ft. high. Adjoining it is a boat-building shed of the same length, 71 ft. in width and 16 ft. in height. An annexe to the saw-mill is being arranged as a saw-sharpener's shop. Needless to say, the equipment in these departments corresponds in modernity of design and adequacy of power with that in the other departments of the works. To the rear of the saw-mill are timber-drying and storing-sheds. The logs will be lifted from the river by the 30-ton crane



REFERENCES.

1. Bulkhead boards.
2. Platers' shed (machinery)
3. Platers' shed (mould loft above)
4. Pneumatic-tool store.
6. Workmen's stairs to yard.
7. General offices.
8. Paint-shop and store.
9. Fire-station and office.
10. Oil-store.
11. Furnace-blocks.
12. Furnaces.
13. Gas-producers.
14. Frame-shop machinery.
15. Scrive-boards.
16. Anglesmiths' shop.
17. Boilersmiths' fitting-shop.
18. Blacksmiths' shop.
19. Engine-shed.
20. Fitting-shop.
21. Fitters' store.
22. Valve-testing.
23. Fitters tool store.
24. North sub-station.
25. Rope-stores.
26. Cable-stores.
27. Ship electric stores.
28. Yard electric stores.
29. Electricians' workshops.
30. Admiralty stores.
31. General stores.
32. Pipe patterns (Hawse, &c.)
33. Store.
34. Joiners' shop.
35. Timber-shed.
36. Saw-mills.
37. Direct-current sub-station.
38. Boiler-house.
39. Rivet-store.
40. South sub station.
41. Ferro-concrete jetty, 200 ft. by 30 ft.
42. No. 3 transformer station.
43. Retaining wall, 331 ft. long.
44. Retaining wall, 340 ft. long.
45. Retaining wall, 642 ft. long.
46. Ferro-concrete jetty, 300 ft. by 30 ft.
47. No. 2 transformer station.
48. Retaining wall, 420 ft. long.
49. Retaining wall, 580 ft. long.
50. Ferro-concrete jetty, 350 ft. by 30 ft.
51. No. 1 transformer station.
52. Retaining wall, 290 ft. long.
53. Retaining wall, 467 ft. long.
54. Ferro-concrete roundhead, 180 ft. long.
55. Retaining wall, 158 ft. long.
56. Rudders.
57. Contractors' workshops.
57A. Carpenters' store.
57B. Masons' store.
58. Plumbers' store.
59. Plumbers', &c., workshops.
60. Acetylene-gas plant.
61. Latrine.
62. Millwrights' shop.
63. Central sub-station.
64. Power-house.
65. Hydraulic accumulator.
66. Air reservoir.
67. Store.
68. Ferro-concrete jetty, 2133 ft. by 34 ft.; 30 ft. at low water of ordinary spring tides in front.
69. Entrances.
70. Plate-racks (10-ton gantry over).
71. Angle-bar racks (5-ton gantry over).
72. Pickling-tanks and draining-rack.
73. Electric capstans.
74. Boat-builders' shed.
75. Retaining-wall.
76. Railway standage sidings.
77. Railway incline to yard (1 in 30).
78. Time-office.
79. Workmen's dining-rooms.
80. Outfitting berth, 30 ft. at low water of ordinary spring tides.
81. Ditto ditto.
82. Outfitting berth, 34 ft. at low water of ordinary spring tides.
83. Ordnance workshop.
84. Latrine.
85. Ship-lighting transformer.
86. Yard.

bulkheads and decks in position in the platers' shed, as this greatly facilitates the preparation of the work for subsequent erection in the ship.

It will be seen that the angle and frame shop is at the head of the largest of the shipbuilding berths. The material, brought by rail, is stored behind the building, and here is installed a gantry-crane of 5 tons capacity and 120-ft. span, for disposing of bars in the racks or lifting them on to railway-trucks to be conveyed to the furnaces. The furnaces are all gas-fired. That for angles is double-ended, 90 ft. long by 4 ft. wide, with bending blocks at each end, while those for plates are 36 ft. by 13 ft. and 25 ft. by 10 ft. 6 in. The equipment of the frame shop, which is 300 ft. long by 380 ft. wide, and about 30 ft. high, is thoroughly modern. Forming part of the same building, but separated by a division wall, is the anglesmiths' shop, where also is a gas-fired furnace and a powerful hydraulic press for stamping out doors, &c.

traversed by 10-ton cranes. The mechanical equipment of the department is very comprehensive, and includes several tools of special design, but we prefer to postpone a detailed description until we can illustrate them. The next building is given up to stores, there being not only general stores, but special Admiralty stores, electricians' workshop, yard electric stores, ship electric stores, cable and rope stores, all embraced in a building 300 ft. long, 120 ft. wide, and 23 ft. 6 in. high, and equipped with cranes for the quick movement of supplies required in the ships during the process of fitting out.

The wood-working departments occupy the remainder of the buildings in the range behind the wharf. The joiners' shop is, like the other buildings, 300 ft. long, and its width of 100 ft. is divided into three bays, with a gallery round four sides of the interior of the building. One of the ground-floor bays is devoted to machinery,

traversing the main fitting-out wharf, and will be placed on railway trucks or laid on the wharf under a gantry forming an extension of the overhead crane-track in the saw-mill, so that the logs can be moved to any of the saws or placed on trucks to be delivered where required.

At present the plumbers, coppersmiths, and sheet-iron workers are temporarily housed, because the site which the shops will ultimately occupy is required in connection with the ferro-concrete work in the yard. This site is between the 1000-ft. ship-berth and the river. The main building, in which they will be accommodated, will be 431 ft. long by 62 ft. 6 in. wide, while adjoining them is the power-house and other departments.

The buildings generally are of a very substantial character, and the roofs of the smaller shops are on the saw-tooth principle, with abundance of light. The platers' shed, which is exceptional, is built up of columns at 80-ft. centres longitudinally, with

TESTING TURBO-DYNAMOS AT THE HEATON WORKS OF MESSRS. PARSONS & CO., LTD.

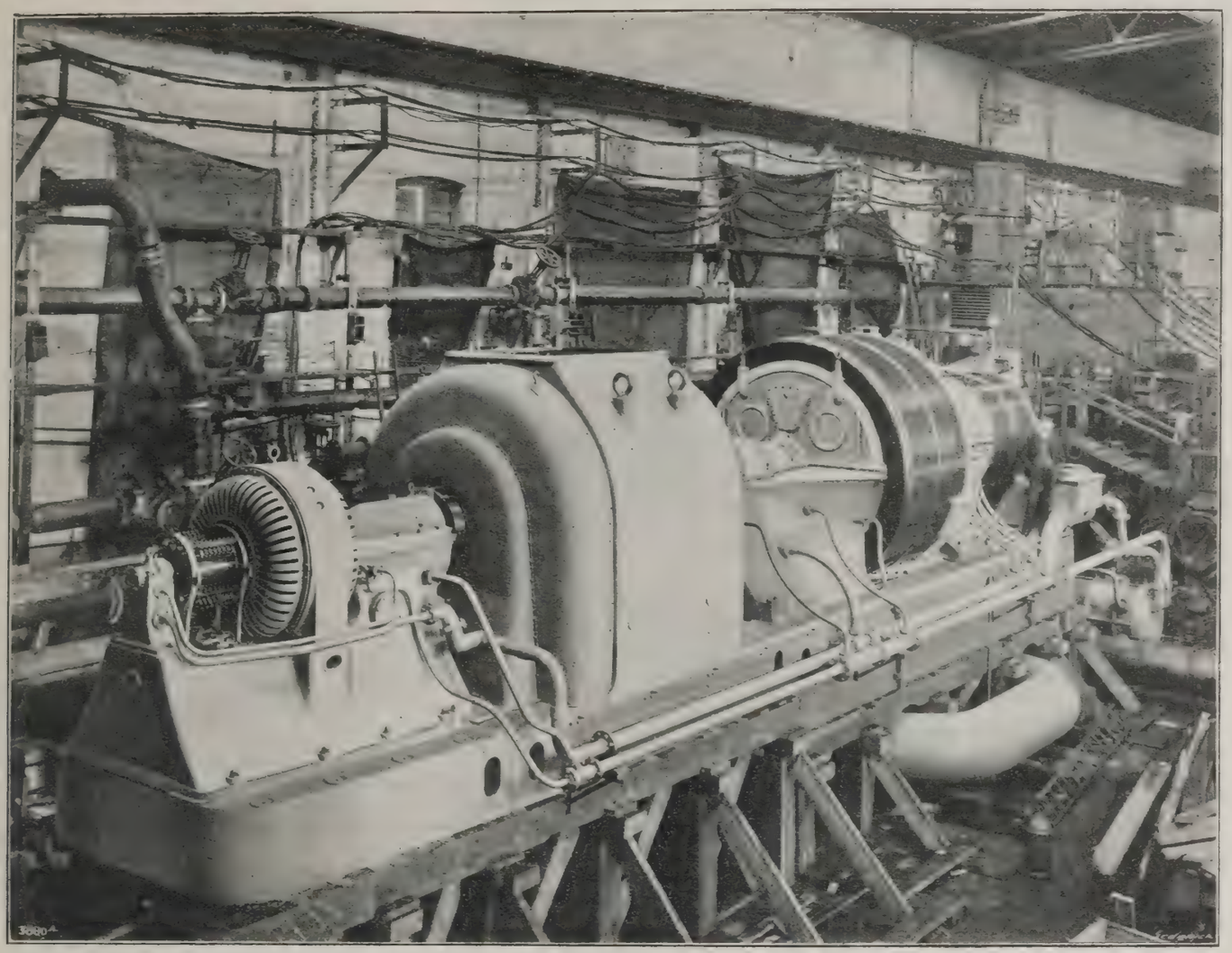


FIG. 1. GENERAL VIEW OF TESTING DEPARTMENT.

four lines of box-shaped lattice girders extending the full length of the building, and carrying the superstructure and tracks for the travelling gantry cranes. These also carry the roof principals, and the roof itself is entirely of Mellowe's patent glazing, as is also the greater part of the side-walls, with a slight portion of corrugated steel.

As regards the power, this is taken from the mains of the Newcastle Electric Supply Company at 6000 volts and 40 cycles per second, and transformed to 440 volts for distribution to the various shops. Primary consideration was given to the problem of obviating a complete breakdown through stoppage of the supply, and at the same time to the desirability of reducing the length of low-tension cable. It was therefore decided that there should be three sub-stations situated at the most convenient points in the works for the distribution of power to the various departments. Thus, the north sub-station supplies buildings grouped in its neighbourhood, behind the fitting-out quay; the central sub-station supplies the machines in the power stations, such as hydraulic pumps, air-compressors, &c.; and the third sub-station is for the machines in the platers' shed and other general purposes in the neighbourhood. As already stated, there are subsidiary transformer stations at the building-berths. In addition to these, transformers have been placed at convenient positions throughout the works, to reduce the current to 110 volts for lighting purposes. The main supply is brought into both the north and south sub-stations in duplicate, and each of these is connected to the power-house, which also constitutes a sub-station. By this arrangement the whole yard can be completely supplied through either the north or south sub-station, and thus the possibility of accident involving the complete failure of supply is reduced to an absolute minimum. The whole of the pipes carrying the electric cables, pressure water, supply water, air for pneumatic purposes, &c., throughout the yard, have been arranged in a common trench, and where these pass under rail way tracks concrete walls have been built to support the railway track over the pipes.

There are about 4½ miles of drains and sewers throughout the works, while the drains on the slopes between the high-level ground behind the works and the level of the yard itself extend collectively to about 9½ miles. Throughout the works there are about 10 miles of railway track, laid with 90-lb. flat-bottomed rails, and with nearly 170 points and crossings. There are a large number of locomotives throughout the works, in addition to 10-ton travelling cranes with 45-ft. jibs. We hope, however, when the works are completed, to return to the subject and give full details and illustrations.

THE TESTING OF TURBO-DYNAMOS.

THE success of the Parsons turbine-driven electric machinery is largely a consequence of the experimental work done at the Heaton Works, and the care continuously exercised to ensure that the specified or guaranteed conditions are fulfilled before the manufactures leave the establishment. From time to time experimental appliances have been evolved, and now the department, which has been rearranged, is not only comprehensive, but admits of extensive and accurate testing work being done. Provision is made for testing at full load for several hours continuously turbo-dynamos having an output of over 3000 kw. The views of the plant which we publish on the present page and page 16 will therefore be studied with some interest.

The boiler plant consists of three large water-tube boilers and one Lancashire boiler, from which steam at any desired pressure is supplied to the steam range. Practically the whole of one side of the test-house, as shown in Fig. 1, is occupied with a network of pipes arranged with suitable connecting-valves and flanges, so as to supply steam to any of the numerous test-beds; a separately-fired superheater is used, so that almost any desired degree of superheat can be obtained, while at the same time the degree of superheat is well under control. Below the steam-pipes and running the whole length of the test-house is a large-diameter exhaust-main communicating with two independent condensing plants. This condensing-main can be separated into two portions in order to allow separate trials on two independent plants to be carried out simultaneously, or, in the case of large-sized machines, both condensing plants can be used together to deal with the exhaust steam. The water from the circulating-pump is taken into large and carefully-calibrated tanks arranged in pairs, so that continuous measurements of the steam consumption of any plant can be made. Means are provided for checking the calibration of these tanks should inspecting engineers desire to do so.

Particular attention has been given to the problem of obtaining accurate measurements of the power developed. Standard instruments are used for this purpose, and these instruments are kept and used in a specially-constructed instrument-

cabin, all the power being led through this cabin and measured there. By this means the standard instruments are kept free from vibration, and since they are not moved about for coupling up to different machines and are frequently calibrated, their accuracy may be absolutely relied on.

In the case of alternating-current machines, the wave-form of every plant is observed and photographed under different conditions of loading, so that engineers can readily satisfy themselves before taking delivery of a plant that their requirements in this direction are being fully met.

Fig. 1, page 3, shows a turbo-alternator having a normal rated output of 6000 kw., erected and undergoing tests up to half load. In the background is the instrument-cabin referred to above, with the telegraph-board used for indicating the load on the machine undergoing test.

In testing turbo air-compressing plants, pumps, &c., the greatest possible care is taken to obtain accurate measurements of the quantity of air used. Fig. 3, on page 16, shows a double-ended turbo-blower on the test-bed. In this case the air is drawn from the test-house, and after being throttled to the required pressure, is discharged through a pipe to a large measuring-drum outside of the building. The measuring-drum is fitted with baffles, to steady up the flow of air and enable a reliable water-gauge reading to be taken immediately in front of the measuring-orifice. In most cases, however, the air is measured on the inlet side of the blower, as this largely reduces the number of corrections which have to be used in working out the results.

The turbo-geared plant, in which the gears are all cut on the special creeping-table patented by Messrs. Parsons, has recently attracted much notice, and particular attention has been devoted by the firm to the problem of obtaining thoroughly reliable tests on such machines. The methods already described for "testing turbo-dynamos" are used when they are applicable, but during the last few years the use of geared turbines for the direct driving of mills has called for the adoption of other methods.

The old mill-engine of the reciprocating type could be tested for its steam consumption per indicated horse-power after it had been erected on the site, and, provided it then realised the guaranteed figures and gave the requisite amount of power, the purchaser was expected to be content. It is needless to say, however, that this method gave no proof that the engine was economical as far as the power actually delivered to the shafting was concerned, although the method was probably the best that could be economically adopted in the case of reciprocating engines. Within recent years, however, when nearly all power extensions for mill-driving are taking the form of geared turbines, the matter has again had to be considered, and in view of the fact that the indicated horse-power of a turbine cannot be arrived at, Messrs. Parsons decided some time ago to instal such plant as would enable them to measure accurately the actual power delivered to the shafting.

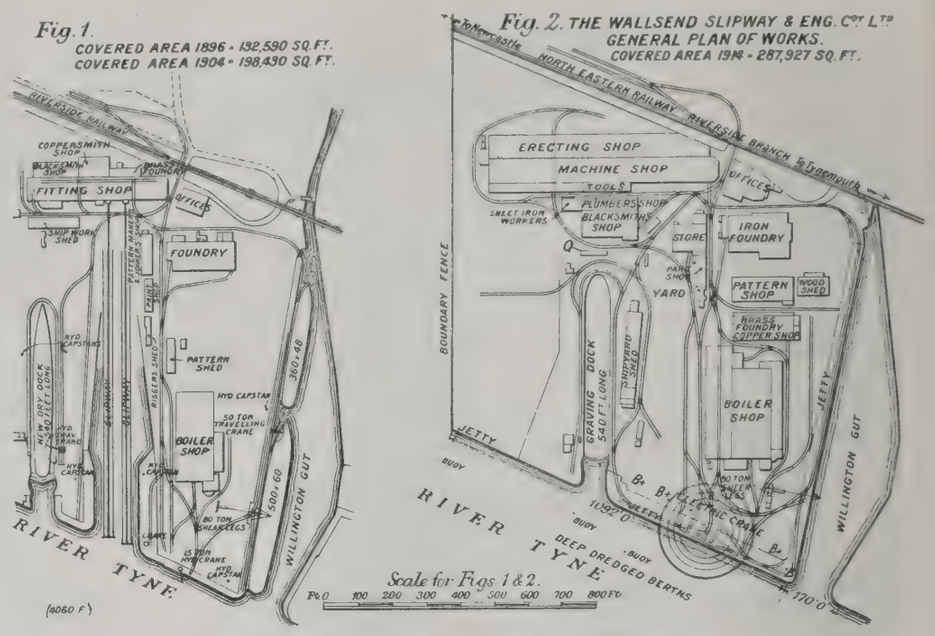
Two powerful Heenan and Froude water-brakes have been installed, with which geared turbines can be tested up to loads of 2000 to 3000 brake horse-power, and one such geared turbine, complete with its rope-pulley, is shown in Fig. 2, page 16. The water-brake for testing can be seen at the right-hand side of the illustration.

The above description of the testing facilities afforded at Messrs. Parsons' works will be of special interest to engineers of plant for delivery abroad. Every effort is made at Heaton to discover any weak points, whether in the design or manufacture, of the machines manufactured, and, as a result, and as a reward of the necessarily high cost of carrying out these elaborate tests, they have been able to secure a very large proportion of the orders for British colonies and dependencies, and for other distant parts of the world.

WALLSEND SLIPWAY AND ENGINEERING WORKS.

FEW, if any, of the engineering factories in the North-East Coast district have made more rapid progress in recent years, alike in regard to the area of the shops and the importance of the work done, than those of the Wallsend Slipway and Engineering Company. The naval architects and engineers who attend the joint meeting next week will find much to interest them in the organisation

THE WALLSEND SLIPWAY AND ENGINEERING WORKS.



FIGS. 1 AND 2. PLANS OF WORKS IN 1896 AND 1914.

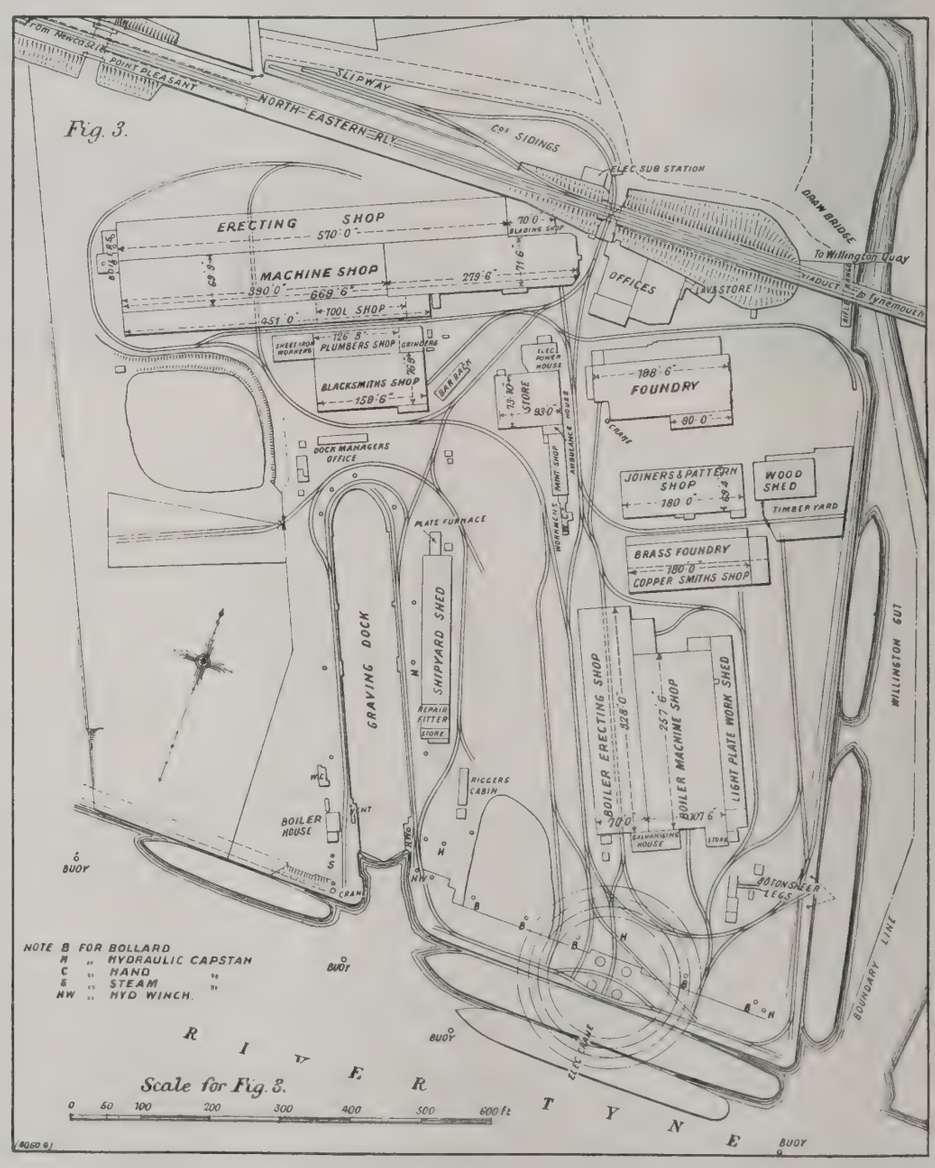


FIG. 3. DETAILED PLAN OF WORKS IN 1914.

WALLSEND SLIPWAY AND ENGINEERING COMPANY'S WORKS, WALLSEND-ON-TYNE.

(*For Description, see Page* 4.)

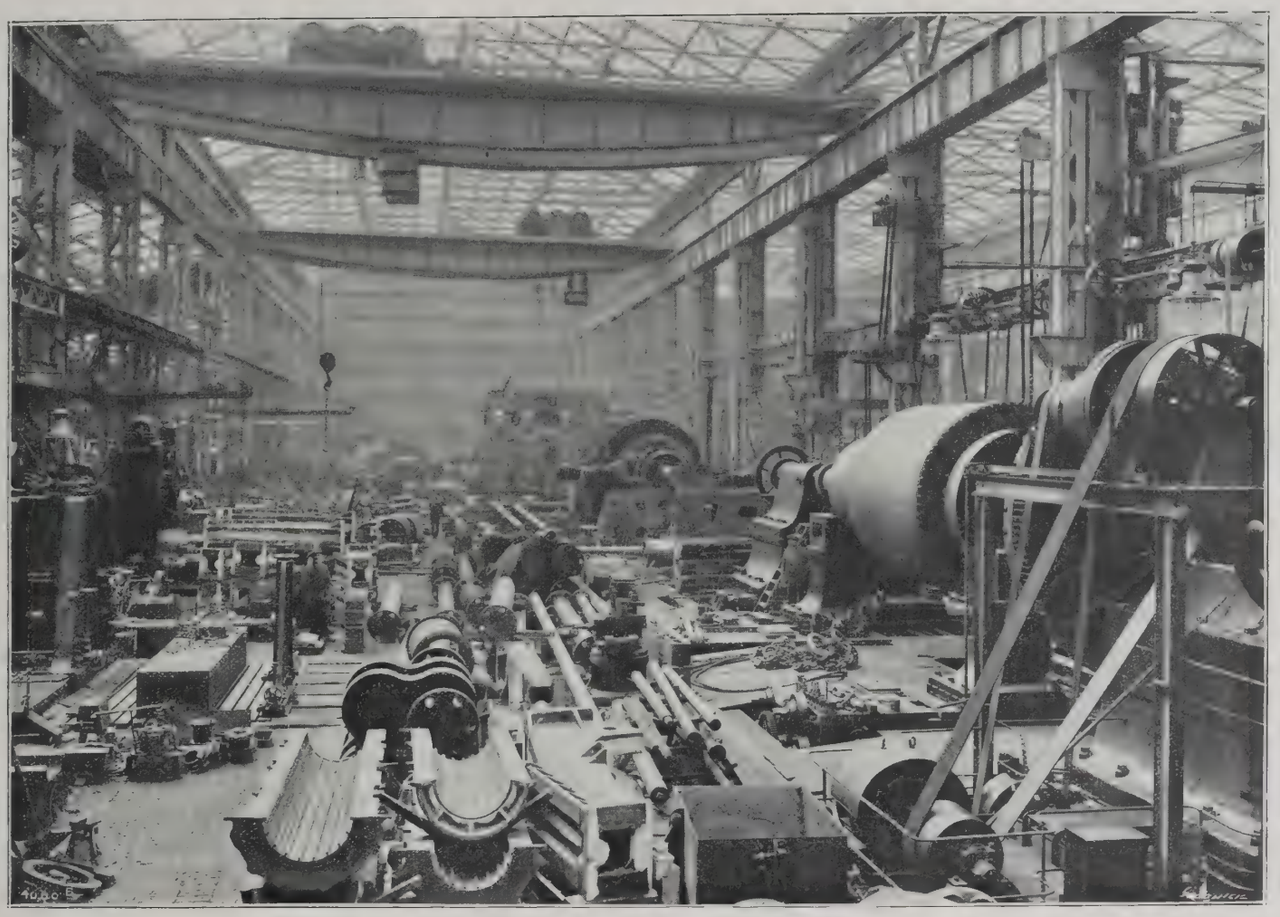


FIG. 5. THE NEW MACHINE-SHOP.

FIG. 6. THE NEW SMALL MACHINE SHOP.

(*To Face Page* 4.)

WALLSEND SLIPWAY AND ENGINEERING COMPANY'S WORKS, WALLSEND-ON-TYNE.

(*For Description, see Page* 4)

FIG. 7. THE ERECTING-SHOP, LOOKING WEST.

FIG. 8. THE ERECTING-SHOP, LOOKING EAST.

(*To Face Page* 5.)

THE WORKS OF THE NORTH-EASTERN MARINE ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(*For Description, see Page* 25.)

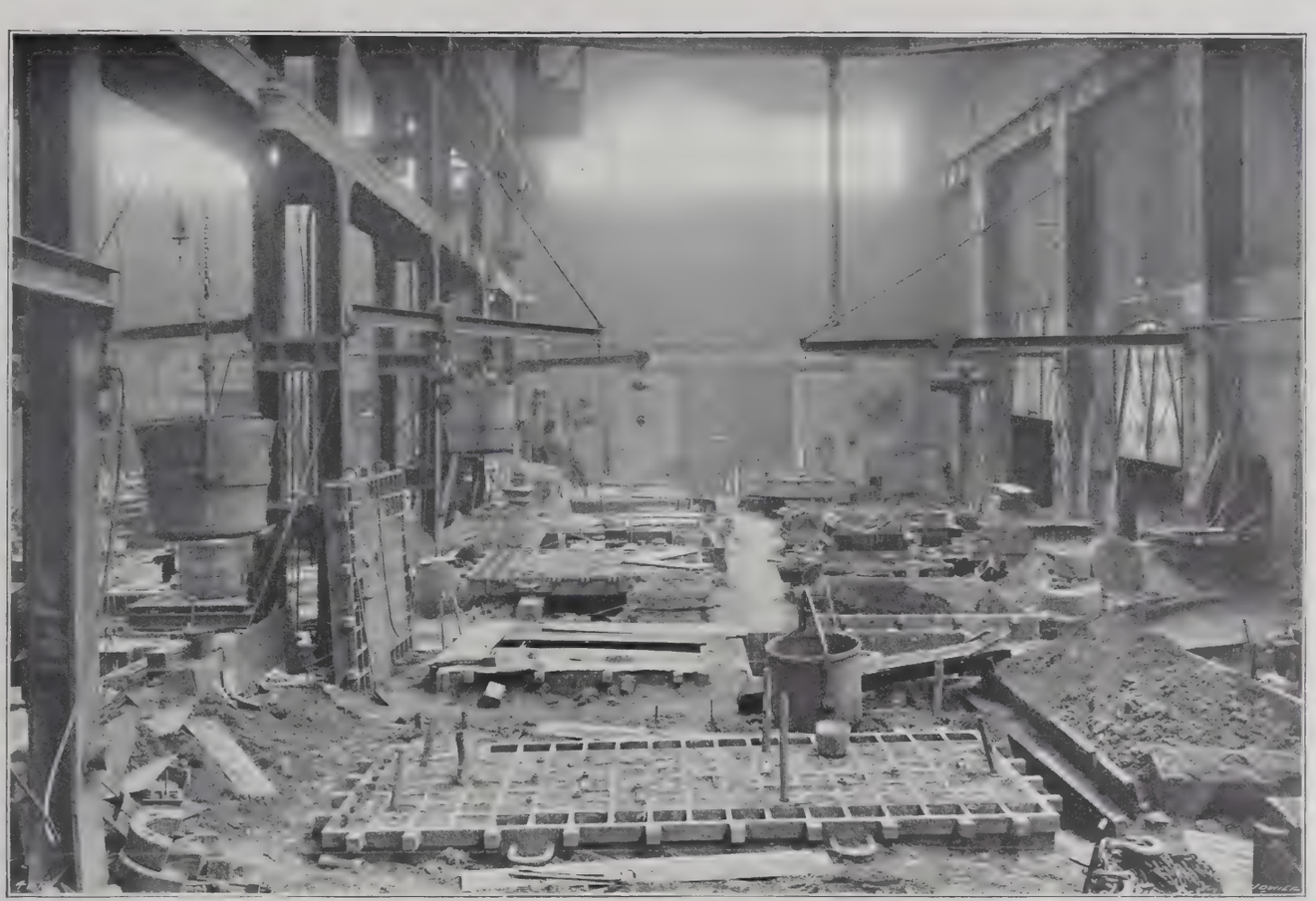


FIG. 1. THE WEST BAY OF THE IRON FOUNDRY.

FIG. 2. THE LARGE MACHINE SHOP.

(*To Face Page* 26.)

THE WORKS OF THE NORTH-EASTERN MARINE ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

(*For Description, see Page* 25.)

Fig. 3. The Erecting-Shop.

Fig. 4. The East Bay of the Boiler-Shop.

(*To Face Page* 27.)

FIG. 4. GENERAL VIEW ON THE WORKS FROM THE RIVER TYNE.

and equipment of the establishment, and will further see very extensive developments, even although they may have been at the works two or three years ago, because large additions to the machine-shops have only now been completed. At the present moment, too, there is in course of construction a large amount of work of a varied and important nature. There are, for instance, the immense turbines of the battleship Malaya, the hull of which is being constructed at the new Armstrong yard at Walker; there is machinery for torpedo-boat destroyers, and a considerable amount of geared-turbine work. The progressive character of the management is further evidenced by the presence of a set of Diesel engines on the testing-bed, while in the mercantile department there are a number of reciprocating engines, of both the triple and quadruple-expansion type.

Reflection upon the progress of the works and upon the position it now occupies leads one to consider the influence of the size of works upon success in the management of such factories. Where the establishment is small, and the turnover not considerable, the burden of management must rest practically on one individual, and, especially if financial resource be lacking, there may be deficiency in the investigation of proposals for the advancement of business, either from the standpoint of design or of new *clientèle*. Again, when an establishment is of immense proportions, and the head cannot give direct personal attention to all that is going forward, there is a tendency to overlapping, and perhaps to inefficiency, even although the assistants are numerous, capable, and well-intentioned. On the other hand, with a moderate-sized factory having a large continuous turnover, justifying the appointment of a staff including men of sound practical knowledge, as well as designers of creative ability, the probabilities are that there is more enthusiasm, more admirably-directed effort, and greater cohesion. These results are in large measure produced by continuous contact between the chief and his staff, and particularly by the amount of direct personal supervision he can give to the work in progress and to all negotiations, either in connection with labour or the satisfying of clients. The Wallsend Slipway and Engineering Works belong to this third class, and it is widely recognised that the success of the works, both from the constructional and commercial point of view, is largely due to the influence of Mr. Andrew Laing, the managing director, who has under him a staff well organised and perhaps more numerous than is to be found in works of corresponding size. This is due to the volume of work done rather than to the size of the establishment. The number of men employed averages at the present time 2430, as compared with 1800 in 1904, when we last wrote upon the works, and with 1165 in 1896. The roofed-in area of the factory has advanced practically in the same proportion since 1896. Now it is 287,927 sq. ft., as compared with 198,430 sq. ft. in 1904, and 132,590 sq. ft. in 1896. But the volume and value of the work done has enormously increased. This is due to improved mechanical equipment as well as to the type of work undertaken. The average production of new propelling machinery in the ten years ending 1896 was 26,145 horse-power. In the next ten years, however, this average had increased to 59,198 horse-power, whereas for the past seven years the average is 83,096 horse-power. On Table I. there is given a return of the output in each year since 1887. It is a striking fact that whereas in the first twenty years of the company's history the output was 432,273 horse-power, it has been 1,077,685 horse-power during the past fifteen years. Up to 1896 the largest engines made were of 4500 horse-power, since then sets of engines of 70,000 to 80,000 horse-power have been completed.

TABLE I.—*Return of Horse-Power Produced Each Year Since* 1887.

Year.	Total I.H.P. for Year.	Average I.H.P. for Each Set of Engines.	Maximum I.H.P. of Any One Set.
1887	17,750	1,200	2,925
1888	23,250	1,100	2,150
1889	39,750	1,420	2,260
1890	40,170	1,550	3,360
1891	34,220	1,500	3,300
1892	25,700	1,350	4,500
1893	16,640	1,850	3,000
1894	21,250	1,125	2,500
1895	29,260	1,725	3,000
1896	13,460	1,350	2,800
1897	22,675	1,625	5,000
1898	68,100	4,000	11,500
1899	67,600	3,400	12,000
1900	51,750	2,200	5,000
1901	46,650	2,350	4,500
1902	69,150	3,850	12,500
1903	42,360	2,500	6,600
1904	41,400	2,600	6,000
1905	66,800	3,200	23,000
1906	115,500	8,250	70,000
1907	70,100	5,390	23,500
1908	33,175	2,015	8,000
1909	55,800	4,295	22,000
1910	67,250	11,210	27,000
1911	72,800	4,550	14,500
1912	123,000	6,835	24,500
1913	159,550	9,385	66,000

The works were originally organised in 1871, primarily as a ship-repairing establishment, with slipways and repair-shops. The manufacture of new propelling engines for ships was commenced in 1874, when Mr. William Boyd became managing director. The company gradually won confidence, and from the outset did good work towards increasing the economy of the propelling machinery of the cargo and intermediate classes of ships. A new era opened in 1897, when Mr. Andrew Laing, formerly of the Fairfield Company, took over the management of the works. Soon afterwards the British Admiralty entrusted the company with orders for the construction of machinery for practically all types of warships built either at the Royal Dockyards or in private shipbuilding works. Most notable of the warships engined are the battleships Superb, Orion, Queen Elizabeth, and the Malaya, and of armoured cruisers the most notable is the Warrior, while a large number of torpedo-boat destroyers have also had their machinery from the Wallsend Works.

As regards the equipment of the works, perhaps the most eloquent testimony is the fact that the largest set of turbine-engines yet completed for a

British warship was despatched from the Wallsend Works within eleven months from the placing of the contract. In referring to the equipment, we propose to devote special attention to the extensions which have just been completed. In Figs. 1 and 2, on page 4, there are shown, drawn to the same scale, two key plans of the works, the former showing the size and arrangement of the works in 1896, and the latter at the present time. It will be seen that the slip-ways have been dispensed with. The Willington Gut is confined largely to ships undergoing repair, and a new jetty along the entire river frontage has been built for new ships. Instead of the old 80-ton sheerlegs there has been erected on the river side jetty a hammer-head electric crane which lifts 180 tons. The old engine-fitting shop was 279 ft. 6 in. long and 71 ft. 6 in. span, but alongside, occupying the site of the old brass foundry, coppersmiths' shop, and blacksmiths' shop, there has been erected a very fine and well-lighted shop by Sir W. Arrol and Co. This has from time to time been lengthened; the last extension, only recently carried out, being 90 ft., so that the shop now is 570 ft. long. In continuation of the old fitting-shop there has been erected a new machine-shop, which is only now completed, having a length of 390 ft. and a span of 69 ft. 9 in. No doubt the old fitting-shop will ultimately be reconstructed, so that the new machine-shop will then be 669 ft. in length. Alongside is now a shop for small machines; it is 450 ft. long. These new shops are seen in the distance to the right of the general view of the works taken from the river, Fig. 4, page 5, and the boiler works are immediately behind the hammer-head crane.

Interior views of the new engine-shops are given in Figs. 5 to 8, on Plates I. and II. In these shops is a collection of machines of various types for dealing with the largest turbines that are ever likely to be designed. Among the new tools in the machine-shop is a Barrow's patent turbine-boring machine, by Messrs. Shanks, of Johnstone. It has a traverse of 6 ft., including boring-stays, and the base-plate is 36 ft. long by 13 ft. wide. This is in addition to a machine fitted earlier for boring the casings and forming the grooves in them. This was a circular planing-machine by Messrs. Armstrong, Whitworth and Co., having a table 20 ft. in diameter, with an available height for work of 13 ft. For rotor-turning work there is a new Armstrong-Whitworth 60-in. lathe, having a bed 66 ft. 3 in. long, in addition to the large lathe which was installed by the same firm in 1904, and was then illustrated in ENGINEERING. The older tool takes work 18 ft. in diameter and 50 ft. long. Messrs. Armstrong, Whitworth and Co. have also delivered quite recently a 6 ft. planing-machine driven by a 30-horse-power motor, and another planing-machine to take work 4 ft. 6 in. by 4 ft. 6 in. high and 13 ft. long. Messrs. G. and A. Harvey have fitted a facing-lathe for turning, boring, and surfacing, the face-plate being suited for work 8 ft. in diameter, and a 4-ft. horizontal boring and facing machine. Another notable recent addition is a Shanks vertical and horizontal planing-machine, with a revolving table 7 ft. by 5 ft. For the erection and testing of turbines there has been fitted in the new shops a very well laid bed, to supersede the old wooden blocks formerly used. The new bed consists of twenty-three cast-iron girders, of a collective weight of 55 tons, and ensures an absolutely true surface.

The latest addition to the machine-shop is illustrated in Fig. 5, Plate I. This shop is 390 ft. long and 69 ft. 9 in. span. To the right in the view there will be seen one of the large turbine-lathes, while beyond there is a turbine-rotor on the balancing-bed, and still further in the distance the first of the Diesel engines made by the firm. The small machine-shop is situated parallel with and to the left of this view, and of this bay a view is given in Fig. 6. It is 451 ft. long and of 30 ft. 9 in. span. The character of the work done is indicated by the collection of parts shown in the view. The new erecting-shop is illustrated by Figs. 7 and 8, Plate II. This shop is 570 ft. long and of 55 ft. span. To the left of Fig. 7 there is seen part of one of the large turbine-lathes—that with 6-ft. centres and 66-ft. 3-in. bed. Beyond is a series of horizontal and radial boring-machines, while to the right, in the foreground, is a vertical and horizontal planer working on a sole-plate, and beyond it three turbine-casing boring-mills. In the distance will be seen turbines in various stages of construction. These are better seen in Fig. 8. The turbine on the left of this view is being water-tested, and on the right there will be seen a portion of a turbine gear-case in the boring-mill. The overhead cranes in these new shops are all of 75-ton lifting power, the newer ones being by Messrs. Armstrong, Whitworth and Co.

The boiler-shop has also been extended. Twenty years ago the average number of boilers made was 30 per annum; now the number is 77. The boiler-shop is in two sections, one 328 ft. long and 70 ft. span, for the erection work, and the other, 257 ft. 6 in. long, in three spans, respectively 31 ft. 6 in., 47 ft. 9 in., and 28 ft. 3 in., for machine work. Parallel with the latter is the light plate-work shed; uptakes, funnels, &c., are assembled in the yard adjoining this shed. As to the equipment, it may be said that the plate-edge planer takes plates 35 ft. long, the vertical plate-bending rolls deal with plates 12 ft. 6 in. wide, and the hydraulic riveting-machine has a gap of 12 ft. Over this latter there has just been erected a Royce electric-crane of 60 tons lifting power; another addition is a 6-in. spindle high-speed drilling-machine, by Buckton, for nickel steel plates. In connection with the hydraulic machine-tools there have been laid down recently by Arrol two sets of three-throw electrically-driven hydraulic pumps, each set being capable of delivering 60 gallons per minute at a working pressure of 1500 lb. per sq. in. There is also a new accumulator, with a ram 14 in. in diameter, adapted for a 16-ft. stroke. There has also been added a two-stage, two-crank air-compressor by Belliss and Morcom. At the end of the boiler-shop there has been built an annexe to accommodate the plant for electro-zincing boiler-tubes, including a three-phase motor and special dynamo by Messrs. Clarke, Chapman and Co.

The iron foundry is 198 ft. 6 in. long, and deals with castings up to 30 tons, while in the brass foundry and coppersmithy the two bays have been extended 60 ft., and additional machine-tools fitted. Another recent improvement is the new general store—a two-storey building, 93 ft. long, 77 ft. 6 in. wide, and 28 ft. 10½ in. high. It is specially heated, and the racks are commanded by a Royce electric jib-crane. A new electric fire-pump has been added.

An interesting feature is that, although the works are entirely run by electric current from the public supply works, the recently-built shops are lighted by high-pressure gas; the old burner-bracket, it is held, confers advantages in the illumination temporarily of the dark recesses of machines or jobs, while the general lighting is said to be steadier than with the electric arc-lamps.

The jetties built along the river front on each side of the graving-dock take ships 700 ft. or 800 ft. long, while the 180-ton hammer-head crane, built by Arrol, has sufficient outreach to command two ships of fairly wide beam. To facilitate the berthing of ships there are three sets of mooring buoys in the river, as shown in the plan. The railway lines to the jetties pass through all the shops, so that the transport of material to the ships is a simple matter. With its graving-dock to take ships 540 ft. long, and the berthage in the Willington Gut, the works are well supplied with accommodation for ships fitting out or being repaired, while the improvements in the plan of the works and in their equipment, to which we have referred, show that a progresive policy is being pursued as vigorously now as during the past fifteen years.

THE NEW JOINT DOCK AT HULL.

(*Concluded from page 867, vol. xcvii.*)

CONTINUING our description of the equipment of the new dock, we may now say something of the pumping machinery for the graving-docks, which was supplied by Messrs. W. H. Allen, Son and Co., Limited, of Bedford. It will be remembered that the installation is electrically driven from a 440-volt direct-current dock system. It consists of two main centrifugal pumps and motors with switch-gear, a drainage-pump and charging-pump, with motors and switch-gear, and, of course, the necessary pipe-work and valves. Messrs. Allen supplied the whole equipment. It is contained in a chamber formed in the wall between the two graving-docks, and is well shown in Fig. 76, on page 8, which is a view inside the chamber. The lay-out is shown in greater detail in Figs. 72 to 74, on page 7. The main pumps are of the "Conqueror" centrifugal type and have suction and discharge branches, 42 in. in diameter. Each pump discharges a mean quantity of 36,000 gallons of water per minute against a head of 40 ft. The pumps run at a speed of 375 to 416 revolutions per minute, and each absorbs a maximum horse-power of 390. The casings and discs are of cast iron, and the spindles are of steel. The spindles run in ring-lubricated bearings, arranged entirely outside the casings. One of the pumps is illustrated separately in Fig. 75.

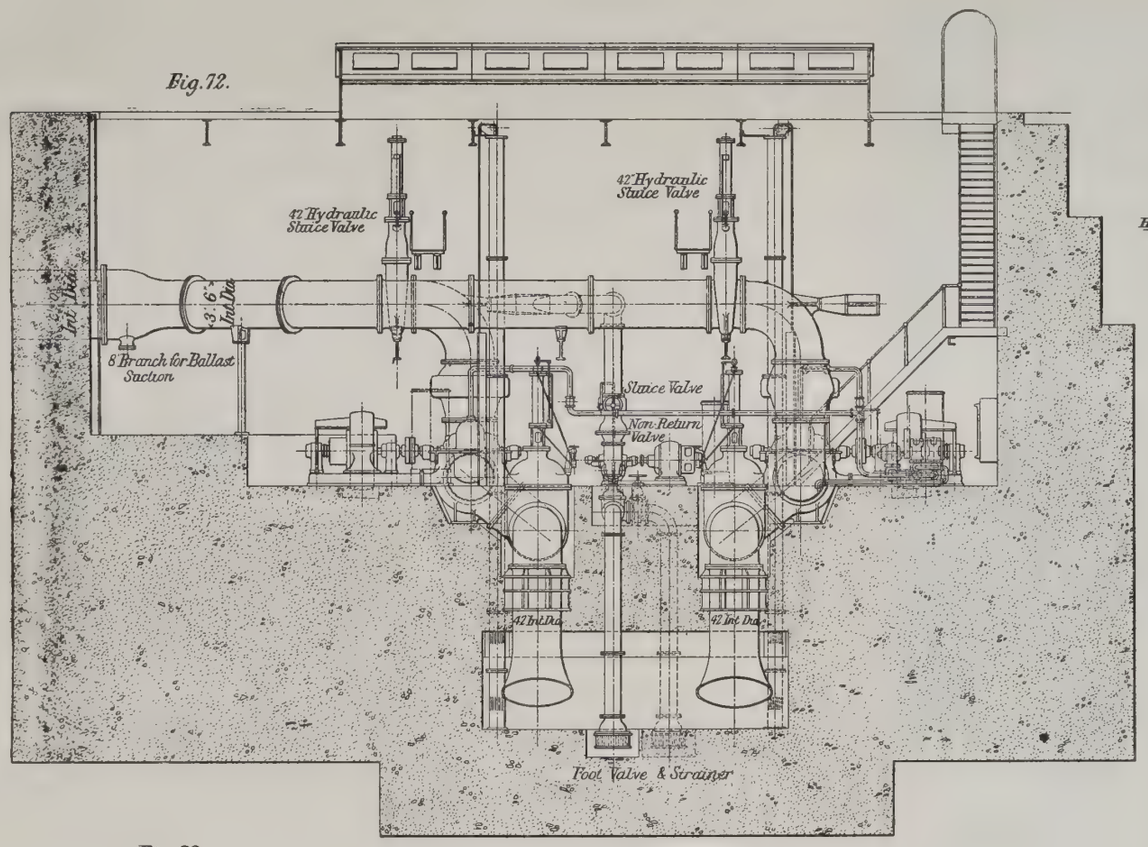
Each pump is driven by a 420-brake-horse-power open-type motor, fitted with shields to prevent water dripping on the windings. This is well shown in the foreground of Fig. 76. The starting-gear for each motor consists of an ironclad pillar containing a multiple-lever starter, formed of a series of edgewise-type switches. Step-by-step operation by means of a slow-motion ratchet-type handle is fitted. This handle actuates a double-pole magnetic blow-out circuit-breaker which interlocks with the starter, so that the breaker can only be put on when the starter is off, and so that the breaker is tripped and cannot be put on again until the starter is returned to the off position in the event of the attendant failing to complete the operation of starting. One of the pillars can be seen to the right-hand side of Fig. 76.

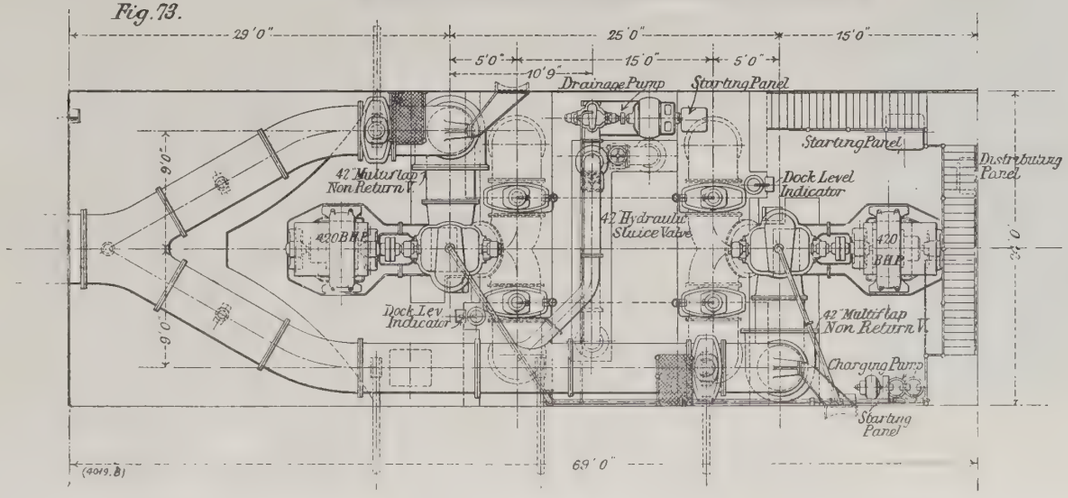
The lay-out of the pipe-work is clearly shown in Figs. 72 to 74. The suction and discharge-pipes of each pump are of cast iron, and are 42 in. in diameter. They merge into a main discharge 60 in. in diameter. Hydraulically-operated sluice-valves are fitted on the suction and discharge sides of the pumps, and so arranged that each pump may draw water from either dock as required. This will be quite clear from the figures. The sluice-valves are 42 in. in diameter, and are arranged to work from the 750 lb. per sq. in. pressure mains which feed the dock-gate operating machinery. They are provided with controlling-valves. A retaining-valve of the multi-flap type with cast-iron casing is fitted on the discharge side of each main pump. The drainage pump has suction and discharge-pipes, 14 in. in diameter, and delivers 3000 gallons of water per minute against a total suction and delivery head of 54 ft. The discharge is carried to one of the 42-in. discharges of the main pumps, as is shown in Fig. 74. The pump-casing is of cast iron, the disc of gun-metal, and the spindle of manganese bronze. The speed of the pump is 1100 revolutions per minute, and it is driven by a semi-enclosed motor of 75 brake horse-power. The charging-pump, which can be seen in the lower right-hand corner of Fig. 74, is of the two-throw single-acting type, with barrels 8 in. in diameter by 5 in. stroke. It is capable of charging the main and drainage pumps and pipe-work in a few minutes. It is driven by a semi-enclosed motor at 750 revolutions per minute. Air-vent pipes have been provided to free the suction culvert from air, and water-level indicators are fitted showing the level of water in the graving docks and outside. One of them can be seen in Fig. 76.

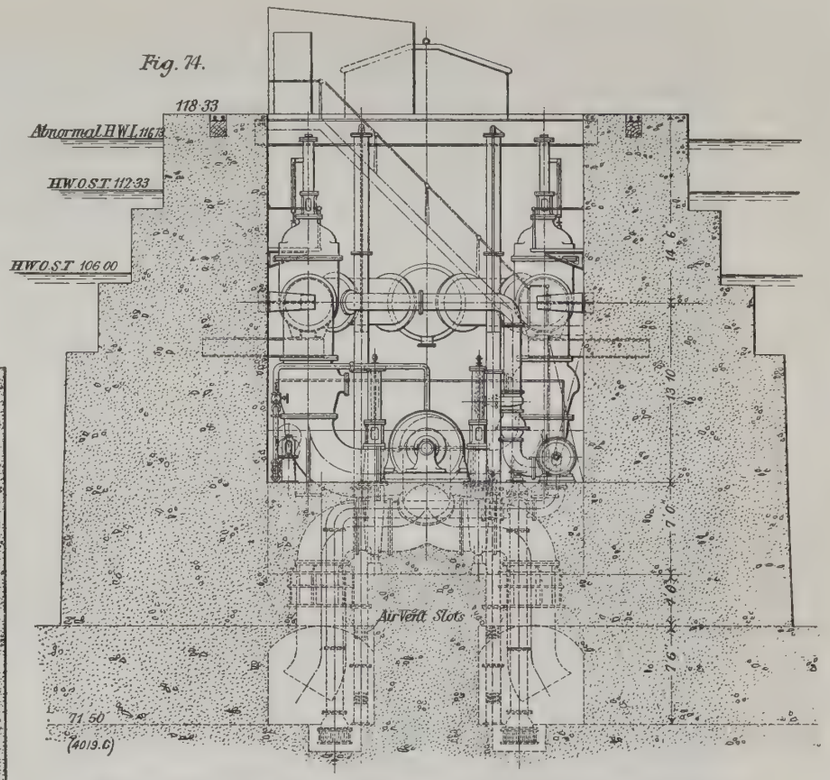
The only features of the equipment of the dock with which we have still to deal are the coal-handling arrangements and the warehouse and quay cranes. We have already referred briefly to the coal-handling plant. It is fixed on the north sides of the main basin and of the north-east arm, and consists of two electrically-driven belt-conveyors and two hydraulic coal-tips. The number of conveyors will ultimately be extended to five. Each has a capacity of 800 tons an hour. The arrangement in each case consists of a tipping-bin situated under a railway siding lying on a gradient. Above the bin there is a tipping-door, and on each side of it a tipping-table lying in the line of the track. Two loaded wagons will be dealt with at a time, and will be run down the gradient under the control of their hand-brakes. On arriving over the bin their contents will be tipped through their bottom doors, if these are fitted, through a hatch into the bin. If end-tipping wagons are in use, they will be up-ended by the tipping-tables, and will discharge through the same hatch. The wagons will then pass on down the gradient, and a second pair will come into position. At the bottom of the bin there is a steel-belt conveyor, which will carry the coal to the quay side, and discharge it through a chute to the ship. The conveyor is carried in a lattice-work girder framework on steel towers, and gradually lifts the coal from the level of the bin below the sidings to a height convenient for discharging to a ship's hold. The quay-side tower carrying the last section of girder framework is fitted with operating gear for altering the level

THE NEW JOINT DOCK AT HULL; PUMPING PLANT FOR GRAVING-DOCKS.

CONSTRUCTED BY MESSRS. W. H. ALLEN, SON AND CO., LIMITED, ENGINEERS, BEDFORD.







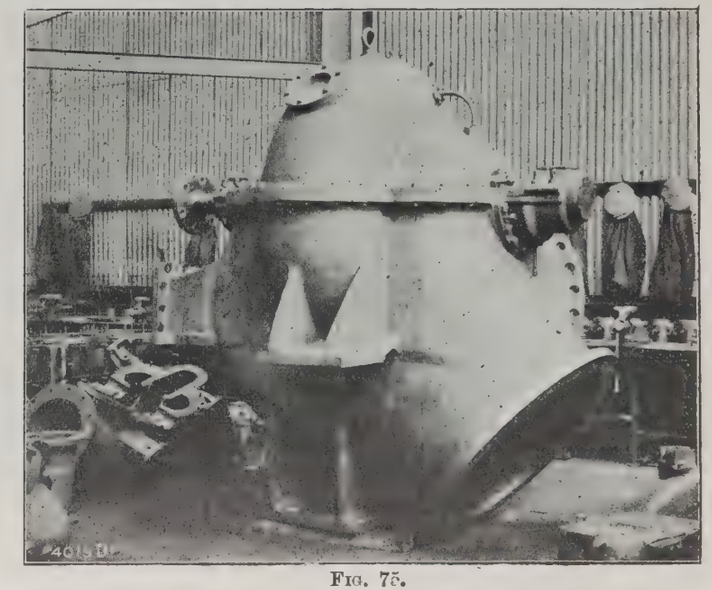


FIG. 75.

THE NEW JOINT DOCK AT HULL.

MESSRS. T. M. NEWELL AND R PAWLEY, MM. INST. C. E., ENGINEERS.

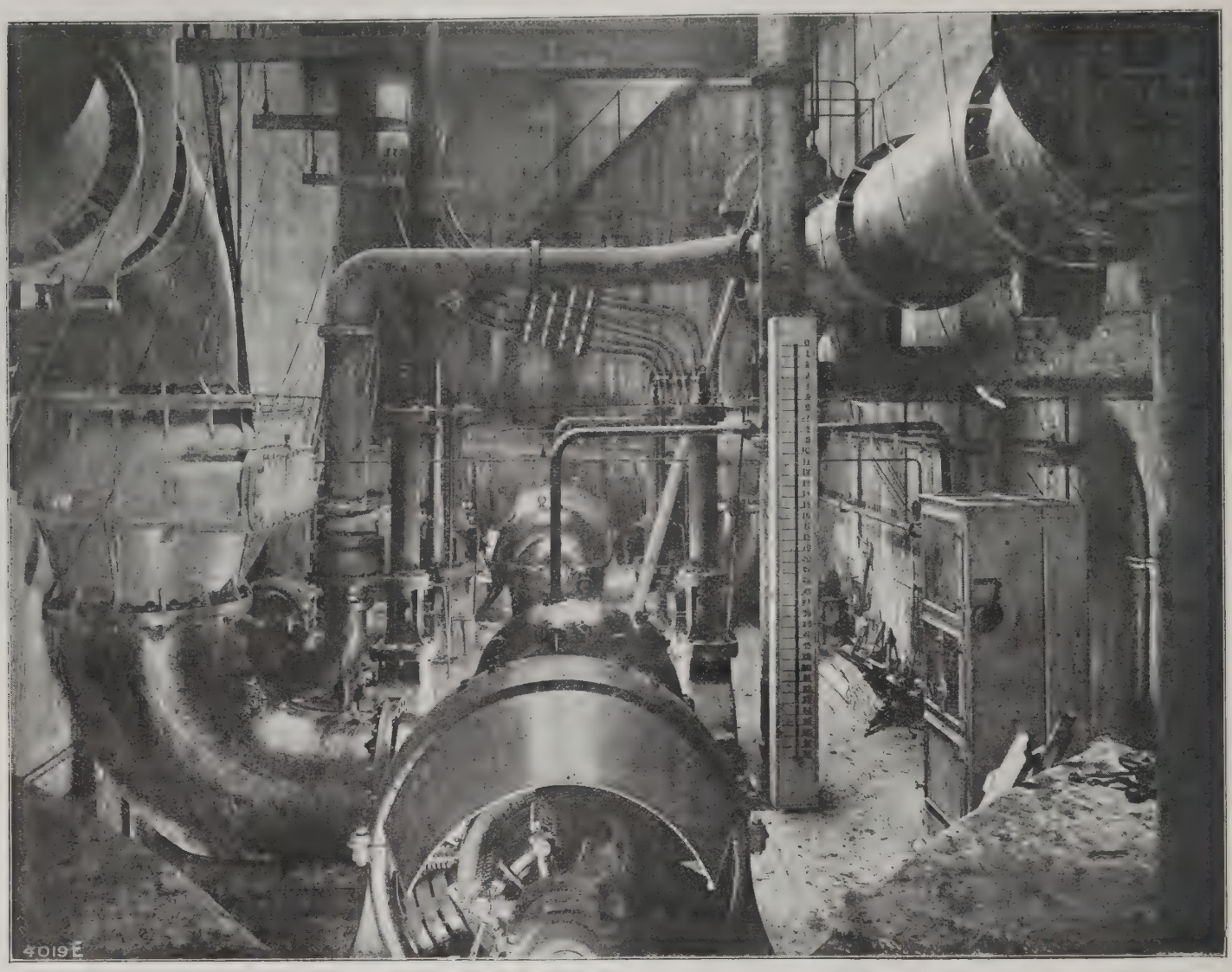


FIG. 76. PUMPING PLANT FOR GRAVING-DOCKS; MESSRS. W. H. ALLEN, SON AND CO., LIMITED, BEDFORD.

of discharge and controlling the position of the chute. The maximum height of delivery from high water of ordinary spring tides is 66 ft. at 28 ft. out. The adjustment in the length of the chute is 13 ft., and it is capable of a lateral movement over 20 deg. The conveyors were supplied by Messrs. Head, Wrightson and Co., Limited, of Thornaby-on-Tees.

The other part of the coal-handling plant consists of two hydraulic coal-hoists, built by Messrs. Sir W. G. Armstrong, Whitworth and Co., Ltd., of Newcastle-on-Tyne. One of them is fixed and the other is movable along the quay side, so that the hoists can be used for loading either one or two ships. Each hoist has a capacity of 500 tons an hour. A view of the hoists during erection is given in Fig. 82, on page 9, while general arrangement drawings of the movable type are given in Figs. 77 to 80, on Plate III., and a drawing of the upper part of the fixed coal-hoist is given in Fig. 81. The hoists are each double-powered and are arranged to deal with wagons of a gross weight of either 25 or 35 tons. The maximum lift from quay-level for the fixed hoist is 72 ft., and the maximum height of delivery from high water of ordinary spring tides 55 ft. The maximum lift from quay-level for the movable hoist is 57 ft. In each case the maximum distance of delivery out from the quay is 28 ft., the adjustment in the length of the chute 13 ft., and the lateral movement of the chute 20 deg.

The constructional features of the moving hoist will be followed from the figures on Plate III. The fixed hoist is generally the same both in lay-out and details, except that it is rather higher, and that holding-down bolts embedded in the concrete take the place of the travelling bogies. We will refer for the remainder of our description to the travelling-hoist shown in the figures. As will be seen, the framework is of steel plates and sections. It is constructed with a free central space, in which the cradle travels in guides. The cradle itself is in essence a platform built up of joists, and having an inverted V frame at each side. These frames carry a cross-bar at their outer end, to which the lifting-ropes are attached. The cradle carries a pair of rails for the wagon being lifted, the rails being turned up at their outer end to form a stop when the cradle is tilted for tipping. The wagon being dealt with is secured to the cradle by chains. Underneath the cradle there is a hopper for dealing with hopper-wagons, an automatic tumbling-apron being fitted to bridge over the space between the lower edge of the hopper and the heel end of the main chute.

The cradle is lifted by three hydraulic rams fixed vertically on one side of the framework. They can best be seen at the left-hand side of Fig. 78. The object in fitting three rams is to save water when less than the maximum load is being dealt with, as in this case all the cylinders need not be used. The main lifting ropes are 7½ in. in circumference. As is well shown in the figures, they are taken over a pair of large sheaves carried at the top of the framework, and are secured to the centre of the top cross-beam of the cage. Multiplying sheaves are fitted for the lifting ropes, the ratio being 2 to 1. One of the lifting cylinders is arranged to be in constant communication with the accumulator. This cylinder balances the weight, the other cylinders supplying the extra power necessary for lifting. The speed of lifting is 180 ft. a minute. The hydraulic cylinder, for tipping the cradle, is placed over the lifting cylinders. It is fitted with 2 to 1 multiplying gear, and operates through a steel rope 4¾ in. in circumference. The arrangement of the lifting and tipping ropes allows the cradle to be tipped at any part of its vertical travel.

The chute is of steel plate and angles, and is fitted with anti-breaking doors at its front end, by which the flow of coal can be regulated. The chute is raised or lowered by temporarily attaching it to the cradle by hinged pawls. Its outer end is raised or lowered, to suit the conditions of working, by means of a wire-rope, 3½ in. in circumference, which is connected to an hydraulic cylinder fixed on the back of the hoist framework. The arrangement is clearly indicated in Fig. 77. Multiplying gear, having a ratio 8 to 1, is fitted to the ram. A lengthening piece, 6 ft. long, is fitted to the chute, its position being controlled by hand-gear. Pressure-water supply to the hoist is obtained through stand-pipes, which are shown in Fig. 78. Connection can be made at various points on the dock-quay.

A very complete arrangement of gantries and sidings has been laid down for the handling of the coal-wagons to and from the hoist. The loaded wagons come along the quay-side and mount a traverser which lifts them the few inches necessary to the level of the cradle platform when in its bottom position. The traverser has to be set only once to suit the position of the hoist, and is not moved as each wagon comes on to it. The traverser has a turntable at its far end, opposite the hoist, and wagons run along it to this table, are turned through 90 deg., and run on to the cradle. They are lifted and tipped, and then lowered to the level of a gantry carrying a second traverser with a turntable. This is partly shown in Fig. 77. The wagons run off on to the turntable, are turned through 90 deg., and move along the gantry to a dead end. Here they reverse their direction, and coming back run on to a branch gantry, which

THE NEW JOINT DOCK AT HULL; HYD

CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITW

(*For Descr*

Fig. 77.

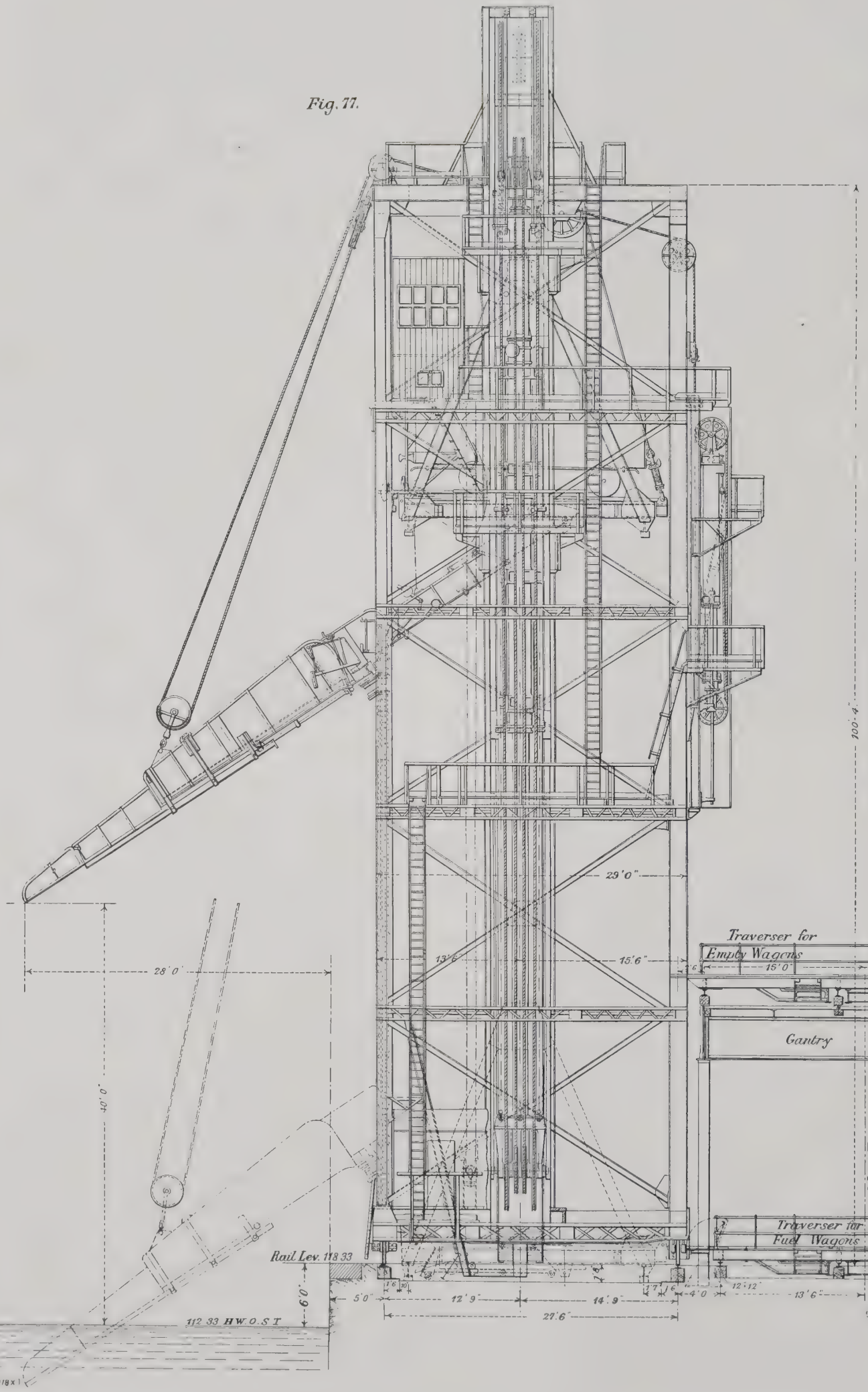
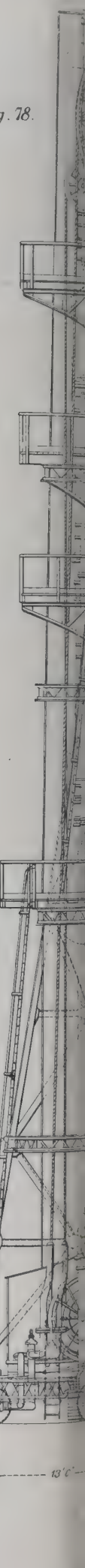


Fig. 78.



LIC TIPPING-HOISTS ON COALING-QUAY.

ND CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE.

(Page 8.)

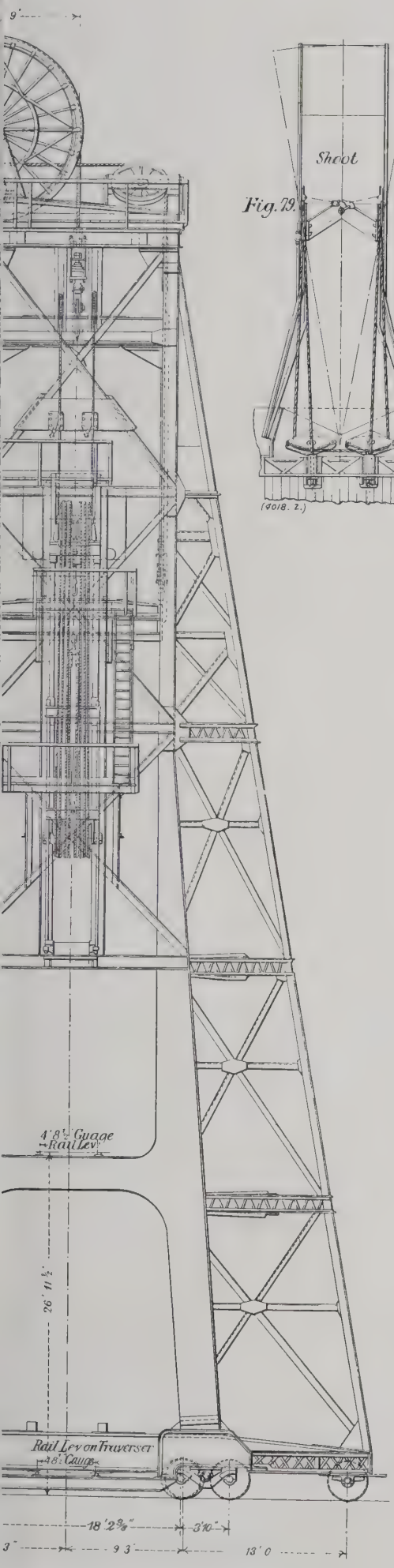


Fig. 79.

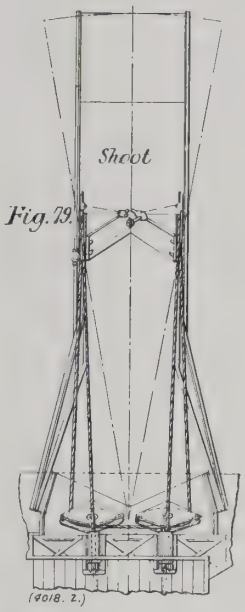


Fig. 80.

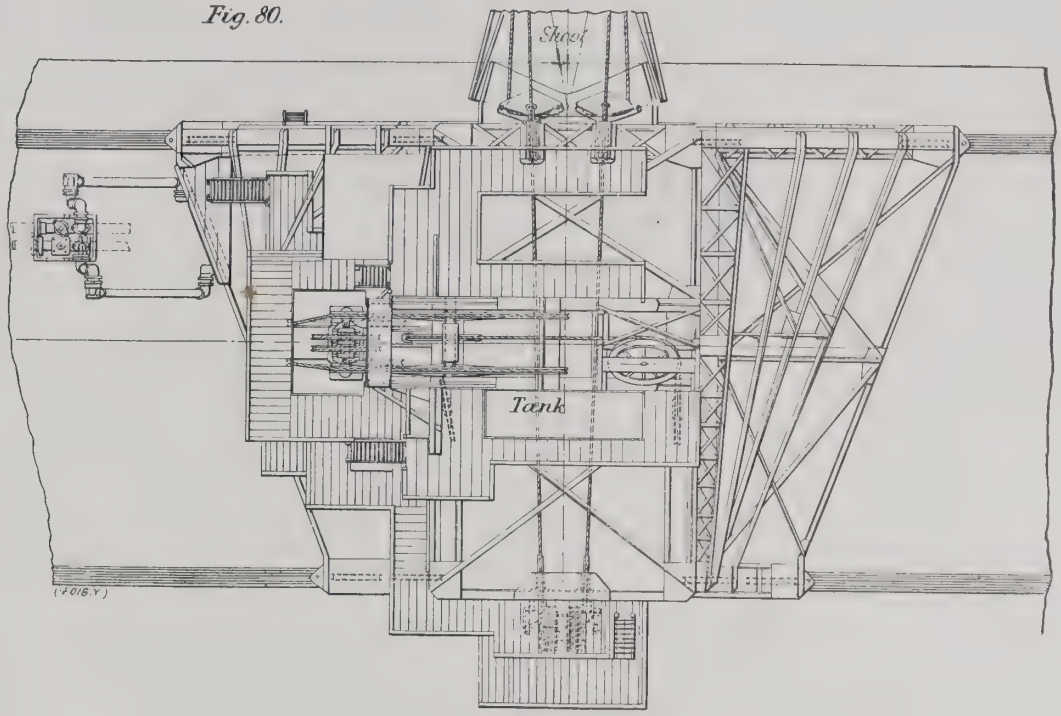


Fig. 81.

THE NEW JOINT DOCK AT HULL.

MESSRS. T. M. NEWELL AND R. PAWLEY, MM. INST. C. E., ENGINEERS.

FIG. 82. COALING-QUAY WITH HYDRAULIC TIPPING-HOISTS.

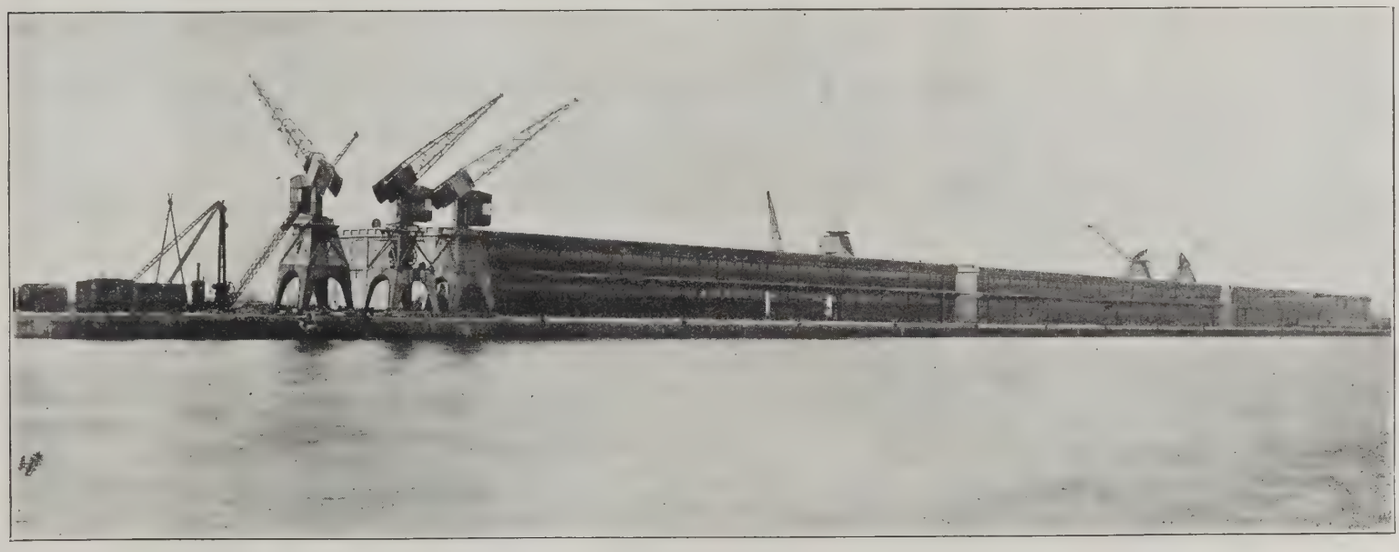


FIG. 83. FERRO-CONCRETE WAREHOUSES ON NO. 3 QUAY.

carries them away to the marshalling sidings. A somewhat similar arrangement is used for the fixed hoist, but the gantry carries no turntable, and the wagons run straight away from the hoist and the siding. The whole lay-out is very ingenious, and should prove very convenient and speedy in practice.

Concluding our description of the dock with some reference to the crane equipment, we may say that present plans allow for the fitting of nine 10-ton, four 7-ton, thirty 3-ton, and nine 1½-ton electric cranes, and one 80-ton floating-crane. The floating-crane, which is intended for general service in the dock, is being built by Messrs. Werf Gusto (A. F. Smulders, of Schiedam, Holland). Of the electric cranes, twenty-five are at present being supplied by Messrs. Royce, Limited, of Trafford Park, Manchester, and fifteen by Messrs. Craven Brothers, of Vauxhall Works, Reddish, Stockport. The electric cranes are distributed over four quays and on the roofs of the warehouses which line two sides of the north-west arm. All are of the travelling type, and the arrangement allows of one 10-ton and three 3-ton cranes working cargo to or from the same ship. The roof-cranes handle cargo from the wharf-cranes, and lift it over the warehouses on the far side, or from the warehouses themselves through the hatches in the flat roof. An idea of the crane distribution is given by Fig. 82, annexed, which shows the south quay of the north-west arm. It should be understood, however, that the crane equipment shown in this figure is not complete, and that the wharf-cranes will be distributed along the whole length of the quay.

The general design of the twenty-five 3-ton cranes, supplied by Messrs. Royce, is illustrated in Fig. 84, on page 10. They are fitted with Musker-Davidson luffing-gear. The maximum radius of the jib is 50 ft., and the minimum 20 ft.; the luffing speed is 150 ft. per minute; the hoisting speed with 3 tons is 150 ft. per minute, and with 1½ tons 250 ft. per minute. The slewing speed is 400 ft. per minute, and the travelling speed 30 ft. per minute. The height from the crane-rails to the point of the jib at maximum radius is 80 ft. The travelling-rails are at 15 ft. centres, and the wheel base of each

crane is 19 ft. The motors, which are of the totally-enclosed type with 6-hour rating, operate from the 440-volt direct-current supply. The hoisting motor is 45 horse-power, the slewing 5 brake horse-power, and the luffing and travelling each 8 brake horse-power. Tramway-type controllers are fitted. Current is conveyed to the cranes through armoured cable from plug-boxes fixed at intervals along the quay, and each crane is provided for this purpose with a revolving cable drum on one of the bottom carriages.

Each crane is supported on four cast-steel travelling-wheels with single flanges on the inside. The travelling motion is fitted with hand-gear. Automatic electrical safeguards against overrunning in either direction are provided for the hoisting and luffing motions. All the toothed gear on the cranes are of machine-cut cast steel, except the motor pinions, which are of raw hide. Each motion is fitted with an electric brake, and in the case of the hoisting motion a foot-brake is also provided on the barrel shaft, for quick lowering without current. In such circumstances the electric brake is held off by a hand release attachment. The gear for hoisting, slewing, and luffing is carried on a central revolving mast which is pivoted and supported at the foot in a cast-steel bearing, and at about the centre of its length by a roller-path. The jib is carried at the top end of the mast by a heavy fixed shaft, and is balanced by cast-iron weights fixed at the tail end of the jib structure. The special advantage of the luffing arrangements is that the load during luffing is not lifted, as in the ordinary jib-crane, but moves in a horizontal line. As a consequence there is considerable saving in power, and a small luffing motor only is required. In addition quick luffing is permissible. We have described the Musker-Davidson gear in detail in the past. The cranes were tested for stability by hanging a load of 6 tons on the hook at the extreme radius in any position of the jib. No jacks or rail-clips were used, and there was no indication of the slightest lift in the structure or the wheels.

Of the cranes supplied by Messrs. Craven Brothers, nine are of 10 tons capacity, and were, in general, of somewhat the same type as those of Messrs. Royce, just described. Five are situated on the south quay and four on the north quay of the north-west arm. They are fitted with Musker-Davidson luffing-gear. Two of the cranes on the north quay and all the five on the south are fitted with telescopic grain-elevators, which are carried by supplementary jibs at the back of the centre vertical post. When not in use the elevator-jibs are derricked to the "in" position, raising the elevators and stowing them alongside the central mast. The cranes are then ready for the ordinary work of cargo-handling. Similarly, when the elevators are put into action the main jib is derricked up to the "in" position. The elevators were manufactured by Messrs. Henry Simon, Limited, of Manchester, and are each capable of discharging 120 tons of bulk grain per hour. They are driven by separate motors and discharge grain down chutes alongside the gantry into the grain subways that we dealt with in our previous article. The speeds of movement of the 10-ton cranes are as follow:—Hoisting 10 tons, 50 ft. per minute; hoisting 3 tons, 150 ft. per minute; luffing speed with full load, 100 ft. per minute; slewing speed with hook at maximum radius at full load, 300 ft. per minute; travelling speed without load, 30 ft. per minute.

Of the 1½-ton roof cranes, three are placed on the roof of the two-storey warehouses of the south quay, and three on the roof of the single-storied warehouse on the north quay. The former cranes have a maximum radius of 47 ft. 10½ in., and the latter a radius of 57 ft. 10½ in. Some of the cranes in position on the south quay can be seen in Fig. 83. The cranes are carried on tracks along the outer edge of the warehouses, the rail centres being 20 ft. 7½ in. The cranes have hoisting, slewing, luffing and travelling motions of the following maximum speeds:—Hoisting with full load, 250 ft. per minute; luffing with full load, 200 ft. per minute; slewing with hook at maximum radius at full load, 450 ft. per minute; travelling without load, 50 ft. per minute. The cranes luff in to a minimum radius of 20 ft. and 25 ft. respectively, and the luffing motion is worked on Messrs. Craven's patent system, by means of which the load is traversed in or out in a horizontal line while luffing. This feature is obtained solely by a beam pivoted at the jib-head, and carrying the jib-sheave at its lower end. A radius rope attached to its upper end is anchored to an A-frame fixed on the revolving superstructure. The sheave is constrained to move in a parabolic path, having a certain relationship to the position of the barrel, which makes the sum of the distances from the barrel to the sheave and from the sheave to the snatch-block, constant throughout the range of derricking. The cranes are of the plated gantry ported type mounted on four travelling wheels, the revolving superstructure being carried on a pivoted centre-post resting at the bottom on a compensating foot-step bearing and guided by back and front rollers inside a vertical roller-path at the top of the gantry. The roller-path also forms a pin-rack for the slewing motion.

THE NEW JOINT DOCK AT HULL.

MESSRS. T. M. NEWELL AND R. PAWLEY, MM. INST. C.E., ENGINEERS.

FIG. 84. 3-TON ELECTRIC JIB-CRANE; MESSRS. ROYCE, LIMITED, MANCHESTER.

THE ENGINEERING DEPARTMENTS AT ARMSTRONG COLLEGE, NEWCASTLE-ON-TYNE.

AN important addition has been made to the already highly satisfactory equipment of Armstrong College in the University of Durham, in the form of an hydraulic laboratory, which has been built parallel to the existing mechanical laboratory. This addition makes more interesting the fact that the inaugural meeting of next week's conference of naval architects will be held in the King's Hall at the College, and that the laboratories will be open for inspection throughout the meetings. Armstrong College is one of the most successful and serviceable of the colleges of science which have grown up in recent years in the provinces, because it brings conveniences for pursuing a study of theoretical work within the reach of those trained on the practical side in the various factories on the North-East Coast. Time was when if, say, a draughtsman was wanted for any of the shipbuilding or marine engineering establishments on the Tyne and Wear, employers had to look to the Clyde and older districts. But, largely as a consequence of the work done at Armstrong College, it is now possible to find in the district men thoroughly capable not only of continuing the traditions of the North-East Coast establishments, but of assisting the advance in recent years towards the improvement in the class of work done.

Armstrong College is, perhaps, wider in its scope than some of the other corresponding institutions in the provinces, as it embraces in its purview every department of the arts and sciences, and fulfils also the function of a normal college for the training of teachers for primary and secondary schools. Degrees are given in practically every department of mental activity. In connection with the agricultural department, much useful advisory work is done in agricultural chemistry, agricultural botany, zoology and forestry, and a live-stock officer gives practical advice throughout the four northern counties. Last year, too, a most promising faculty of commerce was organised, so that it will be seen that Principal W. H. Hadow fully realises the possibilities of the College in its relation to the industries of the district. We are here, however, concerned primarily with the applied science work, and especially the engineering and

THE ENGINEERING LABORATORIES AT THE ARMSTRONG COLLEGE, NEWCASTLE-ON-TYNE.

(*For Description, see Page* 10.)

FIG. 1. GENERAL VIEW OF THE COLLEGE.

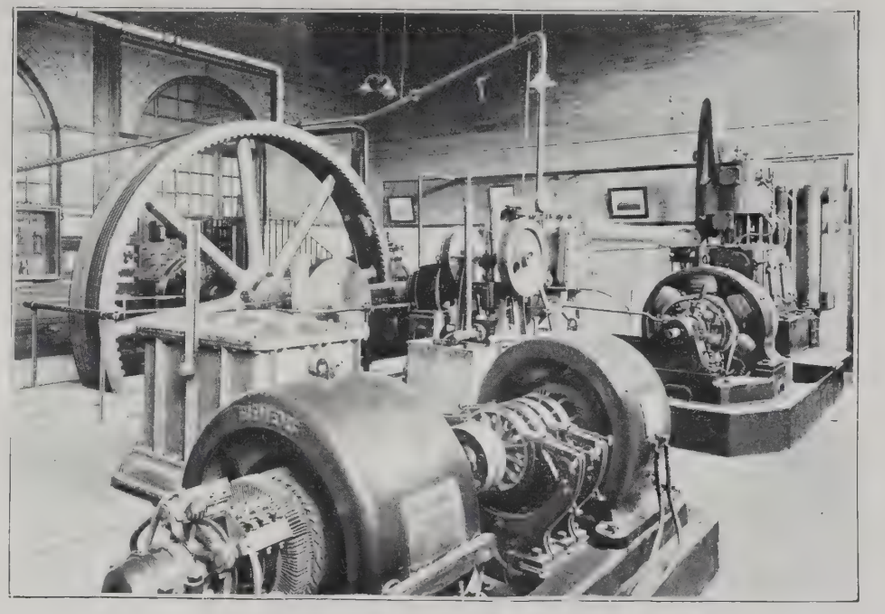


FIG. 2. ENGINE AND DYNAMO-ROOM.

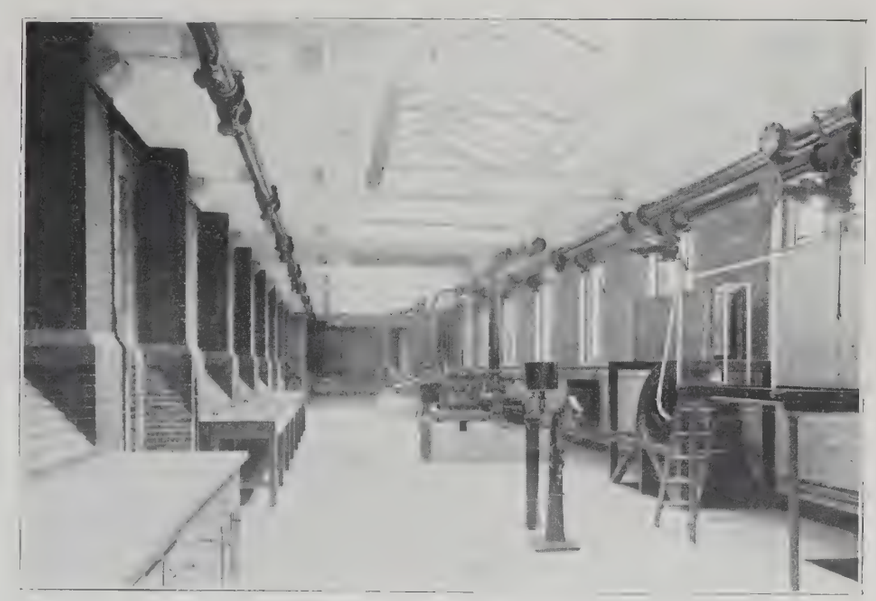


FIG. 3. HYDRAULIC LABORATORY.

FIG. 4. HYDRAULIC LABORATORY.

THE ENGINEERING LABORATORIES AT THE ARMSTRONG COLLEGE, NEWCASTLE-ON-TYNE.

(For Description, see Page 10.)

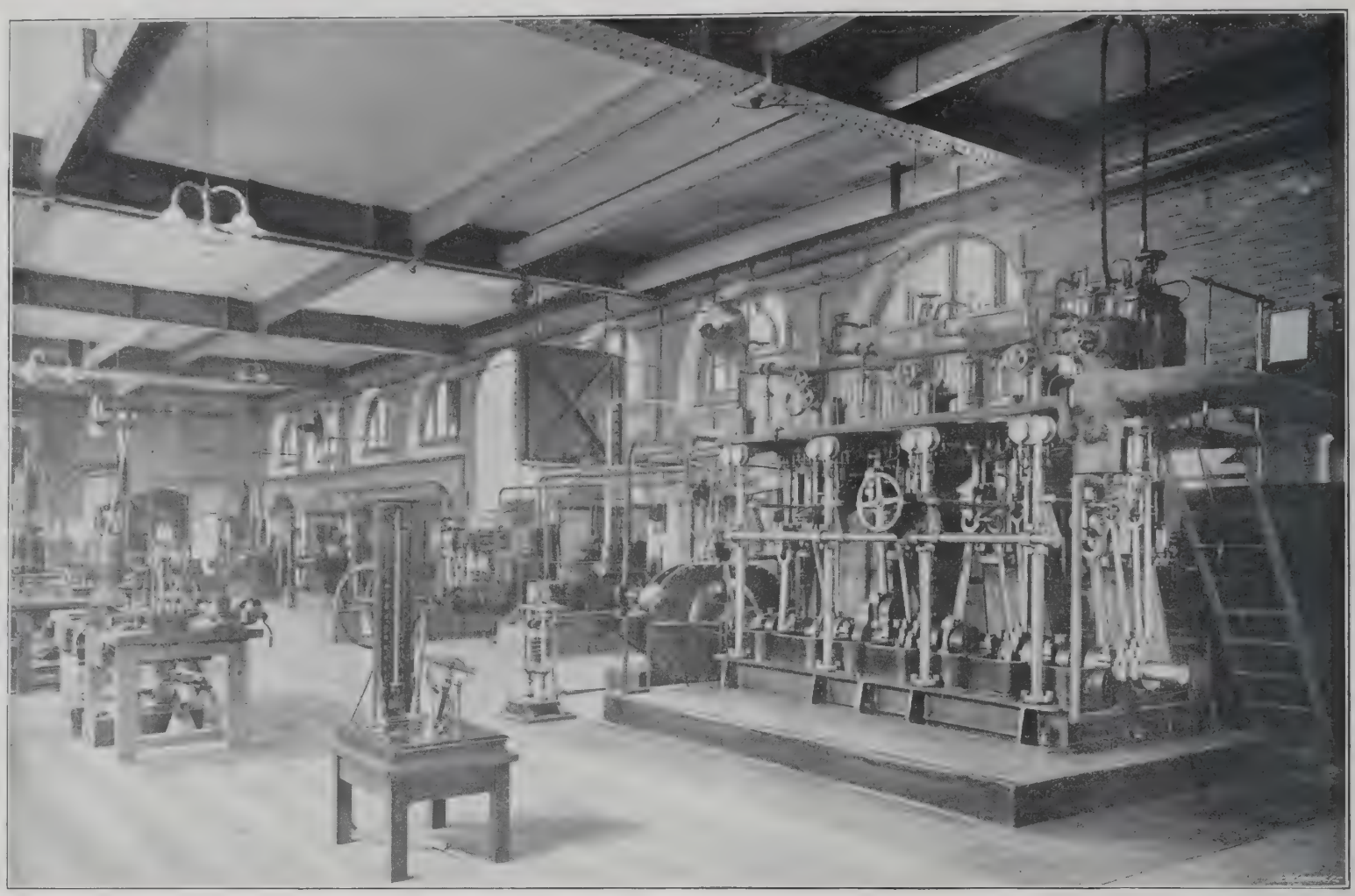


FIG. 5. MECHANICAL LABORATORY, SHOWING EXPERIMENTAL MARINE ENGINES.

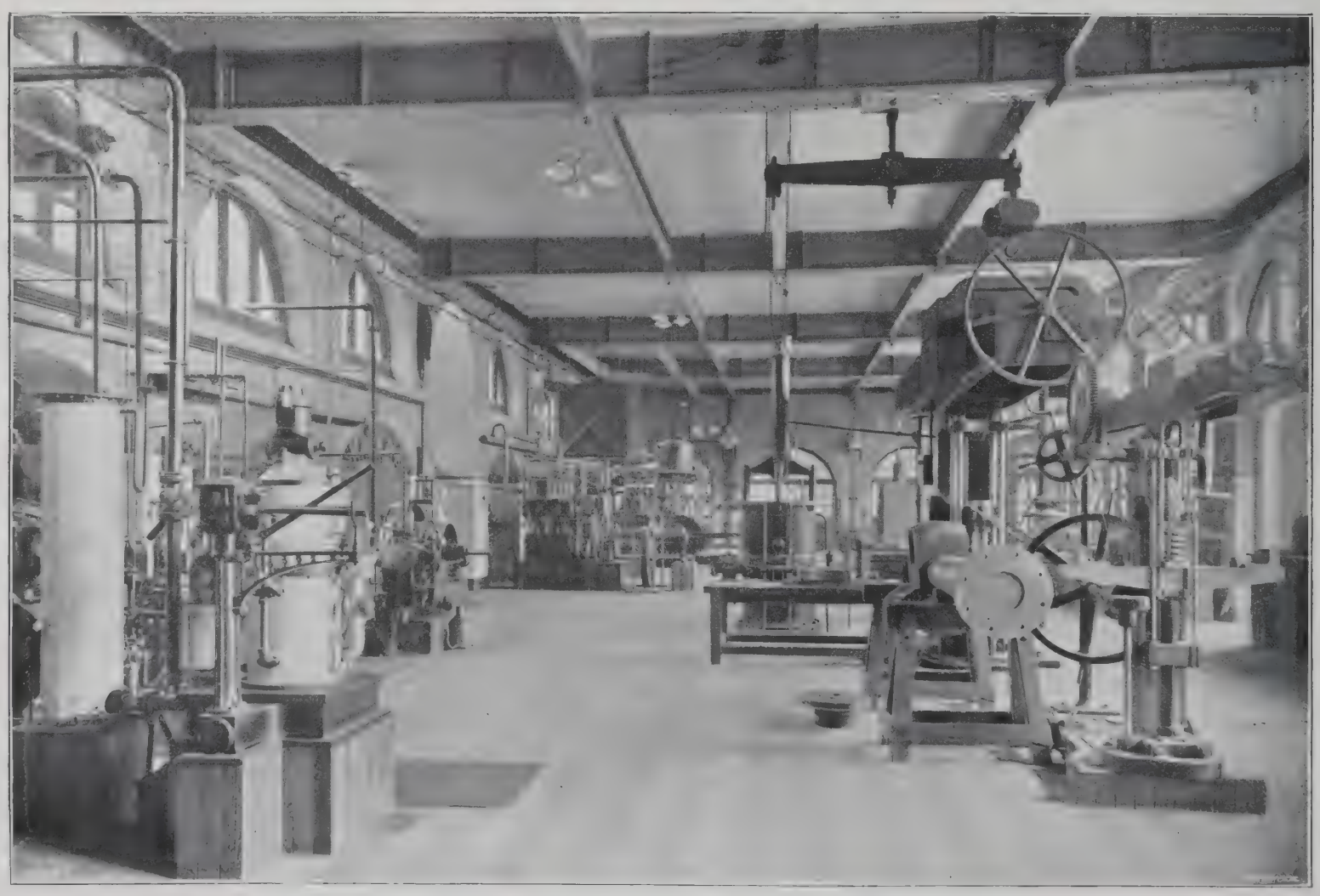


FIG. 6. MECHANICAL LABORATORY, WITH 100-TON BUCKTON TESTING-MACHINE.

(To Face Page 11.)

THE PANAMA CANAL.

(*For Description, see Page* 12.)

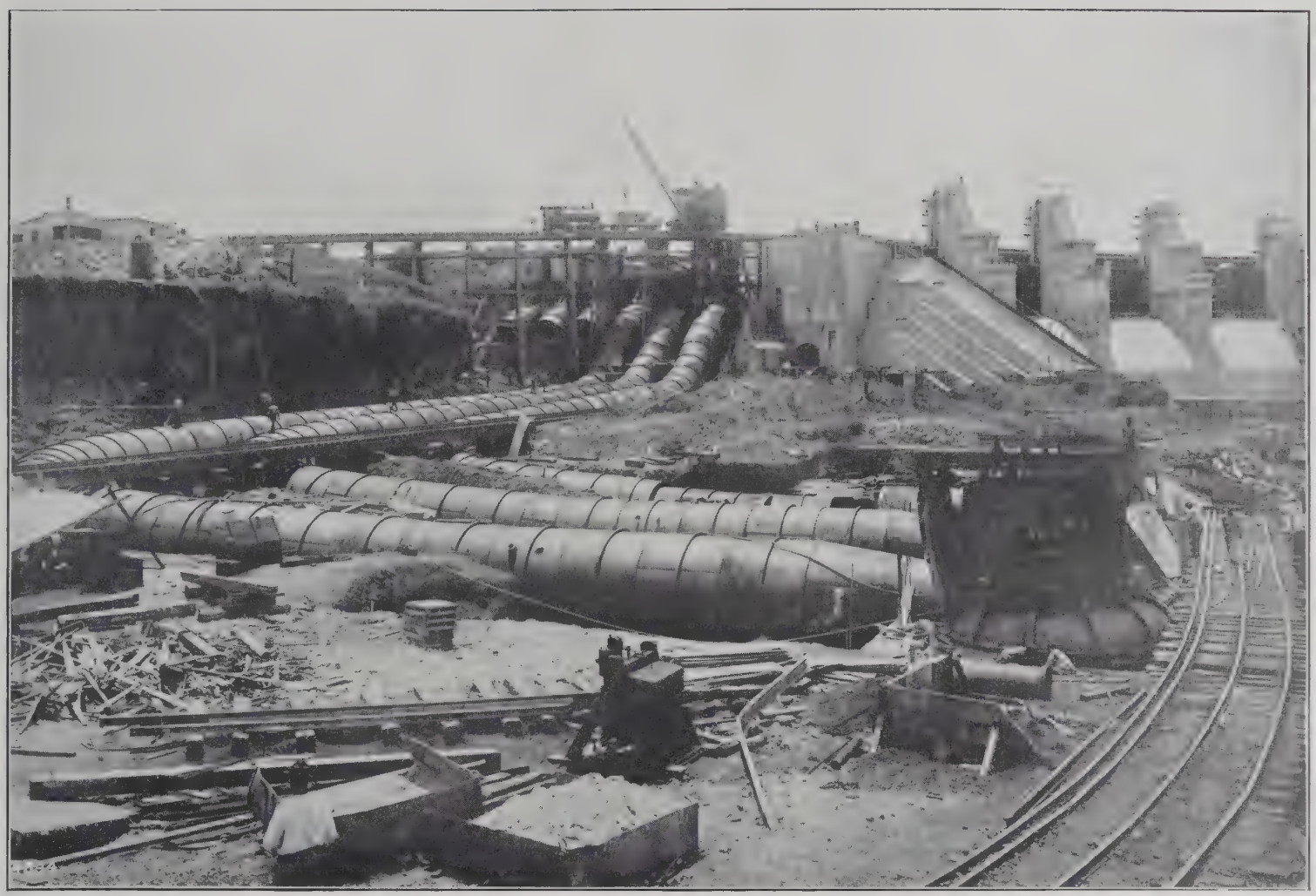


Fig. 195. Pipe-Lines and Site of Gatun Power-Station.

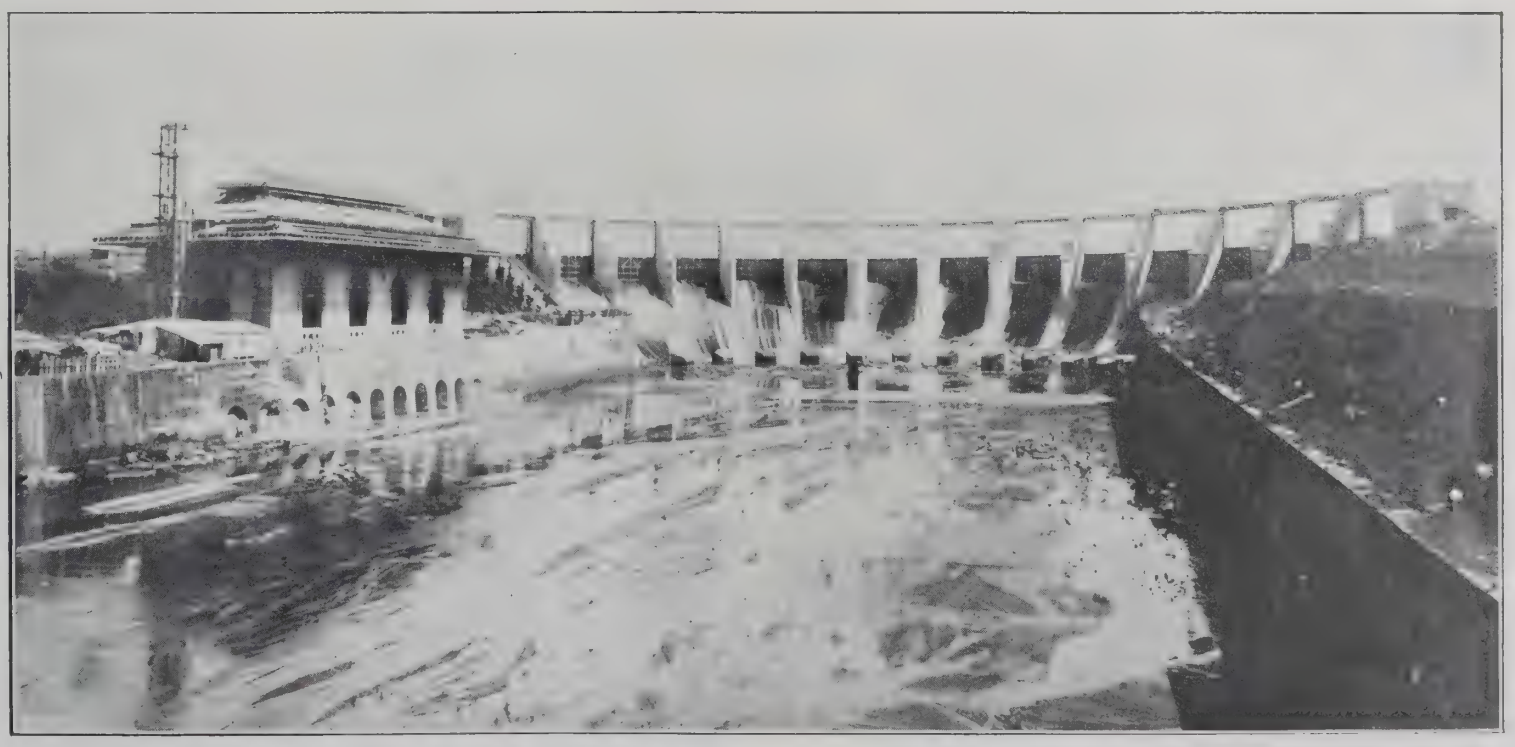


Fig. 196. Gatun Power-Station and Spillway.

(*To Face Page* 12.)

THE PANAMA CANAL.

(*For Description, see Page* 12.)

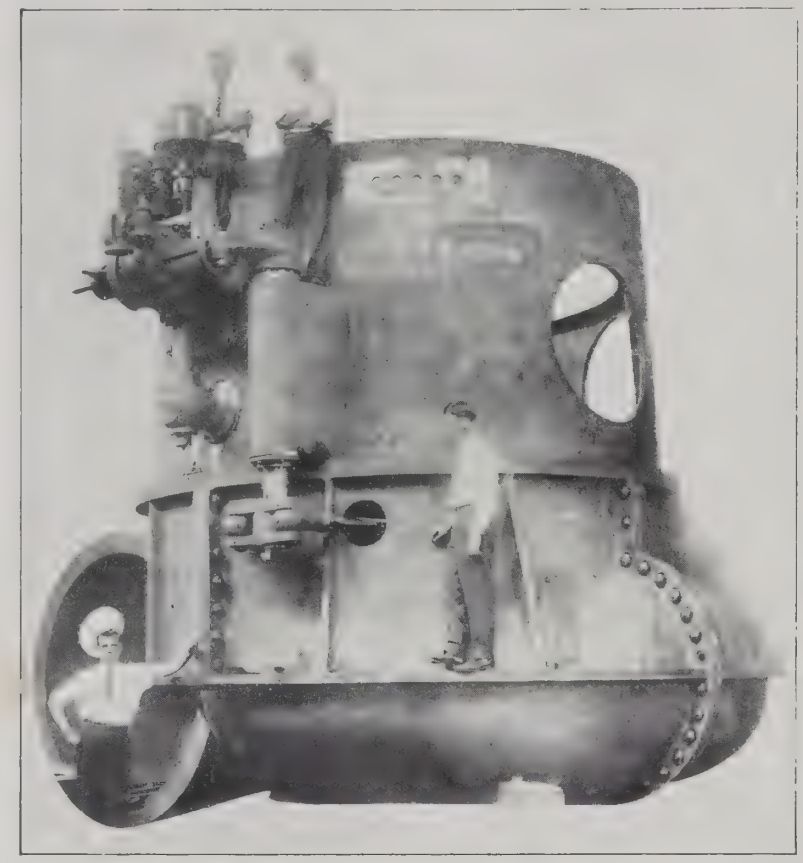


FIG. 197. HIGH-PRESSURE FRANCIS TURBINE.

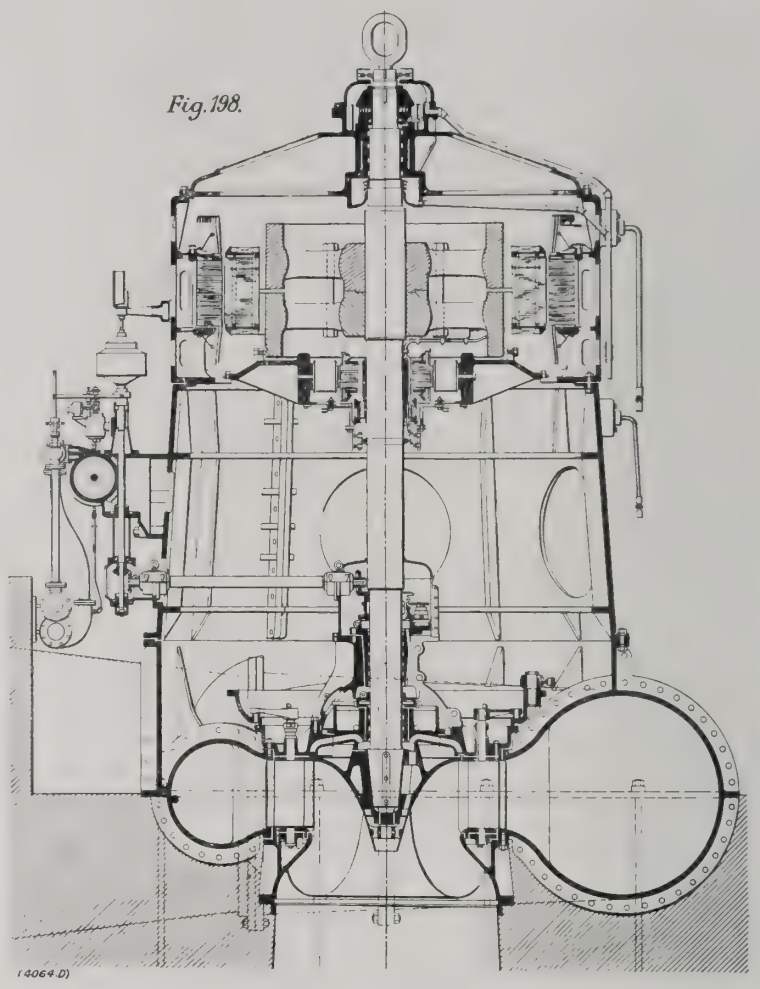


FIG 198. SECTION OF TURBINE GENERATOR SET.

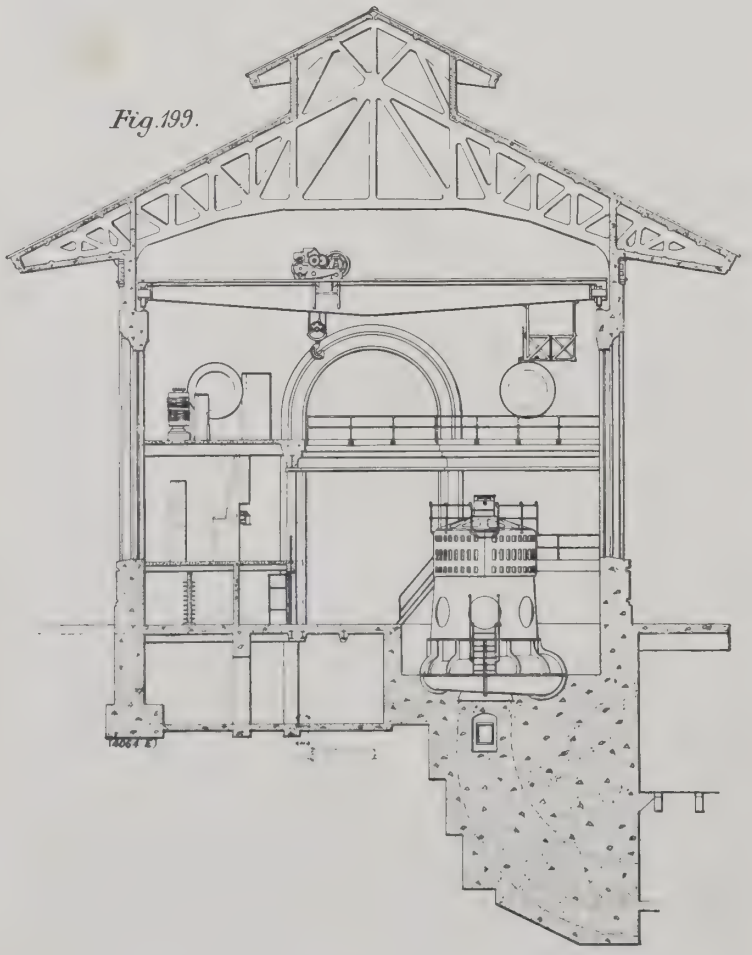


FIG. 199. TRANSVERSE SECTION OF POWER-STATION.

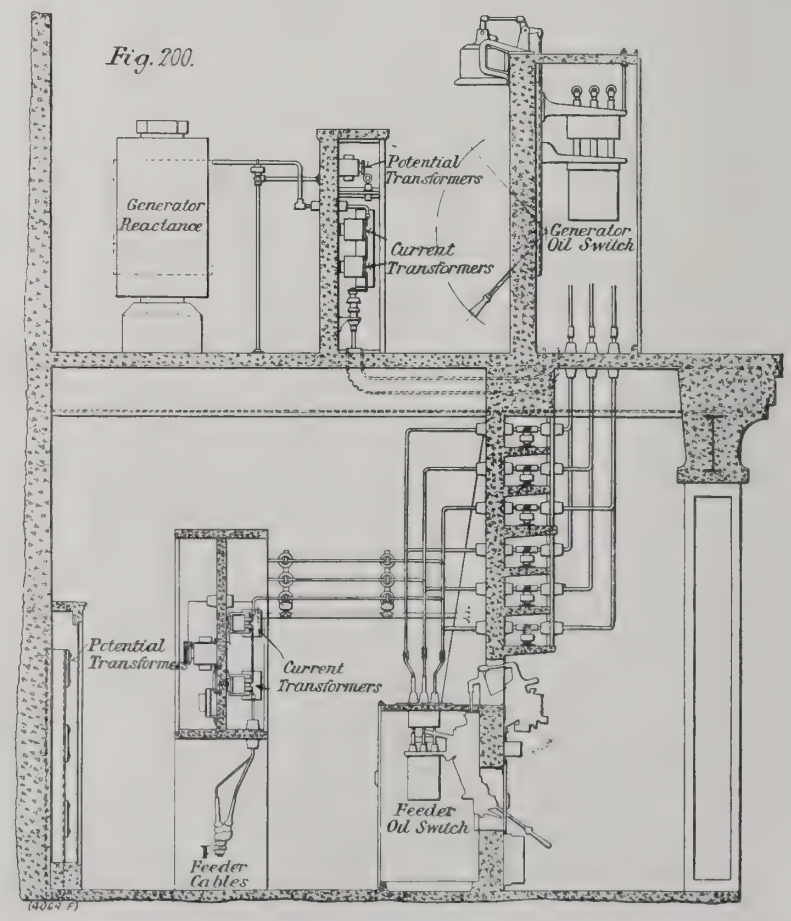


FIG. 200. SWITCH-GEAR GALLERIES.

(*To Face Page* 13.)

naval architecture departments; but one or two facts regarding the general progress of the College may be indicated. It should be understood at the outset that the College is almost entirely for day students, the view taken being that the evening classes in the secondary schools, not only in Newcastle, but in other towns in the district, afford sufficient facility for those who are able only to attend evening classes. Special arrangements were made in 1909 whereby the Rutherford Technical College took over the greater part of the evening work carried on up to that time at Armstrong College, but special courses are arranged, consisting of a series of lectures in the evenings in the engineering and other departments. Thus there has been given a course on the application of the steam-turbine for marine propulsion; another on the results obtained from trials in connection with the experimental machinery in the mechanical laboratory of the College; yet another dealt with hydraulics for civil engineers or others. In other sections there are similar lectures, as, for instance, on applied chemistry, carbonisation of coal, metallography, the utilisation of fuel, and some applications of the electrical furnace.

These series of lectures, which are arranged independently of the ordinary curriculum, have proved most satisfactory, being open to anyone on payment of a purely nominal fee. Another feature of the College is the number of prizes and scholarships which the munificence of those resident in the district has made available for students in the College; while, either as governors or in some other capacity, the employers of labour in the district have shown a keen and helpful interest in advancing the institution. That this help and interest are welcomed is evidenced by the fact that in ten years the number of day students has increased from 503 to 722, while the number of the staff has been augmented from 55 to 90.

The College was founded in 1871 by the combined efforts of the University of Durham and the North of England Institute of Mining and Mechanical Engineers. It was originally intended, as its name—the Durham University College of Physical Science—implies, as a purely scientific institution, but ultimately increasing recognition was afforded by it to the literary side. In 1904 a new wing was opened, in memory of the late Lord Armstrong, and, in his honour, the College then received the title it has since borne. In 1909 the new University of Durham Act, in reconstituting the University, materially altered the status of the College, to which it gave full representation on the new Senate and admission to university degrees in arts as well as in science; admission to degrees in science has been given to the College since its foundation. A view of the College as it is to-day is given in Fig. 1, on Plate IV.

Applied Science embraces the following sections:—Mechanical Engineering (this is the basis of all branches of Applied Science); Marine Engineering, including ship propulsion; Civil Engineering; Electrical Engineering; Naval Architecture; Mining (coal and metal); and Metallurgy. In any one of these sections the Degree of B.Sc. is obtainable after a three years' course of study in certain specified subjects, the list and scope of which in each section has been drawn up by the advice and aid of experts in the several professions concerned. The above refers to the ordinary Pass Degree. An Honours Degree is available in the case of those who can spend a minimum of an additional year at college in the study of more specialised and advanced branches of the subject of the Degree. The M.Sc. and the D.Sc. are both obtainable in the usual way after the lapse of some years of practice and on the presentation of a thesis of sufficiently high standard.

In each section embraced in the Applied Science Section laboratory work is a feature of the course of instruction, and in the laboratories research work is continually being prosecuted. For example, in the Mechanical Engineering Laboratory many series of elaborate and exhaustive experiments have been carried out on machinery of commercial dimensions, on the following previously undetermined points in the economical use of steam in the production of power:—Influence on economy of variation in the cylinder ratios of stage-expansion engines; influence of variation in the degree of expansion in each individual cylinder, and of variation in the total degree of expansion from the first to the last cylinder; influence of degree of vacuum in itself, and the determination of the maximum-economy vacuum in given conditions; surface condensation generally, and the design of surface-condensers and air-pumps from the point of view of maximum economic effect; reciprocating *versus* rotary air-pumps; effect upon economy of degree of boiler pressure; effects of superheating the working steam; re-heating of the steam as it passes through the receivers of stage-expansion engines; relative effects of throttling *versus* automatic-expansion governors; economic effect of different crank-angles in four-cylinder quadruple-expansion engines; and effects due to variation in piston speeds carried to extreme limits. The above is a summary of the principal experiments which have so far been made upon the experimental engines and boiler. Many minor tests of diverse kinds have, in addition, been carried out. There have also been tests on the economy of internal-combustion engines and gas-producing plants.

All research work is, when possible, carried to the point where definite and useful results are arrived at, and in many cases these results have been embodied in papers, which have been read before technical institutions. In the Electrical Engineering Laboratory also a great deal of research work has been undertaken, and in both laboratories this work is still actively prosecuted. As far as is consistent with due attention to their other work in college, third and fourth-year students are required to take part in research work, both in respect of the making of the actual experiments and in reducing, arranging, and analysing and co-ordinating the figures obtained by observation.

A special feature in the applied science training is the close touch maintained between the engineering departments of the college and the industrial workshops of the district. The Professor of Engineering has a standing demand from the industrial establishments of the North of England for students who have done themselves credit in their college course, and who have either earned distinction or taken honours in their final year. Such young men are keenly competed for and are engaged at once to complete their training on the practical side in the best establishments, and are, moreover, generally accorded a "living wage" from the very commencement of their pupilage, which is often a very material consideration. It is an encouraging feature of the present day in this country that young men who have been trained at college in technical theory, judiciously combined with a certain amount of such practice as a laboratory can afford, are undoubtedly in growing demand. The professor finds that all those who have been painstaking in their college career ultimately find posts in the industrial world which suit them, many speedily attaining to positions of trust and responsibility.

Turning now specially to the engineering section, it may be premised that the department of engineering and naval architecture was instituted in 1891, both being then combined. The employers in the district at that time subscribed the funds to establish a Chair, and nominated as professor Mr. (now Dr.) R. L. Weighton, who had ten years previously come from the Clyde to be chief draughtsman with Messrs. Hawthorn, Leslie and Co. From that time forward continuous success has characterised the work of the department, and there has passed from the engineering department a steady flow of men capable of taking an active part in the practical work of the district. This is evidenced by the number of entries in the department of engineering each year since the beginning of the department, as given in Table I. Up to 1906 there is included in the list students in naval architecture, as up to that time Professor Weighton was himself responsible for naval architecture. In that year it was considered that the number of students coming forward for naval architecture justified the institution of a Chair, which is now occupied by Professor J. J. Welch, formerly of the Royal Corps of Naval Constructors at the Admiralty. The falling off in evening students is accounted for by the discontinuance of the ordinary evening classes and the arrangements made with Rutherford Technical College to take over this work. The evening students from that date attended the special series of lectures arranged from time to time within the university. The growth of the department must therefore be judged by the steadily increasing number of entries for the day classes. It should be made clear that each student entered for day-work attends on an average two-and-a-half classes; so that if the total of entries in column 1 of the table is divided by this, the number of students may be ascertained with a fair degree of accuracy. Thus, at the present time, there are 201 students in engineering alone. This, again, is exclusive of large classes held on Saturday afternoons for colliery engineers and foremen miners, and these classes, again, are attended by about 100 students. It is further interesting to note the classification of the students. Table II. gives a list of the numbers attending the various day schools. This, of course, does not include evening students nor Saturday students. It may be mentioned that during the past year the total number of day students was 201, whereas in the first year of the department the corresponding number was twelve. In addition to the classes indicated in Table II., the students, of course, are required to attend classes in mathematics, physics, chemistry, and so on.

TABLE I.—*Entries in the Department of Engineering since the Beginning of the Department.*

Year.	Day.	Evening.	Total.	Remarks.
1891-2	37	198	235	
1892-3	43	183	226	
1893-4	59	190	249	
1894-5	112	191	303	
1895-6	132	194	326	
1896-7	142	284	426	
1897-8	113	266	379	
1898-9	144	286	430	
1899-0	155	283	438	
1900-1	156	306	462	
1901-2	204	281	485	
1902-3	195	300	495	
1903-4	214	269	483	
1904-5	342	253	595	
1905-6	312	272	584	
1906-7	279	258	537	Naval architects not included; separate department instituted.
1907-8	270	196	466	
1908-9	323	209	532	
1909-10	378	87	465	Arrangement made with Rutherford Technical College by which most evening work was transferred to it.
1910-11	408	42	450	
1911-12	428	49	477	
1912-13	454	65	519	
1913-14	498	30	528	

TABLE II.—*List of Students in the various Day Classes in Engineering.*

Day Classes.	1911-12	1912-13	1913-14
Advanced Engineering	16	21	33
Senior Engineering	41	52	57
Junior Engineering	57	56	53
Applied Mechanics	69	60	75
Civil Engineering (Senior)	7	18	11
Civil Engineering (Junior)	15	9	12
Agricultural Engineering	4	2	5
Drawing (Advanced)	22	37	41
Drawing (Senior)	47	47	42
Drawing (Junior)	64	58	62
Laboratory (Senior)	26	40	50
Laboratory (Junior)	60	54	57
Totals for day classes	428	454	498

Fig. 2, on Plate IV., illustrates the power-station and the various prime movers, &c., in it, arranged specially for instructional and research work. There are in this station electric transformers reducing the potential of the current from the public supply mains; a high-speed enclosed compound steam-engine, driving a dynamo, with its surface condenser and pumps; a horizontal Robey engine and dynamo for electric lighting and experimental purposes; an experimental vacuum chamber, and other apparatus.

Figs. 3 and 4, on Plate IV., are views from opposite ends of the new hydraulic laboratory, which covers a floor space of about 2600 sq. ft., and is equipped with recent examples of hydraulic machines. The apparatus includes a multi-stage electrically-driven turbine pump, having a maximum speed of 2300 revolutions per minute and capable of delivering 10,000 gallons of water per hour against a head of 210 ft.; a single-stage high-lift centrifugal pump, also electrically driven, delivering 15,000 gallons per hour against a head of 100 ft.; a steam-driven direct-coupled centrifugal pump, having inlet and outlet mains, 6 in. in diameter, and delivering 36,000 gallons per hour; and a small pulsometer pump, as well as other machines.

Water raised by the above pumps may be used for operating various water-turbines, of which the following are at present installed:—a Thomson inward-flow turbine; an impulse turbine of the Gerard type; a Pelton wheel, with interchangeable cups and nozzles, arranged for a maximum head of 250 ft.; a mixed-flow pressure turbine, with vertical shaft, suitable for working under low heads of from 7 ft. to 12 ft. Of the same capacity as the mixed-

flow turbine is a water-wheel for approximately similar heads, capable of being operated as a high-breast, a low-breast, or an overshot wheel.

All the above turbines are specially arranged for experimental work under varying conditions, suitable measuring-tanks, gauges, brakes, &c., being provided. The centrifugal pumps, for example, are supplied with alternative impellers and vortex passages, and the multi-stage pump can be operated with one, two, or three stages in series. Each turbine or motor has its own separate tail-race and measuring-tank, so that the machines are entirely independent of one another. Tanks for "gauging" experiments, for the flow over weirs and through orifices, on a larger scale, are installed; and also apparatus for investigating stream-line flow, reaction of jets, friction in pipes, loss of head in pipes and bends, &c. Amongst the apparatus for measuring large quantities of flowing water are a precision-meter, with mechanical integrator, a Venturi meter, a Kennedy meter, and various arrangements of tanks, with notches and floats or point-gauges. Three large mains—two 6 in. in diameter and one 5 in.—extend the length of the laboratory, and communicate with a tank of 1000 cub. ft. capacity on the roof of the building. Three feet below the ground-level is a lower tank 3 ft. wide, which also extends the full length of the main laboratory. In addition there are such accessories as cement-testing machines, and, as seen in Fig. 3, tables and benches for carrying out various operations. In addition, there is a smaller research laboratory on the upper floor, reached by the spiral stair seen in Fig. 4.

The research work in the Hydraulics Laboratory has included investigations into the efficiency of centrifugal pumps, investigations of the effects of "whirlpool chambers," guide-blades, and varying blade angles on the efficiency of high-lift single and multi-stage centrifugal pumps; comparative efficiency of various types of hydraulic motors; further investigations into the circumstances which determine whether the flow of water in pipes shall be stream-line or turbulent. Experiments have also been made on air-pumps for the purpose of investigating the influence of water on the effective capacity of air-pumps of various kinds, and of the weight of air discharged with varying speeds and effective capacity of pump. Data have been accumulated as to the hydraulic resistances in surface-condensers, including a practical determination of the losses due to friction in condenser-tubes and headers, losses at entry to and discharge from tubes, and in the transverse flow between tube-plates and condenser-ends. Experiments to determine the coefficient of discharge for air flowing through sharp-edged orifices have also been conducted.

The Mechanical Laboratory is illustrated by Figs. 5 and 6, on Plate V. The central feature of the former view is the experimental engine, which was designed by Professor Weighton, and, when erected, was the largest and most complete engine for this work, and is believed to-day to hold a position no less significant. Apart altogether from the great variation in the working conditions provided for in the design, credit is due to the makers, as forty-six firms were employed to supply the units for the construction of the engine, and all these were worked into place without any trouble. Primarily the engine is of the quadruple-expansion type, but is so arranged that it can be worked as a simple, compound, or quadruple-expansion engine; spare liners, too, are provided, in order that the engine can work at different ratios of cylinder diameter and expansion. It can be adapted for the solution of almost every conceivable problem, as has already been suggested by the variety of tests carried out and enumerated. It is fitted with an hydraulic dynamometer of the Froude type, but designed by the Professor and made at Tyneside many years ago; one-half the torque is by gravity weight, and the other half by spiral spring. There is a recording apparatus associated with the dynamometer. The first kinetic air-pump ever made is in use, and is driven by a De Laval turbine. There is also, in connection with the experimental engine, a "Contraflo" condenser, in addition to the usual condenser incorporated in the back columns of the engine. The experimental engine has also an air-indicator to show automatically and continuously the air passing through the condenser and pump. An interesting feature in Fig. 5 is a Parsons turbine with a flat condenser suspended to the roof girders. Beyond this there are small experimental steam air-compressing engines, such as are used for charging torpedoes. Behind them are two sets of internal-combustion engines worked by producer-gas and by oil. On the left side of the view are seen work-benches, a vacuum-gauge tester, and a part of the 100-ton Buckton-testing-machine. This latter is better seen on the right side of Fig. 6, which is a view of the same laboratory from the opposite end. In front of it, however, is a 10-ton testing-machine, and beside it a crank-shaft for a Diesel engine recently erected. On the left of the view is a small gas-producing plant, associated with the internal-combustion engines seen beyond it, and already referred to. In the distance, in the centre of the view, is the steam air-compressing plant, together with the Parsons turbine with the flat condenser, and beyond the kinetic air-pump and the experimental engine just described. The latest addition to the laboratory is a one-cylinder vertical Diesel oil-engine, capable of working on the four-stroke cycle or the two-stroke cycle, the power under the former condition being 50 brake horse-power, and under the latter condition 100 brake horse-power. This engine has been supplied, on very favourable financial terms, by Messrs. Carels Frères, of Ghent, and is of a type which has recently been fully illustrated in ENGINEERING. This latest addition gives promise of very interesting work being carried out, as many variations in operation are possible, even although there is only one cylinder. It will be seen from the equipment that marine engineering occupies a large part of the curriculum of the laboratory, and it may be added that this subject has always been a special feature of Armstrong College.

As regards the Naval Architecture Department, which is under Professor J. J. Welch, formerly of the Admiralty, the funds are largely provided by subscriptions of the shipbuilders and engineers of the district, and are administered by a Committee of the subscribers acting in conjunction with the Council of the college. Day courses of study are arranged to suit the requirements of the University for degrees in applied science. For a "pass" degree three years of study are required, of which the first year is spent on training in general science, and the two later years chiefly on professional and allied subjects. To obtain a degree with honours, an additional year of professional study is required. There are also post-graduate and research courses. Diplomas are granted to students who do not enter for the university degrees, but who qualify in modified courses of professional studies. It is found that the most successful students are those who have had some practical experience of shipyard or office work before coming to the college. In some cases students take their first year of college on leaving school, but go into works for a year or more before taking up the professional part of their studies, and this arrangement also gives good results.

British Graduates in Honours in Naval Architecture are now eligible as candidates for posts as Probationary Assistant Constructors attending the Admiralty courses of study at the Royal Naval College, Greenwich. Many of the shipbuilding firms of the North-East Coast district are willing to give students practical experience in works or drawing-office during the "long vacation" (July, August, September), and on leaving college most of the British students find places in British establishments. Some of them have risen after a few years of practical experience to posts of responsibility in the technical and scientific departments; others have secured appointments as surveyors with the registration societies. A number of foreign students have been sent to Armstrong College by their respective Governments, and these, after leaving, ultimately pass into the constructors' departments of their respective countries.

The scientific investigations of the "Bulkhead Committee," appointed after the Titanic disaster, are being carried out by a staff working under the direction of Professor Welch in the premises of the College; and the staff engaged upon this work includes several former students of this department, most of them being graduates. One of the present holders of the Institution of Naval Architects Post-Graduate Scholarships (200*l.* a year) is Mr. P. Y. Brimblecombe, whose paper, on "The Stability of Ships in Damaged Conditions," was read at the recent spring meetings of the Institution. Mr. Brimblecombe is continuing his research work for another year. There are also courses of study arranged for evening students. These are largely attended by workers in the shipyards and drawing-offices, and in the case of some firms in the district, promotion in position and pay is made to depend to a considerable extent on attendance at such evening classes, and upon the results of the college examinations. The complete courses extend over a period of five years, and the classes are held from the beginning of October to the middle of the following May. Students are prepared for the Board of Education's examinations in naval architecture, and the college also holds its own examinations at the end of each session. The Shipwrights Company awards 25*l.* each year in prizes to these students. There is no doubt about the excellent results which have come from the encouragement given by local employers to this class of student. From among them have risen some of the best young men to take the more complete training given by the university courses in the day time.

There is also a mining laboratory, in which there are rock-drills, air-compressors, and apparatus on a large scale for testing the explosive nature of coal-dust. The professor of mining and surveying is Professor Henry Louis, D.Sc. The electrical department is under Professor Wm. M. Thornton, D.Sc., and there is included a fair-sized laboratory with all the ordinary electrical machinery required for a liberal course of training. Thus while the mechanical side and naval architecture necessarily preponderate, all departments of industrial activity are embraced in the very comprehensive scheme of this progressive and successful institution.

THE PANAMA CANAL.—No. XI.

GATUN HYDRO-ELECTRIC STATION.

IN the course of this series of articles we have frequently made mention of the electric control and operation of the various machines, the electric supply for the towing-locomotives, for lighting, repair-shops, and other purposes. The required power is to be obtained from two sources—mainly, as a matter of fact, from a hydro-electric plant situated at the Gatun spillway, while a stand-by steam-station will be maintained at Miraflores. A description of the spillway was given in No. 4 of this series of articles,* at which time we also gave a brief account of the power plants, more particularly that at Gatun. We now propose to give a rather more detailed account of this plant, and illustrate it with Figs. 195 to 202, Plates VI. and VII., and page 13.

The Gatun power-station is at present built for a capacity of 6000 kw., with provision for increasing this up to 12,000 kw. if it be decided later to operate the Panama Railroad electrically. It is situated below the spillway of the Gatun Dam, and will utilise an effective head of about 75 ft., though this will be increased in times of high flood, and diminished slightly during a dry season. Water is drawn off from the Gatun Lake through a forebay, the position of which is shown in Figs. 95 and 110,† and to which water is admitted through passages 12 ft. wide, fitted with wrought-iron grids 29 ft. 7 in. high. At present three pipe-lines only are being installed, though provision is made for six. They were shown under construction in Fig. 111,‡ and in a more complete state are illustrated in Fig. 195, Plate VI., herewith, the head ends of the other three showing in the distance at a point just below the forebay. Cast-iron head-gates 10 ft. 6 in. in diameter, with bronze seatings, control the admission of water to the pipe-lines. These gates have two screwed steel stems, on which work bronze nuts fitted with steel bevels, the latter being driven by a 15-horse-power 220-volt alternating-current motor with a speed of 750 revolutions per minute. The motor is placed between the stems, its shaft being extended to them on either side. Hand-operating gear is also provided. The control arrangements are such that when the gate-motor switch is closed at the power-house, the gate being closed and the pipe empty, the motor will commence to open the gate until the admission is sufficient to fill the pipe in about five minutes. On this rate of admission being reached a limit-switch opens and stops the motor. The gate remains in this position until the pipe is full and the water has risen in the 36-in. air-vent pipes

* See ENGINEERING, vol. xcv., page 836.
† *Ibid.*, page 830 and Plate LIV.
‡ *Ibid.*, page 833.

(shown in Fig. 111, already referred to) below the gates. A float-switch then comes into action, closes the motor circuit, and the gate is fully opened, the limit-switch preventing over-travel. The gate is closed by reversing the main switch at the power-house. The pipe-lines have been previously described. They are 10 ft. 6 in. in diameter, and have an average length of 420 ft., and after being riveted up at the site have been covered on the outside with concrete. They are taken to the power-house on the side of the spillway channel, with 90-deg. bends of a radius of 70 ft., as may be seen in Fig. 195. Provision is made on each pipe-line for testing the flow with a Pitot tube while it is in service. A pair of portable tubes for taking readings in the pipe at 90 deg. to each other have been furnished. Each pipe has two 6-in. saddle nozzle connections, arranged at 45 deg. to the vertical, and from these two Pitot-tube supports extend across the pipe. These supports form guides for the Pitot tubes. They are fixed in the pipe, but are easily removable. The 6-in. outlets are fitted

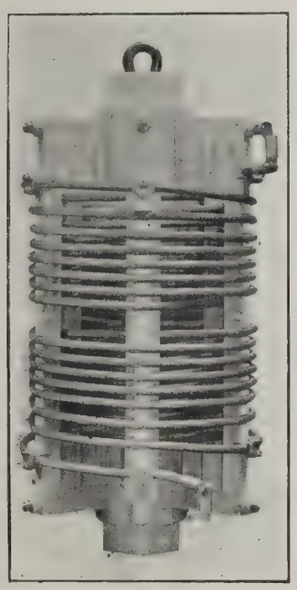


FIG. 201. REACTANCE.

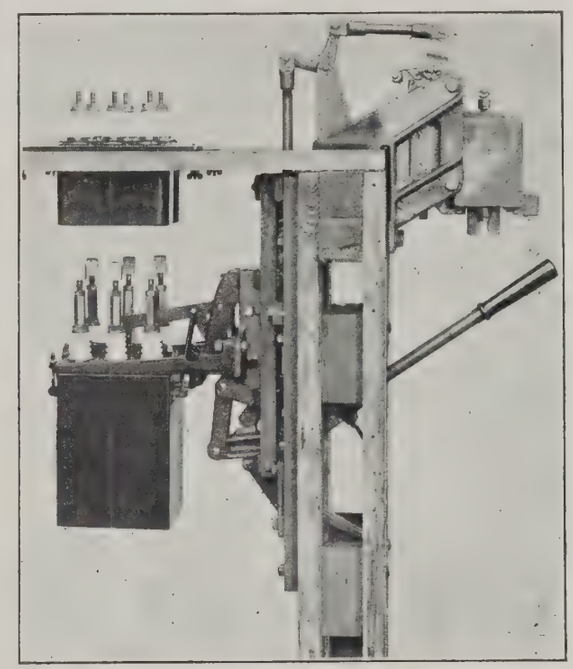


FIG. 202. SOLENOID-OPERATED 2500-VOLT SWITCH.

with gate-valves, and have tongued and grooved flanges, matching the base of the Pitot-tube apparatus. The latter may be bolted to the outlet, the gate opened, and then the tube pushed into the pipe. The tubes are arranged to measure both the static and velocity heads, the readings being obtained by means of U-tubes.

The generating units consist of three 2000-kw. machines, driven direct by Francis turbines with 50-in. runners. Under the 75-ft. head, and running at a speed of 250 revolutions per minute, the turbines develop each 3600 horse-power. The centre of the runner is 25 ft. above the tail-water. The turbine-casings will be seen in place in Fig. 195, while in Fig. 197, Plate VII., we give a larger illustration of one of these turbines, and in Fig. 198 a drawing showing a generator unit complete. The turbines are of the spiral-casing type, and above them are distance-rings carrying the electrical machines. The revolving parts of the turbine and generator are all mounted on a shaft made in one piece, and are suspended from a roller-bearing in the top of the casing.

The suspended weight is about 32 (short) tons, but the runner is designed to exert an upward thrust of about 22,000 lb. when working at full capacity, and the bearing is therefore relieved to this extent. Oil for this bearing is supplied by a lubricating pump geared to the main turbine-shaft, the surplus flowing into a tank, from which the pump takes its supplies. The turbine wheels are of bronze, and weigh about 7000 lb. each. They are finished all over. The governor gear, shown to the left hand in Figs. 197 and 198, is of the Pelton oil-pressure type. The oil pressure for the governors is supplied by two Pelton rotary pumps driven by 10-horse-power alternating-current motors at a speed of 375 revolutions per minute. Each pump is capable of supplying the governors of all three units. The governors, driven by bevel-gears off the main shaft, are furnished with small electric motors for varying the speed of the main units for synchronising purposes. They are also arranged so that the permanent drop in speed from no load to full load may be varied, between a range of 5 per cent. drop to constant speed from friction load to the maximum. Hand control is also provided. The wicket-gates are steel castings finished all over. The gates are all connected with a ring controlled by the governor. The water-passages on either side of the movable gates are fitted with renewable steel plates. The discharge from the turbines is through steel-lined concrete tubes, 71 in. in diameter at the turbine, but increasing to an elliptical section of 9 ft. by 17 ft. at the outlets. The discharge-tubes embody 90-deg. bends. The linings are $\frac{1}{4}$-in. steel plates.

Directly above the turbines are three-phase 25-cycle generators of the revolving field type, of a guaranteed continuous capacity of 2000 kw. at 0.8 power factor, 2200 volts, and 250 revolutions per minute, and an overload rating of 2500 kw. at 0.8 power factor for two hours. The stationary armatures are bolted to heavy cast-iron distance-rings some height above the turbine. The weight of 32 short tons given above for the load taken by the thrust-bearing includes the weight of the generator field and exciter armature. The exciter is arranged just below the generator. It is a 50-kw. machine at 125 volts. Each exciter is capable of furnishing exciting current for two generators under maximum guaranteed load. The exciter-magnet frame is attached to a casting bolted to the distance-rings. By means of clamp-screws the exciter-magnet frame may be attached to the revolving field of the generator, and the whole removed together for repairs.

The generators under official test showed an efficiency of 95.1 per cent. at 2000 kw., 0.8 power factor; of 94.3 per cent. at 1500 kw., 0.8 power factor; and 92.5 per cent. at 1000 kw., 0.8 power factor. The guaranteed temperature rises of 40 deg. Cent. above room temperature, 25 deg. Cent. under continuous operation at full load, and 55 deg. Cent. after two hours at 25 per cent. over-load, were easily met.

The generator sets are accommodated in a station building on the side of the spillway channel, as shown in Fig. 196, Plate VI. The building is unpretentious in style, the walls being of poured concrete 30 in. thick. It measures 61 ft. by 137 ft., being capable of extension, and has an extreme height of 74 ft. The roof is of reinforced-concrete slab construction, covered with Spanish red tiles, and projects beyond the walls for 13 ft. 2 in. A section of the building is shown in Fig. 199, from which it will be seen that the interior is clear to the roof, except for galleries. The floor area is divided into a pit for the three generator sets, a main floor, and two galleries devoted to switch-gear, &c. The turbine-pit is 6 ft. below the main floor. Below the main floor is a basement, containing air-compressing and oil-pumping plant. The main floor is laid with rails, so that 30-ton cars can be brought into the building under the overhead crane, for handling heavy parts. The switch-gear galleries extend the entire length of the building on one side, and at one end are two galleries, used respectively for offices and a machine-room. The switch-gear galleries are shown in section in Fig. 200, Plate VII.

In addition to the direct-connected exciters, two others, motor-driven, are provided. These each consist of a 100-kw., 125-volt generator, running at 500 revolutions per minute, direct connected with a 150-horse-power, 2200-volt, 25-cycle squirrel-cage induction motor. These exciters can also be used for charging the control batteries. The main generator windings are rigid enough to stand a short-circuit under full load, but reactances have been provided to reduce the shock. These will also serve to make synchronising easier and safe. One of these current-limiting reactances is shown in Fig. 201, annexed. They are provided with concrete cores.

The current is actually transmitted across the Isthmus at 44,000 volts, step-up transformers being provided at Gatun and in connection with the stand-by station at Miraflores, and the necessary step-down plants at these places and at Cristobal and at Balboa. The power plants generate and distribute only 2200-volt current. The system of connection throughout is the double-bus double-switch method, any oil-switch being capable of disconnection for repairs and cleaning without interrupting the circuit.

The main switchboard is of the bench type, with a vertical rear board for relays and instruments and control-battery equipment. The space between the front and rear boards is enclosed with metal grill-work, with doors at both ends. Above the switchboard is a second storey, accessible by ladder and accommodating the electrically-controlled generator and exciter rheostats. Of the eight bench panels, one controls the exciters, the next three the generators, and the remaining four the feeder-circuits. A generator voltage-regulator, transferable to either of the two sets of busses, is installed on a separate pedestal, which also carries the synchronism indicators and clock. The exciters are controlled from the bench, but the electrically-operated exciter and field switches are mounted on a separate board located so as to keep the connections as short as possible. This eliminates the exciter busses and the main connections from the control-board, but leaves the control of the whole equipment in the hands of the operator. On the upper of the two galleries, shown in section in Fig. 200, Plate VII., near the end of the building arranged for possible extension in the future, are the control-board, generator reactances, compartment for generator current and potential transformers, and the generator oil-switches. From the latter connections pass through the floor to the busses on the gallery below. On this gallery are also the feeder oil-switches, the compartment for the instrument transformers and the cable bells. Below, on the main floor is the cable vault, to be seen in Fig. 199.

The 2200-volt oil-switches are solenoid operated and fitted with disconnecting gear to facilitate cleaning and repairs, all live parts being completely covered. One of these switches is shown with the disconnecting device open in Fig. 202, annexed. These and the hand-operated switches were described in a previous article.* Briefly, it may be said that by a lever and toggle gear, mounted on vertical guides, the oil-switch is raised or lowered. Above the oil-switch is a stationary base fitted with disconnecting studs, which are coupled to the high-tension leads. The studs carry underneath contact-fingers, which engage with contact-blades fitted on the top of the oil-switch, when the latter is raised by the lever. When the oil-switch is lowered it is completely isolated from the circuit; when raised it is latched in position. An interlock prevents an oil-switch being raised or lowered unless its contacts are open. In the case of the solenoid-operated switches, the solenoid is stationary, and the con-

* See ENGINEERING, No. X., page 241 *ante*.

necting mechanism includes a vertical slotted link, allowing the switch to be raised or lowered without disconnecting the solenoid gear.

Of the plant at the Gatun station, the turbines, as already noted, were built by the Pelton Water-Wheel Company, New York, who, in fact, supplied the whole hydraulic equipment, including gates, pipe-lines, Pitot tubes, governors, &c. The electrical portion of the installation, including the generators, switch-boards, transformers, head-gate motors, switches, and accessories, were designed and manufactured by the General Electric Company, Schenectady, to whom, through the British Thomson-Houston Company, Limited, we are indebted for the foregoing particulars.

We have on several previous occasions referred to the arrangements made for transmission across the isthmus and for transforming at the locks, &c., and need not enter again into this work. Recent advices from Panama stated that the hydro-electric station at Gatun was expected to be in service by the end of May. The transformer sub-stations at Gatun, Miraflores, Cristobal, and Balboa are fairly well advanced, except that at Balboa. Eighty per cent. of the electrical equipment had been received in May, and installation has commenced at Gatun. By the beginning of May, 903 out of 917 track span-bridges for the transmission lines had been erected and work on the conductors was in progress.

INDUSTRIAL NOTES.

THE annual meeting of the Wolverhampton Chamber of Commerce was held on Wednesday, the 24th ult., when the president, Mr. W. Johnson, in moving the adoption of the annual report, called attention to the disastrous effects which labour troubles had upon the trade of the country. Among the more clear-sighted labour leaders there were some, he said, who recognised that strikes had a most injurious effect on the workers themselves. He then dealt with the question of inland waterways, and said that the Chamber had always taken an immense interest in the matter of water carriage in this country, especially as it applied to the immediate district. He was glad they had enlisted the interest of some members of the Wolverhampton Corporation, and added that there was a growing opinion that something ought to be done to improve the waterways. In regard to these, Colonel A. McBean expressed the hope that the Wolverhampton Corporation would look upon the subject of inland waterways from a national and not from a local or parochial standpoint. If this question had taken shape some years ago, the extension of the waterways in the district might have saved the removal of large industries to the coast. To-day the Staffordshire district was being fed by more foreign iron and steel than those interested in iron and steel cared to think about. Foreign competitors were beginning to look upon Staffordshire as their natural market; in fact, as a market to which they had more right than we had ourselves. Foreign competition, he added, was becoming an immense monster, and it must be faced without political sentiment.

A number of points were dealt with at the congress of the International Federation of Postal and Telegraph Servants, held at Caxton Hall, Westminster, on Thursday, the 25th ult. The delegates present represented a very large proportion of postal, telegraph, and telephone employees of Great Britain and Continental countries. The British postal workers' society demanded that all Governments should establish and maintain the eight-hour day principle as an example to other employers of labour, and the concession of full civil and political freedom for employees of the State. They also expressed the opinion that the nationalisation of public services, such as the Post Office, was not necessarily advantageous to the employees and the working class, unless accompanied by steadily-increasing democratic control, both by the employees and the representatives of the working classes in Parliament.

The question of a universal language was also raised by Mr. Koch, a Swiss delegate, who urged the point very strongly, stating that a universal language would better enable the workers to fraternise, thus increasing their solidarity and strength. Some delegates agreed, whilst one stated that if they adopted either Esperanto or Ido they would simply be adding to the existing Babel. It was only in the interests of the "ignorant Englishman who lived on an island," added the delegate, that the universal language proposals were brought forward. Their immediate effort should be to push forward for economic and political emancipation. When they had done that they should be free to educate themselves, and then they would have no need for a "bastard language." A resolution in favour of the fusion of Esperanto and Ido was eventually carried. This resolution has no weight, and will satisfy nobody, least of all the advocates of either of the two universal languages.

A French delegate moved that a thorough inquiry be made regarding the occupational illnesses to which postal servants were subject. The matter, he said, should be regarded in an international spirit, as it affected all postal workers. If they had post-offices in France like those in London, they were inclined to think long and severe illnesses would disappear.

Mr. W. B. Cheeseman, on this point, said he hoped and believed that by the work of the society they were on the way to the elimination of consumption, but other diseases affecting the nerves of the workers were still prevalent. He mentioned the noise and vibration of machines, and more particularly speeding-up methods of work, as probable causes. "We have," he added, "a comparatively large number of men who have been obliged to go to lunatic asylums because their minds have become unhinged in consequence of the strain of their work." It was necessary, he stated, that an inquiry, should be made at once. Medical officers, he alleged, were unwilling to state deliberately what the men were suffering from, and common diseases were often put down as being the cause of illness, when, as a matter of fact, they were due to nervous complaints which had developed. The motion was agreed to.

Mr. T. W. Casey, the general secretary of the Yorkshire Winding Enginemen's Society, had interviews last week with the Home Office respecting a new code of shaft signals; a compromise has been arrived at in the matter, which does not appear generally to give satisfaction. The men were determined that some alteration should be made in the new code issued by the Home Office, otherwise they would not work it. The main point at issue had reference to the signals for winding-men. Under the new code the winders declared it was impossible to wind men against men without serious danger, the reason being that whilst on the one hand the signal 3 to the engineman meant that he could draw the cage away from the bottom, another similar signal from the pit bottom meant that he must keep the cage stationary until he received the signal 1. This was very confusing, and the result of the ballot of the Winders' Society clearly showed that the men would not work to this signal.

Conferences have been held in London with Sir Richard Redmayne (Chief Inspector of Mines), the Right Hon. Mr. McKenna (Home Secretary), and other Home Office officials. The winders asked that in regard to the signal of 3, when men were ascending or descending, this signal should be a warning that men were going to "ride" the shaft, but that before the cage was allowed to move there should be a separate signal of 1 given after the 3. The Home Secretary decided in the men's favour, and granted the additional signal 1. We may add here that the men have throughout received the united support of the colliery-owners in their desire to remedy their grievance.

Mr. Casey, while expressing regret that they could not retain the old signal of 3 and 2—which he still considered to be by far the best and safest—agreed to recommend the winders to accept the 3 and 1 signal in each case of winding men, whether ascending or descending the shaft. He had received an intimation that the Secretary of State was agreeable to the additions to the code on the lines suggested, and would have the alterations incorporated in the code in the proper way.

The coalmen on the Great Northern Railway have been agitating for some considerable time with a view to obtain a revision of their conditions of service. The conditions under which they work include, it is stated, a 72 hours week when on day duty, and 74 hours when on night duty, with no deduction for meal-times. They are paid at the rate of 2¼d. per ton, and at some depots as much as 2300 tons a week are dealt with. This has to be handled by the coalmen, who have to transfer the coal from the staithes to the engines. The men demand a 48 hours week, and the piece-work rate to be advanced by 1d. an hour, also one week's holiday, with pay and a free pass.

The company declined to agree, and the matter was placed before Judge Parry, who has now given his award as follows:—A 55½ hours week, exclusive of 1¾ hours a day for mealtimes, an advance of ¼d. per ton all round, three days' holiday with pay each year after a man has been five years in the company's service. The award applies to all the coalmen throughout the Great Northern Railway system. The new conditions will remain in operation for twelve months.

A dispute regarding non-unionists, which had arisen between the Warehouse Workers' Union and Messrs. Wilson Brothers, Garston, has been settled by Sir David Harrel, the Board of Trade arbitrator. In his award Sir David Harrel states that Messrs. Wilson's claim to the effect that they should continue to maintain their attitude of neutrality and impartiality as between unionists and non-unionists was admitted by the work-people. The workers' request that notices should be placed in the works that the company did not view with disfavour the employment of trade unionists was agreed to by the employers. All parties were agreed as to the procedure necessary in the case of persons who were undesirable, "in so far as undesirable meant persons of immoral character, of objectionable personal habits, or users of obscene or improper language." The claim of the work-people that the firm should be forced to take any steps which might be interpreted as an inducement to persons to join the union appeared, in the arbitrator's opinion, to be inconsistent with the employers' attitude of neutrality and impartiality as between unionists and non-unionists.

We are informed that the concessions which were offered some weeks ago to 'busmen by the London General Omnibus Company, and were accepted by the Licensed Union of Vehicle Workers on behalf of its 15,000 members, will cost the company about 200,000*l.* per annum.

A meeting of delegates of the members of the Railway Clerks' Association from all parts of the North-Eastern Railway system was held at York on Saturday, the 27th ult., to consider further their demand for improved conditions and increased salaries. Mr. A. J. Best, Darlington, presided.

The association some time ago promulgated a demand for a salary scale rising to 150*l.* at 37 years of age; in reply to this, the company introduced a new scale, which, while it accelerated the progress of the younger men, had no effect upon the majority of the senior men.

After discussion, a resolution was passed unanimously expressing (*a*) indignation at the failure of the company to introduce a standard scale on the lines indicated, and condemning the existing system; reiterating (*b*) the demand "that the debased scale in operation in the telegraph department shall be withdrawn, and these clerks shall have salary conditions identical in all respects with those of their colleagues in the other departments;" (*c*) the resolution further expressed surprise and regret that the management still adheres to the decision to exclude the shop clerks from the provisions of the scales for salaried staff; (*d*) the meeting, the resolution continued, "again asserts the claim for recognition of the Railway Clerks' Association, urges the executive committee of our organisation to lose no opportunity of pressing for this right, which has been accorded to those engaged upon the manipulative and operative side of the business, and pledges to them the united support of the clerical staff in any action they may see fit to take;" (*e*) the meeting authorised and instructed the Salaries Movement Committee to seek at once another interview with the Board of Directors, "with a view to placing the whole position before them once more, in the light of the evidence as to actual North-Eastern salary conditions which has recently been obtained, and the further evidence as to salaries in the Civil Service, the Postal Service, and other first-class businesses, which has become available since the interview on July 24, 1913.'

We are informed that the strike of trawler engineers at Fleetwood, to which we referred in our last issue, has been satisfactorily settled. Last week representatives of the Fishing-Vessel Owners' Association and the Amalgamated Engineers' and Firemen's Union held a conference, the result of which was the reinstatement of the discharged engineer.

On Friday last, the 26th ult., evidence was given before the Select Committee on behalf of the Federation of Laundry Associations, who are opposing the Bill for the confirmation of the Provisional Order to include calenderers and machine-ironers in laundries within the Trade Boards Act. Sir J. Compton Rickett occupied the chair.

Mr. J. Stark, secretary of the Federation, complained of the competition of small laundries which were not under Home Office inspection. He pointed out the risks that were run owing to the conditions under which clothes were dealt with in such places. He instanced a case in which chicken-pox had been contracted, and another case where washing was done in a house from which children suffering from scarlet fever had been removed. He explained that variations in wages in the factories were due to the capacity or lack of capacity on the part of the workers. The trade, he added, was quite willing to pay higher wages if a better class of worker could be obtained.

INTERNATIONAL FEDERATION OF CONSULTING ENGINEERS.—The second international congress of consulting engineers will take place at Berne, Switzerland, from the 15th to the 22nd inst. A programme of the proceedings has been issued. All information concerning the congress can be obtained from Mr. de Herbais de Thun, 18, Rue Marie-Thérèse, Brussels.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was again dead idle. In the morning Cleveland warrants were a shade easier, with sellers at 51s. 3d. cash, 51s. 5d. one month. and 51s. 6½d. three months, while in the afternoon these quotations were barely maintained, and sellers named 51s. 2½d. cash, 51s. 4d. one month, and 51s. 6d. three months. There was no improvement in the market on Friday morning; prices of Cleveland warrants were stationary, and no dealings were recorded. At the close sellers quoted 51s. 2½d. cash, 51s. 4d. one month, and 51s. 5½d. three months. The afternoon session was dull, and business amounting to 2500 tons of Cleveland warrants was done at 51s. 1d. cash and 51s. 4d. three months, and closing quotations were called 51s. 1½d. cash, 51s. 3½d. one month, and 51s. 5d. three months. On Monday morning the market was again quiet, and business was limited to 1000 tons of Cleveland warrants at 51s. 1d. and 51s. 0½d. cash. Closing sellers quoted 51s. 1d. cash, 51s. 3d. one month, and 51s. 4d. three months. In the afternoon the tone was a shade easier, and the minimum of dealings took place—namely, one Cleveland warrant at 51s. cash, the session closing with sellers quoting 51s. 0½d. cash, 51s. 2½d. one month, and 51s. 3½d. three months. On Tuesday morning the market was quite idle, and sellers of Cleveland warrants quoted 51s. 1d. cash, 51s. 3d. one and three months. The tone was steady in the afternoon, when 1000 tons of Cleveland warrants changed hands at 51s. 1d. twenty-one days. At the close sellers quoted 51s. 1d. cash, 51s. 3d. one month, and 51s. 3½d. three months. When the market opened to-day (Wednesday) the tone was stronger, but no dealings were recorded, and sellers' quotations for Cleveland warrants were 51s. 1½d. cash, 51s. 3d. one month, and 51s. 5d. three months. The afternoon session was another blank as regards business, and although buyers' quotations were a shade easier, sellers of Cleveland warrants made no change in their prices.

Sulphate of Ammonia.—An improving demand has been noticeable in the sulphate of ammonia market during the past week, and buyers seem more inclined to book a little ahead. The price is firmer, and for prompt delivery the current quotation is now from 10*l.* 12s. 6d. to 10*l.* 15s. per ton, Glasgow or Leith, and for forward lots prices are also the turn better.

Scotch Steel Bars.—The quietness in the Scotch steel trade continues, and there is not the slightest sign of any improvement. With such a scarcity of orders as has prevailed for some time, it is wonderful how some of the establishments have managed to keep going so long. The heavy importation of general material from the Continent has been very severely felt, and instead of the usual stir and bustle at this period of the year, on the eve of the holidays, there is an absence of pressure for deliveries, and the day for closing down will not be unwelcome. Specifications are only for small lots, and inquiries are limited and also of small volume. Plates, sheets, and sectional material are all alike in this category, and the outlook is not promising. The export trade is keeping up fairly well, and although some of the markets are a little unsettled, one or two others are consuming quite respectable quantities of material. Australia and New Zealand are each taking up a considerable tonnage, while India, South Africa, and Japan are moderate buyers. Prices all round are steady, but Continental quotations are about as low as ever.

Malleable-Iron Trade.—The West of Scotland malleable-iron makers report no improvement, and are still suffering from the heavy shipments of material from the Continent, the prices quoted for which they cannot look at. They are picking up moderate orders here and there, and are managing to keep running on a reduced number of shifts on these hand-to-mouth lots. The price of "crown" bars is unchanged.

Scotch Pig-Iron Trade.—Although there has been no notable increase in the demand for Scotch pig-iron, orders have been coming in exceedingly well, and stocks show little increase. Consumers in the South continue to purchase fair quantities, and there is almost certain to be an increased request during the next two weeks, before the annual holidays commence. Export departments are also fairly well employed shipping the noted local brands, and inquiries, though only moderate, are encouraging. The following are the market quotations for makers' (No. 1) iron:—Clyde, 67s.; Calder, Gartsherrie, Summerlee, and Langloan, 67s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 70s.; Shotts (at Leith), 68s. 6d.; and Carron (at Grangemouth), 68s.

Scotch Shipbuilding. — The figures dealing with the Scotch shipbuilding output for the past month are both interesting and satisfactory, the total being 25 vessels of 77,490 tons, made up as follow:—

	Vessels.	Tons.
The Clyde	20	73,680
The Forth	1	3,100
The Tay	1	100
The Dee	3	610
Total	25	77,490

The Clyde output is a good bit ahead of the return for the corresponding month of last year, which was 22 vessels, of 54,478 tons, but it has actually only been bettered on one other occasion—namely, June, 1906, when the total was 124,544 tons. This latter total was swelled by the launch of the Lusitania and the battleship Agamemnon. Dealing with the work of the half-year we find that the output—129 vessels, of 267,677 tons—is rather more than 80,000 tons down from the corresponding period of last year, and which included the Aquitania, but is the sixth highest output on record for the first half of any year. These six occasions are:—

Year.	Tons.	Year.	Tons.
1906	336,258	1912	289,586
1907	302,847	1913	348,475
1911	310,460	1914	267,677

The booking of new work during the past month was more satisfactory than during one or two of the preceding months, and several important contracts are reported. One of these has been secured by Messrs. Barclay, Curle and Co., Scotstoun, and is for a twin-screw oil-engined vessel of 8000 tons gross and 6000 horse-power, for the Russian East Asiatic Steamship Company. Most of the shipyards are still well employed, but one or two labour troubles are at present casting a shadow over the industry, and something more is likely to be heard of them in the near future. Wages, non-union labour, and an eight-hour day are the principal items which will be under discussion very soon.

ONE HUNDRED AND TWENTY-FIVE POUND CONCRETE COTTAGE COMPETITION. — The result of the concrete cottage competition, organised by *Concrete and Constructional Engineering*, will be made known in the July number of that journal, which will be issued on July 4. The exhibition of the 249 designs sent in will be held at the Surveyors' Institution (lecture hall), 12, Great George-street, Westminster, S.W., from July 6 to July 11, between the hours of 11 a.m. and 6 p.m. The assessors, it will be remembered, were Mr. Max Clarke, F.R.I.B.A., Professor Beresford Pite, F.R.I.B.A., and Mr. Edwin O. Sachs, F.R.S. Ed.

THE BRITISH FIRE-PREVENTION COMMITTEE. — The British Fire-Prevention Committee's annual report for 1913, which has been issued this week, shows the extension of its work. Originally the committee devoted itself mainly to testing, but, apart from the conduct of its testing-station, it is doing a considerable amount of advisory work for the public authorities, and latterly also work of a popular character. The first part of the annual report records what has been done as to such questions as celluloid dangers, flannelette dangers, safety from fire on board ship, portable chemical fire-extinguishers, and the formation of the committee's new technical inquiry-office. Another part is devoted to its popular work in issuing "Christmas warnings," and to the popular warning, issued through the Board of Education, as to school entertainments. Then follow a number of official data, such as recommendations or regulations officially issued by the Home Office in the matter of fire precautions.

SUBTERRANEAN RESERVOIRS IN QUEENSLAND.—In the rolling downs country of Western Queensland the artesian supply of water has rendered it possible to carry on industries dependent on water supply. Pastoralists, the western pioneers of Queensland, made fortunes forty years ago in wool, but that was because they had a series of good years. Droughts afterwards decimated these regions. Nature was kind to these early pastoralists, who depended on her to supply water and pasturage, and only assisted her by the construction of dams and tanks. There is now obtained from subterranean reservoirs an unfailing flow of water, both for drinking and irrigation. At the end of 1912 there were 1879 artesian wells in Queensland. The deepest bore is situated at Bimerah, in the central west. This has a depth of 5045 ft. The shallowest bore is at the Manfred Downs, also in the central west, which yields a supply of 2000 gallons per day. The Charleville bore has a depth of 1371 ft., and the largest flow in the State—viz., 3,000,000 gallons per day. The estimated aggregated daily flow from all bores in Queensland is 529,817,860 gallons. This supply necessitated 384.68 miles in depth of boring. In some instances the water has a high temperature, and requires to be cooled before using for domestic purposes.

ALL-STEEL CAR FITTINGS.—We have had the opportunity, in the course of the last few days, of inspecting at the Moorgate Works of Messrs. G. D. Peters and Co., Limited, Moorfields, E.C., a number of samples of interior fittings for all-steel cars, such as are being adopted now on many railways in the United States. The material included a number of steel doors, windows, sashes and frames, portions of sides, sample mouldings, &c., and we were much interested in the sharp and clean finish of the work we saw. The mouldings were particularly good, the rounding commonly present in pressed-steel work being almost completely absent, so that when finished they have the appearance of clean-cut wood mouldings. The samples of mouldings included several of very complicated profile, while the advantage of steel-work of this class was noticeable in the ease with which deep mouldings may be built up out of narrow sections by simple spot-welding. Spot-welding can, in fact, be used with advantage in a good deal of this work. The doors and windows are equally well finished, and when fitted in a car would deceive any but the most expert, unless tested by the touch. The samples are the work of the Hale and Kilburn Company, of Philadelphia, Pa., U.S.A., whose business in this and many other countries is conducted by Messrs. G. D. Peters and Co., Limited. As is well known, there has been a considerable movement in the United States with a view to substituting steel stock for the wooden passenger-cars, and the question of interior finish has thus received a great deal of attention over there. The time and thought expended has resulted in a very good product, and the samples which Messrs. G. D. Peters and Co. have to show can hardly fail to prove of interest to a large number of railway men in this country.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade. — Except for the best qualities, for which there is a steady demand, the house-coal trade is unusually quiet. Business at the local dépôts is on a very small scale. The turn of the month has brought a few more orders for stocking purposes, but has not materially improved the position. Pits that rely exclusively on this class of trade are only working four days per week, and some of them shorter time than this. The demand from London merchants is nothing like what it was at this time last year. The steam-coal market occupies very much the same position as it did a week ago. Big tonnages are going into consumption in the heavy industries, though the export trade is not noticeably larger. Contracting is just a little further advanced. In some cases users have succeeded in obtaining 1s. reduction on last year's figures. Forced selling is reported, though on the whole values are steady. Slacks move unevenly, but a firmer tone prevails in cheaper qualities where weakness has been most pronounced. Coke is on the down grade. Quotations:—Best branch hand-picked 15s. 6d. to 16s. 6d.; Barnsley best Silkstone, 13s. to 14s.; Derbyshire best brights, 12s. to 13s.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 10s. 6d. to 11s. 6d.; small nuts, 9s. to 10s.; Yorkshire hards, 11s. to 12s.; Derbyshire hards, 10s. 6d. to 11s. 6d.; best slacks, 7s. 6d. to 8s. 6d.; seconds, 5s. 6d.; smalls, 4s. to 5s.

Iron and Steel.—There is no difficulty in obtaining supplies of raw material. The difficulty is rather in getting sufficient orders to keep the furnaces working, despite the fact that a considerable proportion of them have been damped down. Users are coming forward very slowly with contract renewals. There is still a great deal of uncertainty as to whether the worst has been experienced in the sagging of values, and, in the absence of any definite feeling, the arrangement of forward bookings is being seriously impeded. Spot business in Lincolnshire products has been expedited by the reduction of official quotations to 52s. 6d. for foundry iron, and 50s. for forge iron. So far the change, which has long been expected, has not adversely affected the sale of Derbyshire products. A good tonnage of hematite is going into consumption. West Coast quotations are firmly held, but a slight reduction is shown in East Coast figures. Steel-makers have taken full advantage of the reduction. There is very little movement in basic iron. The slight improvement in bar iron, consequent upon wagon-building activity, is maintained. While slackness at the steel works is the rule rather than the exception, it is attributable not so much to declining trade as to such quarter-end influences as stock-taking. The gross output is much smaller, but the shrinkage has not been so severe as to give cause for genuine alarm. Cases of undiminished activity are still to be found. Heavy engineers have not only as many orders on their books as to keep them fully employed, but in a number of cases are unable to secure the requisite amount of skilled labour. The big armament firms are quite as busy. Not only are there heavy orders on hand for the British Government, but the requirements of foreign Powers, notably Spain and Russia, in connection with naval re equipment, are exceptionally large. On the other hand, railway material departments could comfortably handle a bigger volume of business. The export demand is their present mainstay. There is a fair inquiry from English corporations for tramway materials. Average activity is maintained in special steel-making, but steel billet makers report a dearth of new business. Machinery for overseas mining purposes is a busy medium, particularly for export to South Africa. Makers of files, engineers' tools, twist-drills, and wire rope have satisfactory prospects. The lighter steel trades are regularly engaged.

PERSONAL.—Mr. William C. Mountain, Sun Buildings, Newcastle-on-Tyne, states that in order to meet the requirements of his increasing practice he has opened an office in London at 66, Victoria-street, Westminster.

ALGERIAN RAILWAYS.—The receipts of the Algerian and Tunisian networks of railways last year amounted to 1,178,170*l.*, as compared with 1,017,338*l.* in 1912. The net revenue last year was 139,770*l.*, as compared with 127,160*l.* An official decree of June 9, 1914, provides that the Governor-General of Algeria is authorised to purchase the concessions of the Bona and Guelma Railway Company. The line purchased will be incorporated in the Algerian State network.

CONTRACTS.—A contract has just been awarded by the Chinese Government to the Niles-Bement-Pond Company for the complete equipment of a small-arms arsenal at Hanyang, near Hankow, China. The contract calls for the delivery of the complete equipment in about two years. This will include all of the machine-tools, jigs, fixtures, cutters, and three complete sets of gauges. All the machines and tools will be built at the Pratt and Whitney Works, Hartford, Conn.—Messrs. J. Dampney and Co., Limited, Cardiff, have recently received an order for 300 gallons of their "ApeXioR" compound from the Victoria Falls and Transvaal Power Company, Limited, their requirements for one year. This company have adopted "ApeXioR" for use in their entire plant of Babcock and Wilcox boilers.—The Preston Town Council has, after a series of tests, decided to order two Hatfield motor fire-engines, fitted with reciprocating pumps, from Messrs. Merryweather and Sons, London. The new engines will be capable of pumping 450 to 500 gallons per minute, and will each carry a 60-ft. fire-escape and a chemical cylinder for throwing a "first-aid" jet.

THE TESTING OF TURBINES AND TURBO-BLOWERS AT THE HEATON WORKS.

(For Description, see Page 3.)

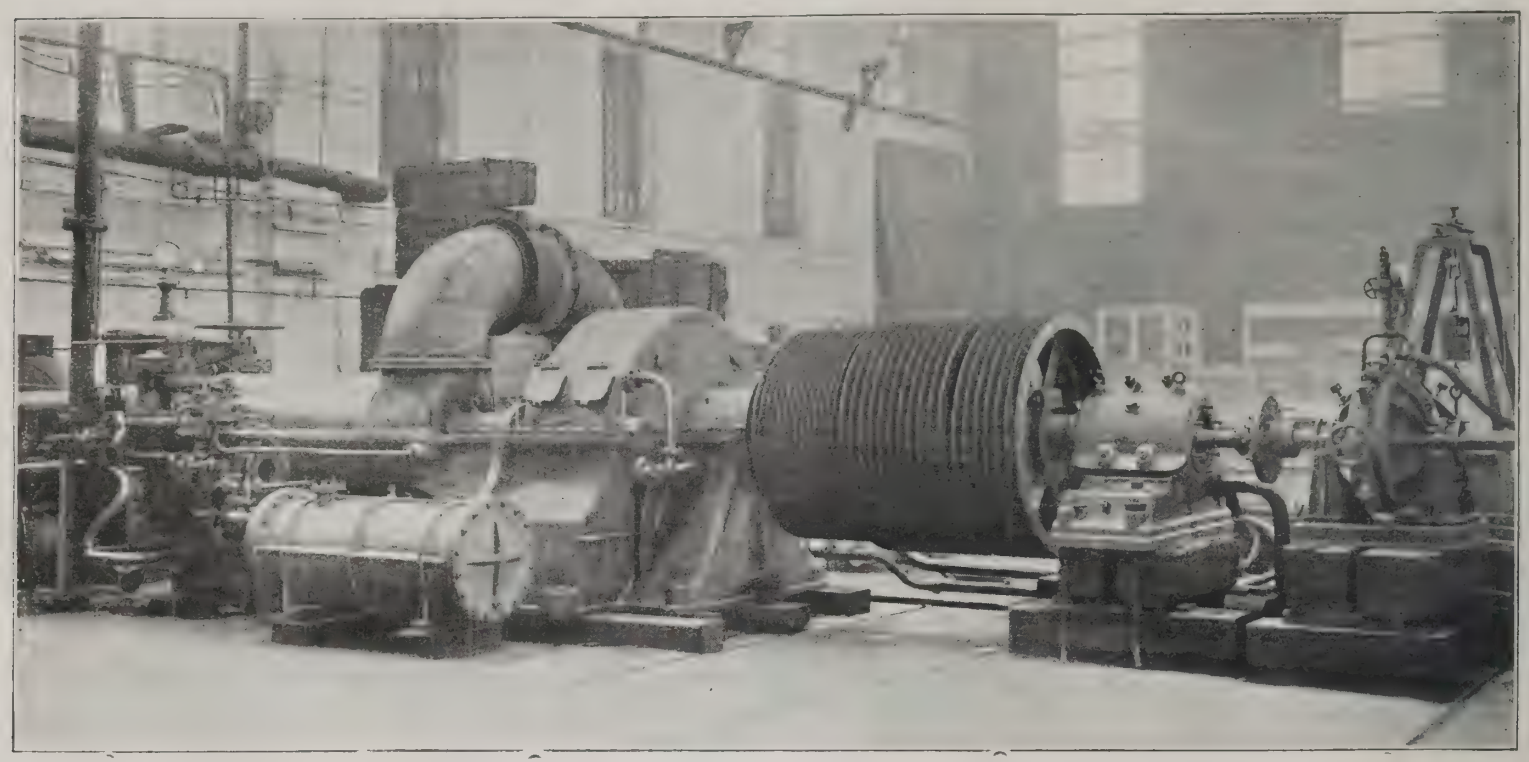


FIG. 2. GEARED TURBINES WITH ROPE-PULLEY FOR MILL-DRIVING UNDERGOING TESTS.

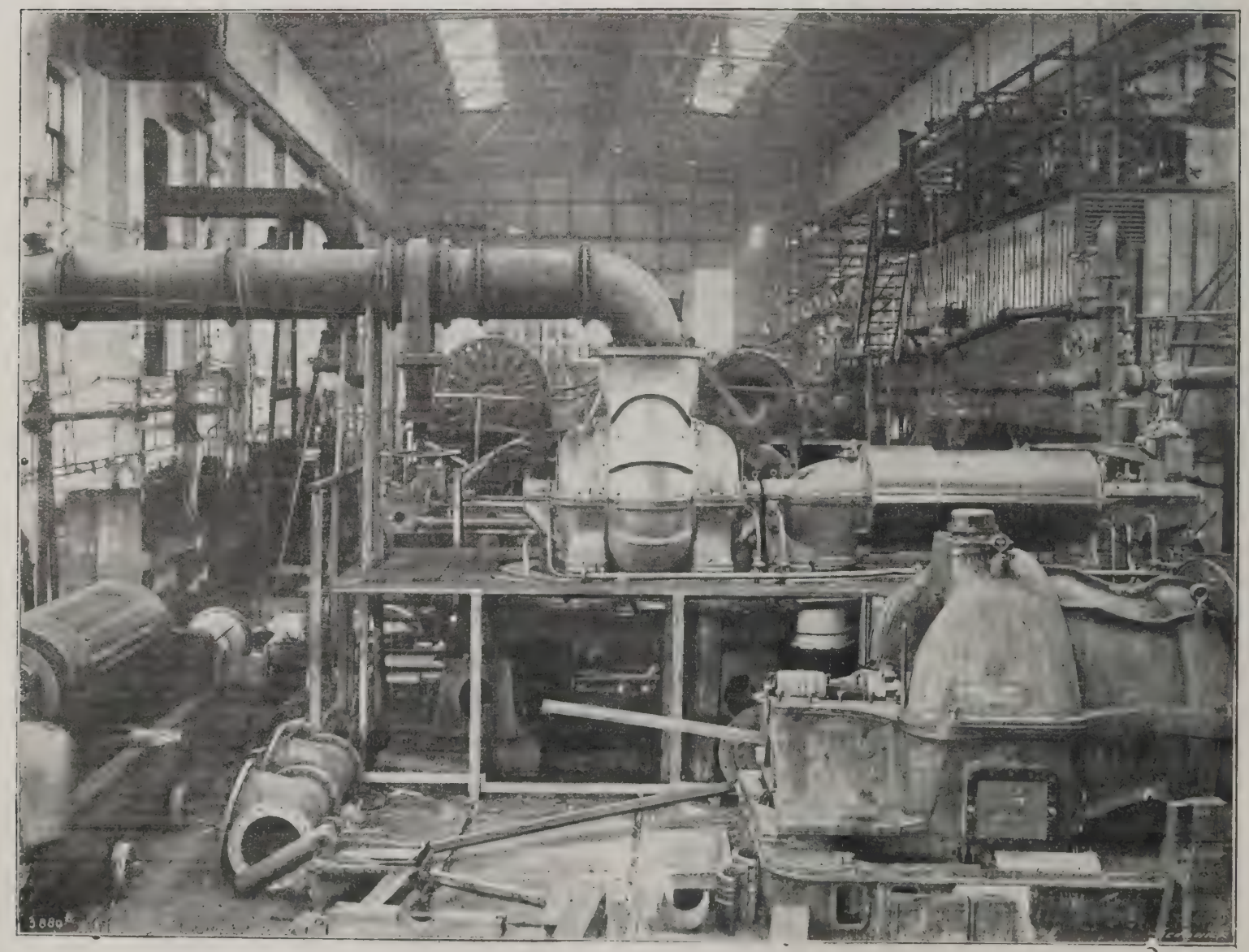


FIG. 3. DOUBLE-ENDED TURBO-BLOWER ON THE TEST-BED.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With Two One-Page Plates of the WALLSEND SLIPWAY AND ENGINEERING COMPANY'S WORKS, WALLSEND-ON-TYNE; Two One-Page Plates of the ENGINEERING LABORATORIES AT THE ARMSTRONG COLLEGE, NEWCASTLE-ON-TYNE; One Two-Page Plate of the NEW JOINT DOCK AT HULL: HYDRAULIC TIPPING-HOISTS ON COALING-QUAY; Two One-Page Plates of the PANAMA CANAL; and Two One-Page Plates of the WORKS OF THE NORTH-EASTERN MARINE ENGINEERING COMPANY, LIMITED, WALLSEND-ON-TYNE.

NOTICES OF MEETINGS.

THE ROYAL SANITARY INSTITUTE.—Saturday, July 4, to Saturday, July 11, at Blackpool. For detailed programme, see page 877 of our issue of June 26.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Monday, July 6, at 5 p.m., general meeting of the members.

THE INSTITUTION OF NAVAL ARCHITECTS; THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND; AND THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Joint Meeting at Newcastle-upon-Tyne. July 7 to 10. July 7, at 10 a.m., Reception in the King's Hall, Armstrong College, by the Earl of Durham, K.G., and members of the Reception Committee, and an address of welcome by the Lord Mayor of Newcastle-upon-Tyne and the Hon. Sir Charles A. Parsons, K.C.B., F.R.S., President of the North-East Coast Institution of Engineers and Shipbuilders. The following papers will then be submitted by the Institution of Naval Architects:- (1) "On the Protection of Battleships Against Submarine Attack," by Professor Sir John H. Biles, LL.D., F.R.S.; (2) "Recent Developments of the Hydraulic Transformer," by Herr Professor H. Föttinger; (3) "Shipbuilding Practice of the Present and Future," by Mr. T. G. John; (4) "Some Notes on the Design of Floats for Aeroplanes," by Mr. Gilbert H. Miller. In the afternoon there will be visits to the works of Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited; of Messrs. Swan, Hunter and Wigham Richardson, Limited, and of the Fullagar Engine, Limited. At 9 p.m. there will be a reception at the Assembly Rooms. On Wednesday morning, at 10 a.m., the following papers will be submitted by the North-East Coast Institution of Engineers and Shipbuilders in the Lecture Theatre of the Literary and Philosophical Society:—(1) "Some Notes on Warships Designed and Constructed by Sir W. G. Armstrong, Whitworth and Co., Limited," by Mr. J. R. Perrett; (2) "A Review in the Progress of the Marine Steam Engine on the North-East Coast during the last Fifteen Years," by Mr. A. C. Ross; (3) "Charging of Two-Cycle Engines," by Professor B. Hopkinson, F.R.S., and "A New Type of Internal-Combustion Engine," by Mr. H. F. Fullagar, M.A. In the afternoon there will be visits to the works of the Consett Iron Company, Limited; of the North-Eastern Marine Engineering Company, Limited; of Messrs. R. and W. Hawthorn, Leslie and Co.; of Palmer's Shipbuilding and Iron Company, Limited; and of the Fullagar Engine, Limited. In the evening there will be a reception and dance in Tilley's Rooms. On Thursday no papers will be read. There will be visits to the works of Messrs. Wm. Doxford and Co., Limited; of the Darlington Forge Company, Limited; and of the Fullagar Engine, Limited. In the afternoon there will be a garden party at Lambton Castle. On Friday, at 10 a.m., the following papers will be submitted by the Institution of Engineers and Shipbuilders in Scotland:—(1) "Influence of Varying Temperatures on the Strength and other Properties of Admiralty Gun-Metal," by Professor A. Campion and Professor John G. Longbottom; (2) "The Strength of Welds by the Oxy-Acetylene Process," by Professor A. Campion and Mr. William C. Gray; (3) "Some Experiments on a Diesel Engine," by Mr. W. S. Burns. In the afternoon there will be a garden party at Jesmond Dene, and in the evening a dinner and a reception for ladies.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Tuesday, July 7, to Friday, July 10, the summer meeting will be held in Paris, &c. The following papers will be read and discussed at the meetings if time permits, but not necessarily in the order now given:—"Recent Development of Express Locomotives in France," by Professor Ed. Sauvage; "Compound Articulated Locomotives," by Mr. Anatole Mallet; "Signalling on Trains in Motion upon French Railways," by Messrs. Solacroup, A. Sartiaux, F. Lancrenon, A. Herdner, A. Claveille, and L. Maréchal; "Development of Internal-Combustion Engines for Marine Purposes," by Mr. Peloux; "Balancing of Internal-Combustion Engines," by Mr. H. F. Fullagar; "The New Niclausse High-Duty Marine-Type Boiler," by Mr. J. Niclausse; "Improvements in Motor-Lorries," by Mr. Peloux.—Tuesday, July 7, at 9.30 a.m. Mr. H. Gall, President, and Members of Council of the Société des Ingénieurs Civils, will welcome the Institution in the hall of the Society, 19, Rue Blanche, after which papers will be read and discussed. In the afternoon excursions will be made to various works of interest, and in the evening the Institution dinner will be held at the Hotel Continental at 6.45 p.m.—Wednesday, July 8, at 9.30 a.m., members will assemble in the Hall of the Société des Ingénieurs Civils for the reading and discussion of papers. In the afternoon visits will be paid to works. At 9.30 p.m. a conversazione will be held at the Société des Ingénieurs Civils, guests being received by Mr. and Mrs. Henry Gall and the Members of Council of the Society.—Thursday, July 9, at 3 p.m. A reception will be held in the Bois de Boulogne by Mr. William Hanning, President of the British Chamber of Commerce, and Mrs. Hanning.—Friday, July 10, various alternative excursions have been arranged to works, &c., in Lille, Valenciennes, and Le Havre.

ENGINEERING.

FRIDAY, JULY 3, 1914.

THE SUPERHEATER ELEMENT.

CONSIDERING the extent to which superheating has already been applied, and the decided success which has attended its employment, it is somewhat remarkable that on the one hand the theoretical efficiencies of various types of superheaters have not been more thoroughly discussed, while, on the other, there is not a more extended knowledge of the experimental work which has been carried out, bearing on the economy of superheating generally. Thus we were rather surprised, at the time of Mr. Henry Fowler's valuable paper on "Superheating Steam in Locomotives," being read recently before the Institution of Civil Engineers, to find that it contained a statement to the effect that the author was not aware of any experiments made to show the relative economy of different degrees of superheat. Although reference was made in other parts of the paper to the results of testing-plant investigations, Mr. Fowler appears by some mischance to have overlooked the work done in this connection at Purdue, and several times referred to in our columns, and at the Institution of Mechanical Engineers. The Purdue series of tests was made with superheat of 0 deg., 130 deg., 145 deg., 160 deg., and 230 deg. Fahr., and so far as they went they were fairly satisfactory. They undoubtedly showed an increase in economy with an increase of superheat, and though not as comprehensive as might be wished, owing to the limitations of the Purdue Laboratory, they are quite worthy of record and consideration.

In tests of this character a difficulty at once presents itself. The ultimate economy of a locomotive has to be taken over both the generator and machinery portions combined. Although the engine efficiency is improved with the introduction of superheating, in the most popular method of producing superheated steam there is some reduction in the efficiency of generation. The over-all result is to the good, unless the superheat is low. This disturbance of the efficiency of generation with different degrees of superheat was discussed at some length in ENGINEERING, vol xcii., page 276, and the points then brought out seem generally to have been confirmed by more recent information. Under the circumstances, in any trials with progressive degrees of superheat, the ideal would be to keep the efficiency of generation as nearly uniform as possible and as close as practicable to that of the saturated-steam boiler. For this to be done, only just so much water-heating surface should be removed as is necessary to give place to the superheating surface requisite for the particular superheat aimed at. Unfortunately, this gradual transition is impossible with the commonly-adopted smoke-tube type of superheater. The necessity of having large smoke-tubes, to accommodate the heater elements, sacrifices a certain amount of water-heating surface, whether the elements be designed for high-degree results or low. According to the superheat adopted, therefore, the work taken out of the gases in these large tubes may vary greatly; the waste heat would in some cases be considerable, and there must perforce be an appreciable difference in the proportion of the heat available to the heat utilised under these several conditions.

In the most efficient smoke-tube superheater the element would be so designed that of the heat carried by the gases entering the large tubes the maximum possible amount would be taken up by the steam and water-heating surfaces. At the other limiting extreme we may suppose a superheater formed of such short elements that they hardly enter the smoke-tubes at the smoke-box end. If for water-heating surface the 2-in. or 2¼-in. tube is of good proportions for some typical boiler, a 5-in. water-heating tube would evidently be less efficient, and a larger amount of heat would be conveyed to the smoke-box through these than through the 2-in. tube. This extra heat would be delivered in our limiting case to a small amount of superheating surface; very little would be taken up, and the heat lost would be large, while the superheat would be low.

We therefore conclude that trials conducted with different degrees of superheat, obtained by merely varying the surface of the smoke-tube type of superheater, are far from the ideal, and generally should be regarded more in the nature of an investigation of the possibilities of this particular type of appliance than as conclusive on the subject of superheating, since in other applications this disadvantage might be overcome. Nevertheless, such trials are valuable as bringing out some very interesting points of which notice might be taken in design.

In 1911 we directed attention in these columns to the fact that the double return-bend element, used in the superheaters of the present day, was a comparatively inefficient appliance. We stated that "for a very large part of the superheater surface the transmission is exceedingly low." This we explained in the following terms, which will bear repetition in view of some recent tests carried out on the Pennsylvania Railroad. The words we used were as follows:—"In only two limbs of each element does the steam flow in a direction favourable to absorption—*i.e.*, in a direction contrary to that of the gas; while, again, in only two limbs is the temperature head considerable for any part of the area exposed. The transmission at the ends of the contra-flow limbs must be considerable, especially in the case of the first. It would also be high at the commencement of the second limb, but there the direction of flow is unfavourable, and the rate of transmission must fall rapidly."

To consider what occurs in an element in greater detail, we may follow the course of the steam in the

various limbs. Starting at the smoke-box end, in the case of the first limb the gas and steam are flowing in contrary directions. The temperature difference, though not very large to begin with, rapidly increases as the steam flows towards the fire-box. Transmission throughout this limb is good, and at the fire-box end is high. On turning the corner and flowing back, at first transmission is good owing to the temperature head, but this drops quickly, and the steam is now flowing with the gas; the transfer of heat falls rapidly with an increase of distance from the fire-box. If it does not become negligible after passing out of the hot zone, it certainly is not very material. On again reversing its direction, and flowing towards the fire-box in the third limb of the element, the contrary flow of the hot gas and increasing temperature head are again favourable; but by now the actual difference between the temperature of the steam and gas has been much reduced. Transmission is therefore much smaller than in the first limb, but towards the fire-box end it increases, and is fairly good for some distance in this neighbourhood. On turning the last corner, the steam, now being raised considerably in temperature, receives a little additional heat, but soon passes out of the zone where the temperature head is of useful magnitude, both steam and gas flowing in the same direction. There have been cases, of course, in which the steam in this fourth limb, instead of absorbing additional heat, has, for a good part of the length, actually been supplying heat to the flue gases.

A simple analysis of this kind suffices to show that the useful work is done on the steam in the first limb, part of the second and third, and a very small part of the fourth; the remaining surface would be as well cut out, when a reduction in pipe friction would be secured. In the type of superheater now so popular it is not possible to cut out the last limb, as the steam must be returned to the front end; but there is no sound reason for keeping to the long return bend, of which a considerable portion is valueless. If a little thought and some experimental work had been expended on the subject at first, we think it questionable whether the present form would ever have been adopted. It would not have been very difficult to have fitted up experimentally a tube and element, so as to obtain a record of temperatures at various points of the steam path, but we do not know of anything of this kind having been attempted. Had it been done, the points we have made above would, we believe, have early become apparent. As it is we have had to wait for the substantiation of our views for the conclusion of a lengthy series of tests carried out on the Pennsylvania Railroad testing plant at Altoona, Pa., U.S.A., the results of which have recently been embodied in a paper read by Mr. C. D. Young, Engineer of Tests, P.R.R., before the Franklin Institute, Philadelphia, Pa. While these tests omitted to vary the water surface in proportion to the superheating surface introduced, any other arrangement, as above pointed out, being difficult to make with the smoke-tube system, the point we are now interested in is made abundantly clear. We will consider the results from the point of view of the variation of superheat with the heating surface, for some particular output. Several facts are brought out. In the first place, we find, as might be expected, that a double return bend of the standard pattern, but extending only half-way down the smoke-tube towards the fire-box, produces a lower degree of superheat than a single return bend of equal surface, but extending down the smoke-tube for the full standard length. The advantage of heating surface in the hot zone is thus made evident. The most interesting point, however, is that an element having a surface of only 75 per cent. that of the standard produced a degree of superheat greater in the proportion of 10 : 9 than that of the complete standard double-return bend.

This 75 per cent. element was of the usual doubled hair-pin type, but with the doubling only extending half way back from the fire-box end towards the smoke-box. The inefficient portion towards the smoke-box end was abolished with the benefit cited. The factors entering into the question are the two temperatures, the speed of the steam and gas, and pipe friction. By cutting out unnecessary length friction is reduced, and the velocity of the steam increased, both tending to better results. Even an element which possessed only 62½ per cent. of the standard element surface, with the doubling extending but a quarter of the usual distance back, gave a degree of superheat which was practically eight-ninths of that given by the standard element. Compared with a single-bend element, an addition of 25 per cent. of surface in the form of a short doubling at the fire-box end increases the superheat 41.6 per cent. An addition of 50 per cent. in the surface, in the form of a return bend, increases the superheat 78.1 per cent. If the return bend is further prolonged to the standard length, the superheat is less than in the last case.

We must confess that there appears to be a little inconsistency in the results recorded for some of the other elements tested, but the point which we think is made quite clear is the high value of the surface at the fire-box end, and the little use of that towards the smoke-box end in three out of the four limbs if high temperatures are aimed at. The endeavour should be to concentrate the heating surface in the most effective zone, so as to keep the total length, and consequently pipe friction and pressure drop, as small as possible. Even with the degrees at present worked to it would appear advantageous to abolish the unnecessary material, weight, and pipe friction; while if, as Mr. Stenning recently suggested, the future will see much higher temperatures aimed at, it would seem that greater attention must be given to these points.

It is impossible in the present smoke-tube system to get rid of the last limb leading the steam back to the smoke-box, but the present useful, or even additional, heating surface might be concentrated in the hot zone in the form of an open cork-screw spiral at the fire-box end of the first limb, the single return member running back from the end nearest the fire-box through its centre. If such an arrangement gave a higher resistance to the flow of the gases, it might necessitate some alteration in drafting at the front end, but this could be easily tested. It might prove feasible to develop some form of sheathing to protect the return limb, to prevent it giving up heat to the gases. There would only be one abrupt change of direction for the steam in such an element instead of the present three.

The tests generally point to the desirability of evolving, if possible, something different from the present smoke-tube element. It may ultimately prove possible to break away from this with advantage. The ideal would be to superheat wholly in a hot zone, as is done in some systems nowadays in marine and stationary practice, and to lead the steam off from this to the cylinders, protecting it on the way. It would reflect greater credit on the present generation if more attention were devoted to this question. It is rather disappointing that practically all the superheater designs adopted on any scale have slavishly followed the return-bend and smoke-tube principle, the distinctive features being some special pattern of headers, pipe-joints, and other matters of application, rather than of principle. It does not say much for the logic of rules which, in proportioning water to steam heating-surface, provide about 25 per cent. too much of the latter, and that of no value. What can be said, too, for those methods which interpret superheater surface as "equivalent" water-heating surface? If part of the surface does no work, it cannot be equivalent to the worst-placed water-heating surface, which even at the tube ends is of some value, owing to the temperature difference between the gases and water still being appreciable. Empirical rules of this kind can only be allowable if it is recognised that they are limited to one type of application, and not to superheating in general, a proviso commonly overlooked.

FURTHER HYDRO-ELECTRIC POWER UNDERTAKINGS IN NORWAY.

THE list of large industrial ventures based upon a continued exploitation of Norway's water-power is steadily increasing. Thus a large power-station with a capacity of some 50,000 horse-power is being laid out at the Folla River, an auxiliary to the Surna, in the Surendale. It will be necessary to construct a tunnel 3 km. long through the Sande mountain, whereby a satisfactory fall will be obtained. In its present state the Folla is of no special moment, but by means of damming, tunnelling, &c., a capacity of 50,000 horse-power for the new power-station is reckoned upon. The station will be located at a place with good harbour accommodation and sites for new industries. In the absence of a natural reservoir it will be necessary to construct a dam across a flat valley, between the steep mountains of the Troldheimen, and the wall across the Folla Valley is to be 20 metres high. This large undertaking is controlled by the owner of the water-power of the Heane River, in the Southern Drontheim district, which, duly exploited, will represent some 15,000 horse-power, and this, it is understood, will be applied to electric ore-smelting. At Folla there are large deposits of limestone, which have been secured.

The building of another hydro-electric power-station has just been decided upon, the cost of exploitation and transmission amounting to about 195,000*l*. The power will be derived from the Högfos Falls, and will amount to some 25,000 horse-power, which is to be transmitted to the town of Risör, a distance of some thirty miles. The fact that the power can be utilised in an existing town, instead of works and dwellings having to be built in an entirely desolate country, as is the case with so many large power-stations, means a very material saving. The Akershus district has just purchased the Raanaasfos Fall; the price for the waterfall is 55,000*l*.

The Arendal Water-Power Company, which is already in operation, is to be greatly extended, at an outlay of some 240,000*l*., and the Bjölvo waterfall is to be exploited.

A Norwegian journal of some standing has recently given expression to some apprehension as regards an over-production of hydro-electric power-stations, more especially as far as the electro-chemical industry is concerned. Only a few years ago it was difficult to find uses for capacities of 5000 to 10,000 horse-power in this industry, but such capacities no longer count for anything. Now the installations and projected schemes comprise capacities of 50,000, 100,000, or even several hundred thousand horse-power, in Norway, Italy, Spain, Savoy, Canada, and even in Iceland. As far as Norway goes, not only are the installations already in operation at Rjukan, Tysse, Arendal, &c., being extended, and that on a large scale, but schemes are being advanced at Sande, Matre, Tyin, Aura, Take, Lysefjord, Bölve, Höjangen, Osa, Glomfjord, &c. If, say, only half of the projects just enumerated are completed within the first few years, the question presents itself as to what shall all this power be applied?

It is a well-known fact that the old, or original, electro-chemical products, aluminium, carbide, ferro-alloys, all have very limited areas of consumption, which no doubt grow every year, but even a small over-production leads immediately to a decline of prices and to crises. Such have already arisen twice during the comparatively short span of fifteen to twenty years which has passed since these manufactures commenced, and experts are already prophesying a third crisis, with ruinous prices below the cost of production, as being near at hand. It will be remembered that during the former crisis at least two Norwegian carbide manufactories had to stop; the losses were heavy, as the factories had to be sold for a song.

On the other hand, the opinion is often expressed that the new electro-technical nitrogen industries—artificial manures—have an unlimited scope for the sale of their products. But this view must assuredly be accepted with considerable reserve. On the market for artificial manures the consequences of over-production are already felt. The quotation for Chili saltpetre has dropped from 10.50 marks in the beginning of March to 9.55 marks in the beginning of May, the market having been unable to receive the offered quantities of Chili saltpetre and artificial manures. Nor does the position of sulphate of ammonia offer any encouragement, as German reports show. Also the demand for cyanide shows signs of falling off.

In addition to all this, new methods have been discovered by which nitrogenic manures can be manufactured chemically, without the aid of electricity (as, for instance, the Haber system), so there seems every reason not to embark too lightheartedly on wholesale exploitation of water-power.

THE ROYAL AGRICULTURAL SOCIETY'S SHOW.

THE Royal Agricultural Society's Show, which this year is being held at Shrewsbury, opened on Tuesday last. This is the third time in the history of the Society that the Show has been held at this

centre. The weather, which means so much for the success of an exhibition of this character, has been propitious, and in many respects the Show has proved an immense success. Only on one occasion has the prize fund been larger than it is this year, while the entries in the live-stock classes are 500 in excess of those of Bristol, last year, and, of course, far ahead of those of the previous Shrewsbury Shows of 1845 and 1884. The implement classes, with which we are more concerned, do not cover the same extent of ground as they did last year at Bristol, nor is the number of stands as great, but the exhibits themselves show no sign of becoming less interesting, and quite a number of new appliances are entered for the Society's Silver Medal.

FIG. 1. THE STOCK MOTOR-PLOUGH; THE STOCK MOTOR-PLOUGH COMPANY, BERLIN.

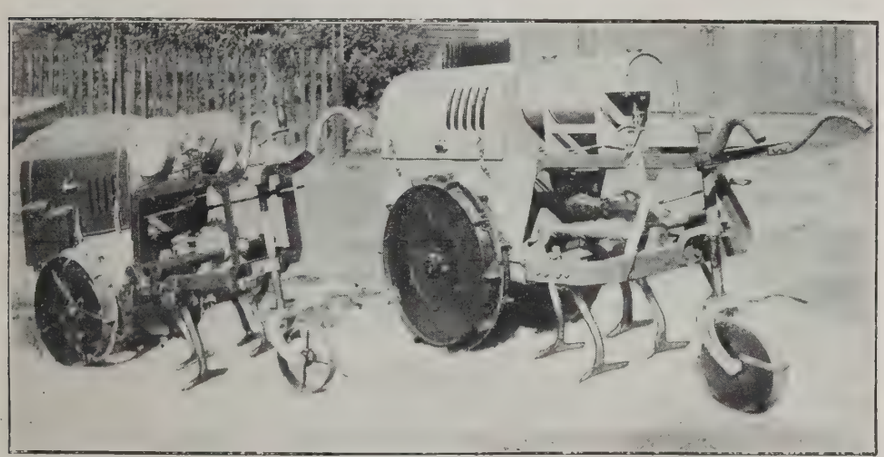


FIG. 2. THE IVEL-BAUCHE MOTOR-HOES; THE IVEL AGRICULTURAL MOTORS, LTD., BIGGLESWADE.

INTERNAL-COMBUSTION ENGINES.

A noticeable feature in this part of the Show is the large number of petrol and semi-Diesel engines of comparatively small capacity, suitable for driving farm machines, &c., and also the number of motors fitted up as portable engines, or actually applied to farm implements.

There are, for instance, several new motor-ploughs. Among them is a large six-furrow plough manufactured by the Stock Motor-Plough Company, of Berlin, whose business in this country is conducted by Messrs. F. W. Moellenkamp and Co., 85, Farringdon-street, E.C. This plough we illustrate in Fig. 1 herewith. This machine has two wheels 7 ft. 3 in. in diameter, with a trailing steering-wheel. The large wheels can be widened for working on very wet land, and various types of grips are fitted to the rims according to the land worked. The weight of the machine is 5½ tons. It has proved very successful on wet soil in the neighbourhood of Boston, Lincs. A single framing runs from back to front of the machine, the motor—a four-cylinder water-cooled petrol engine of 50-55 horse-power—being carried at the front end. Although the machine is large, it is arranged for one-man control from the driver's seat. The shares are raised or lowered by a crank-handle near the seat working a pinion-and-rack mounting for the trailing wheel. A dial near the driver's seat indicates the depth to which the shares are set. This operation can be performed by hand or by power. The drive is by gear throughout, the engine running at 720 revolutions per minute on benzol. There are four forward speeds and two reverse, the speeds ranging from 2½ to 4 miles per hour, according to the land being ploughed. The machine has a fuel-tank of 25 gallons capacity, with a smaller tank for a lighter petrol spirit for starting up. Bosch ignition is fitted, and to facilitate starting there is a compression release lever. The oiling is by the forced lubrication on the Bosch system.

Another motor-plough with several distinctive features is one exhibited by Messrs. Bumsted and Chandler, Limited, Hednesford, Staffordshire. This machine is also a one-man appliance. It is styled the "Ideal," and, in addition to ploughing, can be made to work as a self-contained cultivator, as a tractor, or as a portable plant for driving purposes. As a tractor it has taken a load of 6 tons at 6 miles per hour up a slope of 1 in 10. In this machine the motor is mounted as a four-wheeled tractor, with the plough fitted as an extension-frame at the rear. The model shown had four shares. The engine, of 35 horse-power, is of the four-cylinder type. The fuel-tank capacity is 35 gallons. The machine is provided practically with motor-car control, there being two forward speeds of 3 and 6 miles and one reverse of 3 miles per hour. From the second-motion shaft power can be transmitted from the driver's seat through the free differential gear, or through the locked differential so that the road-wheels cannot rotate independently, or to one or the other road-wheel alone. Foot-brakes are fitted on the differential shafts, and hand-brakes on to the inside of the rims of the back wheels. There is a winding-drum capable of taking 30 yards of steel cable; this can be operated in either direction when the tractor is either moving or stationary. The large wheels are 5 ft. 6 in. in diameter by 10 in. wide. They are fitted with an interesting arrangement of spuds, cam-operated and self-cleaning. These spuds are of ⊏ section, except where they pass through the wheel rim, where they are given extra width by being turned into spuds of F-shaped section. They are pushed out by a steel ring mounted on a large roller-frame bearing encircling the axle, and mounted so that each spud is pushed out as it approaches the ground, and is free to be drawn in by a stiff spring on leaving the soil, thus cleaning itself, and not projecting in the upper portion of the path of the periphery. The projection given to these spuds can be varied from 0 in. to 4 in. by a screw and spanner from the driver's platform. The front axle is of the swivelling pattern, with centre springing, the front springs being 3 ft. long. The back springs are 3 ft. 6 in. long.

The plough consists of ⊏-section frame, more or less of the shape of a parallelogram, with several cross-bars. The shares are mounted on these cross-bars, and can be easily adjusted on them to give any particular width of furrow from 9 in. to 12 in. wide. The plough frame can be adjusted vertically so as to cut furrows 4 in. to 8 in. deep, the draught being through oblique rods attached low down to the motor, and brought up to the plough-frame at the back of the first share, in such a manner as to pull the back three down into the ground. The plough at the end of the furrow is lifted by a crane arrangement consisting of a double-crank axle with two chains attached to the cranks, one being led to the front end of the plough-frame and one to the back. The two cranks are about 100 deg. apart, so that a certain lag is allowed to the back end. The front share is therefore lifted first, and the back end is not raised until the last share has reached the same point.

Of the smaller class of motor appliances we may instance two Ivel-Bauche motor-hoes. These are being shown by the Ivel Agricultural Motors, Limited, of Biggleswade, Bedfordshire. They are actually French machines, and are of two sizes, of 2¾ and 4 horse-power respectively, and both of these we illustrate in Fig. 2, annexed. The machines are extremely handy in movement, and they are suitable for hoeing orchards, vineyards, and plantations. The models are much the same except for the size of engine, the smaller type having an engine 90 mm. by 100 mm., and the larger one 100 mm. by 100 mm. The engine is air-cooled by a little belt-driven fan,

forcing air into a casing which fits round the cylinder after the manner of a water-jacket, but with a large outlet at the back to admit of the current of air escaping. In this way the air is brought into close contact with the cylinder, instead of being to a large extent wasted. The depth of hoeing can be regulated by a trailing wheel. The hoes are mounted on two transverse rocking-shafts worked by a toggle-gear drive from the main shaft, so that a rapid-hoeing motion is given to each blade while the machine itself travels forward. The hoeing motion and the forward travel have independent controls, so that the machine can be moved from place to place with the hoes out of gear. The small pattern (S) will travel between plants set not less than 25 in. apart, and the large (L) between rows 49½ in. apart. This machine has met with considerable success in France. The Ivel Company are also exhibiting, it may be added, two of their regular agricultural motors which are now so well known.

Among the exhibitors of agricultural motors are also included Messrs. Saunderson and Mills, Ltd., of Elstow Works, Bedford. This firm has reduced its types to four standard patterns, and the success of their work may be gauged by the fact that they have increased the output of their works 400 per cent. in three years. The sizes of tractors now built by them are of about 10, 20, 30 and 45 brake horse-power. The latest model of the 10-horse-power size, known as the "Little Universal," is illustrated herewith in Fig. 3. The feature of this machine is that, with some little alteration to the pole, ordinary horse ploughs, &c., can be employed with it. The engine is a single-cylinder, 5½-in. by 8-in. paraffin motor, starting on petrol, with control for the carburettor and vaporiser suited for working with different oils in different countries. The heat taken from the exhaust to the vaporiser can be easily varied, so that good results can be obtained under a wide range of conditions. The change over from one fuel to the other, with the necessary carburettor and vaporiser adjustments, are effected instantaneously. The engine base and the base of the transmission gear-box are a single casting. Three forward speeds of 2, 3, and 5 miles per hour are provided, and one reverse. The machine weighs about 30 cwt., and is only 4 ft. 1½ in. wide. The controls are all near the driver's seat. In this pattern of motor, when fitted with a plough or other implement behind, the whole implement, &c., wheels and all, is lifted bodily off the ground at the end of the furrow, instead of the shares being raised on the wheels. The machine has a draw-bar pull of 1500 lb. It has belt-pulley and a winding-drum on the rear axle; the differential gear has a movable pin-lock. Ignition is by magneto, and lubrication by a geared pump. The firm are also showing their standard patterns in the larger sizes, but only the small machine is entered for the Silver Medal.

The Daimler Company are showing four machines altogether, two of them being lorries, one of the "Colonial" 5-ton type, and the other a light 2-ton machine. The chief feature of interest in the former, which has a 50-horse-power engine, is the new winding-gear with which it is fitted. The gear is powerful enough to lift the machine, and should therefore prove a valuable addition for colonial work. The smaller lorry is of the Daimler Company's well-known standard design. The other two exhibits of this firm are two tractors, one of 50 horse-power and one of 105 horse-power. The former has a four-cylinder water-cooled sleeve-valve engine of 120 mm. bore and 160 mm. stroke. The driving-wheels are 6 ft. in diameter and of 12-in. to 18-in. face. The usual cone clutch and enclosed gear-box are fitted, giving two forward speeds and one reverse, of 5 and 2½ and 2½ miles per hour respectively. The draw-bar pull amounts to 4000 lb. The cooler is arranged in a large rectangular tank. It is composed of a series of thin sheet-metal sections or boxes, with about ¼-in. water space between the two large sides, the edges being made tight with ordinary tinsmith-type joints. The large side sheets have bosses pressed on them at regular intervals, so as to keep the various compartments spaced apart. Some of the bosses have holes, matching holes in the neighbouring section, the joints between the two being made by rubber rings, and the whole lot of sections being drawn up tight. No fan is provided, the current of air through the cooler being induced by the engine exhaust, which is carried into a chimney placed above the cooler.

The larger tractor exhibited by the same firm is primarily intended for work abroad. It has wheels 8 ft. in diameter by 2 ft. 9 in. face, and a six-cylinder engine. It has, in addition, a small donkey engine for starting up the main engine. This machine, which has a draw-bar pull of 12,000 lb., is, of course, of large size, weighing 12 tons, and is only intended for work on an extensive scale. The smaller machine is intended for more general use, such as would serve ordinary purposes in this country. Indeed, it is a noticeable feature of the Show that the smaller farmer is receiving more attention than formerly, several makers catering for this class of farmers, who, if they could replace their horse implements by motor machines at a reasonable cost, would not hesitate to do so, but do not like to expend much money on an expensive machine which must stand idle for a large part of its time.

There are a large number of firms showing lorries and motor vehicles of one type and another. Among these the Leyland Motors, Limited, Leyland, Preston, have a heavy petrol brewer's lorry and a motor char-a-banc for twenty-seven passengers. This vehicle secured the War Office subsidy, the char-a-banc bodies being interchangeable with a platform for aeroplane work. It weighs 2½ tons, and has a 30-horse-power engine. Another exhibit of this firm is a motor fire-engine fitted with a Rees-Roturbo pump. This machine has speeds up to 50 miles per hour, the engine being one of 60 horse-power. Messrs. Leylands recently received orders for twenty-four motor fire-engines for London, which, with eight already working there, makes the largest order yet given for this type of machine. Although Messrs. Leylands have taken up motor-lorry work, they are turning out to-day more steam-lorries than they did before they started building the later type of machine. In Fig. 4 we illustrate one of the uses to which their standard steam chassis has been put. This machine is a vacuum tank for cesspits or gullies. The tank is of 1000 gallons capacity. The chassis is fitted with the tipping gear-drive, which, however, is adapted to work a screw conveyor open in the bottom of the tank, and used to force any solid matter towards the back end, where it is sent out through a 12-in. manhole. A vacuum is produced in the machine by a steam-ejector. When this is formed the suction-pipe is let down into the cesspit or gully by means of a crane on the side of the tank. The cock is then opened, and the tank will fill in 4 minutes. A top man-hole, 15 in. in diameter, is fitted. The whole weighs about 12 tons gross (with the tank full). The machine is

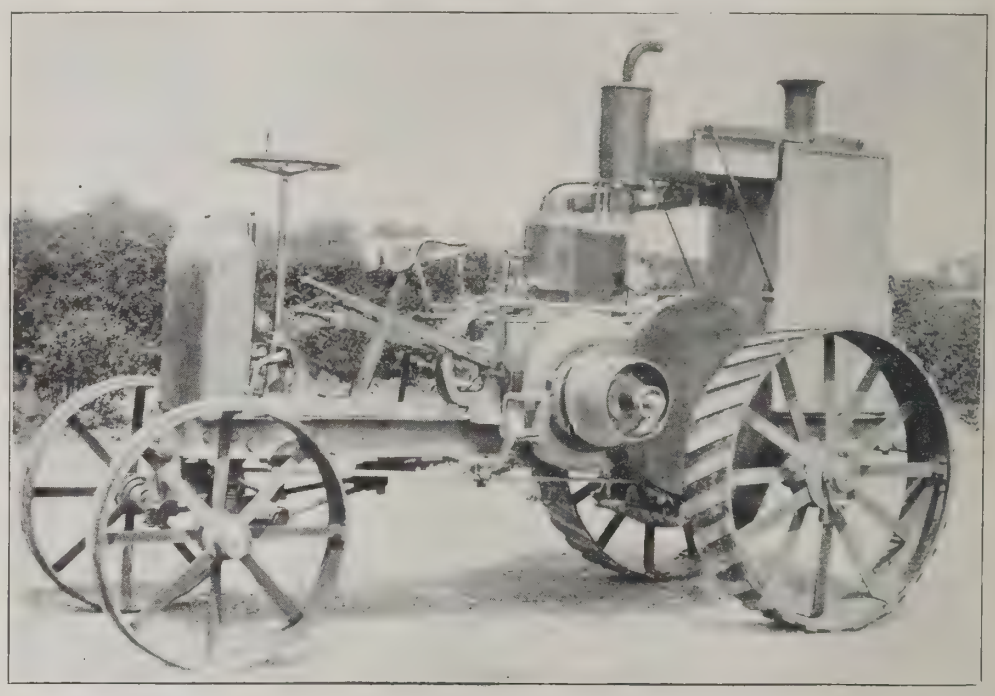


FIG. 3. "LITTLE UNIVERSAL" MOTOR; MESSRS. SAUNDERSON AND MILLS, LIMITED, ELSTOW WORKS, BEDFORD.

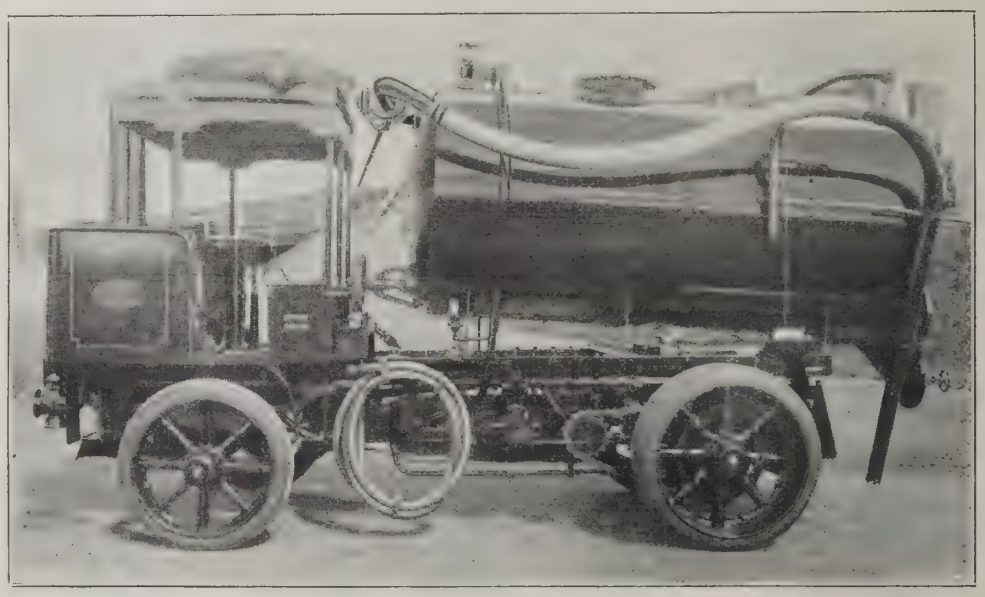


FIG. 4. VACUUM GULLY-EXHAUSTER; THE LEYLAND MOTORS, LIMITED, LEYLAND, LANCASHIRE.

fitted with rubber tyres, and has a speed of 8 miles per hour. The one on exhibition is one of two on order for Nottingham, others having been supplied to Kensington, Chelsea, Bombay, Calcutta, &c.

Among the smaller oil-engines Messrs. Martin's Cultivator Company, Stamford, are showing a new design of crude-oil engine, which we hope to refer to at greater length on a subsequent occasion. These engines are of the semi-Diesel type, two sizes, the 8-10 and the 25-horse-power engines being single cylinders, and the third a twin-cylinder engine developing 20 horse-power. They are two-cycle engines embodying several features, a description of which we shall defer for the present.

Messrs. Blackstone and Co., Limited, are exhibiting a large number of oil-engines, making a special show of their small vertical type. These engines are four-stroke cycle and of very neat appearance, being also very compact. The engine is also mounted as a portable type, of which form we give an illustration in Fig. 5 herewith. In this pattern the engine is mounted on a girder

FIG. 5. PORTABLE OIL-ENGINE; MESSRS. BLACKSTONE AND CO., LIMITED, STAMFORD.

carriage borne by four wheels. A novel feature is the circulating arrangement, which is shown in the diagram, Fig. 6. The circulating pump is dispensed with, and its place taken by a device utilising the impulses of the exhaust. Water flows by gravity from the tank to the chamber A through the non-return valve C. The exhaust pressure also has access to this chamber by way of the pipe B, and the water is driven out past the valve E into the air-chamber D. From thence it passes to the cylinder along the pipe H. The valve E is provided with spring adjustment, so as to regulate the pressure at which it will open. From the cylinder the water passes to the top of a tall cooler, made of a cone of perforated metal, down which it flows into the tank, being brought on the way, of course, into contact with a large quantity of air. The other exhibits of this firm include a 75-brake-horse-power crude-oil engine working with a compression pressure of 150 lb., and fuel-injection air at a pressure of 400 lb.

Messrs. Robey and Co., Limited, Lincoln, are also exhibiting several oil-engines of the semi-Diesel type. These engines are of the two-cycle type, compressing in the crank-chamber. The sizes shown are of 6 and 8 brake horse-power, and two of a larger pattern—one being of 25 horse-power, and the other of 12 horse-power—are mounted as portables. The engines are of the valveless type, and govern on the supply oil; they are started with a lamp. They are very neat in outward appearance.

Among the exhibits of Messrs. Marshall, Sons and Co., Limited, Gainsborough, are two crude-oil engines. These we illustrate in Figs. 7 and 8, page 22, the first showing a 6-brake-horse-power fixed semi-Diesel engine, and the other a portable 16-brake-horse-power engine on the same principle. The former runs at 400 revolutions per minute. It is of the two-cycle type, the rating being the maximum for crude oils and residuals, or the working output for refined oils. There are no air or exhaust-valves in the cylinder-head, and the engine is in consequence very simple. The compression pressure is about 175 lb. per sq. in., which is not high enough to make starting difficult. With good crude oil a consumption of 0.5 pint per brake-horse-power hour is obtained. The governor of the high-speed spring-loaded type regulates the stroke of the fuel-pump. Ample arrangements are made facilitating cleaning of the water-jacketed spaces round the vaporiser head and cylinder. Air for the cylinder is compressed in the crank-case. In Fig. 8 the 16-brake-horse-power portable engine is shown. It is similar in principle to the preceding, but modified, so as to be mounted on a mild-steel girder-frame carried by four wheels. This engine runs at 330 revolutions per minute. The cylinder in this pattern is cooled by water circulated by a centrifugal pump drawing water from a tank under the frame. The pump is always flooded. From the cylinder-jacket the water passes to a cooler, where it falls down over a series of wooden frames, a current of air being induced up through the cooler by the exhaust, which is admitted to a stack above the cooler. The exhaust which is led to this stack previously passes through a silencer in front of the frame, another being arranged at the top of the water-cooler. The fuel-tank is bolted to the silencer on the frame, and in cold weather the fuel is thus kept at a sufficiently high temperature. This engine is fitted with a compressed-air bottle for starting. This bottle is in connection with the cylinder, and can be charged with a pressure of about 150 lb. per sq. in. while the engine is running. The arrangement serves its purpose admirably.

The National Gas-Engine Company, Limited, Ashton-under-Lyne, are exhibiting several engines using heavy crude oils. There are four-cycle engines, with mechanical pulverisers for breaking up the fuel. This pulveriser consists of a valve loaded by a powerful spring, lifted at the end of each stroke of the fuel-pump. The oil passes through a spiral and is broken up into a fine mist, and then passes into hot compressed air, causing partial vaporisation, this process being completed in the vaporiser. The temperature of compression is sufficient to keep the engine going after starting with a lamp. The oil-pump is driven by a quick-acting cam off a cam-shaft. A separate band enables it to be worked by hand or thrown out of gear. The governor is gear-driven, and controls the supply of fuel to the cylinder.

On their gas-engines, some of which are also exhibited, the National Gas Engine Company are introducing a new type of variable admission governing gear. This we illustrate in Fig. 9, on page 22. The inlet-valve is worked by cam-gear by two levers. The motion of one lever is transmitted to the other by means of a movable plate,

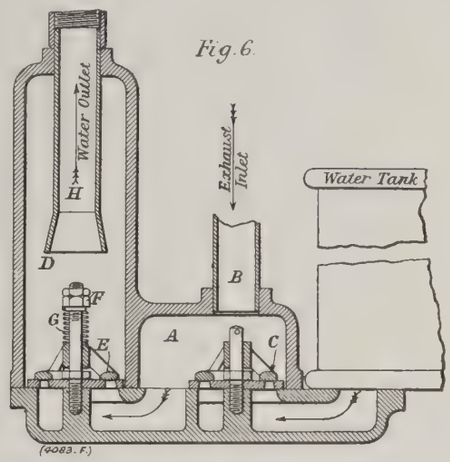


FIG. 6. EXHAUST-DRIVEN WATER-CIRCULATOR FOR COOLING WATER.

the level of which is controlled by the governor. As the speed rises this plate is raised, and the valve-opening is diminished. If the plate falls, the valve-opening diminishes. The inlet-valve is contained in a casting fixed to the back of the cylinder by bolts, and is easily removed without disturbing the valve-gear.

This firm have also a new pattern of bituminous producer-gas plants, of capacity suitable for 120-brake-horse-power engine plant. In this plant the generator has a water-sealed bottom and a conical fire-grate. The water-seal hermetically seals the plant, and provides an easy means of removing clinker. Clinker adhering to the sides of the brickwork can also be removed through poke-holes, &c. From the generator the gas is taken through a large pipe to a scrubber, in which is fitted a feed-water heater. The wet scrubber is fitted with wooden grids, and after passing through these the gas goes through a rotary tar-extractor to a dry scrubber filled with coke and wood-wool. The scrubbers are of thick steel plates, the wet one having a cast-iron base.

The Campbell Gas Engine Company, Limited, Halifax, have several of their standard engines on exhibition. Among them is a two-cylinder vertical marine oil-engine, of 30 brake horse-power, of the hot-bulb crude-oil type, but fitted with an interesting type of reversing gear. With this gear the engine is first slowed down until a pre-ignition may be given. This is arranged for by a block working in a groove and altering the timing of the pump for the fuel injection. When one pre-ignition has taken place, a friction arrangement drags the block back to the normal end of the slot and the pump is then actuated as usual, the engine continuing to run in the reversed direction. In addition to a suction-gas plant, horizontal gas-engine and other types, the Campbell Company have working an 18-brake-horse-power horizontal crude-oil engine of the semi-Diesel type, but of sufficiently high compression (250 lb.) to start up from the cold without using a lamp. This engine has variable governing, regulated by a vertical wedge-block, the position of which is regulated by the governor. This block is interposed between the striker and

the pump-plunger, the stroke of which is altered by the thickness of the wedge in line.

Messrs. Petters, Limited, of Yeovil, are also one of the firms adopting this principle of a wedge directly operated by the governor on their semi-Diesel crude-oil engines. The firm is showing a 50-horse-power single-cylinder engine of this type, as well as others of this class, and, in addition, several examples of a small horizontal engine fitted with magneto ignition. This engine is started on petrol, and then changed over to paraffin. The governing adopted in the case of Messrs. Clayton and Shuttleworth's horizontal oil-engines of the semi-Diesel valveless type consists in raising or lowering, by means of a lever worked by the governor, a rod driving the pump so that it comes into contact with a striking-lever at different distances from the latter's pivot. The striking-lever is moved to and fro by a push-rod worked by a cam on the main shaft. This firm have several engines of this type at work, ranging from 7½ brake horse-power upwards.

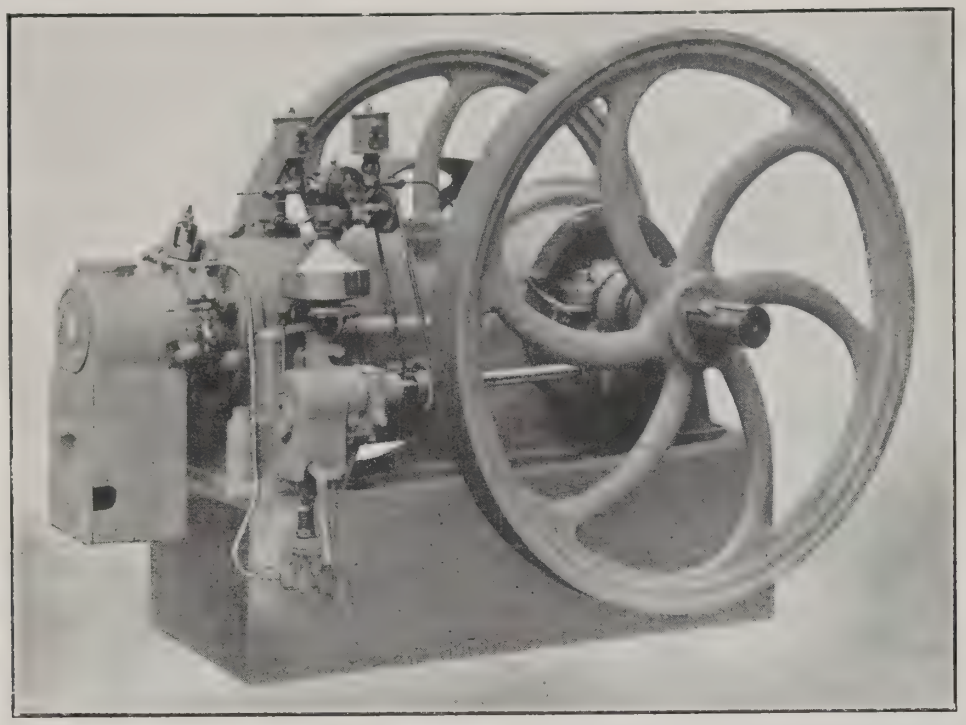


FIG. 7. 6-HORSE-POWER SEMI-DIESEL ENGINE; MESSRS. MARSHALL, SONS AND CO., LIMITED, GAINSBOROUGH.

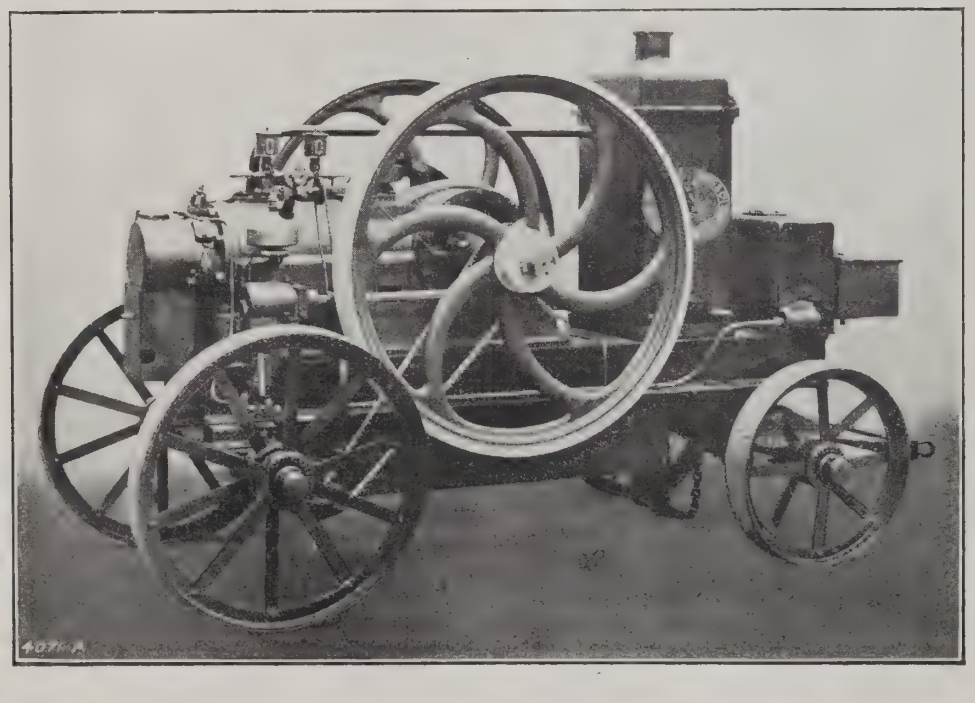


FIG. 8. 16-HORSE-POWER PORTABLE SEMI-DIESEL ENGINE; MESSRS. MARSHALL, SONS AND CO., LIMITED, GAINSBOROUGH.

The exhibit of Messrs. Crossley Brothers, Limited, Openshaw, includes several of their standard types of engines. A standard suction-gas plant with open-hearth grate is at work; this was illustrated by us in ENGINEERING, vol. xcvi., pages 19 and 776. Messrs. Crossley's latest type of gas-engine with variable governing was described in ENGINEERING, vol. xciv., pages 15 and 726.

It is impossible, of course, to mention the particular features of all the internal-combustion engine exhibits. The number of small and cheap engines working is quite astonishing. Judging from the stands, there must be an enormous demand for little engines on movable stands or trucks, but competition does not appear to have a very good influence on the quality of article produced. This is more or less inevitable, but the contrast between the finish of some of these small engines and others is very marked. If the price be low and the engine will work reliably, it will, of course, prove attractive to many, and there are innumerable uses to which quite small units can be put about a farm. A fairly common feature of these engines is the hopper cooling, doing away with the ordinary circulation and tank, and by simplifying the engine, permitting a reduction in price.

STEAM-ENGINES.

Numerous firms, as usual, exhibited steam-tractors and agricultural engines. Among these were to be found Messrs. Marshall, Sons and Co., Limited, of Gainsborough, whose oil-engine exhibits are noticed above. Messrs. John Fowler and Co. (Leeds), Limited, also show numerous engines of this type, including a 14-horse-power ploughing-engine, a 6-horse-power traction-engine, a 7-horse-power road locomotive, and other machines. Messrs. Fowler also show an example of the Fowler-Wyles double-furrow motor-plough. This we described when it was exhibited at the Show of last year. One of the most interesting of Messrs. Fowler's exhibits was a 10-ton steam road-roller fitted with a tar-sprayer and road-sweeping brush. The tar is contained in a tank under the boiler-barrel, and of a capacity of 160 gallons. Above the tank, on the left-hand side of the machine, is a rotary pump. This pump is fitted with piping arranged so that, with a tumbler cock turned one way, tar will be drawn up through a suction-pipe and delivered to the tank. With the same cock thrown over another way, the pump will draw from and deliver into the same tank in order to mix the tar, when this should be advisable. The tank is provided with about 60 ft. of pipe surface, through which either live steam or exhaust steam from the cylinders may be led, for the purpose of warming up the tar before it is passed to the sprayer. The tar is delivered at a pressure of 300 lb. per sq. in. to six jets pointing downwards on a transverse pipe at the back of the engine. A flexible pipe and attachment is furnished, so that the footpaths may be tarred at the same time. In use, a road is first swept clean and then tarred, or the system may be used for grouting new metal. The engine will do in five minutes a length of 300 yards, which is said to be as much as a day's work for an ordinary spraying-machine. The engine itself is a compound, fitted with two speeds and the usual appliances. We hope to illustrate this arrangement in a future issue. The other engines exhibited by Messrs. Fowler were practically their standard types, in which practice has shown very little alteration to be possible in the direction of adapting them better to their work.

Messrs. Robey and Co., Limited, of Lincoln, are exhibiting a 100-horse-power uniflow engine with a locomotive boiler. This engine is on the Stumpf system, on which Messrs. Robey have now built engines for some years. This large engine has the regular Stumpf valve-gear, but a cylinder is

Fig. 9.

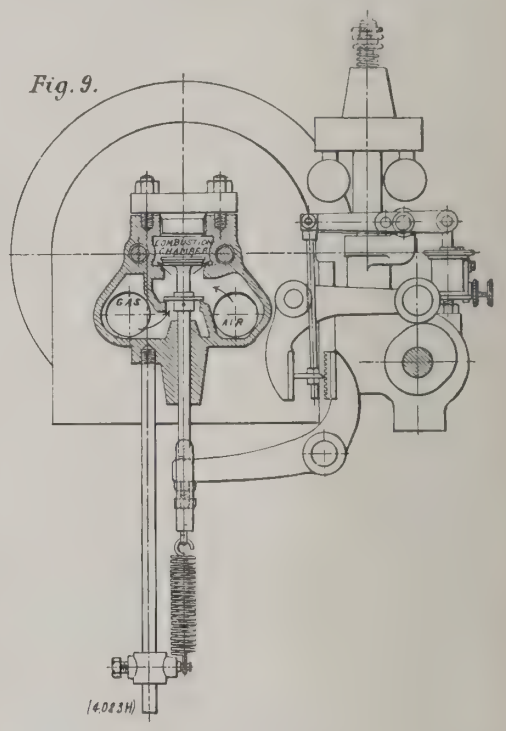


FIG. 9. GAS-ENGINE GOVERNOR-GEAR; THE NATIONAL GAS-ENGINE COMPANY, LIMITED, ASHTON-UNDER-LYNE.

also exhibited in which the uniflow system is adopted in combination with a special form of Messrs. Robey's gear. The boiler is fitted with a superheater in the smoke-box.

Several firms are showing superheaters applied to locomotive-type boilers. For instance, Messrs. Davey, Paxman and Co., Limited, Colchester, who are showing a 32-brake-horse-power gas-engine and suction-gas plant, have also 6 and 7-horse-power traction-engines and a 10-horse-power compound portable engine, of which we give illustrations in Figs. 10, 11, and 12, herewith. This engine has cylinders 6½ in. and 10½ in. in diameter, with 12 in. stroke, running at 180 revolutions per minute. The boiler pressure carried is 160 lb. The superheater is arranged in the smoke-box and gives about 100 deg. to 120 deg. of superheat. The superheater consists of a series of bent tubes, arranged at a level above the flue tubes, so that it does not interfere with the cleaning or repair of the latter. The smoke-box is provided with a double-damper arrangement. These dampers are shown at E and F in Fig. 11, and they are worked simultaneously. When E is in the vertical position and F horizontal, the gases from the flue-tubes pass over the superheater surface. When E is horizontal and F vertical they are by-passed straight to the chimney. This is an advantage when raising steam. The steam enters the superheater at A, and leaves, superheated, at B. Baffle-plates C and D ensure the gases passing over the tube surface. A three-flow tubular feed-water heater is also fitted on this engine, which will develop four times its nominal horse-power at a consumption, we are informed, of less than 2 lb. of coal per brake horse-power. Messrs. Davey, Paxman's other engine exhibits are also powerful machines. The nominal brake horse-power traction engine has a cylinder 8 in. by 12 in. and working pressure of 160 lb., the horse-power developed being 30. This engine has two road speeds, compensating motion, slip-winding drum, and 50 yards of steel cable. The 7½-horse-power engine has a cylinder 8½ in. in diameter by 12-in. stroke. In other features it is similar to the preceding, but develops 35 brake horse-power.

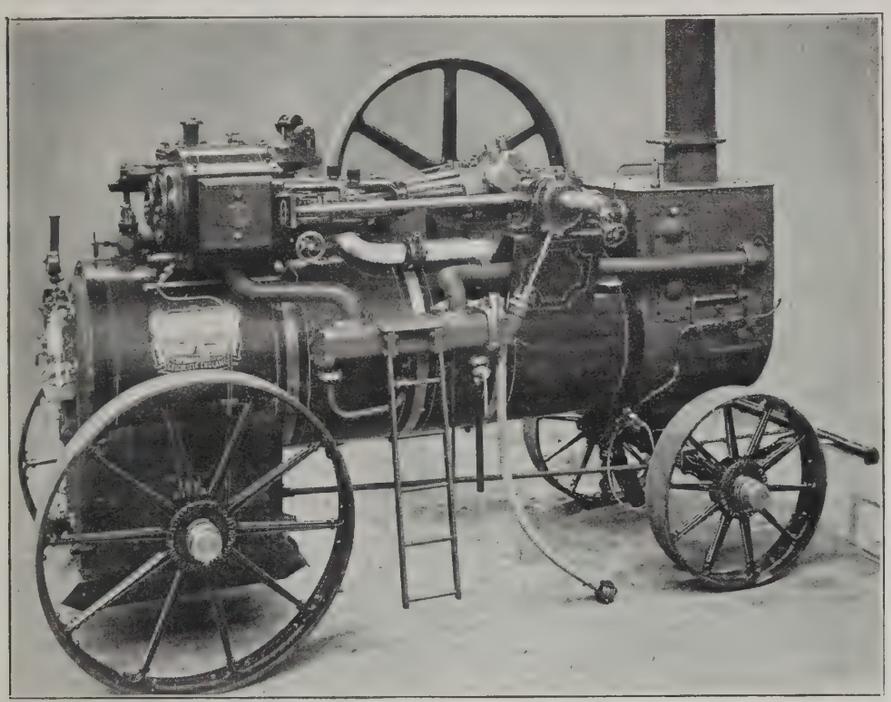


FIG. 10.

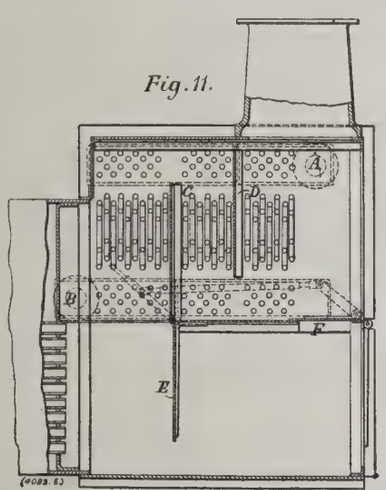


Fig. 11.

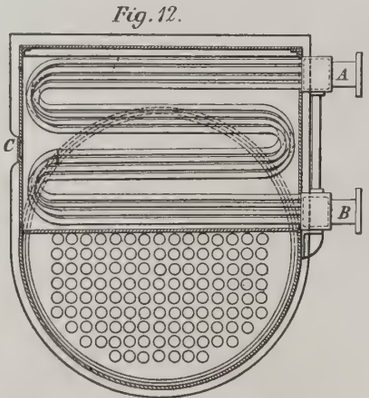


Fig. 12.

FIGS. 10 TO 12. PORTABLE ENGINE WITH SUPERHEATER; MESSRS. DAVEY, PAXMAN AND CO., LIMITED, COLCHESTER.

Messrs. J. and H. McLaren, of Leeds, exhibit various agricultural engines and tractors, but mostly to their standards. The one exception is, perhaps, an 8-horse-power compound agricultural locomotive; but this is properly a revision of a standard type, and not essentially a new design. A 5-ton steam-tractor exhibited by this firm is fitted with their superheater and feed-heater. The superheater is accommodated in the smoke-box above the level of the boiler flue-tubes; it consists of four coils of pipe, round which the waste gases circulate. The coils are placed horizontally and longitudinally, two on either side of the centre line, superposed; steam is brought from the boiler to a header, and distributed between the two pairs of coils, each stream passing through two coils and thence to a header connected with the throttle. Superheat of about 100 deg. Fahr. is obtained with this arrangement in normal working, with higher temperatures when the engine is working hard. The feed-water heater consists of a single coil of pipe in a barrel or cylinder placed horizontally across the boiler-barrel. It is on the pressure side of the pump, is fed by part of the exhaust steam from the cylinders, and heats the feed to about 200 deg. Fahr.

A steam-tractor with an interesting new feature was to be seen at the stand of Messrs. W. Tasker and Sons, Limited, Andover. This is fitted with Hoare's system of spring mounting for the rear wheels, which are chain-driven. The engine is a compound, with 5-in. and 7¾-in. cylinders and 8-in. stroke. It has three speeds and a balanced crank. On each side of the engine is a strong girder, underneath which is the spring mounted direct on the axle. The springs are long and allow of a 3-in. deflection, which is much more than is obtainable with the ordinary rear springing. The movement is taken care of by radius-rods fixed to the axle and frame. These are adjustable to allow for alteration in the chain-length. The first drive is, as usual, by spur-gears; but the second drive, as already stated, is by chain. The arrangement is one which makes the various parts very accessible.

Messrs. Aveling and Porter, Limited, of Rochester, exhibit several of their well-known types, including traction-engines, road-rollers, &c. One of their 10-ton rollers is fitted with Morrison's patent scarifier, a device which is housed in a frame attached to one side of the engine at the rear. The housing is tied by stiff bars to the back axle outside the wheel and accommodates an adjustable frame, which can be raised and lowered. This frame carries digger points, three facing in one direction and three the other, their inclination to the road surface being also adjustable by a lever and quadrant.

At the stall of Messrs. Mann's Patent Steam Cart and Wagon Company, Limited, Hunslet, there is to be seen a steam-roller primarily intended for road-patching work. This machine has a tipping body for carrying the patching material. This body is replaceable by an ordinary body or a water-tank. In addition to two other standard machines, this firm shows a steam-tractor having a horizontal compound engine mounted on a locomotive type boiler working at 200 lb. pressure. The total weight of the machine all included is 4¼ tons, and the wheels have a total width of 4 ft. 8 in., so that the weight works out at less than 1 ton per foot. The tread of the front wheels is inside that of the back, and the land is, therefore, not compressed by the machine. At the back end is a large tank, sufficient for half a day's work, the top of this tank being flat, and capable of carrying a load of 2 tons, in addition to which 6 tons may be hauled behind on a trailer. The machine will pull a four-furrow plough, working 8 in. deep, or two self-binders, and can be used to drive thrashers, &c.

At the stand of Messrs. Ruston, Proctor and Co., Limited, Lincoln, the most interesting exhibit is, perhaps, a new type of side-tipping trailer. In this vehicle, of which we intend to give illustrations next week, the body is supported by twelve small wheels, of which four are carried in bearings fixed to the chassis, while eight are attached to the tipping-body. Above the former and fixed to the underneath of the body are two ⊓-section rails, rails of a similar section but inverted being fitted on the chassis top, below the wheels attached to the body. The body is first traversed and then tipped. The traversing motion is derived from two square-threaded screws placed transversely across the chassis frame and both driven simultaneously by a hand-crank, bevels and a longitudinal shaft. On each screw is a toggle, normally flattened out, and two units, of which one is threaded and works on the screw, while the other is without a thread, and merely slides along the screwed spindle. The sliding-nut is nearest the centre of the machine to start with, with the screwed nut nearest the side from which the screw is being worked. Beyond the sliding-nut is an upright lug, which pushes the body over on the rails. As soon as the traverse is completed the sliding-nut can move no further, and the toggle closes up. This causes the body to tip. One continuous screwing

motion is all that is required of the operator, from start to the end of tipping. The body tips about a centre formed in the kink of two stirrup-irons which span the chassis, the axles of a pair of the wheels engaging in these at the end of the traverse, preventing further movement of that type and converting the traverse into tipping. To draw back the body the toggle first flattens out, the toggle-pin engaging with two Z-bars under the body, pulling the latter down. This toggle-pin, when the toggle has flattened out, comes up against stops on the Z-bars, and as the threaded nut is screwed back the body is pulled into the central position again on the chassis. The body tips to an angle of 40 deg. The tipping-gear is in duplicate, and can be worked from either side to tip on the opposite side, the only preliminary being to turn down two stops on one side or the other. At each end of the body is a rail under which the hooked ends of the side-door levers are engaged during traversing and tipping. One door runs the length of each side, and on the body being tipped the doors are opened automatically by the levers being held while the body tips. The doors are fitted with several wedges, which engage with and disengage themselves from sockets on the body. The wagon can be tipped by one man, the load falling completely clear of the wheels, emptying being completed in 1½ minutes from starting the traverse.

Messrs. Ruston Proctor's other exhibits include steam-tractors, a wood-refuse suction-gas producer and 33-brake-horse-power engine, and also several oil-engines, working with petroleum or crude oils. In the cooler applied to one of these engines, fitted up as a portable engine, the water is taken to the top of a water tower, and from there trickles down vertical fibre-ropes to the tank below the frame.

(To be continued.)

NOTES FROM THE UNITED STATES.

PHILADELPHIA, June 24.

THE only branch of the iron and steel industry normally active is the tin-plate industry, which is running at maximum capacity. It is now threatened with a strike in sixteen of the larger mills, which, if it occurs, will occasion serious inconvenience. The steel-makers are confident that better times are in sight, and there is no unusual struggle to get business. The next branch is steel plate. The week's business shows further expansion, because of the enlarging individual demand for minor requirements. During the past month Australian rail orders foot up 56,000 tons. The Queensland Railway has ordered 16,000 tons from the Maryland Steel Company, and the New South Wales Government has ordered 5000 tons from the Lorain Steel Company. So far the Pennsylvania has ordered 25,000 tons under improved specifications. The freight-rate decision is awaited daily, and much business awaits its rendering. General structural business for the week amounts to 35,145 tons, against 22,725 tons for the previous week. Improving tendencies are manifest. Platemakers figure out they can fill orders for the early summer on 60 per cent. of capacity. Orders offered at less than current rates have been rejected, notwithstanding mills could increase their output 40 per cent. Billets are inactive at 20 dols. Urgent summer requirements have been covered. The probable course of the steel market can be safely outlined by remembering capacity has not been very greatly expanded for some time, while the country's needs have been galloping ahead. The sheet mills are gaining in orders. Bar mills get barely enough business to keep going. Pipe foundries are crowded. Demand for tanks is stronger. Nails are active. Spike output is low, because of restricted railroad building. The larger foundries and engineering plants are slow and cautious buyers.

THE BATTLESHIP "ESPANA."—Sir W. G. Armstrong, Whitworth and Co., Limited, and Vickers Limited, have received a telegram from La Sociedad Espanola de Construccion Naval informing them that the new first-class battleship Espana, carrying eight 12-in. and twenty 4-in. guns, has passed through her gun trials at sea with complete success, giving the greatest satisfaction to the Spanish authorities, of whom the following were present:—Captain-General Barriere, Rear-Admiral Moreno Eliza, General Gallardo, General Gonzalez, Colonel Marabotto, and Colonel Fernandiz the ship being in charge of Captain Carranza. Rounds were fired from each gun in succession, and a final broadside with guns fully elevated. The Espana stood this severe test without the slightest deformation to structure, reflecting great credit on the builders, who are La Sociedad Espanola de Construccion Naval. The vessel was built at the Government Arsenal, Ferrol, and the guns supplied half by Sir W. G. Armstrong, Whitworth and Co., Limited, and half by Vickers Limited.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The pig-iron market is weak and lifeless. Values show a downward tendency, and but for the very excellent statistical situation prices would doubtless be much lower than they are. As it is current rates are considerably below cost of production, and makers talk of putting furnaces out of operation. Sellers of pig-iron are prepared to make concessions to secure business, but buyers are very slow to take advantage of the lower rates named. Fears are now entertained that the dry summer on the Continent may check deliveries abroad, as the canals and rivers used to convey imports up country promise to be low and unnavigable. Political affairs continue to have a disturbing influence on the market, and, in addition to all other detrimental contributions, the present is what is usually the quietest time of the year. Under normal conditions traders look for little business between now and about the middle of August, by which time buying should commence to meet autumn and winter requirements of customers abroad. No. 3 g.m.b. Cleveland pig is on sale at 51s. 3d. f.o.b., and that is regarded as the general market quotation, though some of the leading makers ask a rather higher figure; whilst No. 1 is 52s. 9d.; No. 4 foundry, 51s.; No. 4 forge, 50s. 6d.; and mottled and white iron each 51s.—all for either early or forward delivery. Very discouraging accounts are given of the East Coast hematite branch of the staple industry. Second hands offer Nos. 1, 2, and 3 freely at 59s. for practically any delivery, and some makers will also accept that figure, but several leading producers declare that they will not sell at anything like the price named. Consumers of hematite point out that scrap steel is plentiful and cheap, and that to a considerable extent they are taking it in place of hematite pig. Foreign ore shows signs of movement. Sellers are understood to be prepared to make contracts on the basis of 17s. 3d. ex-ship Tees for Rubio of 50 per cent. quality. Durham coke maintains its value, notwithstanding Yorkshire competition. For average quality of Durham blast-furnace coke delivered at Tees-side works, 17s. 6d. is generally named.

Stocks and Shipments.—The stock of Cleveland pig-iron in the public warrant stores now stands at 78,289 tons—all of which is No. 3 quality. During the month of June stocks of Cleveland pig-iron were reduced by 4947 tons. Shipments of pig-iron from the Tees during the month of June were on a moderate scale, averaging 3476 tons per working day, the total despatches being returned at 86,907 tons, 76,207 tons of which went from Middlesbrough and 10,700 tons from Skinningrove. In May the loadings reached 94,174 tons, or a daily average of 3767 tons; and for June, a year ago, the clearances were given at 95,403 tons, or an average of 3677 tons per working day. Of the iron shipped from Skinningrove, 10,224 tons went to Scotland and 476 tons to Holland. Of the iron cleared at Middlesbrough, 53,955 tons went foreign and 22,252 tons coastwise. Scotland was again the largest buyer, receiving 13,914 tons, whilst Sweden imported 7089 tons; Italy, 6721 tons; France, 6617 tons; Germany, 4928 tons; Japan, 4615 tons; and Holland, 4403 tons. Of the 8227 tons of manufactured iron loaded on the Tees 3912 tons went abroad, and 4315 tons coastwise, and of the 46,796 tons of steel shipped, 41,334 tons went foreign and 4962 tons to home customers. The Argentine took 2011 tons and India 1167 tons of manufactured iron, whilst India was the largest buyer of steel, with an import of 14,206 tons. Other principal buyers of steel were:—West Australia, 8330 tons; the Argentine, 4200 tons; New South Wales, 3082 tons; New Zealand, 2574 tons; Victoria, 1955 tons; and Russia, 1925 tons.

Manufactured Iron and Steel.—There is little new to report concerning the various branches of the manufactured iron and steel trades. Business is quiet, and specifications for shipbuilding material are coming in very slowly. Constructional steel, however, is showing more activity, and new orders are coming forward more freely. Principal market quotations stand:—Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 5s.; iron ship-plates, 6*l.* 15s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron girder plates, 7*l.* 5s.; steel bars (basic), 6*l.* 5s.; steel bars (Siemen's), 6*l.* 5s.; steel ship-plates, 6*l.*; steel ship-angles, 5*l.* 15s.; steel boiler-plates, 7*l.*; steel joists, 6*l.* 12s. 6d.; steel strip, 6*l.* 5s.; steel hoops, 6*l.* 10s.—all less the customary 2½ per cent. discount; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.*; heavy steel rails, 6*l.*; steel railway sleepers, 7*l.* 5s.—all net at works; galvanised corrugated sheets, 24 gauge, in bundles, 11*l.* 5s. f.o.b.—less 4 per cent.

UPPER CONGO RAILWAY.—The expenditure on capital account made by the Upper Congo Railway Company to the close of last year was 3,171,254*l.*, showing an increase of 514,653*l.*, as compared with the corresponding outlay made to the close of 1912. The rails upon the third section of the company's railways, which will unite the Lualaba to Lake Tanganyika, had reached a length of 138¾ miles at the close of May, leaving a gap of 30⅝ miles still to be made good. The works which have been proceeded with of late have not advanced so rapidly as had been hoped and expected. Regular progress has, however, been made upon the whole. Two steamers, with a displacement of 750 tons each, have been ordered for service on Lake Tanganyika. Each of these steamers will be fitted with engines working up to 400 horse-power, and a speed of 8½ knots per hour is to be maintained. The steamers are 173 ft. long by 28 ft. beam.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has continued quiet, owing to the uncertainties attending the strike of marine engineers. Tonnage arrivals over the week-end were rather heavier, notwithstanding the strike influence, and loading operations appear to have proceeded without interruption. At the same time, several large collieries are idle in consequence of excessive stocks. The prevailing opinion among sellers is that the market is more likely to stiffen than to relax. The best Admiralty large steam coal has made 20s. to 21s.; best secondary qualities have brought 18s. 6d. to 19s. 6d.; other secondary descriptions, 17s. 6d. to 18s.; best bunker smalls, 10s. 9d. to 11s.; and cargo smalls, 8s. 6d. to 8s. 9d. per ton. The best household coal has been quoted at 19s. to 20s.; good households have made 17s. to 18s.; No. 3 Rhondda large has brought 17s. 6d. to 17s. 9d.; and smalls have made 12s. to 12s. 6d. per ton. No. 2 Rhondda large has realised 12s. 6d. to 13s., and No. 2 smalls have made 8s. 9d. to 9s. 6d. per ton. Special foundry coke has been quoted at 25s. to 27s.; good foundry coke at 20s. to 23s.; and furnace coke at 17s. to 19s. per ton. As regards iron ore, Rubio has made 16s. to 17s. per ton upon a basis of 50 per cent. of iron and charges, including freight, insurance, &c., to Cardiff or Newport.

Bristol Wagon Company.—The directors of the Bristol Wagon and Carriage Works Company, Limited, report that the balance available for distribution is 12,379*l.* The directors recommend a dividend upon the ordinary share capital for the past half-year at the rate of 5 per cent. per annum, carrying forward 6879*l.*

Tredegar.—Lord Aberconway presided at the forty-first annual meeting of the Tredegar Iron and Coal Company, Limited, held in London, on Friday. In moving the adoption of the annual report, the chairman said the price of coal, except in the case of small coal, was well maintained during the past year. The shipping engineers' strike was a serious factor in South Wales. It had quite disorganised trade, and if it continued, it was highly probable that there would be considerable stoppages of collieries. Sir Arthur Markham seconded the adoption of the report. This was carried, and a dividend of 10 per cent., with 2½ per cent. bonus, was declared.

Finances of Cardiff.—The gross income from the sale of electricity for lighting and other purposes showed a further increase as compared with 1912-13, the gross total being 58,751*l.* From the sale of current there has been a continually increasing income, the figures for the past four years being:—1910-11, 34,959*l.*; 1911-12, 37,800*l.*; 1912-13, 42,574*l.*; 1913-14, 47,503*l.* The capital expenditure on new services, cables, &c., during the past year amounted to 7244*l.* From water and meter rentals there was an income, after deducting voids, irrecoverables, &c., of 76,453*l.*, as against 73,244*l.* in 1912-13, and 71,940*l.* in 1911-12. The water works were rate-aided during the year to the extent of 10,033*l.*, and the total amount levied in that way since 1890 has been 210,764*l.* A rate-in-aid is unavoidable at present. The capital expenditure during the year on water works was 72,784*l.*, most of it being in connection with a new reservoir.

Dowlais.—The Dowlais works have been actively employed, the Bessemer and Siemens furnaces going at high pressure. The Goat Mill has turned out a large quantity of heavy rails, sleepers, billets, &c., and these have been sent away to several South Wales ports for shipment. The Big Mill has produced underground arches and tram-rails; a heavy tonnage of fish-plates has also been despatched.

Closing-Down Collieries.—As a result of the recent amalgamation of the London City and Midland Bank with the Metropolitan Bank of England and Wales, the London City and Midland immediately took up a decided position with regard to the Bedminster, Easton, Kingswood, and Parkfield Collieries. After the men had been paid a week's wages the collieries were closed-down.

Bristol Docks.—In the seven weeks ending with June 20 there was a traffic increase of 8068 tons foreign, a traffic decrease of 650 tons coastwise, and an increase of 215*l.* in dues, as compared with the corresponding period of 1913.

THE RUSSIAN NAVY.—The Budget Commission of the Russian Duma has voted a credit of 12,000,000*l.* for the construction of three ironclads with a displacement of 27,000 tons each, two cruisers of 7500 tons, eight torpedo-boat destroyers, and six submarines destined for the Black Sea. These vessels are to be built at Nicolaieff, under the direction of the Vickers connection, and they are to be completed at the latest by the spring of 1917.

SUBSIDISED LORRY TRIALS.—In our issue of May 22 we dealt at length with the War Office scheme for subsidising motor-lorries for use in time of war, and with the trials which were then being held. A report of the trials has now been issued. At the request of the manufacturers whose vehicles were being tested, no figures are given which can be taken as showing competitive results. It is stated that, generally speaking, the performance was satisfactory, and that there were very few road stops or breakdowns. The consumption averaged 54 gross ton-miles per gallon of petrol for the whole of the trial. At the conclusion of the trial the committee decided to grant certificates to the following firms:—Messrs. Commercial Cars, Limited, class "A" lorry; Messrs. Dennis Brothers, class "A" lorry; subject to tests of improved type of engine being carried out to the satisfaction of the War Department, Messrs. Leyland Motors, Limited, class "A" lorry. The question of granting a certificate to another firm is still under consideration.

NORTH-EASTERN MARINE ENGINEERING CO.'S WORKS, WALLSEND.

When one remembers the large preponderance of cargo-carrying ships in the world's fleet and the immense importance to industry and general economy of living of low freight rates and the highest propulsive efficiency of the general trading ship, it is appropriate that the naval architects during their forthcoming meeting at Newcastle-on-Tyne should visit several of the works producing the machinery of such vessels. As typical of such factories, we illustrate the Wallsend establishment of the North-Eastern Marine Engineering Company, which is to be visited on Wednesday, since these works, under the management of Mr. Summers Hunter, have not only a very large output, but aim, both in experimental work and design, to assist towards the higher efficiency of the propelling machinery of general carrying ships. The company had its origin in 1865, beginning with their establishment at Sunderland, where 1200 men are now employed, and the Northumberland Works at Wallsend were commenced in 1882, and here the number of workmen is 2000. Both establishments carry out the same operations, and are assisted by the company's Northumberland forge, which is situated at Wallsend-on-Tyne, and produces per annum about 2500 tons of forgings of all classes. The general equipment of the two engineering works is somewhat similar, except that at Wallsend the works are on a larger scale, and capable of dealing with larger engines and larger vessels; at the same time the facilities at the two works enable the principal management, which is concentrated at Wallsend, to apportion the work between the two establishments, with a view to the best delivery and the most economical results. As to the capacity of the works, the largest output of the combined concern was in 1912, when the collective power of the marine engines built was 129,125 horse-power, but the average is about 95,000 horse-power, and this is fairly evenly distributed in proportion to their capacity between the two factories. The power of the machinery, as a rule, ranges up to about 6000 horse-power. The naval architects, when they visit the works, will find a fairly representative volume of work in course of execution, there being now in progress engines ranging between 2000 and 6000 indicated horse-power.

As regards the design of machinery, every effort is made to work to standards, varying only in the power to be developed, and it is satisfactory to note that in the great majority of instances the economy attainable by these means appeals to the engineering officers of clients; however, when dealing with vessels for special trades, modifications have to be made to suit varying conditions or ideas. Generally speaking, standard patterns for the merchant engine are used time and again, particularly for main castings, such as bed-plates, cylinders, columns, and slide-valves. Nothing very definite can be said as to the preference for triple or quadruple-expansion engines, but many well-known ship-owning firms are now adopting the latter, which have proved very economical, more especially on long-distance voyages. For standard engines the company have adopted 180 lb. pressure per sq. in. for triple-expansion engines, and 220 lb. per sq. in. for quadruple engines. On inquiry at the works in reference to the use of cast-iron or wrought-iron circular columns in the front of the engine, we were told that most owners preferred wrought-iron, but in other cases the view taken was that cast-iron box columns of the A-frame type, although they did not give the same degree of accessibility to the working parts, made a stiffer job, but were heavier.

Again, as to crank-shafts, some years ago the introduction of hydraulic forged ingot steel led to the built-up type of crank-shaft, and this is now the general practice in the merchant engine, the advantages of this type being well understood. In the machine-shop a Bunsen-burner furnace is fitted for the shrinking on of the crank-pins and end pieces. Another important feature of the North-Eastern Company's work is the extent to which superheating is applied. They were first in England to take out a license for the Schmidt superheater, and during the last three years have installed them in nineteen vessels, having a collective power of 42,000 indicated horse-power. At the present time they have orders in hand to instal the system in thirty more vessels. The combination of such superheaters with the latest design of quadruple-expansion engines results in very high economy in steam consumption, and the firm are developing the system in connection with Parsons marine geared turbines, so that still better results will be realised. In this connection it may be said that the firm have in use an experimental boiler of 700 horse-power, with which a continuous series of experiments is carried out on this and similar problems. Another point illustrative of the progressive character of the company's work has reference to the practice regarding the Diesel engine. Having considered the question of adopting the oil-engine for the propulsion of general carrying ships, they entered into an agreement a few years ago with the Nederlandsche Fabriek Werkspoor, of Amsterdam, for the building of the type of engine constructed by this celebrated Dutch firm. Since then they have done a considerable amount of work for the Netherlands firm, although they have not completed an entire set of Diesel engines. Their work has mostly been in the direction of making castings in their iron foundry, but when increased demand for this type of propelling engine justifies it, the firm intend to build entirely new shops for the production of the Werkspoor type of engine. This, it may be said, is of the four-stroke-cycle direct-acting type, with crosshead guides and open front and drip-feed lubricators, the company being inclined to the view that the four-stroke-cycle type of engine can be constructed for power sufficiently

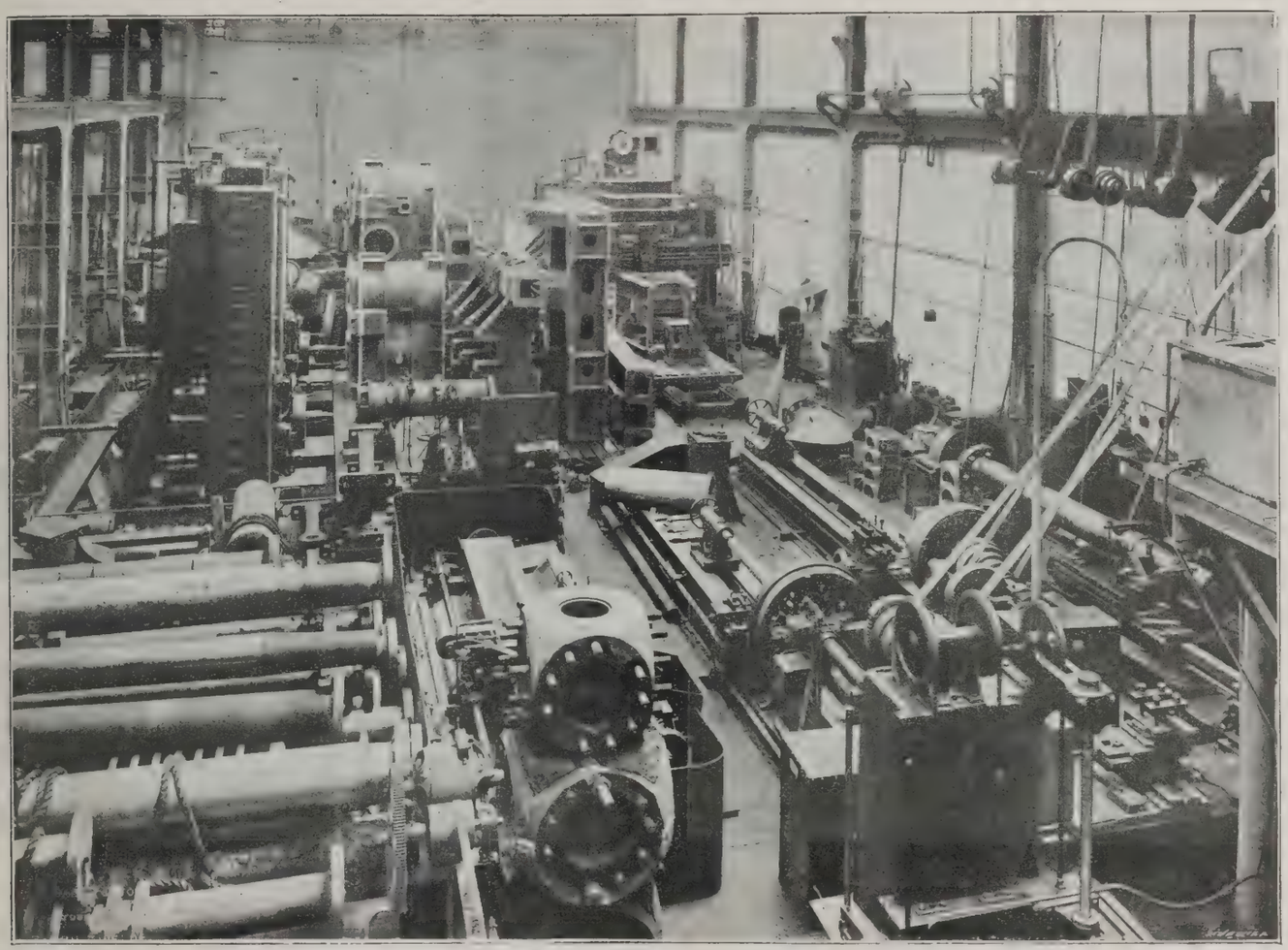


Fig. 5. Shafting-Shop.

high for the class of ship with which they deal, and that it is therefore desirable to ensure the measure of simplicity and reliability that the four-stroke-cycle engine gives.

A direct consequence of the work done in making castings for the Werkspoor Diesel engine has been the establishment and equipment of a metallurgical laboratory. At the same time a considerable amount of research work is being done in connection with the castings for ordinary steam work.

The laboratory, which was started about three years ago, employs a staff of six chemists, and is equipped with the most modern apparatus. The most noticeable are a 50-ton Buckton tensile-machine, a Krupp bending-test machine, a metallographic outfit, and a very recent type of Foster double-purpose radiation pyrometer. Here, too, are collated the records of every casting in the iron foundry, embracing a whole system of foundry control, from the pig-irons entering the cupolas to the castings leaving the machine-shops. It is the floor of the shops terraced in three great steps. Thus the upper ends of the bays of the main building are utilised for the small machine-shop, brass-foundry, brass-finishing shop, smithy, tool-making and fettling department, &c., the roof being 47 ft. from the ground-level. On the second terrace there are the larger machine-shops and the erecting-shops, the height here being 54 ft , while nearer the river again there is, at a level 5 ft. to 8 ft. lower, a shafting-shop, boiler machine and erecting-shops, &c. The foundry occupies two more of the bays at the lower levels. In all cases, however, the overhead cranes in the bays travel the whole length of the shops, and therefore command also the smaller machine-shops. These cranes, in the most important bays—namely, the engine-erecting shop—are respectively of 100, 60, 20, and 10 tons capacity. In the boiler machine-shop there is a 60-ton, a 40-ton, a 25-ton, and two 10-ton cranes. In the fitting-out portion of the boiler-shop the cranes are so arranged that weights up to 150 tons can be conveniently dealt with, the heaviest boiler built so far being over 120 tons. The machinery is dealt with alongside the ships by a 150-ton cantilever crane, built by Messrs. Sir William Arrol and Co., Limited, Glasgow ; the lifting gear by Messrs. Stothert and Pitt, Limited, Bath. The practice at the works is to transfer from the erecting-shop to the ship complete triple-expansion engines up to 2000 horse-power, including the cylinders, columns and bed-plates, the condenser and the pumps worked from the cross-heads being alone separated. In the case of larger engines, the bed-plate, the crank-shaft, connecting-rods, eccentric rods, links and columns are lowered into position first. All the cylinders, even in the case of quadruple-expansion engines, are placed on their columns in one lift.

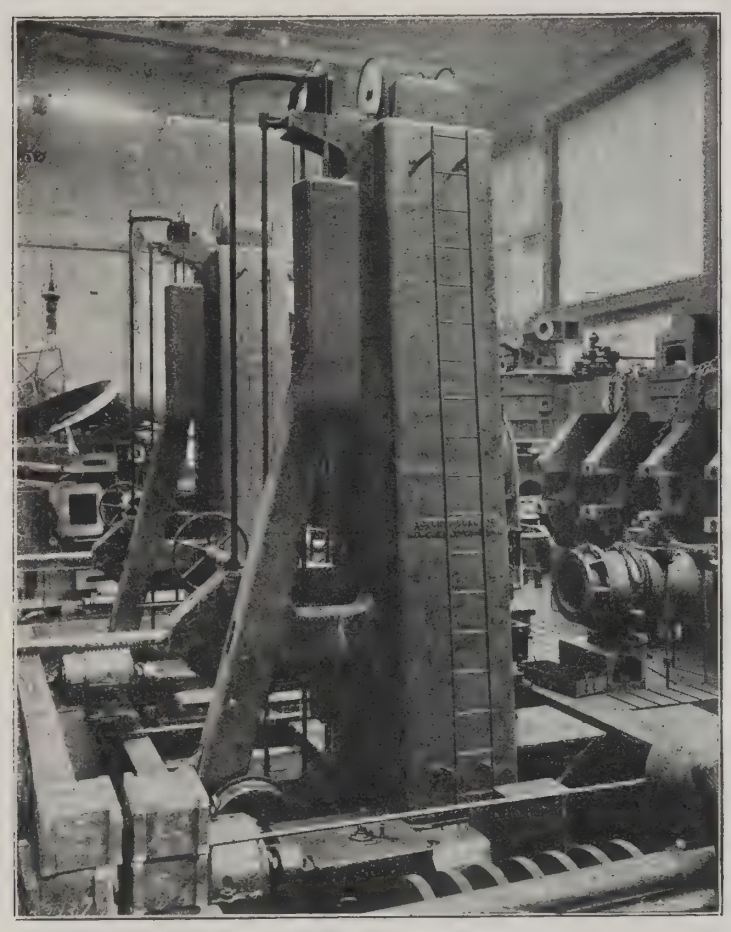


FIG. 6. CYLINDER-BORING MACHINE.

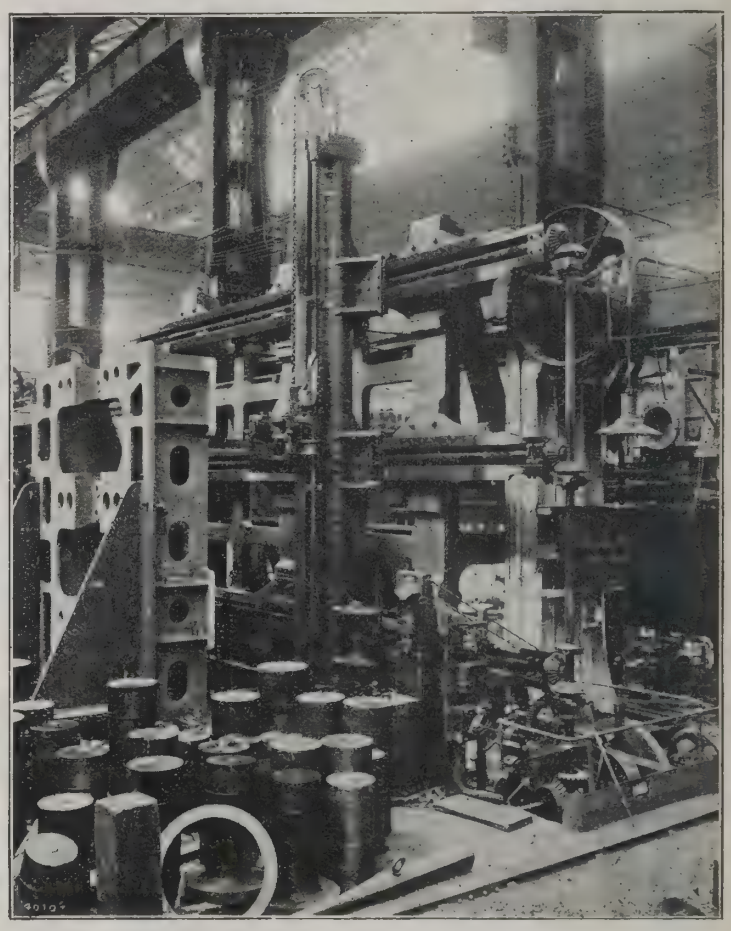


FIG. 7. HORIZONTAL AND VERTICAL PLANING-MACHINE.

In dealing with the manufacturing shops, we may begin with the pattern-shop, which is a separate building in close proximity to the iron foundry, and is fitted with the usual wood-working machinery, including circular saws, band-saws, planing and spindle machines, sand-papering machines and lathes. The iron foundry, Fig. 1, Plate VIII., occupies two of the bays of the main shops, to which reference has already been made. The largest casting within recent times was a bed-plate weighing 45 tons. The influence of the laboratory on the iron foundry is most marked. Previously it was thought that rule-of-thumb methods were sufficient, but gradually it became evident that cast iron was as sensitive to treatment as any other complicated alloy, as, for instance, propeller bronze. Since many vital parts of a marine engine consist of cast iron, it became clear to the company that the efficiency of the engine was largely dependent upon a metal which not only was not understood, but which was not even under control. This is now all changed ; the pig-irons are analysed upon arrival, and each mixture is altered accordingly. By continual study of this and of cupola conditions, it is now found possible to produce castings of any required composition. Thus has this company solved a problem which too long has remained a difficulty with many British firms, and which Continental makers have tackled to their own advantage. As already mentioned, an inspection of the records shows a marked improvement in the quality of the metal. Moreover, the fact that the metal of every casting is now like that of every other casting of its class should, in itself, be logical proof of the incalculable value of the system to users of marine engines.

There are three cupolas, built in an annexe to the foundry, the melting capacity being respectively 8, 6 and 4 tons per hour. Baker blowers are used. The charging platform is at the top of the furnace, the material being raised by cranes. There are seventeen casting-pits, the largest being 23 ft. by 13 ft. 6 in. and 16 ft. by 19 ft. These are used principally for making bed-plates. There are six core-drying stoves with a total area of 16 ft. by 30 ft.

The large machine-shop, Fig. 2, Plate VIII., is 350 ft. long and of 60 ft. span, with a 40-ton crane, having an auxiliary lift of 10 tons, and a 10-ton crane. The principal machines in the department are a boring-mill, Fig. 6, above, to take cylinders up to 108 in. in diameter, table planers taking jobs 16 ft. by 8 ft. by 8 ft., and a 10-ft. chuck-lathe for boring small cylinders. A new lathe with 66-in. centres is in course of installation. There is a large horizontal and vertical planer, Fig. 7, above, to deal with surfaces 20 ft. horizontally and 17 ft. vertically, also shafting-lathes with 30-in. centres and 36-ft. bed. The marking-off table is placed at the end contiguous to the foundry, so that

claimed that all castings of the same class are produced alike in analytical composition and in physical qualities, and that thus their reliability and constancy are greatly enhanced. Since the introduction of this system, the quality of the metal has much improved, as is shown not only in the complete records kept by the departments, but also by the experience of those who have to work the metal in the various workshops. The testing of fuel and lubricating oils, gun-metal, and bearing metal, forms another important branch of the work. There is an experimental casting-room, and research work is constantly in progress. It may be mentioned that for some time past, Dr. J. E. Stead has been working in collaboration with the chief chemist at the works, and has helped him to make the department of real practical value to the works, as well as a place of investigation into the many problems constantly arising in the practice of modern marine engineering.

As regards the manufacturing shops, an admirable adaptation has been made of the conformation of the ground on which they were erected. There is a fairly steep slope to the river here as elsewhere along Tyneside, and the main buildings are constructed on this slope, stretching from the railway sidings and offices down to near the river jetty. The roof of the buildings has been made level, and

the castings, after being cleaned, pass direct to the tables and thence to the machines, and thus traverse the minimum distance. Many of the machines are driven by separate motors and others by belting from overhead shafts, which are operated by electric motors.

The small machine-shop occupies the upper part of one of the bays, and can be entered from the erecting-shop or from the blacksmith's shop which adjoins. It is fitted with the usual lathes and planing, milling, drilling, and slotting-machines. Around it, again, there is a gallery equipped with special grinding, high-speed drilling and other machines, and here all the smaller details of the engines are fitted together and lowered straight to the erecting-shop. Some of the later machines will be examined with interest, notably new high-speed drilling-machines by Messrs. A. A. Jones, Pollard and Shipman, a "New Century" drill by the same makers, and gap-lathes by Messrs. Pollock and MacNab. The blacksmith's shop, which supplies many of the smaller forgings to be machined in these two departments, has fifteen fires, with forging-hammers which are worked with air superheated by the waste heat from the blacksmiths' fires. There are also in this department bolt and rivet-making plants. It will be understood, of course, that the heavier forgings come from the company's Northumberland Forge, to which reference has already been made. The brass-foundry and finishing-shop is also contiguous to this small machine-shop, and here all the fitting and machining of valves, cocks, superheaters, and other small work is undertaken, there being a satisfactory installation of lathes and drilling-machines. Two new lathes of the "all-gear" type have been fitted recently, and enable a large range of speeds to be obtained; as many as fifteen different speeds are possible. Another tool which will interest visitors is a new Lang turret lathe for bar work. The tool-making and fettling-shop, as already mentioned, is also in this part of the main building, and its equipment includes annealing and tool-hardening furnaces. Special note may be made of the tool-grinding machinery.

The location of these various shops greatly simplifies the convergence of the various units, when completed, towards the engine-erecting shop. This shop, Fig. 3, Plate IX., is laid with a concrete base for the building-up of the engines, and the cranes in use, as we have said, range up to 100 tons. Close by it is the shafting-shop, Fig. 5, page 25. In this shop are several very heavy lathes, but perhaps more notable still is a large horizontal drilling-machine with two 6-in. spindles, and a large planer fitted with Lancashire drive, to work surfaces 8 ft. 6 in. by 8 ft. 6 in. by 18 ft. These machines plane and drill bed-plates, cylinders, columns, &c.

A new coppersmith's shop has recently been built near to the jetty at which the vessels are fitted out. This department is 65 ft. by 60 ft., and its equipment includes pipe-screwing, cutting, and hydraulic bending-machines capable of dealing with copper and steel pipes of the largest size. There are the usual fires, blasts, &c.

The boiler-shop, Fig. 4, Plate IX., is in three of the bays in the main building, and each is 450 ft. long, the large fitting-out bay being at the end of the engine-erecting shop, where cranes capable of dealing with lifts up to 150 tons are available. As to practice in connection with the design of boilers, the management state that the double-ended boiler has advantage in respect that it is cheaper to build, lighter in weight, and takes up less space than single-ended boilers for the same power; there is a distinct tendency in its favour for general carrying ships. At the present time there are being constructed boilers each equal to 2500 horse-power. The largest double-ended boiler constructed at the works has a diameter of 17 ft. 1½ in., and a length of 21 ft., the heating surface being 6450 sq. ft. It was built to work under Howden's forced draught, which is very extensively in use in the merchant service, and the total weight, with fittings, is about 121 tons. The largest single-ended boilers were of 17 ft. diameter and 11 ft. 6 in. length, weighing 64 tons, and 16 ft. 3 in. in diameter and 12 ft. long, weighing 70 tons. A feature of the North-Eastern Company's boiler is the system of combustion-chamber wrapper-plate. The plate is rolled in one piece, and the joint is made near the top; there is thus only one joint, instead of two, as in other combustion-chambers, and the joint, being placed high up, is not exposed so much to the action of the flames.

The shell-plates are rolled by a set of rolls capable of dealing with plates up to 13 ft. 6 in. wide and 2 in. in thickness. The largest flanging-machine has a ram capable of exerting a pressure of 110 tons, and a smaller machine of 80 tons. The riveting and shell-plating is done either on a 13-ft. 6-in. or 11-ft. 6-in. gap-riveter, while a smaller tool is used for combustion-chambers, and in addition a number of portable hydraulic riveters are available. There is an interesting tube-hole cutting-machine and a boiler-back drilling-machine. There is also a set of bending rolls for bending angle-irons into rings. There are of course, the usual punching, shearing, and other boiler-making tools.

For some time back the company has been giving special attention to pneumatic appliances, their installation consisting of electrically-driven air-compressors of 600 cub. ft. capacity, working up to a pressure of 100 lb. per sq. in. Experiments have been conducted with a view to improving the pneumatic hand-tools for special operations, particular attention being given to simplicity of construction and reliability in working. In our columns we have frequently referred to the increasing use of pneumatic hammers for riveting, caulking, chipping, &c., and it is interesting to see this being taken up so actively in a modern engineering establishment. The hydraulic power for the tools in the department is maintained by two large hydraulic pumps (duplicate sets). Close to the jetty is a light iron-work shop for uptakes, funnels, &c.

The electricity for lighting and for driving the various shops is taken from the mains of the Newcastle-on-Tyne Electric Supply Company. It is used at a pressure of 250 volts on the three-wire system. Electric arc-lamps are used for illuminating the shops.

The river frontage extends over 1250 ft., and along it is a timber jetty, so that two vessels may lie in the same fore and aft line. There is a travelling-crane of 20 tons capacity, with a radius of 42 ft., traversing the whole length of the jetty. The heavier loads are taken by a 150-ton electric cantilever crane. The leading dimensions of this crane may here be tabulated as follow :—

	Ft.	In.
Height from jetty to rail-level	153	6
Height from jetty to top of tower	124	0
Total length of cantilever	238	0
Length of long arm	148	0
Length of short arm	90	0
Reach of main hook above jetty	143	0
Reach of main hook below jetty	30	0
Total range of main hook	173	0
Reach of auxiliary hook above jetty	143	0
Reach of auxiliary hook below jetty	30	0
Total range of auxiliary hook	173	0
Depth of main girders at centre	25	10
Centres of main girders	14	0
Centres of main columns	40 ft. at bottom; 35 ft. at top	
Tensile stress in members	6½ tons maximum	
Factor of safety in struts	5 minimum	
Test load, main and auxiliary	25 per cent. over full load	
Nature of foundations	4 steel cylinders	
Depth of ,,	Two 73 ft. deep and two 58 ft. deep	
To lift 150 tons at radius of	85 ft.	
,, 120 ,, ,,	100 ,,	
,, 80 ,, ,,	133 ,,	
,, 30 ,, ,, (auxiliary)	137 ,,	
Edge of jetty to 150-ton load	53 ,,	
To lift 150 tons at speed of	5 ft. per min.	
,, 100 ,,	7 ft. 6 in. per min.	
,, 80 ,,	9 ft. per min.	
,, 30 ,, (auxiliary)	12 ft. 6 in. per min.	
,, 7½ ,,	50 ft. per min.	
To traverse 150 tons at	40 ,,	
,, 30 tons at	100 ,,	
To revolve 150 tons at	1 rev. in 10 min.	
,, 30 tons at	1 ,, 5 ,,	
Distance, centre of crane to edge of jetty	32 ft.	
Weight of machinery	82 tons	
Weight of steel work	657 ,,	
Ballast	85 ,,	
Total weight of crane, exclusive of foundations	824 ,,	

This crane, it will be seen, can easily lift loads into two ships lying side by side along the berth, so that there can be great expedition in the fitting of the machinery on board.

The management have recognised the great importance of adequate commercial and office staffs, and the suite of offices is notably spacious and well arranged for an establishment of this size. It may be added further that the management have adopted a liberal policy in respect to their workmen. The piece-work system is largely in operation, and every endeavour is made to ensure suitable habitations for the men adjoining the works. We were much interested in the company's schemes for the better education and training of apprentices, and we notice they give every encouragement to youths attending the evening technical classes.

THE NATIONAL PHYSICAL LABORATORY IN 1913-14.

(*Continued from page* 882, *vol. xcvii.*)

Vibrations of St. Paul's and the Clock Tower (Messrs. Stanton and Batson).—Early in 1913 experiments on the vibrations caused by traffic on St. Paul's Cathedral were made by request of the Home Secretary with the aid of two seismographs. The one for measuring the horizontal component was of the boom type, a boom being pivoted at the inner end, and being held by a wire stretched obliquely from the top of the standard of the instrument to a point near the outer end, which was weighted. The late John Milne used such booms, but his were as light as possible, and not loaded. The instrument used for measuring the vertical component consisted of a steel bar suspended near the one end by a strong spiral spring, and weighted at the other by a weight of 6 lb.; very heavy instruments of this type are used by Wiechert at Göttingen. Kinematograph records were taken with both the instruments. Observations were made in the crypt of St. Paul's, when the traffic was normal and when it was stopped at night near the cathedral. The traffic marked itself by short undulations superposed on the long-period oscillations of the instruments; three motor-omnibuses passing made little impression when running at 6 miles per hour, but at double that speed the oscillations were distinct; yet they were only of the order of about 0.0001 in. Similar results were obtained in the library and in the whispering-gallery, and also in other experiments made in the Clock Tower at Westminster, where the instruments were mounted on the stone floor, 70 ft. above the street level; in the latter case the horizontal movements were more marked.

Dr. Stanton showed, on the inspection day, an interesting experiment due to Reynolds. When two jets of water meet one another in the same vertical plane, the one jet coming from above, the other from below, a circular disc of water is formed, from the edge of which drops are thrown off. When the lower jet is more powerful than the other the disc is slightly cup-shaped. When the two jets are not exactly aligned, the circular disc assumes a lens shape in a more or less inclined plane, not at right angles to the jets as before. Mr. Relf showed the beautiful eddies formed when a vertical cylinder of brass is placed in a slowly-flowing current of water; we have described these experiments when they were in charge of Mr. Eden, who has left the Laboratory.

Tests of Brake Linings (Mr. C. Jakeman, Mr. A. W. Judge).—An extensive research has been carried out for one of the makers of brake linings on some thirty different substances to determine the coefficients of friction under different loads, speeds and temperatures; the materials tried comprised nearly all the cotton fibre and woven asbestos linings in use; further, wood, leather and vulcanised fibre, and some experimental materials. All these substances being bad conductors of heat, block-temperature measurements were out of question, and a very fine hole was drilled in the side of the rim of the friction-wheel, very near the rubbing surface and reaching well under the part of the rim with which the friction-block was in contact. A thermo-couple of iron-eureka wire was placed in this hole, and the leads were taken along the side of the wheel and through the hollow shaft to two insulated copper discs on the shaft running in mercury troughs, from which the other connections were made. A second hole was drilled close to the former to check the measurements, and at the end of a test a thermo-couple was inserted in this hole, the copper discs being cut out; the two series of observations were in very good agreement, but the temperature measurements, made to 0.5 deg. Cent., were possibly a little too low.

The machine illustrated in Figs. 1 to 7, overleaf, comprised a cast-iron wheel A, 20 in. in diameter, 3 in. wide, mounted in bearings and having a

cast-iron friction-block holder B to hold two strips, $2\frac{1}{2}$ in. long and $\frac{3}{8}$ in. wide, of the material under test, pressed on by the lever C and the load W, while the friction-lever F and the load *w* served to determine the tangential pull due to the friction of the blocks. Fig. 1 is an end view of the machine; Fig. 2 is an elevation with one lever support removed; Fig. 3 is a plan; Figs. 4 and 5, elevation and section through shaft and friction-wheels, show details of the two holes M and M_1 and of the copper discs N_1 and N_2, the mercury trough O, and the thermo-couple; Figs. 6 and 7 explain the coupling of the friction-blocks with the links D and the screws E more fully, Fig. 6 being an end view with the end plate removed, and Fig. 7 a section through X X of Fig. 6; G is a dash-pot, J the belt, K the driving-pulley, and S the tachometer.

The wheel was driven by a belt from a 50-horse-power shunt motor, armature current being supplied at 480 or 110 volts, and further speed variation was obtained with the aid of different belt-pulleys Tests were made at rubbing speeds of 600 ft., 2900 ft., and 5900 ft. per minute, and pressures from 5 lb. to 180 lb. per sq. in. were applied to the dry materials, while with lubricated materials the pressure was raised to 290 lb. per inch maximum. The lubrication was effected by two small pipes dropping oil in front of the blocks (not indicated in the diagrams). The materials tested behaved very differently. Some broke away at the edges, some were destroyed by the heat developed; speed as such, did not appear to impose any limits, but the impregnating substance set a limit to pressure and temperature in many cases. This substance was sometimes driven out at low pressures as the temperature rose. The results are summarised for the five chief materials (tried in diverse products):—

Material.	Variation with Increase of		
	Speed.	Pressure.	Temperature.
Cotton-fibre	Nil	Increase	Increase
Woven asbestos ..	,,	Nil	,,
Wood (teak)	,,	,,	Nil
Leather	,,	Decrease	Great decrease
Vulcanised fibre ..	,,	—	Increase (but burns soon)

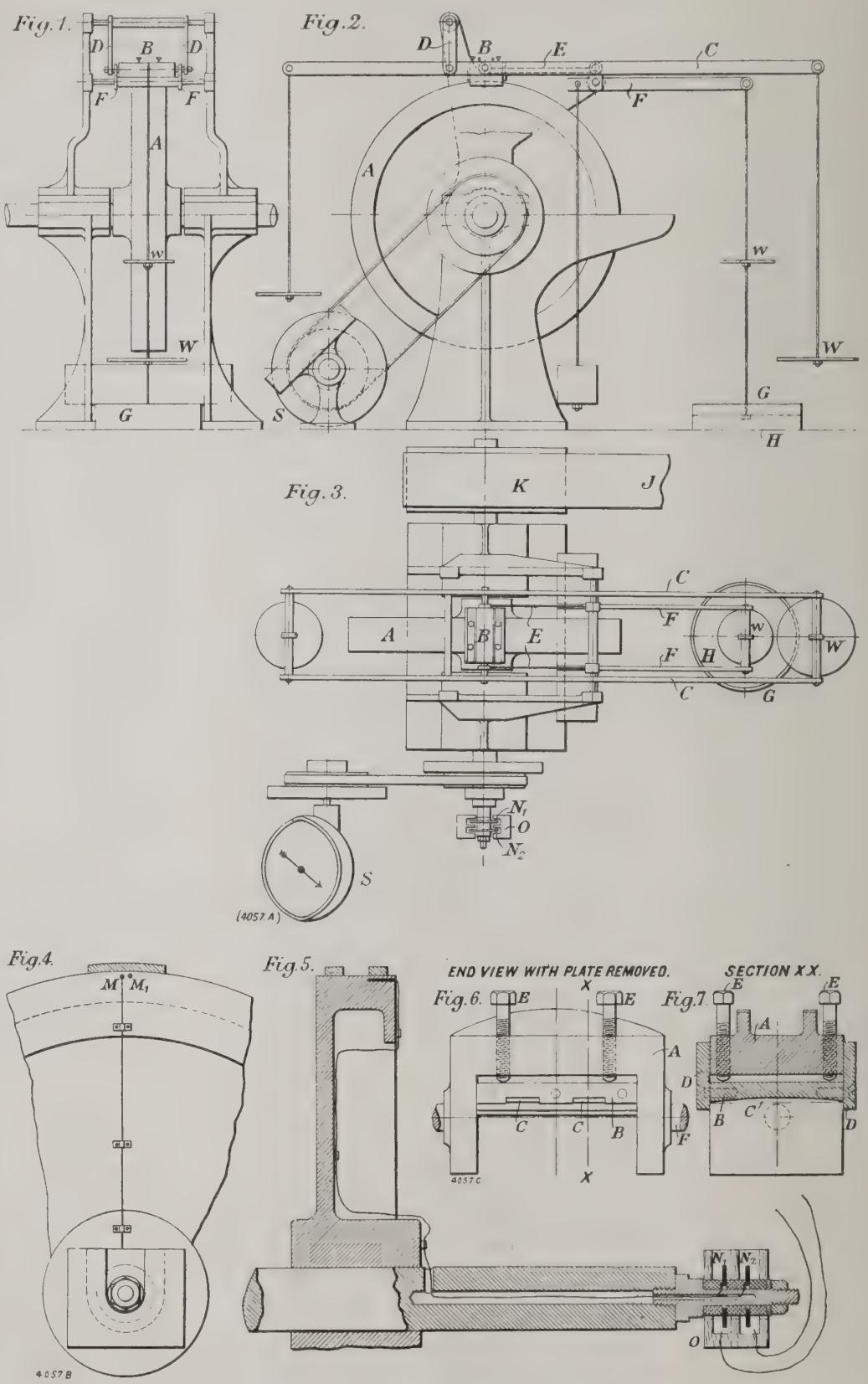
The values of the friction coefficients may be taken as:—cotton fibre, 0.55 to 0.65; asbestos, 0.30 to 0.35; wood, 0.25; leather, 0.2 to 0.8; vulcanised fibre, 0.5.

Thus cotton fibre and woven asbestos gave by far the most uniform and best results; wood rapidly charred and broke away; leather blocks would give almost any coefficient, and were rapidly destroyed a little above 100 deg. Cent.; vulcanised fibre gave a high coefficient, but was useless as brake material, because heat rapidly destroyed it. The low coefficient of asbestos (compared with that of cotton fibre) was at first ascribed to the asbestos being woven with brass wire; but some impregnated asbestos, free from wire, gave similar results, and the impregnation, which serves as lubricant, seems to be the decisive feature, because in asbestos the impregnating substance remains between the fibres (without entering them as in cotton). Lubrication reduced the friction both at high and low temperatures; but the pressure could be raised to such an extent that the same amount of energy was absorbed per unit area as without lubrication without increasing the wear. Starting from rest, the friction coefficient was found to be from 60 to 120 per cent. of the friction when running; a large increase in the friction, as in the case of metal surfaces in contact, was not observed in any case. The growing use of cotton-fibre and woven-asbestos brake-blocks seems hence to be quite justified; it was noteworthy that they answered best when polished by some wear, new surfaces giving lower friction coefficients than worn surfaces.

The Froude National Tank (Messrs. G. S. Baker, late R.C.N.C., M. Inst. N.A., G. A. Millar, B.A., J. L. Kent).—The vacancies on the Advisory Committee caused by the death of the chairman, Sir William White, and of Dr. Thearle, have been filled by electing, as members of the Committee, Sir W. E. Smith, C.B., chairman, and Professor J. J. Welch, of Armstrong College, Newcastle, and also Mr. J. Foster King, Chief Surveyor to the British Corporation for the Survey and Registry of Shipping, Glasgow.

The papers which Mr. Baker presented to the spring and autumn meetings of the Institution of Naval Architects have brought him the Gold Medal of the Institution, and the work done in the Froude National Tank is highly appreciated everywhere. The tank tests made have involved speeds ranging from 21 ft. down to 0.6 ft. per second, and reliable results have been obtained over this range. The carriage track was tested for level, and was found to be very good over the central 300 ft. The amount of water lost in the main tank was 15,000 gallons per quarter, against 18,000 gallons per quarter in the preceding year. The number of models or variations of models tested for various bodies has risen to 101 during the fifteen months ended March, 1914. Of these, 75 were models for shipbuilders (against nine in the previous year); they varied in character from very full vessels having a prismatic coefficient of 0.8, and speed of 10 knots, to destroyers to be tested at 45 knots, and from broad and shallow river vessels to long and deep ocean passenger ships. In many cases considerable reduction in power—in one instance amounting to 25 per cent.—has been realised by the firms acting on suggestions made by the Tank Department that modifications of the model should be tried; quite a number of vessels are now being built whose lines were settled in connection with the tank tests, and two such vessels have made highly satisfactory maiden trips.

The busy work in the large tank has delayed work in the small tank on screw-testing apparatus. But the electrical details for the model screw drive are ready, and experiments on wake and hull efficiency with twin and single screws are being started. The screw models, 4 in. to 10 in. in diameter, are now cast in the tank building from a type metal, lead containing some bismuth; the moulds consist of plaster of Paris mixed with some



FIGS. 1 TO 7. TESTING BRAKE LINING.

lime. The addition of bismuth to the lead prevents the metal from expanding and destroying the delicate moulds.

Hydro-Aeroplane Floats.—The original apparatus for testing hydro-aeroplane floats could only be used for lift and resistance tests. In order to determine the tipping moment of the water forces on the float, to reduce the air resistance and to improve the balance, the apparatus, of which Fig. 8 is a diagram, has been devised. The float is suspended on ball-bearings B by a light aluminium carrier, itself suspended from the rear swinging arm A of a parallel motion erected at the centre of the towing carriage; A rests on knife-edges K, which in their turn are suspended by fine wires which are taken over the pulleys P and are loaded at W. The arm A is therefore free to move vertically in the guides T by an amount measured on S, and the load on the float can be varied. At the fore end of the carrier is a rigid graduated arc having its centre at B, in which a stop can be clamped in any position; this stop engages with adjustable jaws attached to the horizontal frame C, thus allowing a small angular movement (of a quarter of a degree each way usually) from the mean position. The small inclination of C to the horizontal is found by trial and error for any particular speed and angle, and in this way the float can be maintained at any angle to the horizontal. The couple

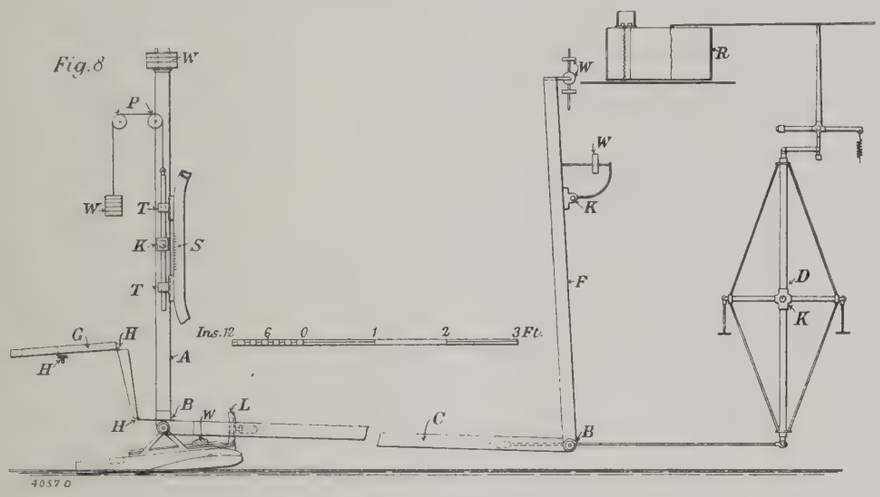


FIG. 8. TESTING HYDRO-AEROPLANE FLOATS.

on the float is measured by means of movable weights on the float-frame, which are adjusted during the run until the stop is just midway between the jaws. The towing force is applied at the fore end through a loose connecting-rod over to the dynamometer D, which records on the drum R; G is a guide-frame, H are hinges, and W is a sliding weight on the float. All the swinging parts being balanced in the air, a slight correction of the force is needed when the float is in water and A slightly out of the upright. A correction has also to be made for the air resistance, which is very small, however, owing to the shape of the struts and the effect of the balance-arm.

Research Work.—The completed research on the resistance of ships and the relation of the position of the humps on the resistance curves to the form of the model was brought before the Institution of Naval Architects by Mr. G. S. Baker last summer, and his remarkable paper was published in our issue of July 25, 1913. The second investigation concerns the question of the longitudinal distribution of displacement in a vessel of the ordinary mercantile type. The twenty models tested had all the same ratios of beam to draught and length to beam, and the same form of mid-ship section; the prismatic coefficients ranged from 0.59 to 0.83, and the parallel body made up 10, 30, 50 per cent. of the ship. In the recent experiments the models have been made without any parallel body at all. The experiments demonstrate clearly to what extent the bow or stern may be filled out not to pay a heavy penalty in high resistance. A particular point studied is the eddy formation at the stern, which affects both the resistance and the efficient working of the propeller. Perfect stream-lines at the stern, it would appear, are only possible if the stream-lines in closing round the ship are only required to move at an angle greater than 15.6 deg. to the line of motion of the ship, and the fullness of the stern should not be increased to an extent to make the prismatic coefficient of the after body exceed 0.75, except in cases of ships of small beam; but even in these cases great care is advisable. The work proposed comprises investigation of the manœuvring power of rudders of various shapes, and the measurement of the torques upon the rudder-heads, and further, the effect of passing ships upon each other. The wave-formation round models is to be studied in the small tank.

Metallurgy and Metallurgical Chemistry (Superintendent, Dr. W. Rosenhain, F.R.S.; Messrs. J. Murdock, A. L. Archbutt, Guy Barr, W. H. Withey, A. Marks, L. L. Bircumshaw, J. D. Grogan, T. E. Rooney, A. J. Turner, D. Ewen, J. L. Houghton, N. P. Tucker, P. G. Ward, and D. Hanson).

Machines, Apparatus, Ventilation.—The equipment of the Wernher building has been facilitated by a donation of 1000*l.* from the Goldsmiths' Company. Among the new machinery installed is a 30-ton tensile, compression, and bending testing-machine by Messrs. Amsler Brothers, of Schaffhausen, worked by a belt-driven three-throw oil-pump delivering oil to the ram of the machine, which has an extra long stroke. The pressure of the oil behind the ram, and thus the stress applied, is measured by a dead-weight pendulum manometer, to which the oil pressure is transmitted by a small piston. For rotating this piston the makers had supplied a handle and belt; but as the turning of the handle is jerky and distracts the attention of the observer, Dr. Rosenhain has replaced the handle and belt by an electric motor and worm-gear. The new Martens ball-machine for Brinell-testing was made by the well-known firm of Louis Schopper, of Leipzig; the ball is only of 5 mm. diameter, and intended for loads of 1000 kg. As the water pressure of the Laboratory is not high enough for working this machine direct, the water pressure in a steel vessel is raised by the compressed-air supply of the Laboratory. The machine is also used for shearing tests and perforations of thin sheet metal, the pressure required for punching a hole being determined. The ventilation plant of the chemical laboratories had to be modified when the laboratories were extended, because the cast-iron blades of the high-speed fan, which was rather noisy, were corroded by the acid fumes, and the fan became much less efficient. The new fan has larger blades, about 6 ft. in diameter, but is run by the same motor ($2\frac{1}{2}$ horse-power) at lower speed, 200 or more revolutions; the fumes are, moreover, filtered before entering the fan, being passed through a chamber lined with glazed bricks, in which fragments of limestone are placed on a succession of glass shelves, a spray of water playing over the shelves.

The Leitz metallograph, mentioned last year, has proved convenient for rapid work at moderate magnifications, whilst for the highest class work at very low powers (up to 10 diameters) and at high powers, a Zeiss vertical camera and the old Zeiss metallurgical microscope are used, illuminated by a hand-fed enclosed arc of the Westminster Engineering Company; a set of Zeiss apochromatic objectives has been purchased. The hinged supports for microscopes, which disappear into receptacles beneath the table when not wanted, were noticed last year.

Cooling-Curves.—The arrangement for taking heating and cooling-curves in vertical furnaces has proved successful. The specimen is lowered into and raised from the furnace, and when the upper end of the furnace is made the heated end, convection currents do not cause trouble in furnaces of 5-in. diameter. The raising and lowering was first attempted by an electric motor; but no motor was regular enough in its pitch circle, and an oil piston-pump, comprising a large and a small tube, a steel piston and a steel needle-valve, is now used for moving an electromagnet up and down; this electromagnet pulls the counter-weight of the suspended specimen, which is thus itself moved. Further to increase the accuracy of the records, an engine-divided glass scale is substituted for the paper scale, and a Campbell bifilar galvanometer for large deflection is used. This need only be brought back at intervals of 2000 microvolts, once every forty, instead of, as formerly, once every four observations. With the now almost automatic method of recording adopted, the observer of the galvanometer has only to tap the key at every transit, instead of plotting the curves from the readings on a chronograph tape; the depression of the key causes a pen, which moves outward at a regular rate from a zero position, to mark the paper and then instantly to return to zero. The new curves are remarkably fine, certainly, and Dr. Rosenhain finds, in agreement with the Bureau of Standards, that the much-disputed point Ar is not a double point.

Alloys Research (Messrs. Rosenhain and Archbutt).—The tests of light aluminium alloys, so much wanted in aeronautics, are continued with all care on a very extensive scale. In order to ascertain whether these alloys really incline to disintegration, as is often alleged, a very large number of castings, both pure and intentionally impure, and of rolled bars, have been prepared in the Laboratory itself and in the foundries and mills of the Atlas Aluminium Works, of Birmingham, and the Melton Works, of the British Aluminium Company. Some 1500 test-pieces, rings of 3 in. diameter, bars of 6 in. length, and also complex castings (motor-cycle crank-cases) have been prepared and carefully machined, numbered and marked, without being engraved or stamped, simple test-pieces being likewise taken for measurement lest any changes should be overlooked in the complex specimens. The test-pieces are measured at intervals of three months for dimensions and electric conductivity by the aid of simple devices, optical levers, *e.g.*, made in the Metrology Department, which measure to $\frac{1}{1000}$ in. with a magnification of 80, the ends of the bars being especially finished for this purpose. So far no changes in dimensions have been discovered, and no evidence of warping has been obtained, although the specimens are kept in different conditions in ovens at 100 deg. or 40 deg. Cent., wet and dry, for instance, in order to imitate damp hot climates, &c. As it was undesirable to insert contact-plugs of other metals into the test-pieces lest the contact-surfaces be damaged by corrosion, these faces are wrapped with rubber tape, or, better still, with wick or cloth impregnated with a thick lubricating oil; both these wrappings stand 100 deg. Cent., and are easily removed for taking measurements. The electric conductivity measurements are made on a Kelvin double bridge, designed by Mr. Melsom, of the Laboratory, and made by Mr. R. Paul.

Experimental Rolling-Mill.—As the rolling and forging of these various aluminium and other alloys cannot, at ordinary mills, be adapted to the special varied objects of the Laboratory, the Laboratory has decided on erecting an experimental mill of its own, and this erection has nearly been completed under the superintendence of Mr. Jakeman. A steam-engine being undesirable, electric power was adopted, and, since the Teddington supply is by three-phase current, and the local power-station declined to have an occasional peak load of 150 horse-power on its mains, a Tudor battery of 120 cells has been installed, which allows of variation between 10 and 240 volts, and thus of speed variations in the motor and mill which would be out of question in works. The motor can also be run on the 100-volt light circuit. The two-high mill, which has been supplied by Messrs. W. H. A.

Robertson and Co., of Bedford, is driven by the electric motor through a belt; two sets of rolls have been installed for roughing and finishing.

The mill will also be very useful in the study of the ternary alloys of aluminium, copper, zinc, to which, in some cases, from 0.25 to 0.50 per cent. of magnesium is added; many of these alloys break up in the rolls, and the ordinary mills are unsuited for dealing with both these hard and soft alloys.

Strain at High Temperatures. Cohesion of Metals Melting-Point of Iron. Cathode-Ray Furnace (Messrs. Rosenhain, Ewen, Hanson).—Owing to Mr. Humfrey's leaving the Laboratory, the work on the effect of strain at high temperature, resumed by Mr. Ewen, has been delayed. The important results of the investigation on the intercrystalline cohesion of metals have been discussed at the Ghent meeting of the Institute of Metals, September, 1913, and elsewhere. The melting-point of iron is to be determined in a vacuum furnace, encased in a glazed earthenware vessel supplied by Messrs. Doulton, which has, with difficulty, been made air-tight by painting it completely with sealing-wax; the vacuum is produced by a high-speed piston-pump of Gaede. The furnace is double, on the cascade principle; the inner alundum tube, $\frac{3}{4}$ in. in diameter, is wound with molybdenum wire (British Thomson-Houston Company) the outer tube, 2 in. in diameter, is wound with nichrome or tungsten (Durain Company); temperatures of 1000 and 2000 deg. Cent. are to be reached in the outer and inner furnace. Outside the furnace is a shield of silica, and then the water-jacket, through which water is sucked under reduced pressure. As it is very difficult to produce and maintain a vacuum in a furnace containing porous materials, cathode-ray bombardment is to be tried in a large-size apparatus (silica tubes) for melting-point determinations, as has been done by E. Tiede; a sparking-coil for 3 kw., giving 16-in. sparks, has been supplied by the Sanax Intensity Company, London, for this purpose.

Etching Steel. Brittle Platinum Dental Wires (Messrs. Rosenhain and Haughton).—The new reagent for etching steel—ferric chloride containing a little copper and tin chlorides—was described on page 783 of our issue of June 5. At the request of the Royal Dental Hospital the brittleness, occasionally shown by the pins of platinum and its iridium alloys used for fixing teeth, is being investigated with the aid of Messrs. Johnson, Matthey and Co. Platinum turns brittle in smoky gas flames, chemists know, and it is thought that some gas effect might take place when the pins are embedded in pasty porcelain; the solder used might also cause the brittleness.

Road Board Laboratory. Textiles. Aeronautics. (Messrs. Rosenhain, Bircumshaw, Withey, Barr, Turner).—At the suggestion of Colonel Crompton the chemical and physical properties of pitch and bituminous substances, alone or bound with sand, &c., are being studied by the penetrometer and other methods; this work was begun by Mr. Bircumshaw in Mr. Crompton's laboratory, and the penetration is determined at a constant rate of speed. Micro-sections are also examined. Glass and textiles further claim much attention. The strength of linen can now be tested at any degree of humidity, disputes previously arising between contractors and purchasers having been traced to atmospheric humidity. Balloon fabrics seem best to be protected against atmospheric influences by metallisation, which is effected in the Laboratory by the Schoop process. The study of metallic crystals by Röntgen rays on the lines of Bragg is to be taken up. The work in the laboratories for metallurgical chemistry is in charge of Messrs. Murdock, Grogan, Rooney, Ward and Tucker.

Electricity. Fundamental Units (Mr. F. E. Smith). *Lorenz Apparatus.*—A large number of absolute measurements of resistance have been made on resistances nominally of 0.001, 0.002, and 0.01 ohm. The results, attained under conditions of unprecedented care, are in excellent accord, and the international ohm would accordingly have a resistance of 1 00052 ohm (10^9 cm./sec.), with a probable error of 4 parts in 100,000. The derived value for the length of a mercury column, representing 1 ohm at 0 deg. C., would be 106.245 ± 0.004 cm. This length is slightly smaller than the mean of previous determinations made by different scientists since 1882. According to an investigation, carried on in the Laboratory in 1908, of the secular changes of the old B.A resistance coils, there were changes in those coils in the period 1882 to 1888. Correcting for those changes, the agreement with the previous ohm values becomes better; yet all the previous values exceeded the value 106.25 (except those of Rayleigh and Sidgwick, 1883, and of Dorn, 1889), and some (Rowland and Kimball, Mascart, Kohlrausch, Duncan and Wilkes, V. Jones) even exceeded 106.30. According to the new measurements, the length of a mercury column having the resistance of one international ohm is 106.30 cm. The mass of this mercury column is 14.4446 grammes. The diameters and axial lengths of the coils of the Lorenz apparatus were re-measured in 1913 and found to agree with the measurements of 1912 within 1 in 100,000. A very slight periodic variation in the pitch of the coils was, however, discovered, due to the leading screw of the lathe; this has to be allowed for by calculations. The coils increase in diameter when under current, and the discs, which rotate in the coil gaps, also increase in diameter. The former increase had previously been determined. To measure the latter, contact points were fixed on the stationary brushes which rest against the rim of the disc; the brushes, it will be remembered, resemble fiddle bows fitted with wire strings; a micrometer was turned until it just touched the contact, when a telephone sounded.

Current-Weigher. Resistance Standards.—In the absolute measurements by means of the current-weigher, the current is either kept constant and its value is calculated from the weight wanted to maintain equilibrium, or the current is varied and its mean value is calculated from the change in the period of the balance. The apparatus is less well suited for the latter method than for the former, but some determinations have been made, correct probably within 1 in 10,000. A disturbing feature in such apparatus is sometimes that the paraffin insulation does not always keep constant, owing to a slight acidity; it has in this case gone down from 1000 to 50 megohms. Two mercury standard resistances have been erected, each being filled three times. Most of the manganin resistances behave excellently, but a few have proved decidedly inconstant, the material being apparently faulty. The exchange of eight sealed manganin coils of 1 ohm with the National Institutions at Paris, Berlin, St. Petersburg and Washington has resulted in a very gratifying international agreement; the Teddington coils changed their resistance by 2 in 100,000 during their absence from the Laboratory, but the changes seem to have been gradual.

Magnetometer. Magnetographs.—The intended electrification of the South-Western Railway passing through Teddington has put the Laboratory on its guard, and a clause has, with the assistance of the Treasury, been inserted in the Act, in accordance with which the company undertake that the magnetic disturbances produced thereby at the Laboratory shall not exceed their present value—there are electric trams near the Laboratory—by more than 20 per cent. Any such disturbances would seriously affect precise electric measurements, and a non-magnetic hut has been constructed in the gardens of the Laboratory grounds, as far away from the buildings as possible, for keeping observations and also for conducting experiments, testing compasses (formerly done at Kew), &c. The hut was designed by Mr. Jakeman, and is built entirely in wood and Keen's cement, which is a kind of plaster, but has to be lined with asphalt to keep the moisture out; all concretes and cements proved hopeless, as they contain iron silicates. The hut is 30 ft. by 16 ft., and has a clear height of 9 ft.; a movable partition divides it into two parts. The new magnetographs of Mr. Smith are suspended by one quartz thread; the sensitiveness depends upon the torsion, and may be made very high by making the angle of twist, usually about 5000 deg., very large, up to 100,000 deg.; the weight of the magnet system, together with the aluminium vanes and the mirror, to which the magnets are attached, can be varied from 0.6 to 50 grammes. The apparatus, which have been constructed in the workshop, are inexpensive, and have, by overdamping, been made to trace the general trend of the horizontal intensity curve, without being affected by sudden fluctuations due to the disturbance from the tram-lines, which do not exceed 5 γ, as a rule ($1\ \gamma = 0.00001$ c.g.s. unit). We referred to these remarkable curves in our notice of the Royal Society soirée of last May. The new magnetometer, also made in the workshop, was suggested by Dr. A. Schuster, who has made a donation of 100*l.* for this purpose; the instrument allows of taking absolute measurements within four minutes; the principle is that the horizontal component of the terrestrial field is compared with the field produced by a current flowing through a coil.

Standard Cells.—The equilibrium in the Weston cells and the hydrolysis of mercurous sulphate in particular are still under investigation. Mr. Smith points out that when hydrolysed and non-hydrolysed salts are in contact with solvent and mercury, the mercury acts as a catalyst. He studies the solubility of mercurous sulphate in water by electrolytic titration—that is to say, by measuring the electromotive force of a cell as the titration proceeds, and noticing the sudden change accompanying the disappearance of the mercury ions.

General Electric Measurements (Messrs. A. Campbell, D. W. Dye, H. C. Booth). *Power Factors of Condensers. Wave-Meters. Inductance.*—The experiments on power factors of condensers have been continued up to frequencies of two million periods per second, thus covering the radiotelegraphic range, and castor-oil, first trusted as di-electric, comes out badly. At 800 periods its power factor is but 0.0005, but at one million periods it is enormously larger—0.038, so that, convenient as castor-oil is for small condensers in general, it cannot be recommended for radiotelegraphic work. Petroleum behaves much better, and mica also, though Mr. Campbell found that its temperature co-efficient was very small between 5 and 30 deg. Cent., but not constant. Castor-oil is undesirable likewise for the large temperature co-efficient of its capacity. He demonstrated this by a simple experiment; he passed currents through two wires, cooled the one in air, the other in castor-oil; the two currents were first of the same order; but as more cells were thrown in, the current through the air-cooled wire became a hundred times the stronger. Characteristic phenomena were also observed when a current gap was produced between two wires immersed in oil; the oil boiled finally, and when the current was slowly raised, the oil column looked like the striated gas column of a discharge tube. Three mutual inductometers have been constructed; the first reads up to 2 millihenrys, and is intended for ballistic galvanometer iron tests at 25 amperes maximum. The second is of 1 microhenry, and to serve for testing nominally non-inductive coils. The third instrument has a range of 4 henrys, and has in bridge measurement of secondary X-ray coils been used to measure up to 2000 henrys. In the wavemeter-room more than 350 coils have had their constants determined, some for wavelengths of 6000 metres. By the aid of a Duddell singing arc and tuning-forks commercial frequency meters are calibrated from 300 up to 800 periods.

High-Frequency Shunts and Resistances.—At high frequencies the self-inductance of a shunt turns out, as was to be expected, to be much more important than its resistance. The time constants of the instrument shunted and of the shunt should be the same for proper working. In the resistance decrement measurements the power spent by a given current in the coil is measured; a thermo-junction is placed on the coil, and the temperature rise, as well as the cooling curve, after switching off are determined. This method confirmed the interesting discovery of Lindemann that a solid conductor behaves at certain frequencies better than a stranded conductor.

Magnetic Tests.—The experiments on the bad effect of temporary, though moderate, strain on magnetic permeability were mentioned last year; the same amount of distortion, when made permanent by passing the limits of elasticity, does not lower the permeability so much. In applying the isthmus method it has been found practical to reverse the magnetising current instead of reversing the test-piece suspended in the gap. The permeability of iron wire and strip, used for lapping telephone cables, in order to increase their inductance, is tested both with rings of the material (by ballistic or other method), and with the lapping in position on the cable, by measuring the inductance; the two methods should agree; stalloid (silicon-iron) is recommended for the lapping. A small iron-core transformer of Mr. Campbell's, containing several flat rings of silicon iron, proved trustworthy at the highest frequencies (two millions), which is very astonishing. The research on the insulation resistance of silica and glass at high temperatures was brought before the Physical Society last August.

Aerials.—Several aerials have been put up; on

one of these the time signals from Paris and Norddeich are regularly received by the Horological Department (Metrology). The aerial is stretched over the ground in a length of 250 m. at a height of 7 m. to 12 m.

Electrotechnics (Messrs. C. C. Paterson, E. H. Rayner, M.A., A. Kinnes, B.Sc., B. P. Dudding, J. W. T. Walsh, B.Sc.).—Routine testing has absorbed 45 per cent. of the time of the staff. Most of the work done is confidential until the publication of the reports.

Photometry. Unit of Light.—The past winter was too mild again to secure very low values of atmospheric humidity for the realisation of the pentane unit (and its humidity coefficient) in terms of the values of electric sub-standard lamps. The intercomparison of the high efficiency standards of the principal national institutions has been concluded, with gratifying results. The final ratios are: Reichsanstalt / 0.9 × N.P.L. = 1.000; Bureau of Standards / N.P.L. = 0.997; Laboratoire Central / N.P.L. = 0.998. The comparisons entailed a colour difference corresponding to that between a carbon lamp at low efficiency and a 1.5 watt tungsten lamp (per mean horizontal candle). These latter photometric standards prove very reliable. Observations on 5.5-watt and 1.5-watt lamps are made with the aid of a flicker photometer. That a high accuracy can be obtained in colour-matching has also been demonstrated by the experiments in which electric sub-standards are measured against black-body radiations from fusing metals. The carbon filament and the tungsten filament have the same black-body temperature for the same colour match, but the specific consumption is, of course, much lower in the latter case.

Navigation and Motor Head-Lights. Factory-Lighting. Illumination Commission.—The research on navigation lights for the Navy, tests of burners, lenses and coloured screens, has been completed, and modified instructions are to be issued by the Board of Trade. The research on dazzling motor head-lights has several times been referred to in our columns. The driver wants the light to be thrown on the road, but the glare on the driver's right-hand side should not rise more than 3 ft. above the road-level, if the public are not to be inconvenienced. These objects can more easily be attained with head-lights of the mirror and lens types than with those of the parabolic type. The introduction of louvred glass fronts, built up of horizontally-arranged slats of glass, which throw the beam down, is to be welcomed. We also described last year the experimental room, 20 ft. by 12 ft., for studying factory-lighting at illuminations from the lowest values up to 20 ft.-candle. Dr. Glazebrook is chairman of the Home Office Committee on Factory-Lighting. Trials have been made with practical workers sitting at different tables, and Mr. Walsh, of the Laboratory, has taken measurements in works. The International Illumination Commission held its first meeting at Berlin in September; Mr. Paterson is secretary, and the bureau is at the National Physical Laboratory.

Special investigations have been conducted concerning the matt white cards serving as reflectors in photometry, and concerning the half-watt lamps containing tungsten filaments in nitrogen under high pressure.

Electrotechnics. Power Measurements.—The very important testing of alternating-current meters and watt-hour meters, on which Messrs. Paterson, Rayner, and Kinnes reported to the Institution of Electrical Engineers in May, 1913, is further being improved and facilitated in various ways. Resistance-boxes of higher values, self-calibrating (being balanced against one another), are used. In order to test three-phase wattmeters with their current and potential transformers under the conditions as they are used in practice, a switch has been constructed to earth the two mains in succession on 20,000-volt circuits, so that the wattmeter may be changed over from one measuring phase to the other, which is required for the two-watt-meter method; the switch is manipulated by wires from the stand at which the Kelvin static voltmeter readings, &c., are taken. A bifilar suspension has been given to this voltmeter to stop the "creep," which is hardly appreciable under ordinary circumstances, but troublesome with the fifty-fold magnification adopted; at the same time the moving system has been made of a light aluminium alloy, containing 25 per cent. of copper and 5 per cent. of zinc. The standard water-tube resistances, which answer very well, have been supplemented by 1½-in. tubes for 500 and 2000 amperes. The new motor alternator of Messrs. Crompton is very convenient for expeditious testing. It consists of a 25-horse-power continuous-current motor and a rotating field alternator; on to the shaft of the set is coupled one of the original Siemens alternators (5 kw.) feeding the voltage circuits, while the new alternator feeds the current circuits through step-down transformers. The field of the voltage machine can be shifted in relation to the current machine in the usual way; a heavy fly-wheel and copper discs running in the mercury pools for leading in the currents steady the currents.

Ebonite. Heating Tests of Field-Coils. Radio-telegraphy.—The pernicious effect of light on ebonite has been studied for the Admiralty. Mr. Rayner's work on the heating of field-coils has been resumed with coils especially wound by the British Thomson-Houston Company and by Messrs. Siemens Brothers; the results show that it is advantageous to impregnate coils of cotton-covered wire after winding, whilst the use of a protective covering of tape may increase the internal temperature by 15 deg. Cent. As secretary of the Advisory Committee of the Postmaster-General on Wireless Telegraphy, Mr. Rayner has visited the stations at Cullercoats, Clifden, Berlin-Nauen, Copenhagen and Hanover, and the erection of a research laboratory for radiotelegraphy in connection with the National Physical Laboratory is planned.

Direct-Current and Resistance Measurements (Messrs. S. W. Melsom, and H. C. Booth).—The test-work has much increased. The question of the unreliability of ebonite exposed to light has come before this department in connection with the ebonite tops of the boxes for resistance coils. The coils are now placed in brass boxes filled with oil, and are connected with the terminals and the mercury cups, both nickel-plated and varnished to withstand the creeping of mercury, on the top; the insulation between the cups and the top of the box is amberite; inside the box ebonite washers may safely be used.

Conductor Rails. Electric Cables.—The conductivity of conductor rails is generally stated in terms of standard copper or of Matthiessen's copper value, and misunderstandings arise as to whether copper and steel are compared as to the same length and weight, or as to the same length and sectional area. Since steel rails are bought by the number of pounds per yard, the comparison should be made accordingly, and the resistance be expressed in ohms. The question is occupying the Engineering Standards Committee. So far as the work at the Laboratory goes at present, the resistance of steel rails seems to vary directly, and the temperature coefficient inversely, with the total contents of impurities; the observed resistances in microhms per 100 lb.-yard varied from 13.9 (electrolytic iron) to 20.5 for conductor rails; an ordinary rail gave 25.3 microhms. The work for the Wiring Rules of the Institution of Electrical Engineers has made good progress, and the research on the heating of buried cables is now well in hand. Inquiries have been sent to fifty electricity-supply authorities; Mr. Melsom has visited various stations, and automatic temperature records of feeder-cables will preliminarily be taken.

(To be continued.)

METALLIC PERMANENT-WAY.—The exports of metallic chairs and sleepers from the United Kingdom for the five months ended May 31 were 48,313 tons, as compared with 53,961 tons in the corresponding period of 1913, and 46,549 tons in the corresponding period of 1912. British India takes the largest share of our exports of metallic permanent-way, having absorbed 39,382 tons in the first five months of this year, as compared with 40,202 tons and 36,679 tons in the corresponding periods of 1913 and 1912.

GERMAN RAILS.—The deliveries of German rails in the first five months of this year compared as follow with the corresponding deliveries in 1913:—

Month.	1914 Tons.	1913 Tons.
January	211,390	229,821
February	214,567	229,856
March	206,325	232,437
April	199,139	234,252
May	231,072	237,101

The aggregate deliveries for the first five months of this year were accordingly 1,062,493 tons, as compared with 1,163,467 tons in the corresponding period of 1913. It will be observed that the May deliveries showed more steadiness and approximated closely to the corresponding movement in May, 1913.

CATALOGUES.

Winding-Engines.—We have received from Messrs. Andrew Barclay, Sons and Co., Limited, Caledonia Works, Kilmarnock, Scotland, a catalogue section illustrating some of the principal types of winding-engines they have been building during recent years. The illustrations show engines of the coupled-cylinder type, fitted with drop, Corliss, Cornish, or slide-valves, and having either cylindrical or conical drums. The firm's auxiliary foot-brake for winding-engines is also illustrated and described in the catalogue, which forms a section of a new complete catalogue now in course of preparation.

Bearings.—The Berlin-Anhaltische Maschinenbau A.-G., of Dessau, Germany, have sent us a copy of their catalogue of "Bamag" economic bearings for machinery and line-shafting. These bearings are of the ring-oiling type, with either plain cast-iron or white-metal-lined bushes. Full particulars, with prices in marks, are given of open and closed pedestals with fixed or swivelling bearings, pedestals with water-cooled bearings, pedestals with sleeves for loose pulleys, thrust-bearings, open and closed hangers, wall-brackets, and pillar-brackets. Mr. C. A. Matthews, of 22, Bridge-street, Deansgate, Manchester, is the representative of the firm for the North of England and Scotland.

Fittings for Half-Watt Lamps.—The General Electric Company, Limited, of 67, Queen Victoria-street, E.C., have issued a pamphlet giving particulars of fittings specially designed for use with half-watt lamps. The intense brilliancy of these lamps, and the fact that they get much hotter than ordinary lamps, renders special ventilating and distributing arrangements necessary, and the long neck of the lamp has also to be concealed if artistic effects are aimed at. All these points have been taken into consideration in designing the fittings dealt with. Most of the fittings are equipped with the firm's special "Superlux" or "Equiluxo" glassware, experiments having shown that these glasses give the most efficient results, combined with very pleasing effects; other glasses can, however, be supplied, if desired. The pamphlet, which is fully illustrated, states prices and gives full particulars of a large selection of fittings for interior and exterior lighting.

Mercury Vapour Lamps, &c.—We have received from the Westinghouse Cooper-Hewitt Company, Limited, of 80, York-road, King's Cross, N., a number of pamphlets giving particulars of mercury vapour lamps and other apparatus manufactured by this firm. Among them are continuous blue-printing machines, water sterilisers, the "Rectigraph" photographic apparatus for copying drawings and documents, and a special type of silica lamp for laboratory use. These silica lamps are intended to form an efficient, reliable, and economical source of ultra-violet rays for use in scientific or industrial research work, and also to produce monochromatic visible light for spectroscopic work and polarimetry. The lamps are made in two distinct types. In one of these the tubes are very similar to those used for ordinary illuminating purposes, and are supplied with holders, so that they can be fitted up on an ordinary laboratory stand. Lamps of the other type have U-shaped tubes, so as to get the necessary length of arc in a small space. The tube is mounted on a marble base, which it overhangs in such a manner that the rays are not obstructed in any way. Each type is made in two sizes, rated for convenience according to their luminous intensity, which ranges from 1200 to 8000 candle-power; they are suitable for working at all usual voltages.

Turret Lathes.—We have received from the Judson-Jackson Company, Limited, 50, Marsham-street, Westminster, S.W., a pamphlet illustrating and describing the Schaerer patent high-speed full-swing combination turret lathes for chuck work of all descriptions. These lathes can swing 31-in. work in the gap and 22½-in. work over the bed. They have all-geared headstocks, giving twenty different spindle speeds, with only fourteen gears, all of which are hobbed from steel, and most of which are case-hardened. The number of feeds provided is twenty-four, and twenty-four screw-cutting changes can be obtained by means of a magazine-box; provision is also made for cutting coarse and odd pitches. The bed is of the box type, carried right down to the floor, thus ensuring great rigidity; it also forms a tank for cutting lubricant. The front saddle runs on slides cast on the front of the bed, the upper slide being of the V type, while the lower one, which is near the base of the bed, is a broad, flat, vertical surface. Special attention is called to the fact that cuttings cannot get on to any of the slides. The turret-saddle, which is exceptionally long, runs on two V slides, placed as high as possible in order to make the turret rigid. It is fitted with a power-driven quick-traverse motion, which works in both directions, and is automatically stopped at the end of the bed. Many other special features are referred to in the pamphlet, which gives a general specification for the machine, and illustrates its more important details; prices are also stated.

THE ITALIAN NAVY.—The Italian ironclad Christoforo Colombo, now in course of construction, will have a displacement of 26,000 tons, and will carry eight guns of the heaviest description, in four double turrets, and sixteen smaller guns. Two new ironclads have been commenced for the Italian Navy, and they are to be completed in three years. They are to steam at the rate of 25 knots, and power is to be developed exclusively from petroleum. Each ship is to be propelled by three screws, two of which will be worked by Parsons turbines, while the central screw will have a Diesel motor for cruising.

FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several foreign engineering projects taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Spain: The *Gaceta de Madrid* announces that tenders will be received, up to July 13, at the Negociado Correspondiente del Ministerio de Fomento, Madrid, for the construction of new moles at the Port of Alicante. The time allowed for the work is two years, and the upset price is put at 832,219 pesetas (about 30,800*l.*). The notice contains a clause to the effect that at the first competition materials to be used will be confined, with certain exceptions, to products of Spanish manufacture, but that in the event of no decision being arrived at a second competition, in which foreign products may be accepted, will then take place. In the latter event Spanish products will have a 10 per cent. margin of preference over foreign.

Morocco: H.M. Chargé d'Affaires at Tangier has forwarded an extract from the *Bulletin Officiel* of May 22 containing a "Dabir" granting a concession to the Compagnie Marocaine de Fedalah for the construction and working of a public port at that place. Special provision has apparently been made for the work of construction being put up to tender. According to the *cahier des charges* annexed to the Convention for the concession, the works will include the construction of a jetty 200 metres (218 yards) long from the outer of the two islands in the bay, and the construction of wharves, "terre-pleins," a basin of 4 hectares (9.8 acres) area, and sheds and warehouses, the latter to be equipped with cranes, &c. The works must be finished within 15 months.

United States of America: H.M. Consul-General at Chicago reports that the State of Illinois intends to make strong efforts to improve the condition of its roads, and proposes to spend some 65,800*l.* this year on the construction of about 600 miles of hard roads throughout the State. In this connection an order for 1,600,000 sacks of cement has already been placed.

Mexico: The *Diario Oficial*, Mexico City, contains the text of a contract entered into between the Department of Agriculture and Colonisation and Señor Miguel Lanz Duret, representative of Messrs. Mengel Brothers, authorising the construction and working of four railway lines from the boundaries of the firm's concession in the Quintana Roo Territory as far as the River Hondo and Chetumal Bay, between the towns of Ramonal and Ubero. The concession is for a period of ten years, and the lines may be acquired by the State at the expiration of that period if desired. The *Diario* also contains the text of a contract entered into between the Secretary of the Treasury and Public Credit and Señor Enrique Fernández Castelló, for the partition and development of land reclaimed from the sea at Vera Cruz. The works specified include the construction of conduits, sewers, and mains for the drainage of superfluous and rain-water, and for the supply of drinking water, the construction of necessary embankments, and the paving of roads and footpaths.

FRENCH ROLLING-STOCK.—In the course of last year 121 locomotives, 96 tenders, and 4072 miscellaneous carriages and vehicles were delivered to the Northern of France Railway Company. The 121 locomotives comprised 25 compound six-wheeled-coupled engines, one compound locomotive, with five-coupled axles of the decapod type, 94 compound engines, with four-coupled axles of the consolidation type, and one compound locomotive, with three-coupled axles. Since January 1, 1914, further orders have been given for 43 locomotives and 1183 miscellaneous vehicles.

NORTHERN COAL, IRON AND STEEL COMPANIES.—We have received from the Business Statistics Company, Limited, of 20, Victoria-street, Westminster, S.W., a copy of a booklet they publish at the price of 1s. net, giving financial statistics of the various coal, iron and steel companies in the North of England. Two pages of the book are devoted to each company. On the first page are given a list of directors, the name of the secretary, the amount of capital and debentures, annual output, highest and lowest prices of shares during the past few years, and other useful information, while the second page is devoted to a summary of the more recent balance-sheet and profit-and-loss account; the profits made, dividends paid, sums placed to reserve, &c., during the past few years are also mentioned. The book, which it is proposed to issue annually in future, should thus prove very useful to investors.

CHILIAN RAILWAYS.—The Chilian Parliament voted last year a sum of 30,000 dols., to be given as prizes for the best designs of general railway works for dealing with the repair of 500 to 600 locomotives, 500 passenger carriages, and 6000 goods wagons. The first prize was to be 20,000 dols. and the second 10,000 dols. Messrs. the Niles-Bement-Pond Company, New York, took the matter up, and sent complete drawings showing the ground plan and elevation of every building; a plan of the yard, with tracks, yard cranes, paving, &c., complete; plans of the wiring, power distribution, central power-station and its equipment, the machine and erecting-shop, the machine-tools being in groups, one group for each item of the engine. The awards, we are informed, were made in the first week of June, and the firm named were awarded the first prize, the second prize going to a Belgian and English combine. It is expected that the shops will cost 3,000,000 dols.

THE PHYSICAL SOCIETY OF LONDON.

AT the meeting held on June 12, at the Imperial College of Science, Professor T. Mather, F.R.S., Vice-President, in the chair, a paper entitled "*Note on the Connection between the Method of Least Squares and the Fourier Method of Calculating the Coefficients of a Trigonometrical Series to Represent a Given Function or Series of Observations*," by Professor C. H. Lees, F.R.S., was taken as read in the absence of the author.

In view of the number of alternative methods which have been suggested for calculating the coefficients of the terms of a Fourier series to represent a number of observations of a variable quantity, the author points out that the Fourier method gives the most probable values of the coefficients, since it makes the sum of the squares of the errors at the points of observation a minimum.

Dr. C. Chree mentioned that the method was dealt with in Tait's "Natural Philosophy," but no proof was given. Professor Lees had supplied the proof, and the paper was of interest on that account.

Dr. W. Wilson (communicated remarks) said: Professor Lees deals with a function $f(x)$ of period l, whose values are given in the whole interval from 0 to l. In this case the validity and uniqueness of the Fourier expansion (provided $f(x)$ is subject to certain restrictions) have been demonstrated with complete rigour (Dirichlet, "Collected Works," vol. i., pages 133 to 160; and G. Cantor, *Journal für Mathematik*, LXXII.). It seems to me, therefore, that there is no question of the reliability of the Fourier coefficients, and the fact that the method of least squares leads to the usual Fourier expressions for the coefficients confirms the reliability of this method rather than that of the Fourier coefficients themselves.

A paper entitled "*A Magnetograph for Measuring Variations in the Horizontal Intensity of the Earth's Magnetic Field*" was read by Mr. F. E. Smith.

In the case of unifilar instruments for recording variations in H, if θ is the angle which the magnetic system makes with the magnetic meridian, M the moment of the magnet, and H the horizontal intensity of the earth's field, equilibrium results when $MH \sin \theta = T \phi$, where ϕ is the torsion of the fibre and T is a constant. In the instrument described ϕ may be made great or small, but high sensitiveness is secured by making ϕ great. The magnet system is supported by a quartz fibre, and critically aperiodic damping is obtained by means of an aluminium vane and two parallel damping plates. To diminish the sensitiveness the effective length of the fibre may be reduced. The general usefulness of the instrument is illustrated by photographic records, which show the instrumental peculiarities to be very small, and indicate that unless the system is aperiodic increased difficulty must result in the interpretation of the records. An over-damped system responds but slightly to rapid pulsations in H, but follows the slow changes which are common all over the world. The general sensitiveness of the records is about 3 mm. for a change in H of 0.00001 C.G.S. unit, but one record shows a displacement of 8 mm. for such a change.

Dr. Chree thought the instrument ingenious and likely to be very useful for the purpose for which he understood it was primarily intended—viz., the observation of the disturbances produced at the National Physical Laboratory by existing and prospective electrical tramways and railways. There were various features in the existing disturbances whose investigation seemed likely to be of interest and to the public advantage. There were also certain natural phenomena, for example, "pulsations," or small oscillations of magnetic force, for whose investigation the instrument from its great sensitiveness seemed well adapted, only for such purposes it would have to be set up at some station, such as Eskdalemuir, remote from London or any other large centre of electrical industry. There were, however, two features—viz., the somewhat rapid variation of scale value across the sheet, and the fact that the instrument responded sensibly to changes of declination as well as horizontal force, which, he thought, stood somewhat in the way of its employment for ordinary observatory purposes.

Mr. R. S. Whipple asked whether the author had considered the advisability of flashing a spot of light across the sheet to give the time scale, as was done at Potsdam.

Mr. C. W. S. Crawley considered the tramways were a great nuisance to magnetic observers. He had gone a good deal further in sensitiveness than the author, and even when situated 16 miles from the nearest tramways he had found them very troublesome. The little kick in the middle of the disturbance which Mr. Smith thought might be an instrumental error had often been noticed by him, and was a definite phenomenon in no way due to the instrument.

Professor T. Mather asked if the author had tried using the finest quartz fibre which he could handle. It appeared that the instrument took two or three seconds to attain its final position. If a finer fibre were used, a lighter and quicker magnetic system could be employed.

The author, in reply, agreed with the remarks of Dr. Chree. He had thought it would be interesting to set up an instrument to detect very small pulsations, such as might occur during solar eclipses, while neglecting the larger ordinary disturbances. He admitted that the variation of sensitiveness across the sheet would be a disadvantage to an ordinary observatory assistant, but it gave him no trouble whatever. In reply to Mr. Whipple, he had already started to employ the flash of light method for the time scale. In reply to Professor Mather, there was no doubt that the system could be made a good deal lighter if it were desired to measure very sudden disturbances lasting only a few seconds.

A paper entitled "*The Atomic Weight of Copper by Electrolysis*" was read by Mr. Albert G. Shrimpton.

Four copper cells separating two silver cells were run in series. The areas of the four copper cathodes increased from 10 to 50 s. cs. By plotting the weights of the copper deposits against the corresponding areas of the cathodes, and extrapolating to zero area, the weight of the deposit is corrected for under experimental conditions. The atomic weight of copper

$$= \frac{\text{corrected weight of Cu}}{\text{mean weight of Ag}} \times 107.88 \times 2.$$

The mean atomic weight for ten determinations = 63.563, with a mean error of ±.003. To obtain a uniform coherent deposit of pure metal the following points were considered:—

1. Cylindrical cells with stationary and rotating cathodes were used.

2. The cathode current density must be kept below a certain limiting value to prevent the formation of non-coherent deposits, due to secondary deposition. This was found to depend upon the geometry of the cell, the concentration of the electrolyte, the presence of acid and other impurities, the addition of a porous pot, and the rate of revolution of the cathode. Formulæ are given by which the limiting cathode current density can be found for all conditions of the cell for Cu, Ag, Au, and Zn.

3. To prevent the formation of loose crystalline clusters the current density must also be kept below a certain value depending upon the weight to be deposited. (Formulæ are given.)

Mr. F. E. Smith congratulated the author on the results of his work. He appeared to have triumphed over many difficulties, and for his particular purpose had converted the copper voltameter from an instrument of error into an instrument of precision. In future work he hoped that Mr. Shrimpton would avoid the use of common porous pots. They might produce trouble, and were not necessary, as all voltameter work could now be carried out without the introduction of any medium between anode and cathode. He should be pleased to give Mr. Shrimpton full particulars. The statement respecting deposition of hydrogen was, he thought, incorrect. It was not logical to assume that hydrogen ions were first deposited because of the lack of copper in the neighbourhood of the cathode, and then to state that as soon as they were deposited they went into solution again, and in doing so displaced copper from the solution. With regard to crystalline growths at the bottom of the cathode, he believed these were due to the high current density at the base due to the passage of the current through the liquid descending from the anode. There was also a possibility that the electrolyte was not quite pure. In the silver voltameter he had obtained striated deposits with impure electrolytes, but not with pure solutions. Mr. Shrimpton also stated that silver deposits from acidified solutions were normal; this was not his experience, nor that of other investigators. He believed the deposit to be less in mass when the electrolyte was acid. A rather important question arose with regard to any Cu_2So_4, which might be formed in the cathode space. Richards (who also extrapolated to zero area, as Mr. Shrimpton had done) remarked in his Paper: "A value obtained in this way must correspond to a deposit of copper slightly too great; for the mode of correction—*i.e.*, extrapolation to zero area—does not take account of the growing, although slight, presence of cuprous salts." Mr. Shrimpton said the extrapolation to zero area covered this case. The speaker thought the point was one that should be settled. Of course, when one reduced the area, the current density at the cathode was increased, and so also was the fall of potential near the cathode; this might have some influence.

Dr. J. H. Vincent mentioned that after working out the conditions necessary for satisfactory results, the author had performed the ten determinations quoted in the paper straight away, no results being rejected. As they all came within 1 part in 6000 of the mean, there appeared to be no doubt that the correct conditions for satisfactory working had been obtained.

Dr. S. W. J. Smith thought the author's views on secondary deposition could not be correct as they stood, although it was conceivable that sudden variations in the surface concentration of the copper sulphate, due to irregularities of convection, might make it possible for hydrogen to be deposited at one moment and to go into solution again at the next. Non-coherent deposits could be explained without invoking the aid of hydrogen. He thought the author's empirical conclusion that the limiting current density depends upon the concentration of non-ionised molecules had some theoretical support.

A paper entitled "*Note on an Improvement in the Einthoven String Galvanometer*," by Mr. W. H. Apthorpe, was taken as read.

BRITISH COAL EXPORTS.—The exports of coal from the United Kingdom in the first five months of this year amounted to 30,149,492 tons, as compared with 30,781,229 tons in the corresponding period of 1913. The expression "coal" includes also coke and briquettes. The principal exports to May 31 compared as follows with the corresponding exports in the first five months of 1913:—

Country.	1914. Tons.	1913. Tons.
Russia	1,304,074	1,442,564
Sweden	1,408,560	1,744,500
Germany	3,378,673	3,512,982
France	5,852,799	5,356,675
Spain	1,503,304	1,620,152
Italy	3,900,684	3,930,725
Egypt	1,425,024	1,303,316
Argentina	1,615,571	1,509,586

Upon the whole the exports have barely held their own thus far this year, the progress usually observable having sustained a check.

THE ALEXANDRA DOCK EXTENSION AT NEWPORT.

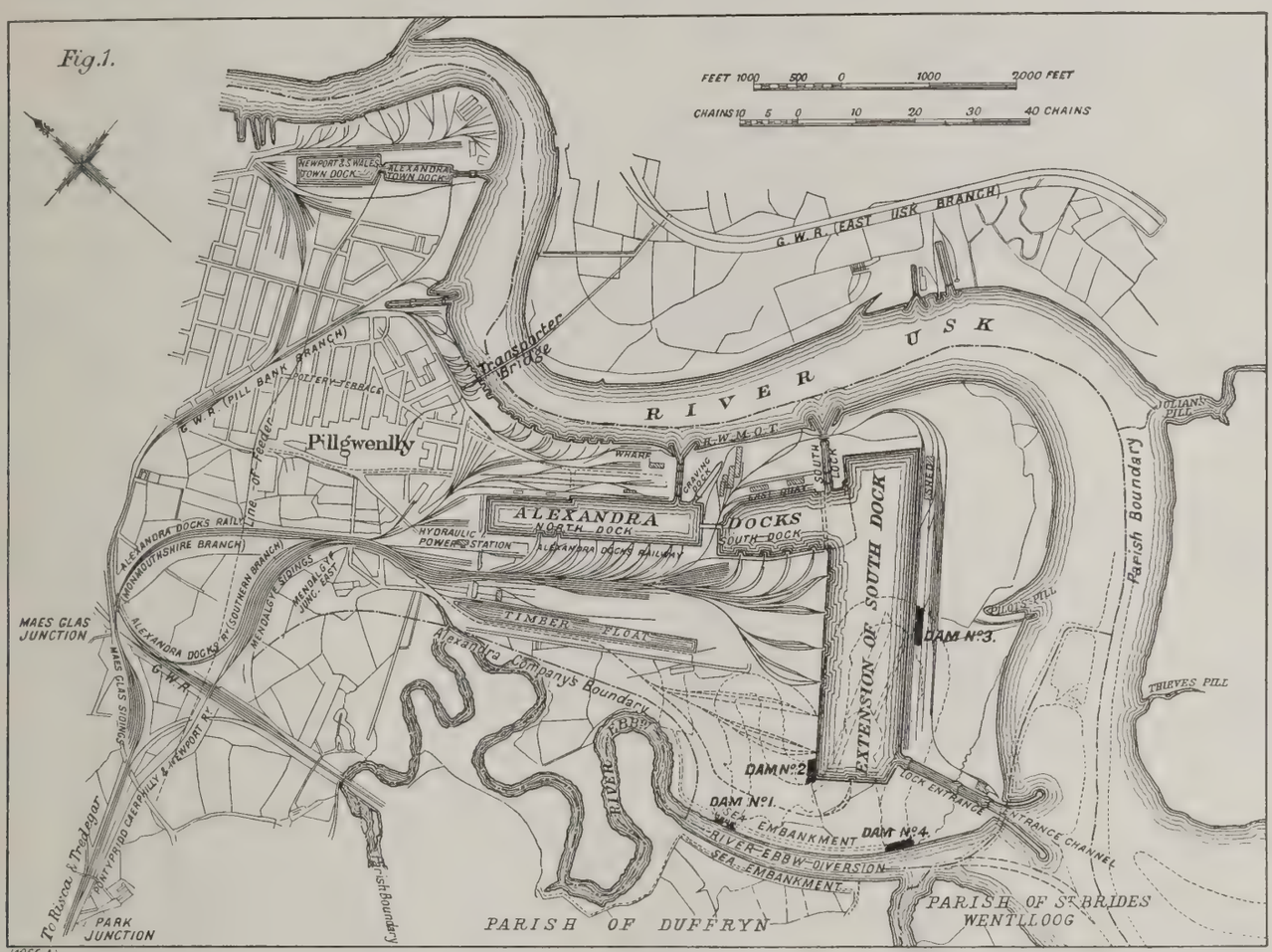
NEXT Tuesday will mark the culmination of a work which should do much to help forward the prosperity of Newport. On that day the latest dock extension and the new river entrance to the dock system will be opened by Prince Arthur of Connaught. Much of the work to be formally inaugurated has been in use for some time, the procedure adopted on the dock extension having allowed of the earlier part of the work being put into service before the completion of the later; but the bringing into service of the new lock forms a fitting occasion for a formal opening. This lock will greatly add to the utility of the extended dock, and will enable full advantage to be taken of its great area and depth, both by allowing a much larger type of ship to frequent the port than has been possible hitherto, and by increasing the facilities for ships of a more moderate size.

The trade of Newport is of a general character, and is by no means confined to coal, although, in view of the favourable position of the town in relation to the South Wales and Monmouthshire coal-fields, this latter commodity naturally occupies a prominent place in its exports. We believe that in coal exports Newport holds a position second only to one of the South Wales ports, and that in general cargo shipment it occupies the first place. Situated in Monmouthshire, Newport is geographically more favourably placed for handling trade to or from the Midlands than any of its immediate rivals, while it is in an equally good position as far as much of the South Wales coal-field is concerned. It is further situated on a river having an average width of about 1000 ft. and with one of the largest tidal ranges in the world, amounting to over 38 ft. at spring tides. This enables it to accommodate ships of large size and capacity. The new work that has been undertaken will enable even greater use to be made of these advantages than has been possible in the past, and should further establish the importance of the port.

The docks at Newport are the property of the Alexandra (Newport and South Wales) Docks and Railway Company. Those furthest up the river—the Alexandra, Newport and South Wales Town Docks—were constructed by an earlier company in 1842, and were purchased by the present owners some time after the construction of the Alexandra North Dock. The Town Docks are of 11½ acres, and are used for coal shipping and general trade. The entrance-lock is 200 ft. long and 61 ft. wide. The Alexandra North Dock, situated further down the river, as shown on the map given in Fig. 1, on this page, was opened in 1875. It has a river lock 350 ft. long by 60 ft. 9 in. wide, and is equipped with hydraulic coal-tips on one side and cranes and sheds for general trade on the other. The dock is 2500 ft. long by 500 ft. wide, and is connected to the South Dock by a channel 60 ft. wide, over which there is a road and rail swing bridge. The South Dock was opened in 1893. It is 1500 ft. long and 640 ft. wide, and has an entrance-lock from the river 503½ ft. long and 72 ft. wide. The dock is laid out with hydraulic coaling-tips on one side, and for general cargo on the other, on the lines of its neighbour, the North Dock. As will be seen from Fig. 1, ample railway accommodation is provided on the quays of both docks.

The extension of the South Dock, with which this article is more particularly concerned, lies at right angles to the old South Dock, as will be seen from the map, and with it forms virtually a single basin. The construction has resulted in a single dock with an area of 96 acres. Work on the extension was commenced in 1905, and, as has been mentioned, was so carried out that part of the new accommodation could be brought into operation before the completion of the remainder. The east end and some of the coaling-berths on the north side were first constructed and have been in service for some years. The west end, much of the south wall and the new southern entrance from the river, have only just been finished. The extension is 4000 ft. long by 1000 ft. wide, and has an area of about 76 acres. The average depth of water is 33 ft. The north side and west end of the dock are laid out for coal-handling, and four hydraulic hoists situated on the quay have been in use for some years. Three new hoists for high bunkering are now on order and will be situated two on the north quay and one on the west, in positions indicated by the railway connections shown by broken lines in Fig. 1. The south quay will be equipped throughout with cranes, sidings and sheds for handling general merchandise, the whole of these arrangements at the east end being already in service. The lock entrance is 1000 ft. long by 100 ft. wide and has a depth over the outer sill of 45 ft. at high water of spring tides, and 35 ft. at neap tides. A new electric power and pumping station has been built close to the new lock. Other new work carried out in connection with the estate has been the provision of a rolling road and railway bridge at the river end of the old South Lock, and the building of a ferro-concrete river jetty equipped with cranes between the north pier of the North Lock and the river coaling-jetties at Pillgwenlly. The whole of these works have been carried out to the designs and under the supervision of Messrs. Sir John Wolfe Barry, Lyster and Partners, with whom up to the time of his death the late Mr. C. A. Brereton was associated. The resident engineer was Mr. J. D. C. Couper, M. Inst. C.E., to whom we are much indebted for the assistance he has rendered in the preparation of this description.

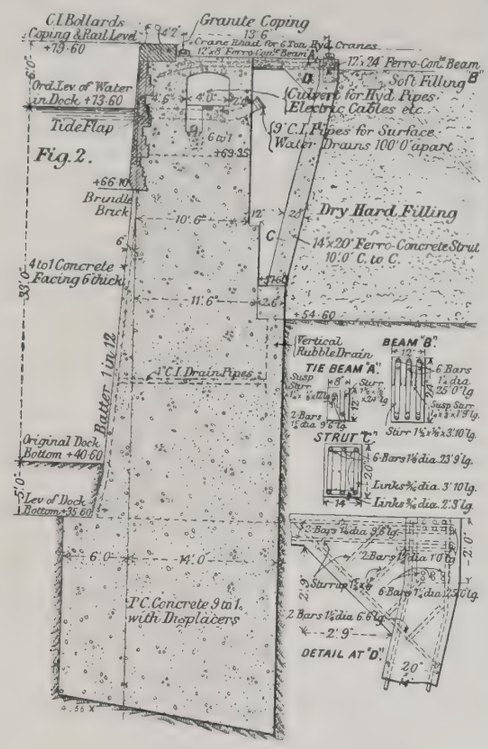
Fig. 1.



The whole of these works have been carried out to

In describing the works, we will first deal with the general methods of construction of the dock and lock; then passing to the entrance jetties and to the lock-gates, and concluding with some account of the general machinery equipment. The construction of the dock, having been carried out in various stages, has been the subject of numerous contracts; but the whole of the work has been done by Messrs. Easton. Gibb and Son, of 9, Victoria-street, London, S.W. The site, as will be seen from Fig. 1, is bounded on two sides by the River Usk, and on one other by the Ebbw, a tributary of the Usk. The general level of the ground before work was commenced was some 7 ft. below present quay-level. The site was covered for a depth varying up to 40 ft. or so with a soft muddy clay, known in South Wales as "bungum." Below this there was a layer of gravel, overlying marl. The gravel was, in general, very hard and of good quality, but proved treacherous in places,

where beds of nearly pure sand were encountered. It was, in places, 20 ft. thick. The marl was of good quality, and gave a firm foundation wherever it was reached.

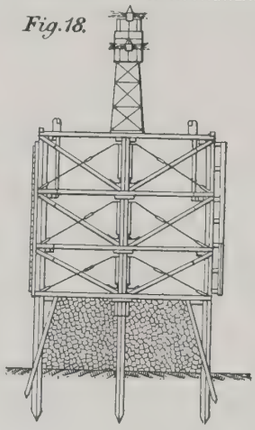

C.I. Bollards
Coping & Rail Level +73·60
Granite Coping
Crane Road for 6 Ton Hyd. Cranes
17'x24' Ferro-Con.te Beam
Soft Filling
Culvert for Hyd. Pipes Electric Cables etc.
9" C.I. Pipes for Surface Water Drains 100'0" apart
Ord. Lev. of Water in Dock +73·60
Tide Flap
Dry Hard Filling
14'x20' Ferro-Concrete Strut 10'0" C. to C.
Brindle Brick
4 to 1 Concrete Facing 6' thick
Vertical Rubble Drain
TIE BEAM "A"
BEAM "B"
STRUT "C"
6 Bars 1¼ dia. 25'0" lg.
6 Bars 1¼ dia. 25'9" lg.
Links ⅝ dia. 3'10" lg.
Links ⅝ dia. 2'3" lg.
Batter 1 in 12
C.I. Drain Pipes
Original Dock Bottom +40·60
Lev. of Dock Bottom +35·60
T.C. Concrete 9 to 1 with Displacers
DETAIL AT "D"
Fig. 2.

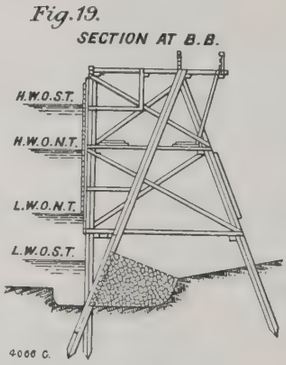
this work was in progress, excavation, chiefly by means of Ruston-Proctor diggers, was started at the eastern end of the dock. A bank of earth, the position of which is indicated in Fig. 1, was left between this excavation and the south wall of the dock, and was not removed until water had been admitted to the extension. A bank was also left on the left bank of the River Ebbw, shutting out its waters from the excavation. Concurrently with these two pieces of work a floating dredger was excavating in the old channel of the River Ebbw, removing material up to the line of a diagonal bank across the south-west corner of the dock, which is indicated by dotted lines in the plan. This bank formed a boundary of the dock, as it was constructed before the lock works were put in hand.

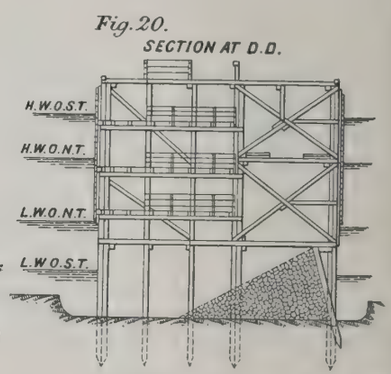
By the time this dredging in the Ebbw Channel was completed the excavation of the upper lift of dock was carried on in the dry. At the same time the eastern portion of the south wall was built. Water was then admitted to the extension, and the bank separating it from the South Dock was removed by means of a bucket-dredger. The dredged material was pumped ashore by means of a floating suction-dredger, taking the material from the barges, which were filled by the bucket-dredger. The material was dumped to the north-west of the dock extension, on the land to be covered by the railway connections to the new coaling-hoists.

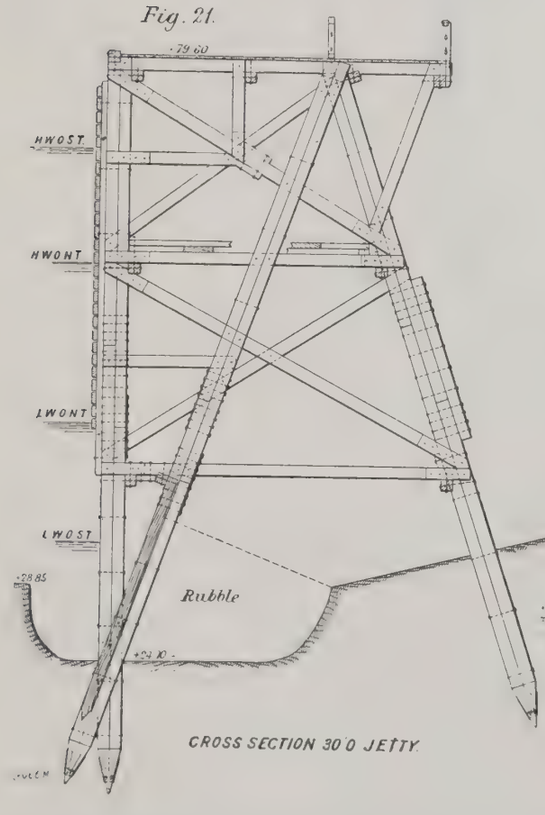
As the extension has a depth of water of 33 ft., and the South Dock one of only 30 ft., there is a step between the two. Its position is indicated by the double broken lines running across the South Dock from the north wall of the extension in Fig. 1. The work we have so far described completed the

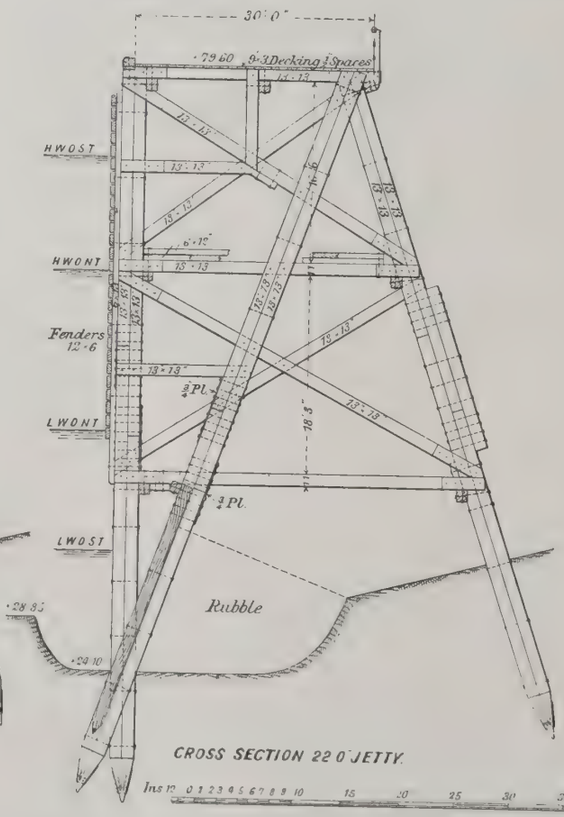
CROSS SECTION OF ROUNDHEAD.

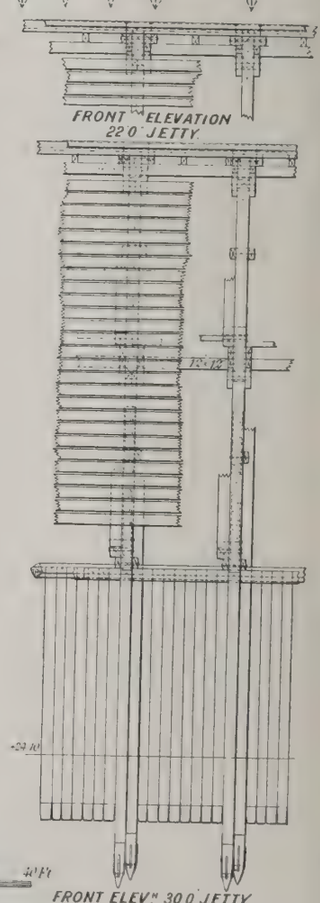












At the commencement of the construction of the dock, the River Ebbw meandered across the western end of the site, in the course indicated by broken lines in Fig. 1, and among the first work to be undertaken was the construction of the diversion channel well to the west of the position of the future dock. This channel was taken out in the dry mainly with a Lubecker land-dredger. The top lift only was removed in this way, and, in the first instance, banks were left at each end of the diversion, and no water was admitted. While the diversion had been finished, and the floating dredger was put to work to cut through the two ends of the diversion, and to take it out to its full depth. As soon as the two ends had been cut through, and while the deepening was proceeding, the old channel of the Ebbw was cut off by tipping-dams at the ends, as shown in Fig. 1. When dams Nos. 2 and 3 had been completed the portion of the old channel between them, crossing the site of the dock extension, was pumped out, and the remainder of the excavation of the dock as it was first put into service. The area of water available for use was roughly half that of the present dock, since, although the area indicated in the plan is rather more than this, the tapering west end was not all available for shipping, as the depth was insufficient beyond the fourth coal-hoist. This end was dredged out later.

Before proceeding to a description of the construction of the lock and south-east corner, which formed the subject of a separate contract, we may say a little more in detail of the dock as it was com-

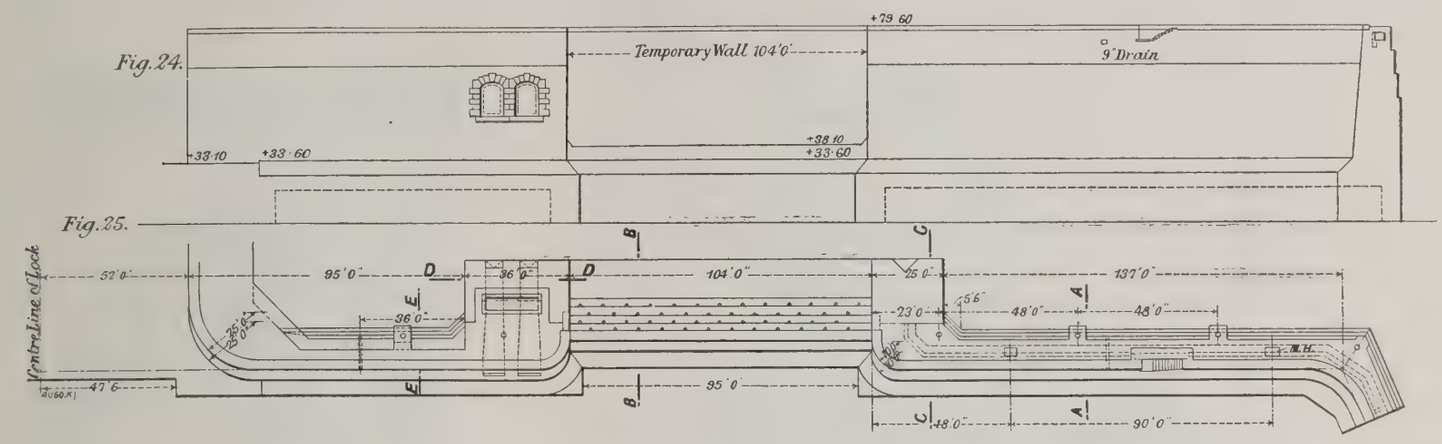
pleted up to the time we have now reached. The whole of the work put into the original extension was of a permanent character, and now forms part of the completed dock, except, of course, that the diagonal bank has been removed. The main work of excavation, as we have said, was done in the dry, and the banks were completed before the admission of water. The level of the bottom of the dock lay in general about 10 ft. above the gravel. The banks on the north side and the east end are slopes pitched with stone, obtained by the contractors from a quarry specially opened a few miles up the river valley. On the north side there are four hydraulic coal-hoists, and three more are on order. The hoists are carried on concrete piers, in connection with which some interesting work was done, but it will be better to defer detail reference to them until we deal with the coal-handling plant as a whole. We should say that, in general, surface tipping had to be resorted to to raise the land to quay-level, and that spoil taken from excavation was used on this work.

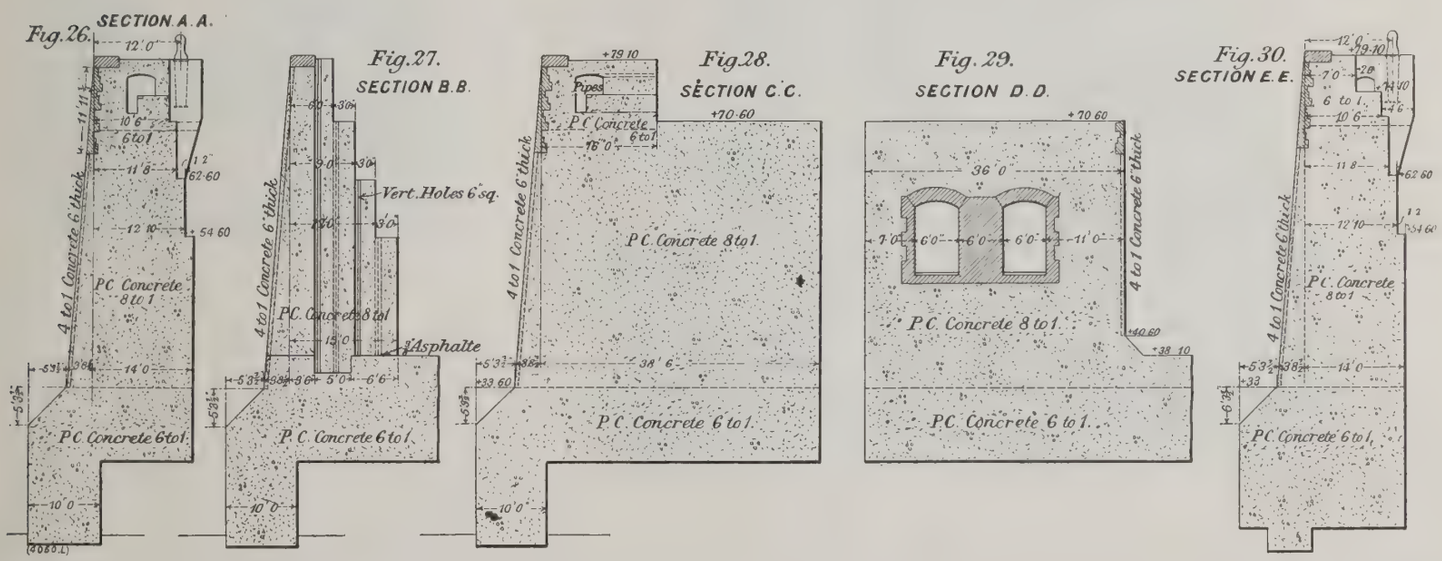
The only wall proper in the extension in its original form was that forming the south quay. It is of mass concrete resting on the gravel formation. The foundations were taken out in timbered trenches. A characteristic cross-section of the wall is given in Fig. 2, on page 34, from which it will be seen that a hard-stone filling was put in behind the wall, and the ground behind this made up with soft filling. A culvert for hydraulic pipes, electric cables, &c., runs through the upper part of the wall. Cast-iron surface drain-pipes are carried through the wall at 100 ft. intervals, while lower down the wall is backed with a rubble drain connected to the dock by weep-pipes. One of the most interesting features of the wall has reference to the carrying of the crane-road for the 6-ton hydraulic cranes which serve the quay. The arrangement is well shown in Fig. 2. The front crane-rail lies directly on the concrete mass of the wall, but the back one is carried by a 12-in. by 24-in. Hennebique ferro-concrete beam, which lies parallel with the quay-front. This beam is supported by 14-in. by 20-in. ferro-concrete struts, and 12-in. by 18-in. ferro-concrete ties spaced 10 ft. apart. The struts sit on one of the back steps of the wall. The whole arrangement was built in the air, and the stone-filling afterwards packed round it. A view during building is given in Fig. 31, on Plate XI. The construction is very neat, and while economical in material, gives an entirely satisfactory foundation for the cranes. This quay is equipped with a shed and railway-sidings at its east end for handling general traffic. We will, however, refer more in detail to these features when dealing with the dock equipment.

Turning now to the construction of the lock and the south-east corner of the dock, it will be remembered that the old channel of the Ebbw River, which crossed the lock site, had already been isolated by the tipping of dams Nos. 3 and 4. This channel was pumped out, and the excavation of the south-east corner of the dock proceeded in the dry, a bank being left to separate it from the earlier part of the extension which was in use. In the meantime a clay bank was tipped across the front of the site from Pilot's Pill to the left bank of the new mouth of the Ebbw River. This bank lay almost exactly over the high-water mark, which is indicated in Fig. 1, and formed the first or inner dam, under the protection of which the inner end of the lock and the western part of the South Quay wall were constructed. The east and west river banks were then tipped. These are the banks which form the present river boundaries and sweep north-east and north-west from the land end of the entrance jetties, as shown in Fig. 1. Some trouble was experienced with these river embankments owing to the action of the tides and the greasy nature of the foreshore mud, but satisfactory banks were finally obtained. The outer faces were pitched with rough stone. Before the river embankments were completed the tipping of a second temporary dam was taken in hand. This was formed round the outer end of the future lock. It formed approximately a half-circle in plan, and projected into the river a distance nearly halfway down the length of the future jetties. It joined up with the river embankments at its inner ends.

This second temporary dam was formed of rubble stone backed up with sand and clay, and when it was completed the construction of the outer end of the lock was taken in hand behind it. When the walls at the outer end of the lock had been completed, a third temporary dam was tipped inside the second temporary dam, cutting across the lock site about the middle of the length of the outer pen. The first temporary dam was then cut through, and the lock-walls in the neighbourhood of the middle gates were completed. A view of the inner compartment of the lock at this stage showing the invert trenches being excavated and the first temporary dam in the background is given in Fig. 32, on Plate XI. In the meantime a concrete monolith dam was sunk between the lock-walls outside the outer gate compartments, and when this was completed the portion of the third temporary dam between the lock-walls was removed. The dumpling of the outer portion of the lock was then excavated, and the invert put in. The inner and outer gate-chambers had in the meantime been completed. While the gates were being erected, the outer portion of the second temporary dam was removed by dredging, and the East and West river walls were completed up to the backs of the lock-walls. The building of the timber jetties was then commenced. When the gates were completed, water was admitted to the new corner of the dock extension and to the lock, and the removal of the monolith dam was commenced. The earth bank which had been left between the old and new parts of the dock extension was then removed by dredging.

In this brief sketch of the general method of procedure, we have, for the sake of clearness, omitted any reference to the details of the lock or of the method of building the walls. Referring to construction, in the first instance, we should say that all the wall foundations were taken out in





timbered trenches. The trenches for the South Quay wall, and parts of the side walls of the lock, were timbered with 2-in. vertical poling-boards. Where, however, the bungum was too soft for the use of poling-boards, the trenches were surrounded by half-timber or whole-timber sheet piling. Owing to the hardness of the gravel, the sheet-piling could only be driven into it to a depth of 3 ft. or 4 ft., and consequently poling-boards were used when excavating through the gravel below the sheet piles. In the case of the wider trenches, king-piles were driven at intervals of about 20 ft. on the centre line of the trench, and the trench was timbered with struts extending from walings fixed against the sheet piling to horizontal timbers running between the king-piles. As, however, the king-piles could only be driven a few feet into the gravel, they had to be lengthened when the excavation reached their points. The method adopted was to cut off the points of the king-piles with their shoes, and to insert short vertical timbers below them, secured by vertical flitches, thus lengthening them downwards as the excavation proceeded. The face of the gravel below the sheet-piling was timbered with 2-in. vertical poling-boards, as described above. This method of working proved perfectly successful, although the job was marred by one bad accident, in which the trench for the south-west wing wall of the lock fell in where some treacherous ground was encountered. This trench was subsequently surrounded by steel-sheet piling and successfully re-excavated.

Details of the lock will be seen in Figs. 3 to 10, on Plate X. It is one of the largest in the world, being 1000 ft. long and 100 ft. wide. The two pens are 600 ft. and 400 ft. long respectively. The depth of water on the outer sill at spring tides is 45 ft., and at neap tides 35 ft. Double levelling culverts have been constructed throughout, an upper and lower one in each wall. These can be seen in the cross-sections on Plate X., while their intakes are shown in several of the general views. Among these we may mention Fig. 33, on Plate XI., which shows the former in position for the upper culvert in the east wall of the inner gate-chamber. The view is taken looking north. Fig. 34, a view of the inner gate-chamber at a later date, shows the intakes very well. Fig. 35, on Plate XII., shows the multiple intake to one of the low-level culverts during construction, while Fig. 36, subjoined, is a view inside the levelling culvert of the new lock entrance. This view shows the grooves for the hand and hydraulic sluices, which we will refer to more in detail later.

A view of the inner gate-chamber, showing the gate-sills, roller-path foundations for the gates, and the forebay under construction, is given in Fig. 37, on Plate XII., while a view of the same chamber ready for the erection of the gates is given in Fig. 38. The sill-stones for the emergency caisson can be seen in the foreground. The laying of these sill-stones is shown in Fig. 34, Plate XI., already referred to. A view of the completed lock showing the culvert intakes on both sides is given in Fig. 39, Plate XII. A temporary footbridge, used during the completion of the lock, can be seen in this view. Two general views of the locks are given in Figs. 40 and 41, Plate XIV. Both these views are looking north. The former shows the invert of the outer compartment under construction, while the latter, which was taken from the top of the power-station chimney, shows the lock nearly completed. A feature of this work to which we have not yet referred is that the level of the water in the dock system is maintained at a higher level than the general high-water mark of the river. To enable this to be done make-up water must be supplied. In the old dock system the water was obtained from the Ebbw River at Bassaleg, a pipe-line being taken from it at this point to the north end of the North Dock. For many years, however, this supply has proved insufficient, and a pump was erected on the North lock pier in 1895. With the completion of the extension this supply in turn has become insufficient, and a new pumping station has been built and equipped as part of the new work. It is situated on the east side of the lock entrance and is indicated in Fig. 1. The plant of the station we will refer to later, but in connection with the construction of the lock we now draw attention to the 12-ft. diameter delivery culvert through which the power-station pumps supply water to the dock. This culvert, which is of cast iron for the greater part of the length, is embedded in the east wall of the lock. In can be seen in various stages of the construction of the lock in Figs. 40 and 41, Plate XIII. Fig. 40 is a view looking south-west, and shows the culvert dipping down to discharge its water near the bottom of the dock, Fig. 41 shows the culvert partly erected, while Fig. 42 is the trench for the east side wall of the middle gate-chamber.

Before dealing with the entrance-jetties, we should like to say something of an interesting concreting plant which was constructed and patented by Messrs. Easton Gibb and Son in connection with the building of the lock. This plant is shown in Fig. 46, on Plate XIV., and Fig. 47, subjoined. It consisted of a Smith mixer mounted on a travelling carriage which also carried the boiler and steam-engine for driving the mixer. At the top of the carriage there was a hopper divided into two compartments, each of which carried one charge for the mixer. At the back of the mixer there were two elevator skips worked in guides in such a manner that when one skip was discharging its contents into one of the divisions of the hopper at the top of the mixer, the other was at the bottom of the guides ready to receive another charge of material. These skips are clearly to be seen in Fig. 47. Behind the mixer-carriage, and running on a parallel line of rails with it, were two belt-conveyors driven by chains from the engine of the mixer. Over the belt-conveyors were fixed measuring-boxes for measuring sand and stone, and the conveyors, which were running continuously, discharged the stone and sand into whichever skip was in the lower position. One of the conveyors is clearly shown in Fig. 47. The sand, crushed stone, and cement were brought up on trucks on a third line of rails parallel with the conveyors. The wagons containing the cement, which was gauged into bags before being loaded, were placed immediately behind the mixer, so that the requisite number of bags could be discharged directly from the wagon into the skip. The sand and stone were unloaded by hand from the wagon into the measuring-boxes above the conveyors, and as each skip came into position to receive a fresh charge, the contents of the requisite number of measuring-boxes were allowed to drop through the bottom-opening doors of the boxes on to the conveyors, and the measured charge was thus conveyed to the skip. Meantime the requisite quantity of cement was emptied from the cement wagon directly into the skip. The positions of the wagons in relation to the conveyors when the plant was in operation is shown in Fig. 46.

The skips were raised from their loading position to the top of the carriage, and *vice versâ*, by a friction

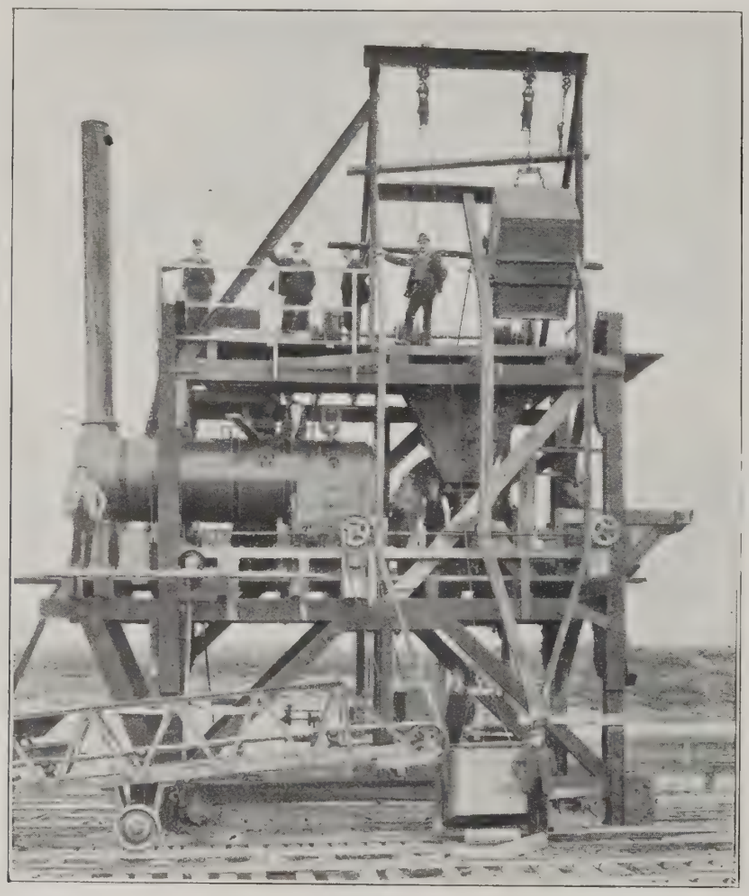


FIG. 47. CONCRETE MIXER.

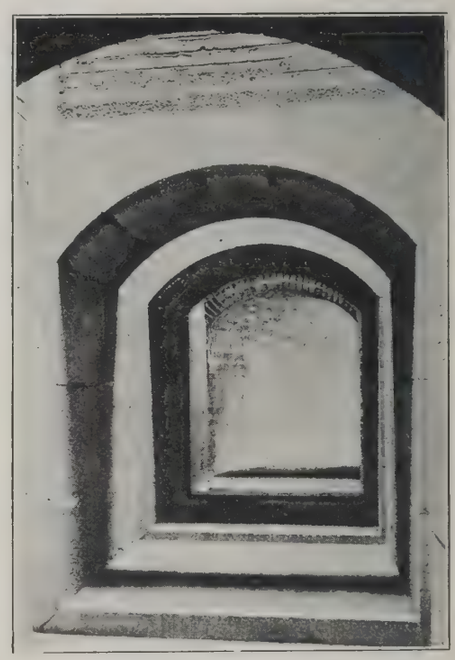
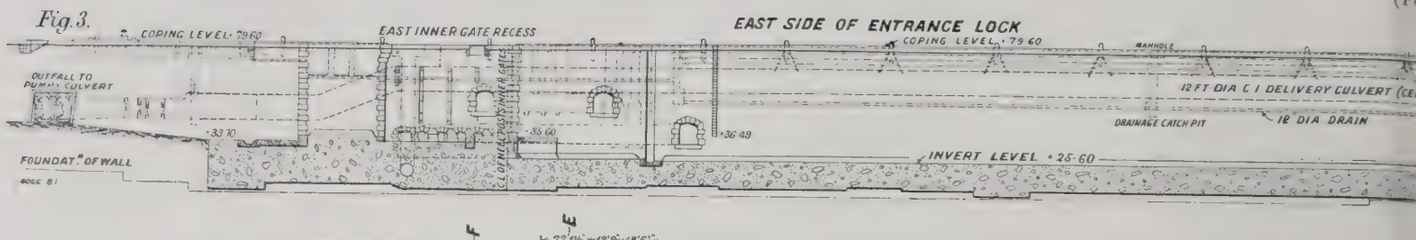
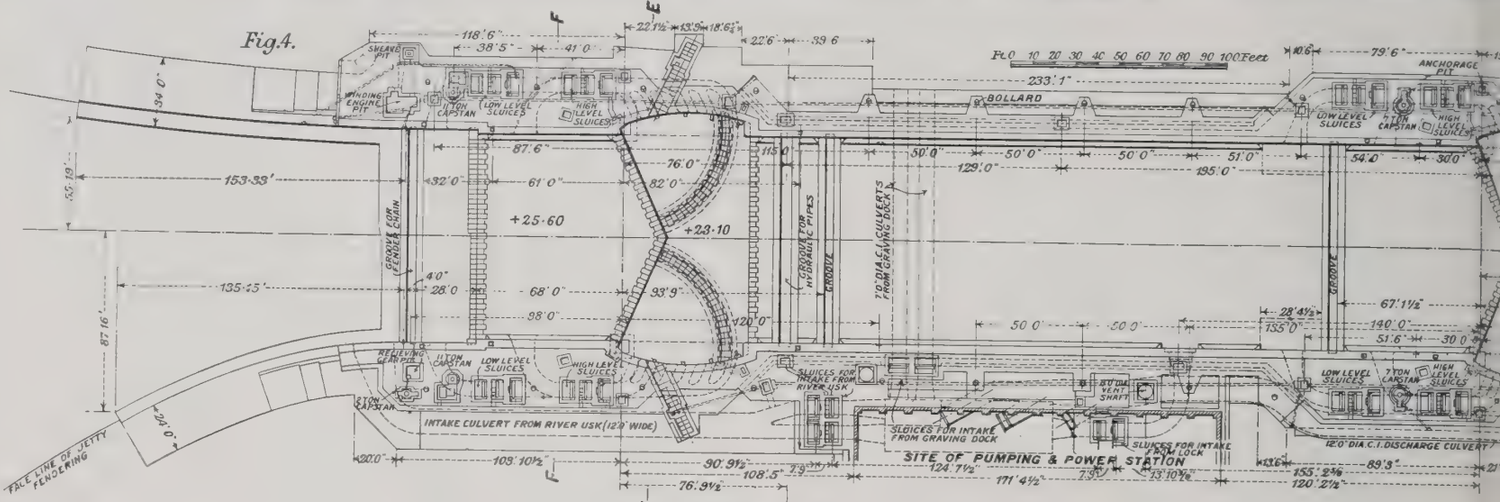


FIG. 36. CULVERT LEVELLING.

THE ALEXANDRA DO

SIR JOHN WOLFE BARRY, LYSTER





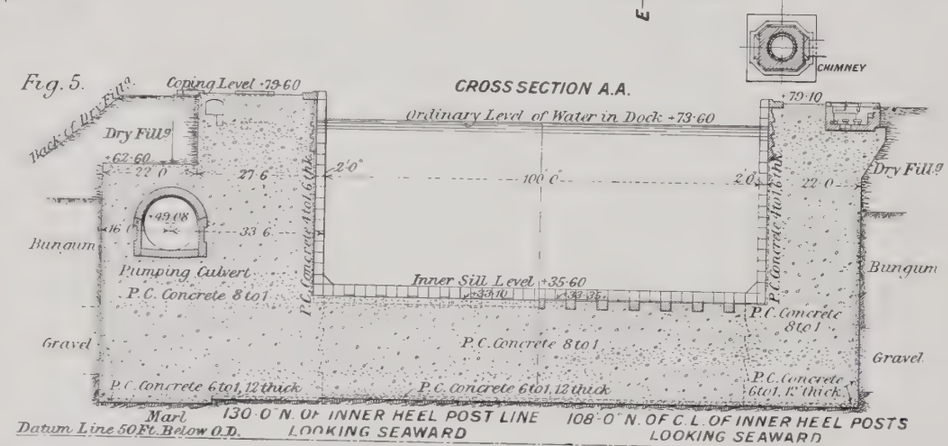
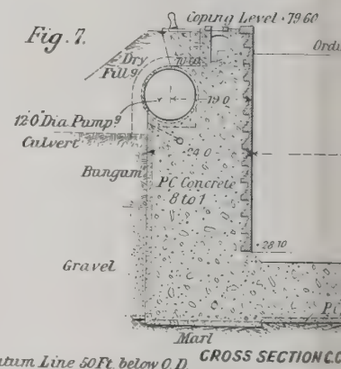


Fig.5.
CROSS SECTION A.A.
Coping Level +79·60
Ordinary Level of Water in Dock +73·60
Dry Fill
Bungum
Gravel
Pumping Culvert
Inner Sill Level +35·60
P.C. Concrete 8 to 1
P.C. Concrete 6 to 1, 12 thick
Marl
130·0 N. OF INNER HEEL POST LINE LOOKING SEAWARD
108·0 N. OF C.L. OF INNER HEEL POSTS LOOKING SEAWARD
Datum Line 50 Ft. Below O.D.



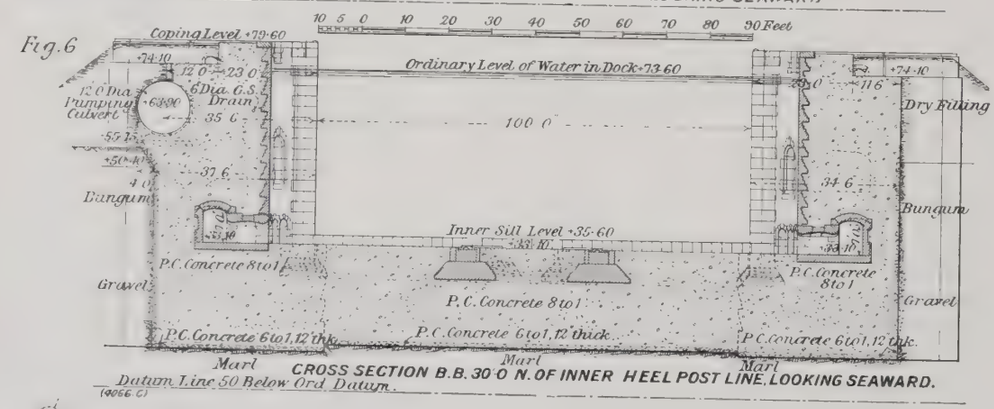
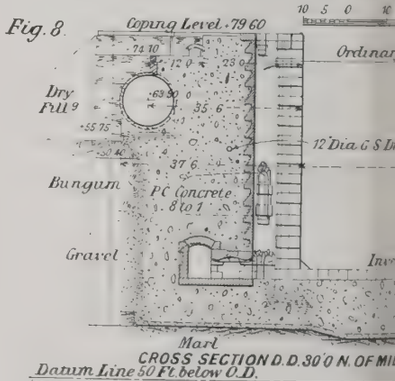
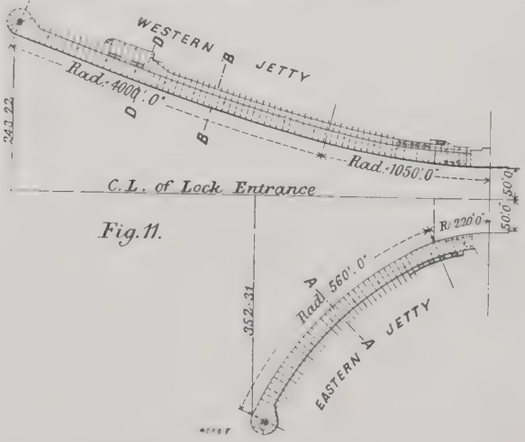
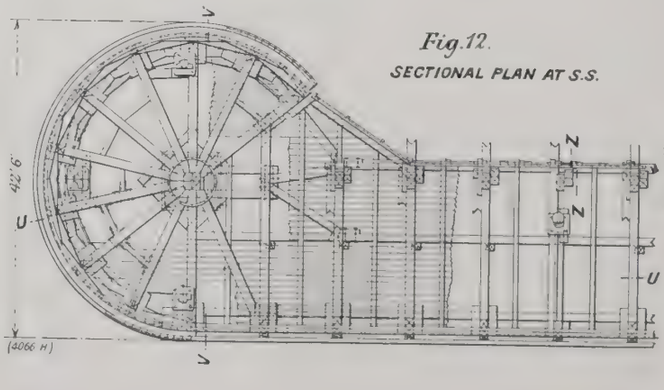
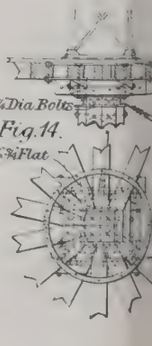


Fig.6
Coping Level +79·60
Ordinary Level of Water in Dock +73·60
12'0 Dia Pumping Culvert
6 Dia G.S. Drain
Dry Filling
Bungum
Gravel
Inner Sill Level +35·60
P.C. Concrete 8 to 1
P.C. Concrete 6 to 1, 12 thick
Marl
CROSS SECTION B.B. 30·0 N. OF INNER HEEL POST LINE. LOOKING SEAWARD.
Datum Line 50 Below Ord. Datum









CNSION AT NEWPORT.

. INST. C.E., ENGINEERS, WESTMINSTER.

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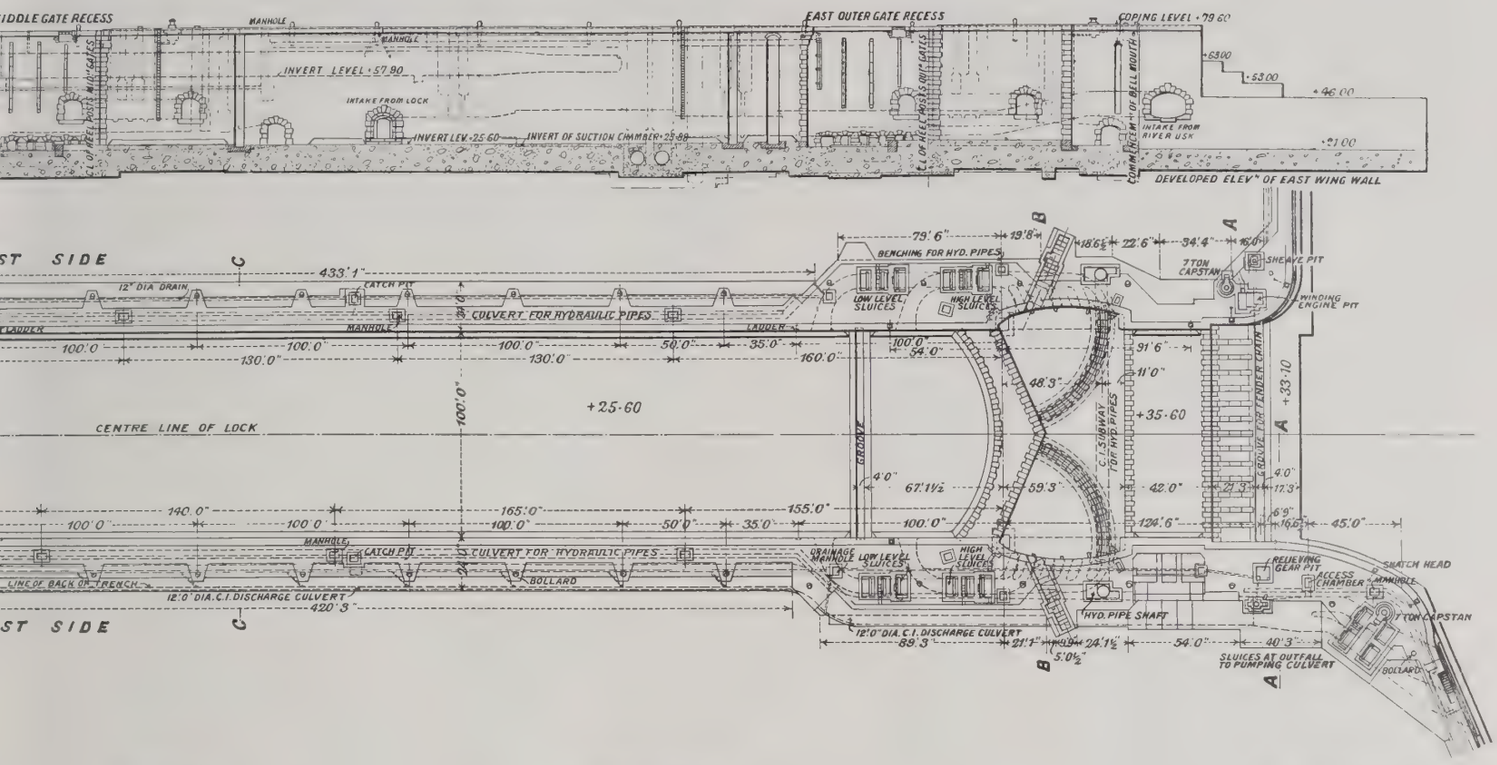
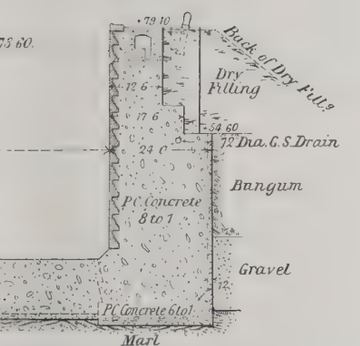
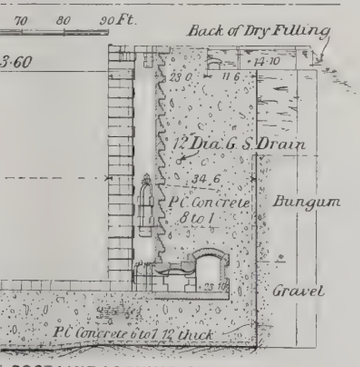


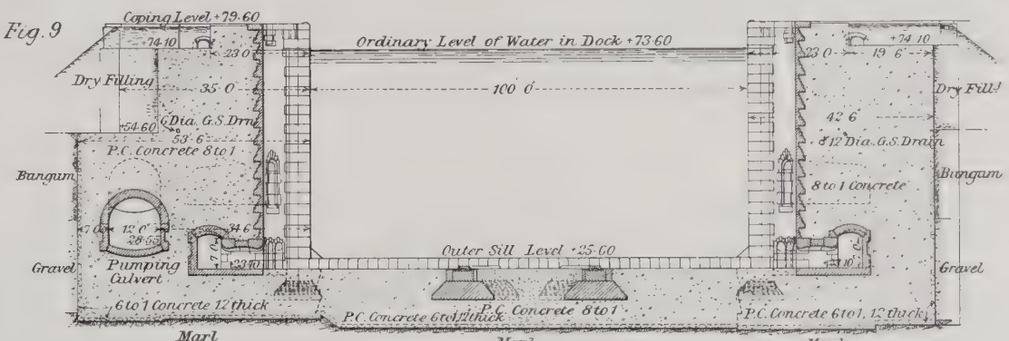


MBER HEEL POST. LOOKING SEAWARD.



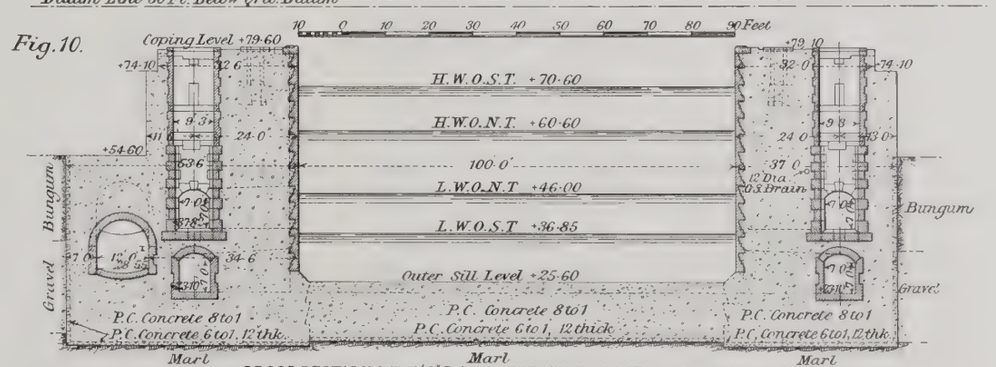
L POST LINE, LOOKING SEAWARD.

Fig. 9



Datum Line 50 Ft. Below Ord. Datum CROSS SECTION E.E. 30'0" N. OF OUTER HEEL POST LINE, LOOKING SOUTH.

Fig. 10.



CROSS SECTION F.F. 16'0" S. OF OUTER HEEL POST LINE LOOKING SOUTH.

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(4066 E)

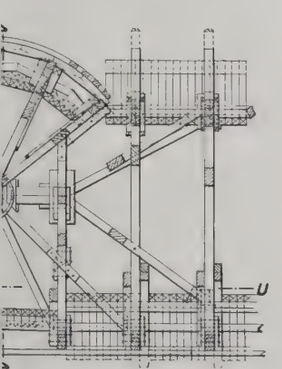

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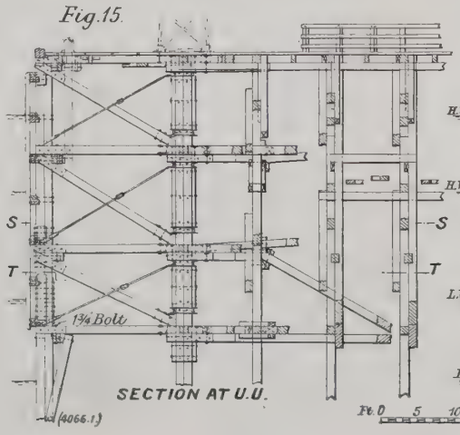
Fig. 15.



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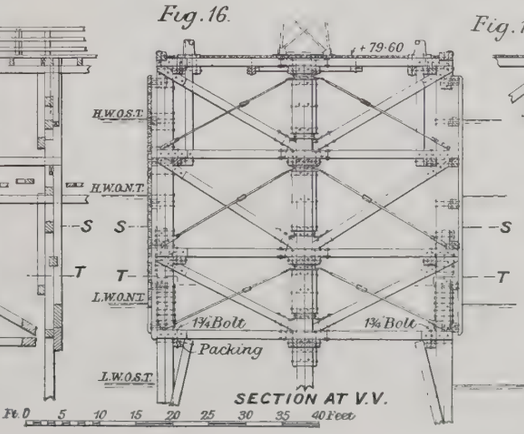
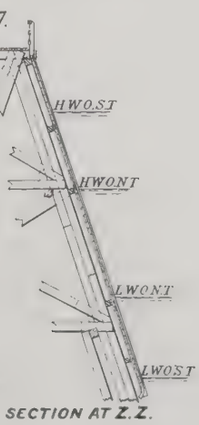
(4066.1)

Fig. 16.



SECTION AT V.V.

Fig. 17.



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THE ALEXANDRA DOCK EXTENSION AT NEWPORT.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C. E., ENGINEERS, WESTMINSTER.

(*For Description, see Page* 36.)

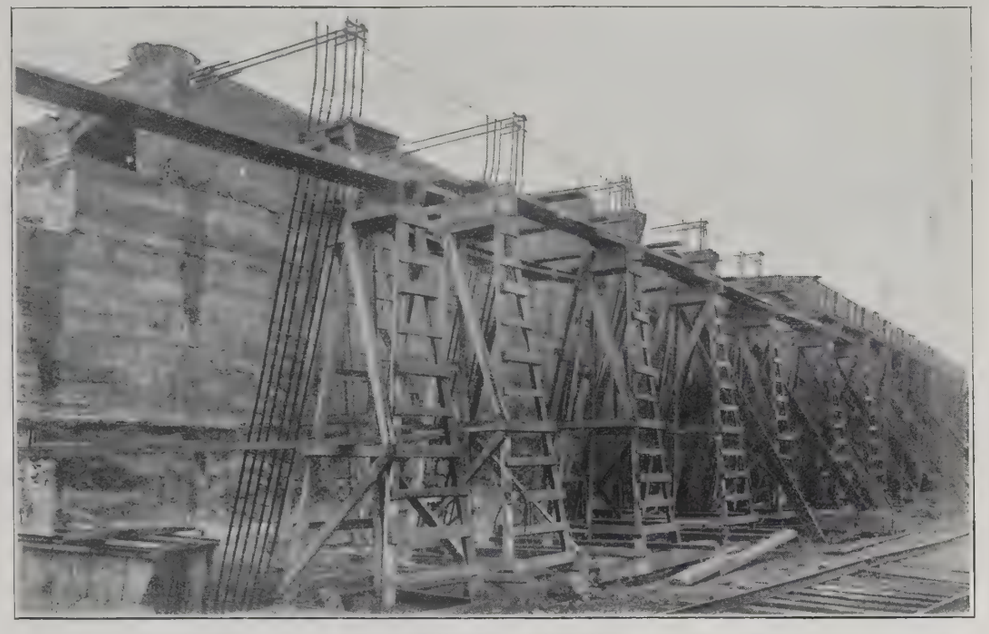


FIG. 31. SOUTH QUAY WALL; FERRO-CONCRETE CRANE-ROAD BEHIND WALL UNDER CONSTRUCTION.

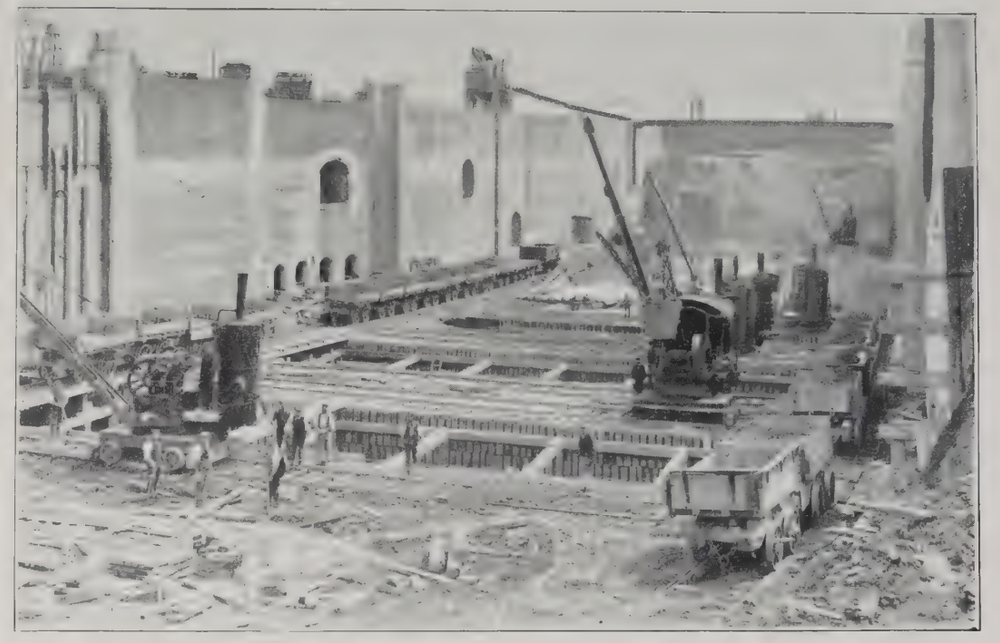


FIG. 32. INNER COMPARTMENT OF LOCK, LOOKING SOUTH, SHOWING INVERT TRENCHES.

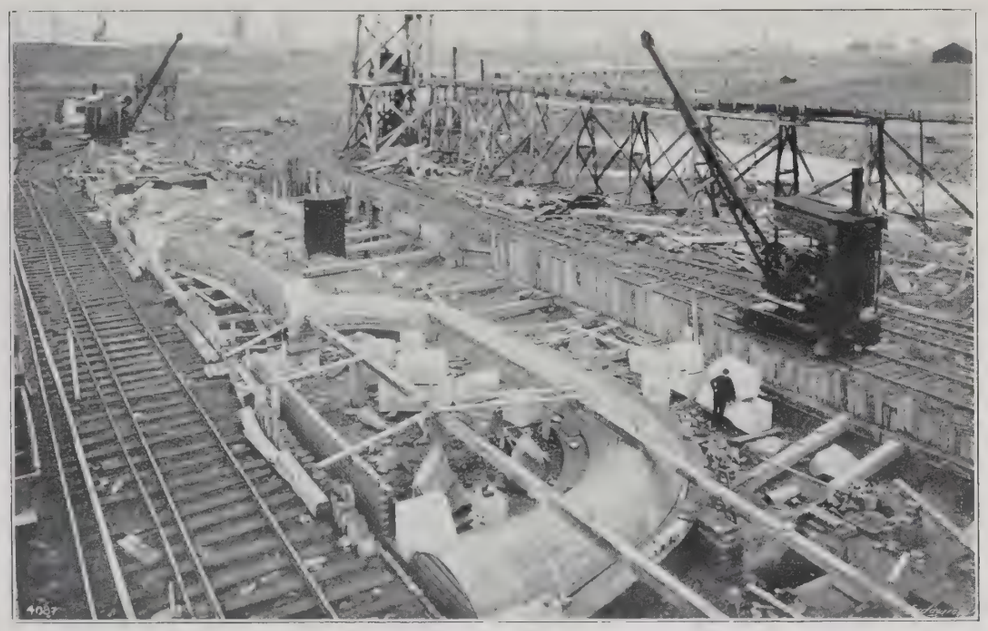


FIG. 33. NEW LOCK ENTRANCE; INNER GATE-CHAMBER WITH CENTRING FOR UPPER LEVELLING CULVERT IN POSITION.

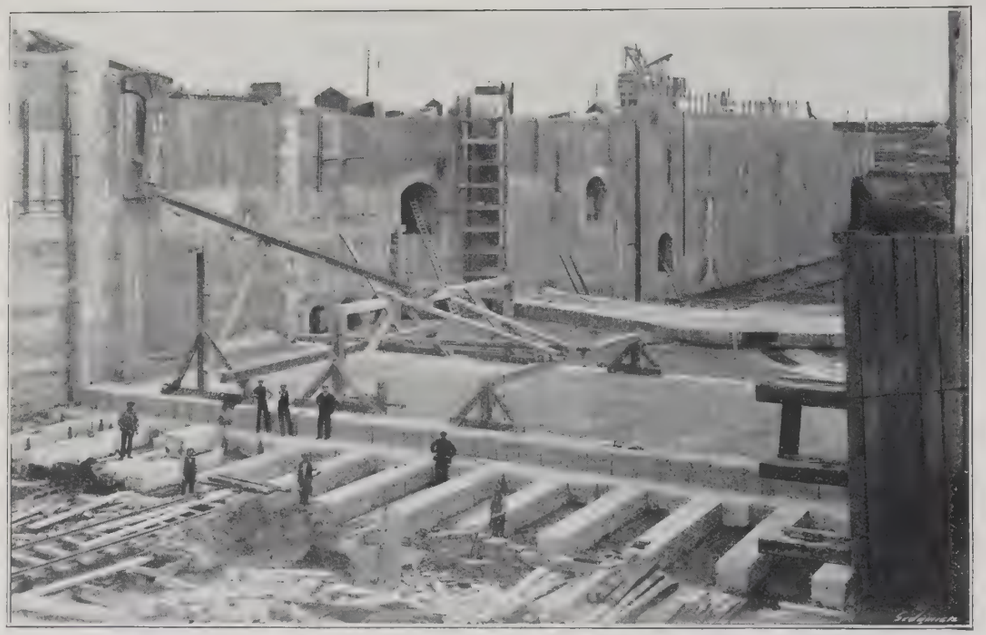


FIG. 34. INNER GATE-FLOOR, SHOWING SILL STONES FOR CAISSON.

THE ALEXANDRA DOCK EXTENSION AT NEWPORT.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C. E., ENGINEERS, WESTMINSTER.

(*For Description, see Page 36*)

FIG. 35. MULTIPLE INTAKES TO LOW-LEVEL CULVERTS IN GATE RECESS.

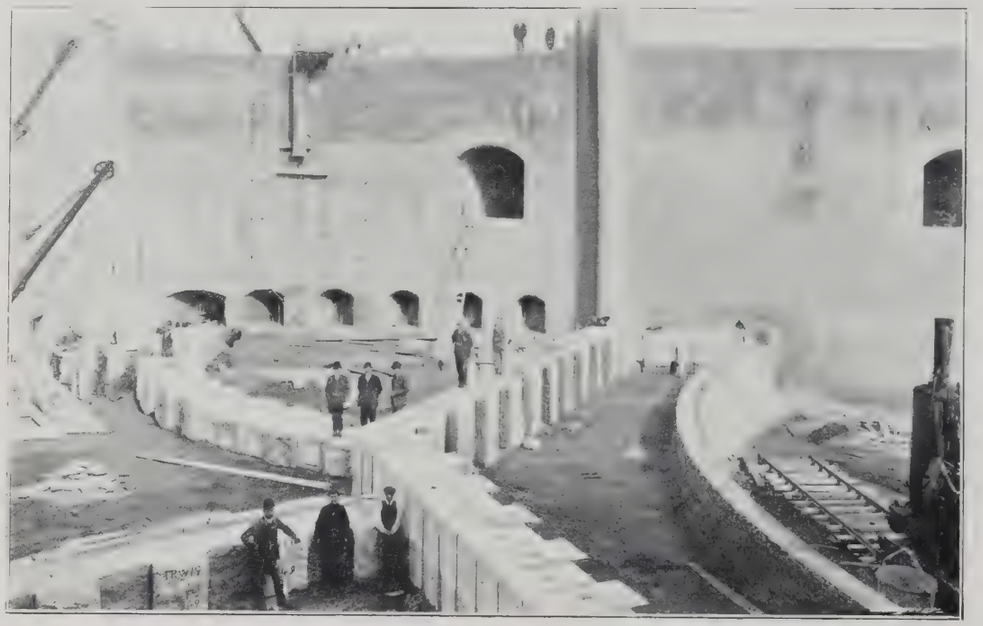


FIG. 37. INNER GATE-CHAMBER, SHOWING GATE SILLS, ROLLER-PATH FOUNDATIONS, AND FOREBAY UNDER CONSTRUCTION.

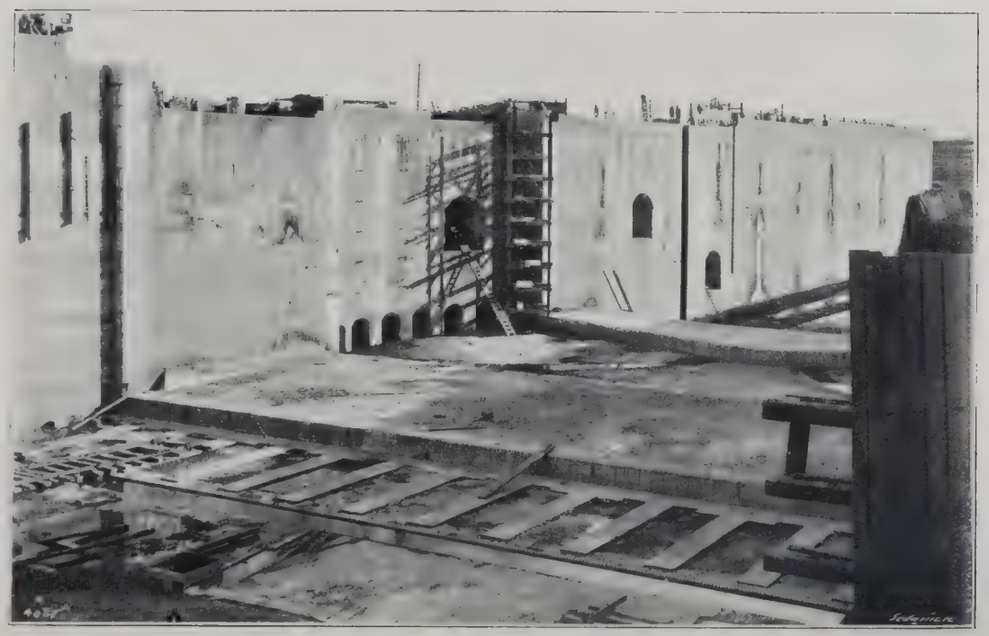


FIG. 38. INNER GATE-CHAMBER READY FOR ERECTION OF GATES.

FIG. 39. NEW LOCK ENTRANCE; VIEW OF COMPLETED LOCK, LOOKING NORTH.

THE ALEXANDRA DOCK EXTENSION AT NEWPORT.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C. E., ENGINEERS, WESTMINSTER.

(*For Description, see Page* 36.)

FIG. 40. NEW LOCK ENTRANCE; EAST WALL OF INNER GATE-CHAMBER, SHOWING 12-FT. CULVERT FROM POWER-STATION.

FIG. 41. NEW LOCK ENTRANCE; DERRICK-CRANES ERECTED AT INNER GATE-CHAMBER.

FIG. 42. NEW LOCK ENTRANCE; TRENCH FOR EAST SIDE OF MIDDLE GATE-CHAMBER.

FIG. 43. NEW LOCK ENTRANCE; VIEW LOOKING SOUTH FROM DOCK IMMEDIATELY BEFORE ADMISSION OF WATER.

THE ALEXANDRA DOCK EXTENSION AT NEWPORT.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C.E., ENGINEERS, WESTMINSTER.

(*For Description, see Page* 36.)

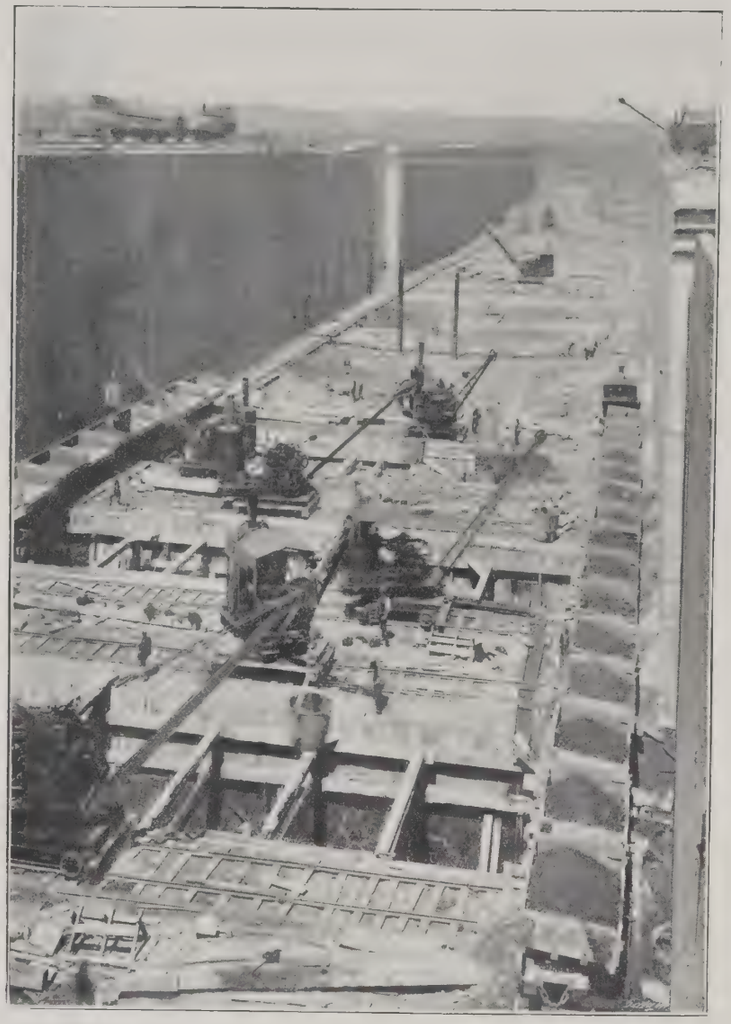


Fig. 44. New Lock Entrance; Invert of Outer Compartment under Construction.

Fig. 45. New Lock Entrance; View from Top of Power-Station Chimney, looking North.

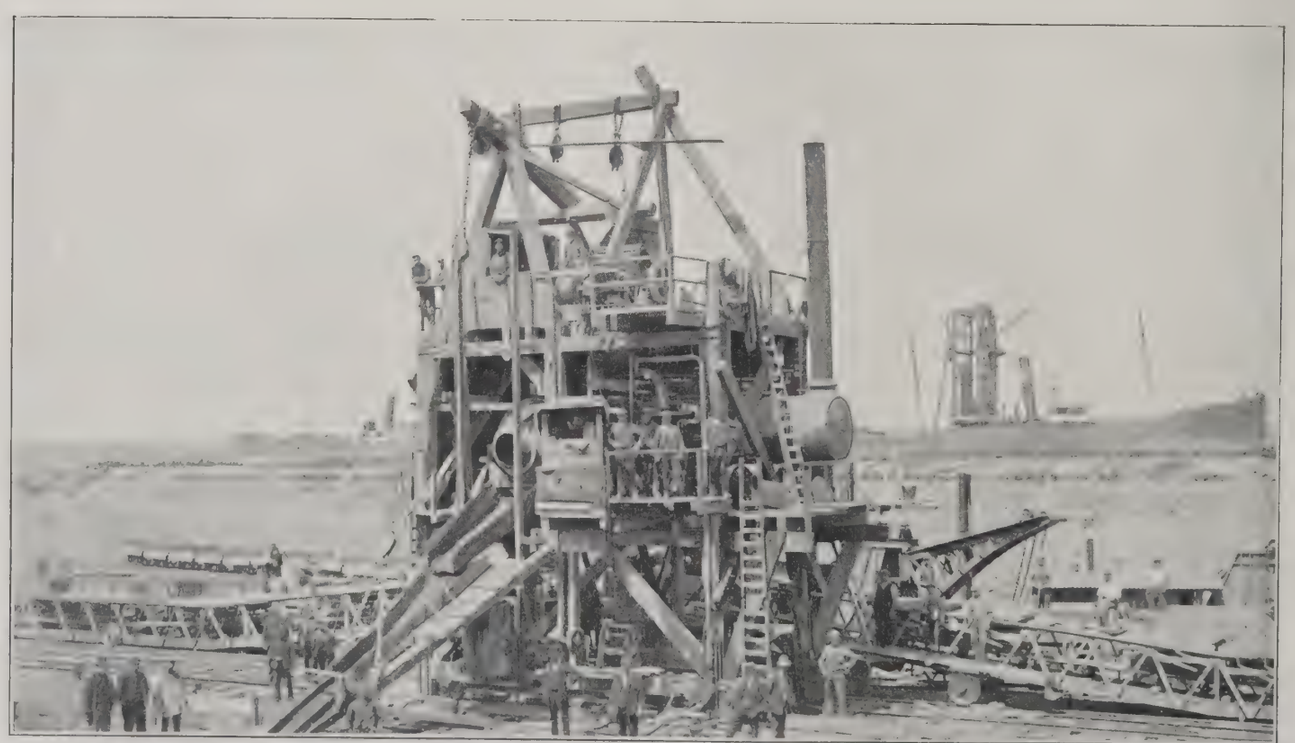


Fig. 46. Concrete-Mixer, showing Two Belt-Conveyors in Use.

(*To Face Page* 37.)

winch worked by the mixer-engine. The full skip on reaching the top of its travel discharged its contents into one or other of the compartments of the storage hopper, one compartment of which thus always contained a charge for the mixer. The charge from the hopper descended through the door in the bottom of the hopper into the mixer, and the requisite quantity of water was added. The mixing was then completed, and the mixer tilted so that it discharged its contents into a chute which conveyed the concrete into its place in a trench. The chute can be seen in Figs. 46 and 47. For depositing concrete in the upper part of the wall above the level of the mixer the chute was raised to a sufficient height to allow the concrete to flow by gravity into position in the wall, and the mixed concrete was discharged from the mixer into a skip hanging on the front of the mixer-carriage. The skip was then elevated by means of a friction winch, and discharged its contents down the chute. Traversing gear was provided by which the mixer-engine could be utilised to travel the mixer from one position to another alongside a trench, and the belt-conveyors were secured to the mixer, so that they travelled with it. A great deal of work was done with this plant, which proved very convenient. It can be seen in several of the views of the lock under construction, as, for instance, Fig. 32, which shows the concrete being conveyed from the chute down the side wall of the lock in a distributing-pipe.

The river jetties, which are shown in the remainder of our present illustrations, do not require a great deal of comment, as their general lines and details will be seen from the figures, Figs. 11 to 23, on Plate X. and page 34. Fig. 11 is a general plan of the lock entrance showing the form of the jetties, while Figs. 12 to 17, Plate X., give details of the round-heads at their outer ends. Characteristic cross-sections of the jetties themselves are given in Figs. 18 to 20, on page 34, while Figs. 21 to 23, on the same page, show sections and details to a larger scale. The jetties are constructed of pitch pine throughout, and the piles consist of two 13-in. by 13-in. pitch-pine timbers bolted together and shod with a heavy cast-iron shoe, 10 in. square at the base, the points of the timbers being protected by steel plates, $\frac{1}{8}$ in. thick. This type of pile was adopted after numerous experiments, and it was found that by dredging away the superincumbent clay before the piles were pitched, it was possible to drive them down well into the gravel. They were driven by means of a 50-cwt. steam-monkey on an overhanging pile-frame which travelled upon the piles already driven. On the back side of the west jetty there is a landing-pier for passenger steamers. Each jetty carries twin harbour lights on light steel towers on the round-head. A new channel has been dredged from the lock entrance to the buoy which marks the mouth of the River Usk in the Bristol Channel. The narrowest bottom width of this channel is 650 ft., and it widens to 900 ft. opposite the lock. The depth is 42 ft. below high water of spring tides. A channel will also be dredged on the west side of the west jetty to give depth for steamers using the passenger-pier. This channel will not be deep enough for the conditions of the lowest tides, and when a steamer arrives at such time it will use the east side of the jetty, at which landings have been erected. This arrangement will not interfere with the use of the lock, as no steamer of large size will be entering or leaving it at the state of low tide at which passenger-steamers could not use the pier on the west side.

The land to the west side of the lock entrance has been reserved for a graving-dock, and a temporary wall has been put in in the wing-wall at the south-west corner of the dock. This wing-wall is illustrated in detail in Figs. 24 to 30, on page 35. The position of the temporary wall is clearly shown in Figs. 24 and 25. In addition to this wing-wall, provision has been made for the future graving-dock by the putting in of the necessary culverts connecting it to the power-station pumps and the main dock. The same pumps will handle the graving-dock water which handle the water from the river. A view of the front of the lock from the dock end is given in Fig. 43, Plate XIII. This shows the wing wall at the right-hand side with the intake culverts to the graving-dock. On the right-hand side can be seen the openings of the discharge culverts from the power-station. These culverts are carried down close to the bottom of the dock, as has already been mentioned. The idea is to prevent disturbance of vessels in the dock.

(To be continued.)

THE ROYAL AGRICULTURAL SOCIETY'S SHOW.

(Concluded from page 24.)

THE Eagle Engineering Company, Limited, of Warwick, exhibited several oil and petrol-engines, their latest type being illustrated herewith in Fig. 13. This is a petrol-engine, which has been designed principally for the New Zealand market, in which it has met with great success. It has a horizontal cylinder, with the inlet-valve above and the exhaust beneath at the back end. The petrol is led by gravity from the fuel-tank over the crank to a carburettor, near the back end close to the induction-pipe, which is fitted both with a valve for varying the air-supply and also with a needle-valve for the petrol. The mixture then passes into a short mixing-chamber, and thence is admitted to the cylinder through the inlet-valve. The inlet-valve is of the suction type, but it is also controlled by the governor, which also controls the exhaust; that is to say, the exhaust is opened, and the inlet positively held closed when an explosion has to be cut out, the governing being on the hit-and-miss principle. The governor is of the centrifugal type, arranged on the main shaft inside the flywheel. On this shaft is a cone, worked out and in by the action of the governor. If the cone is forced out by the action of the governor weights, a short lever connected with the hit-and-miss gear is pushed away from the shaft, the lip and striker engage, and a long lever running back to the engine-valves is held down. This holds the exhaust open and the inlet closed. This lever is movable sideways on its pivot, roughly midway in its length, and for half-compression for starting can be pulled out on its pivot, so that it works on a half-compression cam alongside the normal cam. The

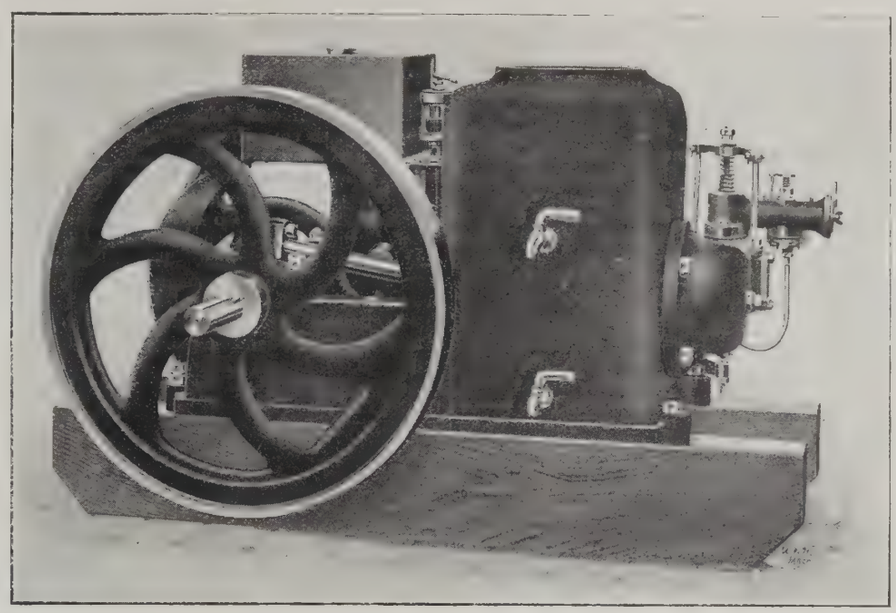


FIG. 13. 5½-BRAKE-HORSE-POWER WARWICK PETROL-ENGINE.

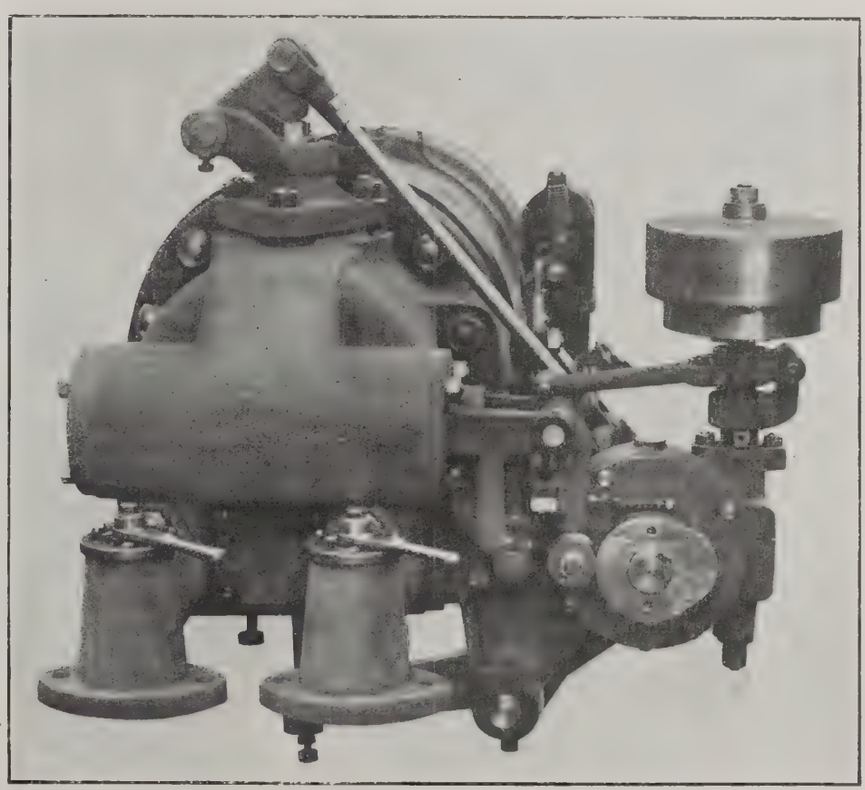


FIG. 14. GOVERNING-GEAR OF 54-BRAKE-HORSE-POWER FIELDING SUCTION-GAS ENGINE.

cylinder is fitted with a large box-shaped hopper-cooler sufficient for two to three hours' working at full load, provision being made for drawing off and changing the water if necessary. The cylinder-head is also jacketed, and a lead disc is fitted, so that in case of frost this should fail instead of the casting. The magneto is gear-driven.

A novelty was to be seen at the stand of Messrs. Thould and Hutchinson, of Upton-on-Avon. This was an engine constructed by Messrs. Hardy and Padmore, Limited, Worcester. It was an oscillating petrol-engine of about 5 brake horse-power. This engine, built to the Southall patents, was mounted on a diagonal frame, and was fitted with two fly-wheels and small driving-pulley. The cylinder had a bore of 5 in. in diameter, the stroke also being of 5 in. It works on the two-cycle principle, the air being compressed at the gland end of the cylinder, and then forced through a passage and port to the back end, on the port being uncovered by the piston. The compression is then completed at the back end. The cylinder is fitted with two trunnions, ground and fitting into ground bearings. Through the bearing and trunnion on one side the charge is admitted, a non-return valve being placed just outside the bearing. The exhaust is through the other trunnion. Magneto ignition is furnished, governing being accomplished on the throttle. Water from an overhead tank is led through an iron pipe to the frame, and thence to the cylinder by a piece of flexible pipe. The return to the tank is by a length of flexible hose. The engine has a speed of about 450 revolutions per minute. The two fly-wheels are 36 in. in diameter, and the whole plant weighs about 10 cwt.

We described the 45-brake-horse-power horizontal semi-Diesel crude-oil engine exhibited at the stand of Messrs. Fielding and Platt, Limited, Gloucester, in our issue of the 26th ult., page 872. This pattern of engine the firm is making in sizes ranging from 45 to 160 brake horse-power. The engine works on the ordinary four cycle, with great steadiness. This class of engine will use any liquid fuel suitable for the Diesel type of engine. Another new departure for Messrs. Fielding and Platt is a small pattern of vertical petrol motor, with two fly-wheels, and of 4 brake horse-power capacity. This little engine runs at 700 revolutions per minute, using 0.650 petrol. The engine is governed on the throttle. High-tension ignition is provided, and pump feed for the carburettor. The engine is substantially built and well finished, as would be expected in work by this firm. The firm also showed working one of their suction-gas plants, capable of being started up in 10 minutes, and to which we have referred on previous occasions in ENGINEERING. A 54-brake-horse-power Fielding suction-gas engine was working off this plant. This engine had graduated governing, with an explosion for every cycle, a feature which, it may be mentioned, ensures steady running and much better conditions for the suction-gas plant than the hit-and-miss system. A view of the back end of the cylinder-head is shown in Fig. 14, page 37. In these engines the gas and air supplies are both fitted with regulating-valves. These are shown below the horizontal cylindrical casing in Fig. 14, the gas-valve being that to the left, and the air that to the right hand. After these valves the gas and air pass into two separate compartments in the back head communicating with either end of the cylindrical casing. Inside, this casing is divided into three compartments by two vertical partitions. The left-hand partition has a hole in it, and forms the seat for a valve. The right-hand partition also has a circular hole in it. Through the casing runs a horizontal spindle, on which is fixed a valve closing the outlet from the gas compartment to the central of the three chambers. On this spindle is also a circular disc or baffle, which, however, does not completely close the hole in the other partition between the air and the central chambers. A movement of the valve-spindle to the left allows gas and air in proper proportions to enter the central or mixing-chamber. The amplitude of the mixing-valve movement, and, therefore, the quantity of the charge, is governed by the position of a distance-piece or sliding fulcrum between two levers. The first lever is operated by the cam-shaft, its motion being transmitted to the second through this sliding fulcrum, the level of which is controlled by an arm which is raised or lowered by the governor. If it is lowered, the movement is large; if it is raised, it is reduced, and a smaller charge is taken in. This engine and plant were running daily during the Show for ten hours in a manner which left nothing to be desired.

On the small four-cycle horizontal engines of Messrs. Petters, Limited, of Yeovil, to which we referred last week, which start on petrol and run on paraffin, governing is accomplished off the exhaust-valve with a hit-and-miss gear which cuts a charge out. In this gear there is a special exhaust lever, of which we give an illustration in Fig. 15. A cam-operated lever forming part of the exhaust lever has pivoted to it, at its outward end, a governing lever weighted at its upper end. The up-and-down movement produced by the cam tends to make the weight kick. This tendency is controlled by an adjustable spring, so that the governing action may be set for a certain range of speed. If the amplitude of the movement of the weighted end of the lever rises above the normal, owing to increase of speed, a striker and lip do not engage, and the exhaust remains closed, the products of combustion remaining in the cylinder. The half-compression gear is thrown in by shooting and locking a simple bolt, which can be equally quickly released, and is then returned to the normal position by a small spring. Magneto ignition is adopted. This is also employed on the firm's well-known pattern of small two-cycle engines working on paraffin.

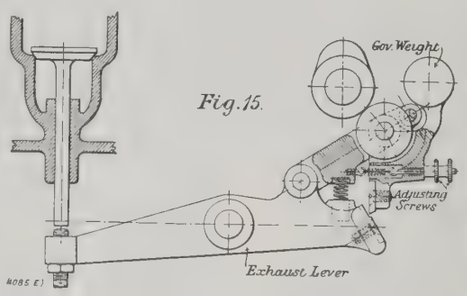


Fig. 15.

FIG. 15. GOVERNING-GEAR FOR PETTER OIL-ENGINE.

An interesting design of motor-plough was shown at the stand of the Wyles Motor-Ploughs, Limited, 2, Collingwood-street, Newcastle-on-Tyne. Two of these implements were on view, one fitted up as a plough and one with a cultivator attachment. The machine created a good deal of interest, being of such a size as to replace ordinary horse ploughing, and therefore coming within the reach of a fairly large number of farmers. We illustrate the plough, shown in Figs. 16 to 18, page 39, of which Figs. 16 and 17 show views of the machine but without the shares. The plough has a $4\frac{3}{4}$-in. by $6\frac{1}{4}$-in. single-cylinder, four-cycle internal-combustion engine of $8\frac{1}{2}$ brake horse-power, using petrol, benzol, paraffin, or alcohol. The engine and gear-box are arranged to form one unit placed at the front, and are carried upon frames of channel steel which extend the whole length of the machine. The main-drive clutch, of the cone type, is fitted within a pulley arranged to drive by belt all forms of farm machinery, *e.g.*, chaff-cutters, sheep-shearers, pumps, hay-elevators, root-pulpers, &c. By arranging the clutch within the pulley in this way, and carrying the pulley itself, by means of a sleeve, on ball-bearings, all stress set up by the belt pull is entirely removed from the engine bearing, and the belt-drive is operated through the clutch.

The drive to the road-wheels is by Renold roller-chain to the first-motion shaft, and then by cut-steel spur-wheels to the main driving shaft. Two speeds are provided by sliding pinions on the first-motion shaft. The whole of the gearing, including the chain, is entirely enclosed in an oil-tight and dust-proof gear-box provided with inspection doors. There are two one-way hardened-steel clutches on the main driving-shaft, so arranged that while both wheels are positively driven, either wheel is free to overrun the other for steering purposes, or either wheel may be driven alone. The controls for this purpose are in the form of hand-grips under the left plough-handle. The control for the friction-clutch is a similar hand-grip under the right handle. The engine is governed to run at a constant speed of 1000 revolutions per minute under all conditions, and the operator is free to give all his attention to the clutches.

In order to run with one wheel in the furrow and the other on the top of the land when ploughing, each wheel is mounted upon a radial arm capable of movement around the pinion, thus giving vertical movement while retaining the correct gear centres. The right-hand wheel is held in any desired position by means of the hand-wheel and screw adjustment shown. At the end of each furrow, in order to lift the ploughs to the surface of the ground, and to obviate any tilt of the machine while traversing the headland, it is necessary to bring the left-hand wheel into the same vertical position, relative to the frame, as that occupied by the right-hand wheel. This involves lifting the whole frame of the machine on the left-hand side, and to effect this easily and rapidly the following novel power arrangement has been introduced. It will be seen in Fig. 16 that a double set of ratchet teeth are provided on an extension of the radial arm carrying the left-hand road-wheel. With these ratchets two pawls, mounted upon the frame, or rather upon the gear-box, engage. These pawls are operated by a single lever, shown upon the handles of the plough, in such a manner that each pawl comes into operation as the other is removed. The action is as follows:—On releasing the upper pawl the frame falls by gravity to the position shown in the drawing. The exact depth of ploughing is set by the hand-wheel and screw adjustment. On reaching the end of the furrow the lever is thrown over, thus disengaging the upper pawl, and the pressure of the teeth of the driving pinion, engaging with the gear-ring on the road-wheel, is sufficient to raise the frame; that is to say, that the driving pinion, instead of causing the wheel to revolve, climbs up round the gear-ring, and so raises the frame. The movement of the lever in removing the upper pawl permits the lower one to fall into place and retain the frame in its elevated position.

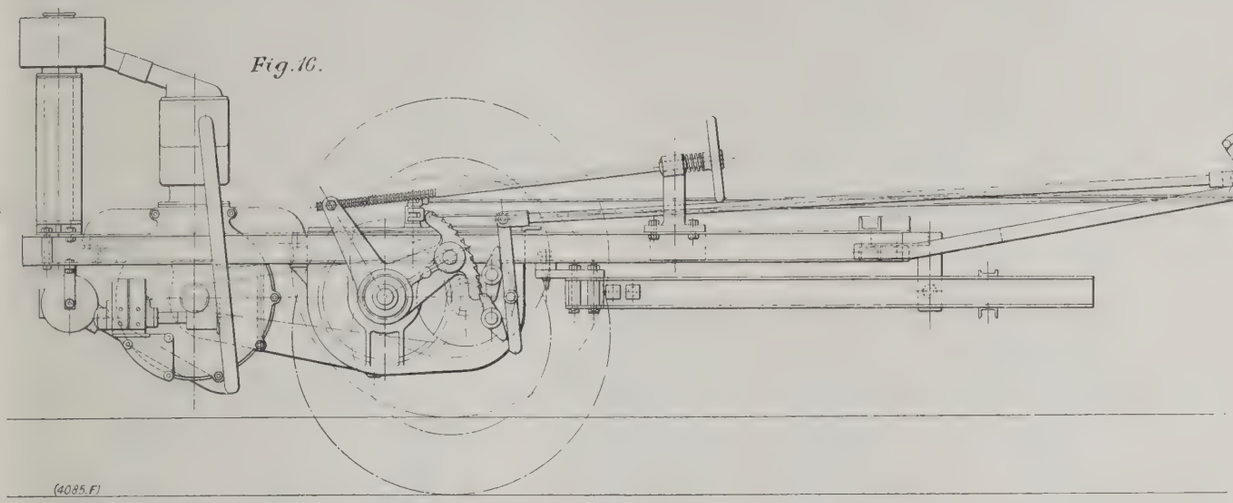
Thus the ploughs are lifted to the surface of the ground without stopping the machine, and then by driving one wheel only the plough is swung round upon the other wheel as a pivot. This form of lifting-gear has been evolved after long experiment. The simplicity of the arrangement now adopted is noteworthy, there being no gearing, either hand or power, in connection with the scheme, apart, of course, from the main driving gear.

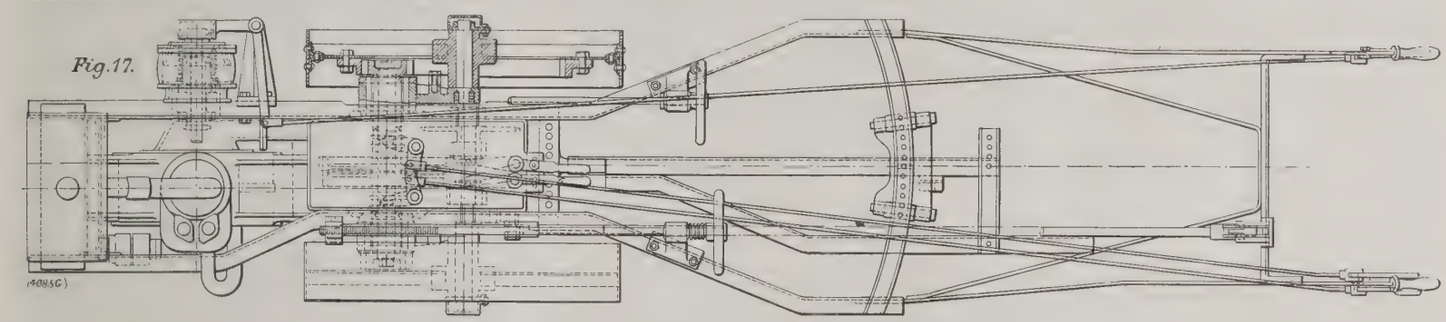
The maximum wheel adjustment allows for a 10 in. depth when ploughing one furrow. The machine is exceedingly well balanced and easy to manipulate. Traverse is arranged at the back end of the frame and plough-beam by means of a roller-frame. The work done is exactly of the character of that performed by horses. Three acres per day can be accomplished for a fuel consumption of about $1\frac{1}{2}$ gallons per acre. With labour at 4s. per day, and fuel at 1s. 3d. per gallon, the cost works out to between 3s. and 4s. per acre. The plough is arranged for turning two furrows. The shares are not shown in the drawing, owing to the variety in use. The plough can be removed for replacement by a cultivator merely by withdrawing the draw-pin. After the first furrow is cut the plough becomes self-steering, and has been worked unattended except for turning at the ends of the furrows. The length of the machine is 12 ft. over all, and its width over the axle-caps 2 ft. $4\frac{1}{2}$ in. Its weight, with the shares, is 12 cwt.

One of the most novel ploughing-machines exhibited was that by the Darby-Maskell Motor-Plough Syndicate, 49, North-road, Lancaster. This is a machine weighing 5 tons, and supported on three travelling wheels, the two leading being provided with motor-car steering, and the trailing-wheel having two wide treads; the four treads are out of track. All wheels are driven. The engine is a 40-brake-horse-power four-cylinder Maudslay petrol-engine, mounted on the frame at the leading end of the machine. The leading wheels are spring-mounted, and are both gear-driven from a transverse shaft, fitted inside the pinion on each side of the machine with universal-motion transmission. The back wheel is chain-driven. The machine carries behind a V-shaped frame, the V being horizontal, pointing out behind, with the wings reaching some distance up the length of the machine. Each wing is a frame carrying two large enclosed sprockets, round which work a long endless chain. The sprockets and chain-boxes, the latter providing roller-paths for the link-pins, are inclined slightly to the vertical, inwards at the bottom.

Each chain carries six plough-shares; each share is in two parts, attached to separate links, so that when on the horizontal they match properly, but will also pass round the end sprockets. There is a large vertical gear-box at the point of the V at the back of the machine. The endless chains are driven from this, its drive being from the main shaft, transmitted by a heavy Cardan shaft. The machine travels forward at from ½ to 1 mile per hour, and three ploughs are at work simultaneously on each side. The machine makes V-shaped furrows all down the field, each share starting to plough 9 in. in advance of the previous one. It therefore ploughs six furrows at the same time. The ploughing action assists the machine forward to some extent. The machine ploughs up its own wheel tracks. The whole plough-frame is suspended at both ends by chains passing over pulleys on a kind of crane rigging, so that both ends of the plough-frame are raised or lowered at once. The machine turns in little more than its own length, and can plough into corners. The V-shaped frame can be detached and the machine used as a tractor, or the plough-shares can quickly be changed for cultivating-tools, either tines or discs. The controls, steering, &c., are brought to the driver's platform. The machine has been constructed for the Darby-Maskell Syndicate by the Eagle Engineering Company, Limited, of Warwick.

At the stand of Messrs. Richard Garrett and Sons, Limited, Leiston, a variety of machines were shown, including a compound semi-portable, a 7-horse-power traction engine, steam motor-wagons, &c. The most novel exhibit was, however, the Garrett-Crawley agrimotor, for ploughing and other purposes. This machine has a long frame of rolled steel section, mounted on two main carrying-wheels, a land wheel trailing at the rear end. A 25 to 30 brake-horse-power four-cylinder petrol-engine is mounted at the leading end, with cone-clutch transmission to a longitudinal shaft. The drive to the main wheels is by worm off the longitudinal shaft to a transverse shaft, and thence to the wheels by chain and sprockets. There is levelling gear for the near main wheel, the trailing land-wheel also being adjustable as regards height. The machine, when fitted with a three-furrow plough, is very nicely balanced. Either of the main wheels can be de-clutched for turning, the drive being then only to one which will work the machine round. The plough is suspended at the front end by links under the main frame, and is pivoted at the back end. The front end can be raised by levers and rods from the end of the machine; the back end can be adjusted for different heights by putting the pivot in one or the other of a series of holes in the land-wheel frame. The beam of the plough can be swung over at the back end on a roller-path by a hand-lever for steering. The main wheels can be shifted out and in on their axles, so as to obtain some variation in gauge, to clear crops. The whole machine weighs only 30 cwt. in working order, and has a speed of 3 miles per hour. It will plough 5 acres a day at a cost of 4s. 6d., compared with 10s. for horse work. The plough is really self-steering after the first furrows are cut. It was recently sent from end to end of a field unattended, except for a man at each end of the furrow, to turn it round. All controls, except the levelling gear for the near wheel, are brought to the back end of the machine.





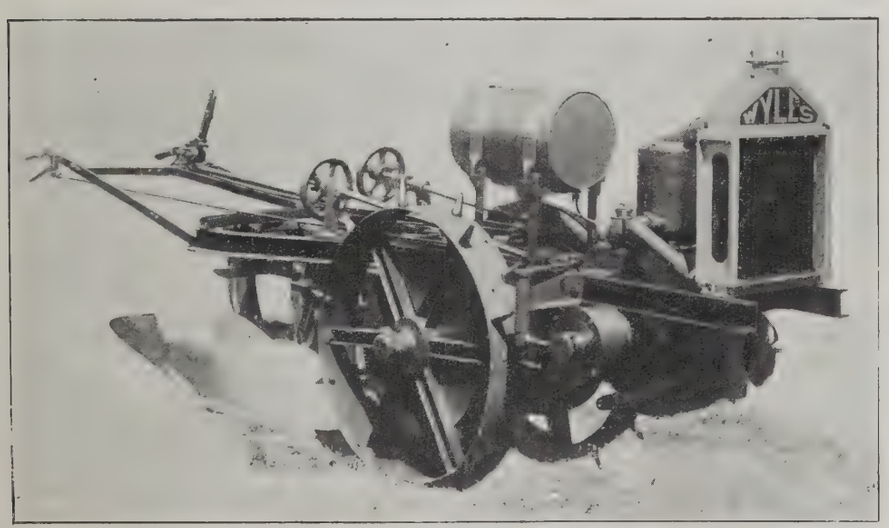


FIG. 18.

FIGS. 16 TO 18. WYLE'S 8½-HORSE-POWER MOTOR-PLOUGH.

At the stand of Messrs. H. R. Marsden, Limited, Leeds, a new machine was shown in the form of a portable self-propelling stone-breaking plant for road-making. This is known as the Blake-Marsden macadam plant, being constructed to the Taylor-Marsden patents. The plant consists of a four-wheeled steel-framed chassis, on which is mounted a 16-in. by 9-in. frictionless hammer-action stone-breaker with a Marsden elevator, overhead screen, loading hoppers, together with a 25-brake-horse-power oil-engine, gear-box, &c. The sides of the stone-breaker are of mild steel, and the ends of cast steel. The moving parts are balanced, and friction losses are reduced to a minimum, the power taken being only about 60 per cent. of that taken by the original Blake-Marsden eccentric machines. From the breaker the stone passes to a short revolving screen in two sections, which separate out the dust and small chippings, passing the large stone on to the elevator, in the buckets of which it is raised to the top of the machine. It is here passed into a revolving screen of two sections, one of which passes 1½-in. and the other 2¼-in. stones into separate hoppers, provided with doors high enough above the ground to permit of a cart being backed up underneath. The oil-engine is arranged

at the front end of the frame, and drives the back wheels by chains and sprockets. The gear-box will give two speeds—namely, 2 and 5 miles per hour, and a reverse. The stone-breaker is belt-driven. Steering is done by the front wheels on the ordinary traction-engine system.

Several interesting displays of weighing machinery were to be seen, the greatest novelty being, perhaps, an automatic weigher at the stand of Messrs. W. and T. Avery, Limited, Birmingham, for weighing liquids, and suitable for water, oils, liquid fuel, sugar-cane juice, &c. This machine consists essentially of an even-armed beam, with a weight-box at one end and a hopper at the other, the hopper balancing the empty weight-box. In the weight-box are placed weights to the load it is required to weigh off, which, according to the size of the machine, may be anything up to several tons. The weights in the box draw down that end of the beam, which action opens a gate-valve of the guillotine type over the hopper, and the liquid to be measured flows into the hopper. As soon as the weight of liquid balances that of the weight in the box, the beam tends to swing level, the gate-valve is closed, and the supply cut off. At the same time the hopper is designed so that it overbalances at this stage, empties, and then rights itself, the weights pulling back the beam to the original position when the valve is again opened for filling the hopper afresh. A cam-stop is provided to prevent the hopper tilting over if it should be desired to check by pointers the correctness of the balance of the load and weights.

A complete milling-plant of a capacity of 1 to 1½ sacks per hour was shown running at the stand of Messrs. Thomas Robinson and Son, Limited, Rochdale. This plant was entirely automatic, one attendant being in charge, but having practically nothing to do. It was driven by an oil-engine, the complete plant requiring only about 10 horse-power. This exhibit included a scourer, a cyclo-pneumatic separator, a three-pair high mill for first, second, and third breaking, two double reduction mills, a sextuple plansifter, and a centrifugal bran-dressing machine. The installation was fitted throughout with the necessary elevators, trunks, &c., and all the machines were totally enclosed. The bearings in most cases were of the ball type, self-lubricated throughout, and well clear of the interior parts of the machines. The whole exhibit, including the platform on which the machines were staged, occupied a space of 25 ft. by 20 ft. The plansifter was of the double-crank type, supported from the floor on legs, with ball and socket joints. At another part of their stand Messrs. Robinson had another plansifter on a similar principle at work, and also one suspended from overhead by cranes, the motion being obtained from an overhead belt brought down to two pulleys at the edge of the plansifter, and from thence round a pulley in the centre of the machine, which drove an unbalanced weight. The new cyclo-pneumatic separator was described and illustrated in ENGINEERING of the 26th ult., page 873, and need not be again referred to. The firm also showed double diagonal roller-mills with a new adjustment gear, so that both ends of the rolls may be adjusted by one movement. A model sack-chute on Messrs. Robinson's system was also an interesting little device. This sack-chute is arranged with circular arc slides between the floors, but instead of being continuous the direction of the arc is reversed at each floor. The sack may be said practically to wriggle down, and arrives at the bottom with very little greater speed than at the intermediate floors. Sacks can be run out on any floor, and the whole chute can be accommodated in a corner of the building.

The general finish of the metal and wood-work in Messrs. Robinson's machines must be, we should think, unsurpassed in excellence. It is a very noticeable feature of the firm's products.

We omitted to mention when dealing with Messrs. Ruston, Proctor and Co.'s exhibit last week that some of their machines are now fitted with ball-bearings. Our attention was directed to a 4-ft. 6-in. thrashing-machine and a clover-huller provided in this manner, which, we understand, are the first applications of ball-bearings to be made to machines of this character. The bearings are of very simple design, the balls running in a ring-cage, the shaft being turned and the plummer-block bored to the proper fit. An end cap is fastened over the block by two studs and nuts. Once filled with grease, these bearings will run for a season without attention.

Among the smaller things a very interesting, and to some extent astonishing, water-raising device was to be seen at the stand of Messrs. W. H. Willcox and Co., Limited, 32-38, Southwark-street. This appliance, aptly termed the "Marvelo," is virtually a chain pump with nothing but the loop of an endless chain depending into the well. To keep the chain in place a deep-rimmed pulley is slung in the loop of the chain lowered into the well. At the top end the chain is run over a pulley-wheel worked by gearing by a hand-crank. The top pulley is enclosed in a casing, with a delivery pipe leading away from the lower portion. The chain consists of a link-chain surrounded by a spiral, Fig. 19. For large capacities a multiple spiral chain of the type shown in Fig. 20 is used. The lower part dipping into the well catches up the water while the spiral is opened by the curvature of the pulley, and retains the bulk of it till the highest part is reached, when the centrifugal force, while the spiral is bent open at the top pulley, throws the water out into the

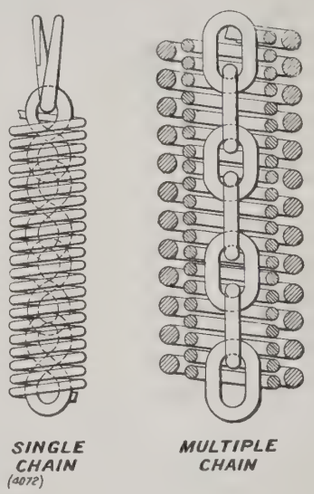


FIG. 19. FIG. 20.

FIGS. 19 AND 20. WILCOX'S WATER-ELEVATOR.

casing, whence it flows away. The capacity of this simple appliance is surprising, and it will handle water from depths of 200 ft. or more. The chain is made up in lengths of 3 ft. or 4 ft., which can be readily joined together to obtain the desired length. The apparatus requires no permanent fixtures in the well at all, and no buckets, guides, &c.

The Society held no trials of implements this year, though a number of new appliances were entered for the Silver Medal; many of these have been described above and in our previous article. In 1915 important trials are to be held in four classes. The first class will be devoted to direct-tractor internal-combustion plant of 20 brake horse-power or less, suitable for ploughing not more than four furrows 9 in. wide by 6 in. deep. A gold medal and 25*l.* will be awarded in this class. A similar award will be made in a second class for a direct internal-combustion plant of over 20 brake horse-power, or steam-ploughing outfit capable of ploughing not more than six furrows 10 in. wide by 8 in. deep. In another class, for which a similar award will be made, the self-propelled plough must turn not more than four furrows 9 in. wide by 6 in. deep; while in a fourth class a silver medal and 10*l.* will be awarded for a plough suitable for direct tractor work, and turning not more than six furrows. These trials will take place in August or September of next year, and final regulations will be issued in due course.

PORTLAND CEMENT.—A large new cement factory is about to be constructed in West Sweden, where extensive property has been secured for the purpose. The share capital is not to be less than 300,000*l.* and not to exceed 6,700,000*l.*

MERSEY DOCKS.—The Mersey Dock and Harbour Board proposes to erect, at a cost of 226,500*l.*, a shed 500 yards long by 50 yards wide on the south quay of the new Gladstone Dock at Liverpool, with the necessary cranes and railway lines for handling cargoes. The shed will occupy a space of 15 acres; it is to be a three storey building, and it is to be set back from the quay so as to allow space for a double set of railway lines. A final decision has not yet been arrived at upon the general subject.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE summer meeting of the Institution of Mechanical Engineers commenced at 9.30 A.M. on Tuesday last, the 7th inst., when members assembled in the hall of the Société des Ingénieurs Civils, 19, Rue Blanche, Paris. In the unavoidable absence of Sir Frederick Donaldson, owing to the strike at Woolwich Arsenal, the duties of chairman devolved upon Mr. Michael Longridge, Vice-President. The members of the Institution of Mechanical Engineers were first welcomed to Paris by Mr. Henry Gall, the President of the Société des Ingénieurs Civils de France.

In opening the proceedings, Mr. Henry Gall, speaking on behalf of the Société des Ingénieurs Civils de France, said that the agreeable duty which had devolved upon him of welcoming the Institution in Paris, was one which he undertook with the greatest pleasure, and added that he was glad at being accompanied on that occasion by one of their Past-Presidents, Mr. Gustave Eiffel, who had been made Honorary Life Member of the Institution of Mechanical Engineers. He was sorry Sir H. Frederick Donaldson was unable to be present at the Paris meetings, and he asked Mr. Michael Longridge to kindly convey to him the regrets of the Paris Société. He thanked the Institution for having selected their building for the holding of their meetings, and expressed the hope that the visitors' stay in Paris would be a pleasing one; he felt sure its effect would be to tighten the bonds of sympathy which united the two nations.

Mr. Michael Longridge, who, as we have stated, occupied the chair in the absence of Sir H. Frederick Donaldson, speaking in French, thanked their French colleagues for their most cordial reception, and for having put at their disposal their Paris building for the reading and discussion of the papers which had been prepared for the occasion, six of which, out of seven, had been written by French engineers. The President of the Institution was deeply sorry at having been prevented at the last moment from coming; he had been kept back by his duty to his country, and he (the speaker) would not fail to transmit to him the regrets which had been expressed by their excellent friend, Mr. Gall. The Institution had visited Paris the last time twenty-five years ago, and the members present who had taken part in that visit had retained the most pleasant recollections of it; he felt sure they would take away with them better recollections still of their present visit. He thanked the French Société for the trouble they had taken for providing both for their instruction and their enjoyment. He also thanked, in this connection, Mr. William Hanning, the President of the British Chamber of Commerce in Paris, and their own secretary, Mr. Worthington; such meetings involved a vast amount of trouble and work, and both these gentlemen had been indefatigable in their efforts. Speaking in English, he added that the absence of Sir Frederick Donaldson would prove a great disappointment, but he was not absent through his own fault, but through what their French friends would call a case of *force majeure*. On his motion, their French colleagues were accorded a hearty vote of thanks for all the kindness which had been shown to the Institution.

The Secretary next read the minutes of the former meeting, and then the names of the members transferred and newly elected. This terminated the ordinary proceedings.

FRENCH EXPRESS LOCOMOTIVES.

At the conclusion of the formal business the Chairman called upon Professor Ed. Sauvage to read his paper entitled "Recent Developments of Express Locomotives in France." This is reproduced *in extenso* elsewhere in this issue. Professor Sauvage summarised it, after which, before calling upon the meeting to pass a vote of thanks to the author, Mr. Longridge remarked that he could recall the time when the express trains on the Northern Railway of France were drawn by Crampton locomotives with large single driving-wheels at the back of the fire-box. These engines had necessarily very little adhesion. Their main advantages were supposed to be the low centre of gravity and the absence of coupling-rods. They had learned since then that coupling-rods were not such an evil as was once imagined, while a low centre of gravity was not so desirable as it once appeared. The main points of the paper related to

the advantages of compounding and superheating not taken by themselves, but in relation to the traffic to be handled, and to the question of the boilers of these enormous engines, which he thought rather valuable features. He hoped these points would be well discussed.

Mr. Henry Fowler, who was the first speaker, remarked that there was little to say, unless he entered upon the wide field of details. There were no passenger locomotives being built now in England without superheaters. Although the author had not gone into details, there was one matter he thought he might mention. It related to the tightness of the large smoke-tubes in superheater engines. When these tubes were of the ordinary length in English practice they did not have much trouble. When they were long—as, for instance, 16 ft.—the trouble of keeping them tight became serious. In a particular case he had in mind, the trouble, perhaps, arose on account of the exceptionally bad water; but if leakage once started, it was very difficult to stop. The author's remarks about dispensing with the smoke-box damper and gear in superheater engines were interesting. The same thing had been tried in England with success. It would be a good thing to get rid of this damper if possible. In England not much had been done in combining compounding and superheating; only two roads were doing anything of the kind. He thought the engine of the future would be the four-cylinder superheater compound. With regard to the pressure drop of 42½ lb. per sq. in., mentioned in the paper as occurring on the P.L.M. system, such a drop was against his experience. He had found that the drop due to the tortuous character of the steam passages was usually made up by the increased fluidity of the steam in a superheated state. On the Pennsylvania Railroad they had just produced a very large "Atlantic"-type locomotive, and Mr. A. W. Gibbs, of that system, considered that there was still a large future before this class of engine (4-4-2). With reference to Mr. Longridge's remarks on coupling-rods, he would say that no engine ran so well as a single-wheeler, and no engine slipped so readily when called upon to haul a load.

Mr. A. Herdner, Chief Engineer of the Southern of France Railway, who followed, said he regretted he was not really fluent in English, and asked to be allowed to speak in French. In the author's Table IX. there was a misprint. He (the author) had mentioned two-cylinder superheater "Pacific" locomotives; all the "Pacific" locomotives were now four-cylinder engines. The author had mentioned the coal consumption as being 14.1 kg. per km. in the case of the engines using superheated steam, and 14.616 kg. in the case of those using saturated steam; the difference was about 0.5 kg. per km., and that on a service of from 9 to 10 months. In the commencement the difference had not varied much, but it had decreased later. On locomotives provided with superheaters, it occurred that the cleaning of the superheater was liable to be neglected occasionally; the exhaust side was also liable to be neglected. The difference in coal consumption, however, had never exceeded 1 kg. per km., a result which he attributed to the too small size of the superheater; the latter might, perhaps, have a sufficiently large superheating surface, but then the section available for the passage of the hot gases was too small compared with the total passage section. In their present engines only 38 per cent. of the gases passed through the superheaters, and when they repaired these engines, they would increase the number of superheater tubes. The divergence that might exist between the locomotives of the Southern of France and the other French railways was more apparent than real. On the Southern of France they had many compound engines; they found that the construction of locomotives having four cylinders, but not compounded, was not justified, and he (the speaker) had always been of Mr. Sauveur's opinion in this respect. When using compounding and superheat, the number of cylinders to be adopted had to be taken into consideration, and when comparing together engines that were comparable, it was found that the steam consumption with two cylinders was much less than with four. The gain corresponded to a saving of about 1 kg. of coal on, say, 12 kg. to 13 kg. per km., which could only be traced to the difference in the number of cylinders, the engines being otherwise comparable one with the other. In this connection he gave the following figures for coal consumption:—13 kg. for a four-cylinder "Atlantic" engine using saturated steam; 12 kg. for a four-cylinder "Atlantic" engine using superheated steam; and for the two-cylinder engine about 800 grammes less (12.200 kg.) than the first. In these three instances the engines could be compared the one with the other. But he did not conclude therefrom that the two-cylinder engine using superheated steam should displace the four-cylinder one completely, for there were far too many variables to make it possible to draw a final conclusion. But if, for instance, upkeep were considered, the cost of upkeep of a four-cylinder engine was much higher than that of a two-cylinder engine. Further, the repairs to a boiler having a registered pressure of 15 kg. to 16 kg. per sq. cm. was more costly than those to a boiler for a pressure of 12 kg. to 13 kg. with superheat. He was now building engines of the "Pacific" type, having two cylinders, generally similar to the four-cylinder ones, with the same grate area and the same superheat, and was going to test them in comparison with the latter. He believed they would prove more economical.

Mr. G. W. Hutchinson was the next speaker. He referred to the experiments made on the Northern Railway of France with water-tube fire-boxes, drawing attention to the engine shown in Fig. 10 of the paper, which he believed was fitted with a water-tube fire-box. It would, he thought, be interesting to know how this design behaved in practice. Did the arrangement make for better steaming? Did the tubes require much attention to prevent leakage or frequent renewal? One way in which to increase the power of the modern locomotive was to raise the pressure. He did not know whether the ordinary fire-box would stand much increase of this kind, but he thought the water-tube fire-box offered a good chance of accomplishing this. If the water-tube box for high pressures were used with the ordinary barrel, the latter would have to be made extra strong, and would therefore become a good deal heavier. That would be objectionable from some points of view. He therefore thought a complete water-tube boiler should be devised. Possibly early attempts would prove failures, but success would doubtless come in the end. At previous meetings a common fund for experimental work had been suggested. He thought the production of a water-tube boiler a suitable subject for some such joint effort.

Mr. E. Ronceray said that he had not been connected with locomotive work for many years, but when he had been in former days he had always been under the impression that compounding had been adopted because the valve-gear in use was unsuited to high pressures. There were other gears now available, and he had himself recently designed a gear with constant lead, exhaust, and compression, the only variable being the cut-off. If a gear of that type had been adopted, he thought the compound would have made less headway. On Mr. Longridge requesting Mr. Ronceray to submit a drawing of this gear for inclusion in his remarks, he promised to do so.

In reply to the discussion, Professor Ed. Sauvage said that there was little really for him to comment on. With regard to Mr. Fowler's remarks on the drop of pressure on the P.L.M., the Northern Railway had had similar experience. Large ports and straight passages were undoubtedly necessary. French engineers would like to be able to use the 4-4-2-type engine instead of a six-coupled type, and they would do so to a much greater extent if the axle-loads permitted on the Pennsylvania Railroad were permissible on their systems. With regard to Mr. Herdner's contribution, the two-cylinder engines he spoke of would certainly be watched with interest. Of the "Baltic" engines referred to by Mr. Hutchinson only two had been built. They were powerful but expensive. The Northern Railway was very reserved as to their performances, &c. One of the two had an ordinary box, and the other a water-tube fire-box. The latter was not a success, and was in continual need of repairs. Though several companies in France had tried it, so far this type of box had not proved satisfactory. Mr. Ronceray's gear sounded interesting, and he hoped he would meet with greater success with regard to it than had some of the others that had been tried. The tightness of the large tubes did not present any great trouble; perhaps it would be interesting if he added to his paper details of the methods adopted to ensure this.

Compound Articulated Locomotives.

The next paper to be taken was one by Mr. Anatole Mallet, and was entitled "Compound Articulated Locomotives." This paper, which we reproduce elsewhere in this issue, was summarised in French by M. Mallet, who explained the principal features of his system by means of a model.

Mr. Longridge said the subject was one of special interest to those who had to do with pioneer railways where curves were sharp and grades heavy. In his locomotive days, the Fairlie engine used to be employed with success; the Fairlie was practically two locomotives coupled together. The joints of the steam-pipes used to give trouble then. He had once designed an articulated locomotive for heavy goods traffic; he had coupled his wheels by means of steel cogs. His attention had first been drawn to the matter by the work on the Mont Cenis route, where the grades were 1 in 8 and there were curves of 40 metres radius. The longest rigid wheel-base he believed had been then 8 ft. 6 in., and that had suggested the use of articulation. However, it was found that the two-cylinder type of locomotive, without any complication, was best after all. He would like to hear the later experience of others.

Mr. Edgar Worthington was called upon by the Chairman, and remarked that it was the first time since he had occupied the position of Secretary that he had been asked to contribute remarks to a discussion. Engineers owed a great deal to Mr. Mallet's work in the development of the modern locomotive, not only with regard to the articulated type, but also for his pioneer work in connection with double expansion. He (the speaker) had had twenty-three years' experience as a locomotive constructor. In the early days (about 1875-80) everyone looked to Mr. Mallet and his work to see if it was worth while spending money on developing compounding. At Crewe, under Mr. Webb, he had fitted the first Mallet arrangement used in England to an old Trevithick engine. Webb, Worsdell, and von Borries all followed Mr. Mallet in Europe. For a long while there was no development of that kind in America, but in India Mr. Sandiford took the subject up. That, perhaps, was wandering slightly from the subject of the paper. Fairlie engines had been worked on the Festiniog Railway before Mr. Mallet introduced his engine. On the previous visit of the Institution to Paris there had been Mallet engines at work on the Decauville railway. In the early days there had been trouble with the steam-pipe joints; that had now been overcome, but in the course of time many expedients had been resorted to with a view to finding a substitute for the Mallet engine. Some of them were expensive, as, for instance, the type of twin-engines adopted for the Kojak Tunnel in India. In this case there were two engines with one large tender between them, but ultimately more tenders were built, and the engines paired off with them. Mr. Mallet had come out at the top of all these experiments, as was proved by the wide-spread adoption of his engine in the United States.

Dr. H. S. Hele-Shaw said that he was not a locomotive man, but it might interest the meeting to know that there was in course of successful development an articulated system in which oil under pressure was conveyed from the locomotive to the driving wheels. The oil-transmission system was making rapid progress owing to the progress of the Diesel system, and by it flexibility, similar to that obtainable only with the steam-engine, would soon be a characteristic of the Diesel locomotive. The need of that flexibility was recognised. The articulation system to which he referred gave no trouble; the transmission of the oil through the joint at high pressure had been quite successful. This problem had given a good deal of trouble in connection with two rail-cars, but it had been overcome. He thought the transmission of steam through an articulated joint rather more difficult probably than that of oil, which acted as a lubricant.

Mr. F. H. Livens said he was not competent to discuss the paper from the locomotive man's point of view, but he would like information with regard to firing. With the increase in power and size of locomotives the boiler and grate were much enlarged. The difficulty of firing wide grates had been mentioned in Mr. Sauvage's paper, and preference had been expressed for narrow grates. Mr. Mallet's paper spoke of grates of 70 sq. ft. to 100 sq. ft. area. If there was difficulty in firing the grates

mentioned by Mr. Sauvage, what would it be in the case of these large American engines. He would like more information on the fire-box question. How many doors were there, and how much coal was fired? He thought great difficulties arose at the heat-producing end of the locomotive.

Mr. G. W. Green said he had just returned from Chili, where on the Nitrate Railways they used Fairlie engines. The lines were full of curves and heavy grades of 3 per cent. The best engines on that system were the Fairlies, some of which had been in use since 1864, the latest having been built in the shops in South America in 1911. There were no Mallet engines. The others were all fixed wheel-base engines, six-coupled. Their chief trouble was the coal, which had to be used either in the form of briquettes, or was so small that it had to be carried in sacks. He had not heard of trouble with the articulated joints of the steam-pipes. Some time ago they had had a Shey engine from North America. It pulled its load up hill all right, but when it was loaded with about 12 cars of 30 tons capacity each, and the train was run down the line at the usual speed, the gearing on the locomotive caused it to skid practically the whole way down, and it was not used again. The line rose about 3000 ft. in 25 miles.

Signalling on Trains in Motion.

The third paper to be taken on Tuesday morning was a composite contribution by the engineers of six different French railway systems. It was entitled "Signalling on Railway Trains in Motion," and described systems in use on the Northern, Eastern, Southern, State, P.L.M. and Orleans Railways. It will be reproduced in a future issue of ENGINEERING. In the meantime it is only possible to say that the system adopted on the Northern Railway was described by Mr. A. Sartiaux; that of the Eastern Railway by Mr. F. Lancrenon; that of the Southern by Mr. A. Herdner; that of the State Railways by Mr. A. Claveille; that of the P.L.M. by Mr. L. Maréchal; and that of the Orleans Railway by Mr. E. Solacroup. In many cases the authors themselves were unavoidably prevented from being present, but in most instances a short verbal description of the apparatus was given, either in French or English, by some one connected with the railway in question. The systems referred to embraced audible or visible cab signals with rams or "crocodiles" in the road, usually in between the rails.

The first speaker on this subject was Mr. J. A. F. Aspinall, Past-President, who said that as that was the first paper to be read on the subject, it might be supposed that the subject had not received much attention in England. That, however, was not the case. They had, on the North-Eastern Railway, the system developed by Mr. Raven, and on the Great Western Railway there was another of a somewhat different type. In France the subject had received attention for a long time. In 1875 he had come over to see the system developed by Mr. Lartigue on the Nord, which was still in use in a modified form. He also greatly appreciated the courtesy which had enabled his colleagues recently to see what was now being done in France. In England we had been slow to adopt such systems, because we preferred to rely on the thoroughly-trained enginemen and signalmen. The systems described transferred the responsibility for everything being in order from these well-trained men, who appreciated their responsibility, to a body of electricians who had to attend to the condition of the contacts and connections, not only all over the system, but also on all the engines. These electricians, who, after all, were of the nature of ordinary wiremen, had not nearly the same sense of responsibility as the drivers and signalmen. That, perhaps, might be answered by reference to the fact that the machine itself reported, so to speak, whether it was in order or not. That was so in some systems, but not in all, especially in the simpler type, which, however, offered some advantages. Imagine the thousands of men coming into business in our great cities of a morning held up because some little contact had failed. It was not a question of cost, or of dislike, but much more so of the uncertainty with regard to the reliability of the present-day systems which prevented their wider adoption. Referring to another matter, it became necessary a few years ago for every gang of platelayers to be provided with a watcher. The responsibility was withdrawn from the men themselves and transferred from, say, six pairs to one pair of eyes. Accidents to these men had greatly increased as a result, and if the watcher was abolished he thought the accidents would certainly decrease. If we adopted apparatus of this kind, he thought the miniature signal in the cab inadvisable. The sounding apparatus was better, because it was unwise for the driver to take his attention off the road. The audible signal was effective in attracting his attention. With all these systems a brush contact and a ramp or crocodile were used. The most convenient places for these were naturally in the centre of the engine and track. But now that electrification was being adopted, and a fourth rail was employed, it was impossible to put the ramp in the centre of the track; also there were water-troughs in the centre of the road. If the brush were put low, it would clear the water out of the trough; if high, it would not touch the ramp; while if the ramp were placed high, it might foul the water-scoops. It therefore became necessary to put the ramp to one side. That involved the use of two brushes. They were experimenting on the Lancashire and Yorkshire Railway in the directions he had mentioned, and sincerely hoped that they would arrive at satisfactory results.

Mr. H. Fowler said that on the Midland Railway they had a branch fitted up with the Great Western system. He thought the length of the "crocodiles" used on the French railways was too short. In England the flat length adopted was about 20 ft. He thought they had been slow, because they had foreseen the difficulties which the system introduced. One of the gears described adopted a spring in the whistle gear, on which the whistle action was dependent. They had tried to keep clear of all parts like that which might be liable to derangement. He would be glad to hear whether any difficulty had arisen from the spring breaking. There was nothing to show "line clear" on the French systems, as far as he could see. That, they considered a necessary indication in England. He would also like to know whether any difficulty arose with the tripping lever shown in Fig. 18 of the paper, and whether it was liable to damage on being struck at high speed. Such levers were not regarded with favour generally, and such parts were often, he thought, liable to harm from almost inexplicable causes, stones lifted from the ballast, and so on.

Mr. W. A. Stanier spoke of the Great Western Railway system, known as the audible cab system, using a T-shaped ramp placed centrally in the 4-ft. way. The engine carried a contact and had a battery circuit. In a box in the cab was an electric bell and a siren. In the event of a failure the siren sounded. Ramps were at present fixed at the distant signals, and on two branches the line had been converted to this system at the distant signals. On single lines polarised relays energising the ramps prevented the engine getting a wrong indication. The recent improvement had been the application of the system to the control of the brake, and a train could be pulled up even with the regulator full on. The driver could not blow off without attending to the signal. The drivers were getting used to the system, but at first they seemed to prefer to see something. On the main lines the general opinion was that it was all very nice, but they could not see the action of the signals ahead, and it seemed to lead to delay. In fog, however, it worked otherwise. Men with the system on their engine worked to time. As a result, the system was likely to be extended. Mr. Aspinall's requirements he considered to be filled by the Great Western system. The point raised about the wiremen and electrical contacts was covered by ensuring a danger signal being given in case of failure. No small semaphore was used, but an audible signal. The ramp was fitted in the centre of the track and was of reasonable length.

Mr. P. M. Baker said that his experience in India led him to make a reference to Mr. Aspinall's remarks on first-class men, which, of course, did not apply to that country. Twice he had lately been stopped in the most important train crossing that continent on account of both the station-master and signalman being away from their posts. Several times drivers waiting by the roadside had heard signals go off, and had jumped on their engines and started without troubling to see whether they were for them or some other train. Anything which would prove reliable, and would repeat the road-signals and apply the brake, would be an advantage. As far as he could see, the systems described provided no means of detecting broken circuits, except in one case. A danger signal which failed was worse than no signal at all. The Great Western system gave a danger signal in the event of any failure. Then there was the probability of failure of the contact. How were the brushes made reliable? He would be afraid of getting shorts on the wiring to them. The Krammer-Kapp system of induction, he thought, had advantages over these contact systems. In this system two balanced inductive circuits were used, and it went to "danger" if anything failed with one circuit. Its chief disadvantage was the need of a motor-generator or some other means of providing power. He would like to know the percentage of failures to movements in France on the systems described.

Mr. Moutier, who had introduced the subject, speaking on behalf of his company, the Northern of France Railway Company, said, in reply to the discussion, that all the remarks which had been put forward by Mr. Aspinall were important, and would be gone into by them with all due attention. The question, however, resolved itself purely and simply into a question of principle; it was purely and simply a matter of deciding whether the repetition of signals upon the engine foot-plate formed an integral factor of safety, or merely an additional guarantee. If it were considered as forming part and parcel of the railway signalling system, it was dangerous, and it would be better not to have resort to it. It was useless to add to the usual signalling apparatus, which worked satisfactorily, another—a new device—which would only act as a kind of brake on the former, and complicate matters; the new device would have to be absolutely impeccable. If, on the other hand, the new device be simply considered as an additional, an invisible extra guarantee, when it failed, the driver would remain, and would act in his full capacity, no accident occurring should the additional guarantee fail. It was necessary, therefore, to consider the device simply in the light of an aid; where this had been done in the correct light no inconvenience has resulted. The light in which it is considered was probably the only point which divided the engineers of the two countries. He advocated, therefore, the use of the device simply as an addition made to the present existing means of safety. In regard to the recording by the device both of an open line and a closed line, there were two schools of thought.

Some engineers had stated that the device led the engineer to consider solely what occurred on the footplate, and he lost the habit of watching the signals on the track. From this there was but one step to proclaim that the latter signals would become useless. But if these were done away with, the publicity they afforded would also be done away with; it would be impossible to ascertain where a driver had failed. When it was said that the apparatus led to accidents, all depended upon the point of view from which the question was considered. If the device were considered as an adjuvant, a kind of mentor, all difficulty was brushed away.

Some speakers found the fixed ramp, or "crocodile," too short; but it could be made longer, and if longer, the number of misses would be less. Were it never frosted over they would be less still. The ramp was a "mentor," and when it did not work, the "mentor" was simply absent for the time being. It could be lengthened and thereby reduce the number of times it failed to act. Mr. Briard, for the Eastern of France Railway, had explained his device in which the ramp contained petroleum, thereby obviating the difficulty due to frost and rust.

In regard to the regulation of the spring for the whistle signal, that part of the device entered into the whole simply on the lines he had indicated, those of an additional guarantee. The life of the contact brush had also been mentioned, but this was not a costly element; the brush was easily supervised and easily replaced when worn.

Referring again to Mr. Aspinall's remarks, he (Mr. Moutier) said that on the Northern of France they had no electric traction. But this was a consideration for both the Paris-Orléans and the Southern of France Railways. Mr. Aspinall feared that the brush might be too high and miss contact, or too low, when it would be liable to tear up the "crocodile." The cases in which it would be too high were very few, and if too low it could not tear up the "crocodile," since a wooden shield on a slope was in front of the "crocodile,"

up which the brush travelled before it arrived on the latter. He, however, had noted Mr. Aspinall's remarks in regard to the stray currents that might occur on electrified lines. He thought he had replied to all the remarks, and emphasised the fact that the device should simply be viewed in the light of a vigilant mentor who, should the driver become inattentive, would "tap him on the shoulder, calling him back to his duty."

On the motion of the Chairman, the authors were awarded a hearty vote of thanks for their contribution.

On Tuesday afternoon various alternative visits had been arranged, as, for instance, to the works of Messrs. A. Darracq et Cie., the Établissements Baudet et Donon, the Compagnie Electro-Mecanique, or the Conservatoire des Arts et Métiers. In the evening the Institution Dinner was held at the Hotel Continental.

PROCEEDINGS OF WEDNESDAY, THE 8TH INST., &c

On Wednesday, the 8th inst., members reassembled at 9.30 A.M. for the reading and discussion of papers. Four papers were considered—viz. :—"The New Niclausse High-Duty Marine-Type Boiler," by Mr. J. Niclausse; "Development of Internal-Combustion Engines for Marine Purposes," by Mr. Drosne; "Balancing of Internal-Combustion Engines," by Mr. H. F. Fullagar; "Improvements in Motor-Lorries," by Mr. E. Brillié. These we shall reprint in an early issue, and the discussions will be dealt with in our next issue. In the afternoon of Wednesday visits were paid to the works of Messrs. Niclausse; of Messrs. Hotchkiss and Co.; of the Société Anonyme des Etablissements Delaunay Belleville; of the Société Général de Constructions Mécaniques; and to the Fonderies et Ateliers de la Courneuve. In the evening a conversazione was held at the Société des Ingénieurs Civils, by the invitation of Mr. Henry Gall, Mrs. Gall, and Members of Council of the Société. On Thursday and to-day other excursions have been arranged, including, to-day, visits to works at Le Havre, Valenciennes, Lille, &c.

(To be continued.)

INDUSTRIAL NOTES.

AT a labour conference held on Wednesday at the Caxton Hall, Westminster, a scheme for consolidating the whole of the bodies affiliated to the National Transport Workers' Federation and the General Labourers' National Council into one consolidated union, with an estimated membership of 400,000, was approved. In addition to the thirty societies represented at the conference by 150 delegates, several of the smaller unions had expressed approval of the amalgamation. According to a statement made after the conference by Mr. Robert Williams, secretary of the Transport Workers' Federation, twenty-six societies expressed entire approval, two were against it as drafted, and two remained neutral.

During the past and present weeks there has been a very serious strike at Woolwich Arsenal. It commenced last Friday, the 3rd inst., in consequence of an employee refusing to erect a machine upon a concrete foundation which had been laid down by non-union labour during a strike. The man was brought before the Chief Superintendent, Sir Frederick Donaldson, and, upon persisting in his refusal, was discharged. Thereupon there was a general strike in the Royal Carriage Department, some 1500 men of the Amalgamated Society of Engineers coming out. On Saturday many other men followed their example, until there were between 7000 and 8000 out. The Labour Protection League announced that all the labour organisations had ordered their men to come out solidly and every gate at the Arsenal to be picketed. On Monday only a few hundred men, out of some 11,000, remained at their posts in the Royal Laboratory, Royal Carriage Department, Royal Gun Factory, Mechanical Engineering Department, the Building Works Department, and in the Army and Navy Ordnance Department. There was also a suggestion of calling out all the workmen at the Government dockyards at Plymouth, Devonport, and Portsmouth. The more important unions involved were the Amalgamated Society of Engineers, the Labour Protection League, the Workers' Union, the Coach-Builders, Steam-Engine Makers, Associated Smiths, Wheelwrights, Electrical Workers, and Ironfounders. On Tuesday the local Labour leaders and Mr. Will Crooks, M.P. for Woolwich, had an interview with Mr. Asquith, and later in the day the Prime Minister stated in the House of Commons that the Government had decided to appoint a Court of Inquiry, consisting of five persons, with Sir George Askwith as chairman, to inquire into and report upon the origin and circumstances of the dispute. The strike committee met on Tuesday night, and after a further discussion with Sir H. F. Donaldson, it was announced that the following terms had been agreed upon :—

(1) All men to return to work in their former position. (2) The Court of Inquiry to deal with the principle which has led to the dispute. (3) Whatever the result of the inquiry, whether in favour of the men's contention or not, Entwistle, who originated the dispute, and any other man similarly placed, not to be punished. (4) Where building work has already been executed, the men to be recommended to offer no objection to working upon it, provided their work is followed by no "black-leg" labour.

This is an opportunist settlement which settles nothing, and leaves the matter to be fought out at some future date.

The Insurance Commissioners recently issued the draft of a Special Order which deals with the insurance of casual labourers in the Port of London, and is intended to meet two difficulties. Casual men in the Port of London are very generally employed by the day or half-day. Under the ordinary provisions of the Insurance Act the first employer was liable for the whole contribution, and after Monday there was, therefore, a tendency in selecting men to give preference to those whose cards had already been stamped. One consequence of this state of matters was that men who did not obtain work early in the week were induced to stamp their own cards. This, of course, meant a heavy burden on the casual men, a considerable proportion of whom could not rely upon more than two or three days work in the week.

It is now proposed that all casual men employed in the Port of London, between Westminster and Gravesend, in loading or unloading ships or craft, or in warehousing goods, will be required to deposit their insurance card at one of the special offices or clearing-houses to be established by the Commissioners, and they will receive in exchange a numbered tally, which will act as a means of identification.

Every employer will be required to make a return once a week of the tally numbers of the men he has employed on each day of the week. He will also be required to give to each man he employs a voucher for each day of employment.

When giving evidence before the Royal Commission on Railways, on Thursday, the 25th ult., Sir Charles Owens, director and late general manager of the London and South-Western Railway Company, stated that his objections to nationalisation related to political pressure, the enormous character of the undertaking, the absence of elasticity in fixing experimental rates, and the lack of efficiency under Government departments. His experience of Government departments was not such as to induce him to expect the same average of efficiency as was obtained under the administration by commercial men.

To the remark that under unification the railways could be worked by a central administration in the district, and divisional officials, as under the present system, Sir Charles agreed, but he added that a unified system with central administration would be an enormous undertaking, and would have to be worked more or less on the Post Office system, and he did not think it would be satisfactory. The tendency of amalgamation and absorption had been in the first instance for the larger companies first to lease and work the smaller concerns. But under complete unification the idea would be to place all railways under one management, and he did not think Parliament would be inclined to hand over the railways to any such central body. He was aware that in America railway companies controlled very much larger areas of distance than in this country. But the class of work considerably differed. In America it was a wholesale business, but in England the work was of a much more general and retail character. For this country he could conceive no better system than the existing amalgamations and working agreements, and he did not think he could recommend much larger units.

In regard to the grouping of companies in zones or divisions, and for the railways operating in those zones to be constituted in one company, he said that such an end would be desirable, but he thought it would be more likely to be attained by removing restrictions which were sought to be placed on companies, and by removing difficulties in the way of getting further powers, than by legislation in the way suggested. If he might be allowed to say so without offence, the policy of Parliament had been constantly to facilitate the inclusion of one railway company in the district of another.

He was in favour of railways being grouped into zones and placed under the management of one company in the interests of shareholders, traders, and the public generally. The public were already getting large advantages by this system of combination.

The general manager of the London and North-Western Railway has recently announced that important concessions will be made to the members of the company's staff. A regrading affecting 1700 persons on the system is to take effect on August 1, the details of which will shortly be issued. There is to be a general promotion to higher classes, involving increases of 10*l*., 20*l*., and 30*l*. yearly, and all receiving the 90*l*. maximum (the lowest class) will now receive 100*l*. The rise will affect the superintendents and the clerks at the passengers and goods stations; it has been brought about by the fact that, with the growth of the company's business, work and responsibility have increased. The concessions, it has been stated, will cost the company thousands of pounds a year, and the cost will continue increasing, since the rise in salaries is permanent, and affects every class of clerk.

The Scottish District Minimum Wage Board have issued an award in regard to the application of the Scottish miners, referred to on page 875 of our last volume, for an increase in the minimum wage from 5s. 10d. to 7s. 6d. per shift, and by other grades of underground workers to a corresponding extent. It has been decided to bring the wages of firemen and shot-firers, who act as firemen, from 5s. 6d. to 5s. 10d., the change to take effect from the first pay-day after the date of the award. No change is made in regard to the other grades of workmen.

At the meeting of the Leeds City Council, held on the 1st inst., a scheme for establishing a thrift fund for the employees of the Leeds Corporation was entered into. It is proposed that the employees shall contribute to the fund at the rate of 9d. in the pound on their wages or salary, the Corporation contributing a similar amount. Compound interest is to be paid at the rate of 3¾ per cent. per annum, and the accumulated sums are to be available on retiring at the age of sixty-five, which, it is suggested, should be fixed as the compulsory retiring age. In the event of the death of a member before that age, arrangements would be made for payment to relatives, and there would also be payment out in the event of an employee ceasing to be a member of the fund.

In introducing the scheme to the Council, Alderman C. H. Wilson (Chairman of the Finance Committee) said he had been charged from time to time with inhuman conduct in having had to do with the scrapping of old men, and he had said before that they had made retiring allowances. They were still making such allowances; but the system seemed to be entirely one-sided. They had had to keep men who were absolutely inefficient, and that was not in the interests of anybody.

Alderman Wilson further said that the scheme was to be voluntary, and with regard to the forfeiture of payments for misconduct, an organised strike would not be deemed misconduct. He estimated the cost at a 2½d. rate, but he declared that this would be saved by stopping the retiring allowances, and by dealing differently with old servants.

It was decided to adjourn the consideration of the scheme until the next meeting of the Council.

We are informed that the Financial Committee of the French Senate have rejected the proposal for the Saturday half-holiday for State employees. The half-holiday for the latter employees had been promised by the Cabinet, and the President of the Republic had given the measure his support. The rejection of the measure may have far-reaching consequences.

The quarterly return, sent on the 29th ult., by the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England, to the Consett Iron Company, Limited, and Mr. Bradley, operatives' representative, relating to the wages to be paid at the Consett Works in the quarter beginning on Wednesday, the 1st inst., reads as follows :—

"We have received from Messrs. Price, Waterhouse and Co. the result of their ascertainment of the average net selling price of steel plates at Consett for the months of March, April, and May, 1914, and we hereby certify that, in accordance with the agreement entered into on March 30, 1898, the wages to be paid to the steel-millmen during the months of July, August, and September will be 2½ per cent. below the rate prevailing during the current quarter."

The men at Consett Works suffered a reduction of 5 per cent. in the quarter beginning March last, and their present wages are 15 per cent. above the standard. Their last advance of 2½ per cent. was in September last year, the wages then being 22½ per cent. beyond the standard; and in the December quarter the wages remained stationary.

The strike at the Copenhagen free harbour, which has lasted for more than half a year, has somewhat unexpectedly been terminated. Several attempts had been made to bring it to a close; the conciliator had done his best, but the men, contrary to the advice of the leaders, were stubborn, and tried to implicate the other harbour hands in the conflict. Renewed negotia-

tions among all the parties concerned have, however, resulted in an agreement, according to which the free harbour company consents forthwith to take back 200 of the men on strike on the same conditions as those in force for the other hands. Both parties undertake to do their best to enable work in the free harbour to progress amicably. The free harbour company has secured the right to keep 299 of the men engaged during the strike of the permanent hands, and a corresponding number of the old men will be without employment. On this point the men would have fared better had they accepted, instead of rejecting, the proposal put to them two months earlier.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, July 1.

THE month of June has shown a general slight improvement in iron and steel. Price concessions are still made on attractive orders. We are entering on the mid-summer shut down. In many cases it will continue through most of this month or until new business justifies. Railroad buying has shown improvement. The Pennsylvania Railroad order has been reported as finally placed at 137,000 tons, 56,000 tons less than last year. No general improvement is expected until general confidence is stronger; notwithstanding the enormous crops about to be harvested, business drags. In pig-iron large producers are being offered contracts for future delivery at current prices, but in several instances these orders have been declined. The 70,000-ton pig-iron order for the New York subway has been finally placed with Pittsburgh and Buffalo foundries. The increased demand for foundry grades is affording encouragement. Basic pig, after several quiet weeks, is now active in the West. Rail orders for the week are 40,000 tons, besides a 10,000-ton order for export to Siam. Car-builders are doing better. Both plate and structural-steel makers are pleased with the volume of business made up of small orders. Bar iron has been shaded to 1.15 dols. Even at that, only necessary material for immediate use is bought. Further curtailment of pig-iron production is in sight. The New York Central Railroad is negotiating for 4000 cars, in addition to the 5300 recently placed. Negotiations are in progress to-day for 80 locomotives and 11,000 cars. The large Persian pipe-line order was taken, and work will soon begin. The pipe-foundries are all busy, and reports indicate a long continuance at maximum capacity.

THE SUEZ CANAL.—The report of the Suez Canal Company for 1913 states that ten years ago vessels with a displacement of more than 4000 tons each passing through the canal represented scarcely 22 per cent. of the total shipping dealt with; last year, however, the proportion rose to 44 per cent. Ships of upwards of 6000 tons displacement, ten years ago, represented only 1 per cent. of the aggregate amount; last year the proportion rose to 5 per cent. In 1912 the average time occupied by vessels in passing through the canal was cut down (by 35 minutes) to 16 hours 19 minutes, and this was maintained last year. The number of vessels which used the canal in 1913 was 5085. Last year, while the total trade done was less than in 1912, it showed a marked gain in the tonnage of loaded merchant ships, the quantity of merchandise carried being 25,775,000 tons, quite a record. The heaviest business was done east and south, and included coke from Great Britain, sugar from Adriatic ports, petrol from Russia and the United States, and phosphates from Algeria and Tunisia. A special feature was the size of the consignments to India and farther Eastern ports of worked metals, machinery, and railway material. Burma, Siam, Indo-China, and East Africa are increasing their trade with Europe, and the same may be said of China and Japan.

THE SAN FRANCISCO EXHIBITION.—The announcement is made that the United States Steel Corporation and its subsidiary companies propose to have a comprehensive exhibit at the Panama-Pacific Exposition in San Francisco in the year 1915. It will begin at the ore-fields and carry on an educative picture of its operations in ore-mining, rail and water transportation, dock operations, coal, coke and pig-iron production, steel manufacturing in its various lines, and will also illustrate the processes of manufacturing of many of its subsidiary companies' products; also how it utilises its by-products, showing many of the uses in which its general products are employed, typifying the advancement in the uses of the country's resources. In addition to these material exhibits the Corporation intends to exhibit in a comprehensive manner, by moving pictures, its operations throughout all departments, showing the ramifications of the processes of the Corporation. It is proposed as well to set forth to the world the work which the United States Steel Corporation has done towards the social welfare of its employees and those depending upon them. Also many forms of safety devices that have been devised by the Corporation officials and its employees. In this social welfare department will also be shown the methods employed by the Corporation for the aid and care of the injured, and the improvement of the employees' conditions at work, and the benefits that are aimed to be afforded to employees at their work and in their surroundings. Also the power that is given to the employees, through their committees, to bring about these improved working conditions and surroundings.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—A further improvement in the export demand has had a strengthening effect upon the hard-steam market, which, in consequence of local industrial weakness, was showing a somewhat irregular tendency. Since the conclusion of stock-taking the manufacturing demand has reverted to a normal condition. Among colliery-owners, however, there is wide complaint that the production is being seriously restricted, and working cost unnecessarily increased, because of miners absenting themselves from work. House coal is dull and weak. Prices continue to decline. The bulk of the yearly contracts, which are generally completed a month before the present date, are still outstanding. The Coal-Owners' Association is as determined as ever to maintain last year's advance, but it is evident that weakness exists somewhere, further contracts having been arranged at 6d. reduction. Slightly quicker progress is being made with renewals of gas-fuel contracts. Deliveries are being expedited so as to clear off arrears on expiring contracts. Slacks are not benefiting to the extent anticipated by the reduction in the house-coal output. Lower grades are very weak. For no class of coke is there more than a moderate demand. Quotations:—Best branch hand-picked, 15s. 6d. to 16s. 6d.; Barnsley best Silkstone, 13s. to 14s.; Derbyshire best brights, 12s. to 13s.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 10s. 6d. to 11s. 6d.; small nuts, 9s. to 10s.; Yorkshire hards, 11s. to 12s.; Derbyshire hards, 10s. 6d. to 11s. 6d.; best slacks, 7s. 6d. to 8s. 6d.; seconds, 5s. 6d.; smalls, 4s. to 5s.

Iron and Steel.—Another almost blank week has been experienced by South Yorkshire pig-iron vendors. Seeing that prices have touched what everybody appears to regard as a rock-bottom level, and that warrant stores are phenomenally low, a revival might be expected at any moment, but at present there is no indication of such a welcome change setting in. Against this is to be set the fact that bar-iron is almost unsaleable, and that there is very little necessity, therefore, to cover contracts. Present depression is seen at its worst in forge iron, which fluctuates greatly. Foundry iron is a more settled medium, and what few contracts have this week been arranged have chiefly been in this product. In both, however, the tendency is downwards. Derbyshire foundry is quoted at 9d. reduction on last month's figures, and Derbyshire forge at 1s. reduction. No further reduction has been made in the official price of Lincolnshire sorts. Though no great amount of business is passing in hematites, values are firm. The current figures are 73s. 6d. for West Coast and 68s. 3d. for East Coast hematite. Since the cessation of excessively hot weather and the completion of stock-taking, the output of steel has greatly increased. New business is now being booked in fairly satisfactory proportions, though there is a good deal of complaint at the size of the orders. There is no revival on home railway account, but requirements of foreign concerns are on a large scale. The activity at the big shipbuilding centres is also fairly reflected in the state of industry in the local engineering shops. Nothing has occurred to mar prosperity in the armament departments, which have substantial contracts on hand for almost every country in the world. Notably is this the case with Messrs. John Brown and Co., who have just completed their jubilee year with very satisfactory results. Makers of both crucible steel and steel billets are not too well placed for new business, but there is little to complain of in either the home or the overseas demand for edge-tools, mining and agricultural implements, or machinery. Steel alloys are a more profitable medium. Scrap, on the other hand, is a drug on the market.

THE DERWENT.—A meeting of a committee who have promoted an application to the Board of Agriculture for the formation of a drainage board for the Derwent Valley was held on Friday at York, to consider a report of Mr. R. F. Grantham, the Commissioner who held an inquiry into the application. Mr. Grantham has considerably modified the extent of the area proposed to be included under the board, but the area is still a workable one. The engineers appointed in connection with the scheme (Messrs. W. Fairbank and Co.) presented a report on the area suggested by the Commissioner, and a sub-committee was appointed to consider the question in connection with certain proposals as to the lower reaches of the river.

STEAM POWER USED FOR GENERATION OF ELECTRIC CURRENT IN PRUSSIA.—According to recent statistics, there were employed for the generation of electric current in Prussia steam-engines, portable and stationary, with a capacity of 1,410,000 horse-power, and steam-turbines used for the same purpose of 1,160,000 horse-power. As the total registered capacity of steam-turbines amounts to 1,240,000 horse-power, it will appear that 95 per cent. of the aggregate is used in the generation of electric energy. Altogether, 2,570,000 horse-power of steam-power are thus employed in the generating of electricity, and although it is a very substantial figure, it must be looked upon as minimum, inasmuch as many steam-engines used for this purpose are not included in the record. In addition to the above it must be remembered that a vast number of gas and oil-engines are used for the same purpose, in addition to water power; but of these there is no record. The largest total capacity of steam power used for generation of electric current is in the Arnsberg district with 389,898 horse-power, and the Dusseldorf district with an aggregate of 419,051 horse-power. Berlin-Potsdam comes next with 375,889 horse-power.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—A marked change for the better is noticeable, at all events so far as Cleveland pig-iron is concerned. This season is usually the quietest period of the year, but there are indications of revival, and several traders now take a much more cheerful view of the outlook, and speak hopefully of a brisk autumn business. The removal of the Russian import duty on pig-iron has brought more inquiries from that quarter than were looked for. One or two more sales to Russia are reported, and further business may follow, though Germany being so favourably geographically placed, will probably benefit most by the Russian concession. Values of Cleveland pig now show an upward movement. One or two small lots of No. 3 g.m.b. have realised 51s. 9d. f.o.b., and the general market quotation is fully 51s. 7½d.; whilst other qualities have also improved, No. 1 having become 54s. 1½d.; No. 4 foundry, 51s. 4½d.; No. 4 forge, 50s. 10½d.; mottled, 50s. 4½d.; and white, 50s. 1½d., all for either early or forward delivery. Better accounts are given of the East Coast hematite pig trade. Though a few contracts for mixed numbers are understood to have been made at rather less, it is now not probable that 59s. could be shaded, and that is the recognised market quotation for practically any delivery. Sellers report a fair amount of business put through at the foregoing quotation, and that buyers are much less disinclined to pay it than they have been. There is practically nothing passing in foreign ore, but prices tend downward, notwithstanding continued high freights, due largely to labour troubles. There are sellers on the basis of 17s. 3d. ex-ship Tees for Rubio of 50 per cent. quality, and consumers declare that they would have no difficulty in buying at the rate of 17s. Sellers of Durham coke show much reluctance to give way at all, but the position is a trifle easier, though the local demand keeps fairly good. For Durham blast-furnace coke, of average quality, 17s. 6d. is still asked for delivery at Teesside works, but business might be done at a trifle less. A good deal of Yorkshire coke is being taken up at comparatively low figures.

Stocks and Shipments.—The stock of Cleveland pig-iron in the public warrant stores here now stands at 78,653 tons—all of which is No. 3 quality. Since the beginning of the month the stock has been increased by 364 tons. Shipments of pig-iron from the Tees are on only a moderate scale. To-date this month they average 3015 tons per working day, the total despatches being returned at 21,105 tons, 19,458 tons of which have gone from Middlesbrough and 1647 tons from Skinningrove. To the same date last month, the loadings were given at 13,388 tons, or a daily average of 1912 tons, and for the corresponding part of July a year ago, the clearances reached 25,958 tons, or an average of 3708 tons per working day.

Manufactured Iron and Steel.—There are no new features of moment in the manufactured iron and steel trades. New orders are scarce. There are, however, orders on the market for rails, but they have not yet been allotted. Principal market quotations stand:—Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 5s.; iron ship-plates, 6*l.* 15s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron girder plates, 7*l.* 5s.; steel bars (basic), 6*l.* 5s.; steel bars (Siemens), 6*l.* 5s.; steel ship-plates, 6*l.*; steel ship-angles, 5*l.* 15s.; steel boiler-plates, 7*l.*; steel joists, 6*l.* 12s. 6d.; steel strip, 6*l.* 5s.; steel hoops, 6*l.* 10s.—all less the customary 2½ per cent. discount; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.*; heavy steel rails, 5*l.* 15s. to 5*l.* 17s. 6d.; steel railway sleepers, 7*l.* 5s.—all net at works; galvanised corrugated sheets, 24 gauge, in bundles, 11*l.* 5s. f.o.b.—less 4 per cent.

Blastfurnacemen's Wages.—The ascertained net selling price of No. 3 Cleveland pig for the months of April, May, and June, has been certified at 51s. 0.70d. per ton, as compared with 51s. 5.13d. in the previous two months. This means a reduction in blastfurnacemen's wages of 0.50 (one-half) per cent., which brings the wages from 24.25 per cent. above the standard to 23.75 per cent. above the standard.

FRENCH TRANSATLANTIC NAVIGATION.—The working of the French General Transatlantic Company in 1913, after providing for reserve and redemption allocations, was attended with a profit of 94.852*l.*, as compared with a corresponding profit of 85,600*l.* in 1912 and 128,686*l.* in 1911. The balance available for 1913 admitted of a dividend of 7s. 2d. per share, 1251*l.* being carried forward.

THE ROAD BOARD—GRANTS TO HIGHWAY AUTHORITIES.—During the months of April, May, and June, 1914, the Road Board indicated additional advances to highway authorities, amounting in the aggregate to 340,112*l.*, of which 277,357*l.* was by way of grant, and 62,755*l.* by way of loan. The total advances made and indicated up to June 30, 1914, amount to 5,553,924*l.*—4,106,462*l.* by way of grant, and 1,447,462*l.* by way of loan. The formal advances by way of grant made, with the approval of the Treasury, during the last quarter, amounting to 267,436*l.*, were applied as follow:—

	£
Road crust improvements	231,753
Road widenings and improvement of curves and corners	24,016
Road diversions	5,125
Reconstruction and improvement of bridges ..	5,542
New roads and bridges	1,000

During the same period, advances by way of loan, amounting to the sum of 105,266*l.*, have been arranged.

RECENT DEVELOPMENT OF EXPRESS LOCOMOTIVES IN FRANCE.*

By Professor EDOUARD SAUVAGE, Member, of Paris.

Two papers on French locomotives by the author of the present one had the honour of discussion at the meetings of the Institution, one, in 1900, on "Recent Locomotive Practice in France,"† and the other, in 1904, on "Compound Locomotives in France."‡ This third paper, dealing with the further development, during the last decade, in the construction of locomotives for express service on French railways, has been prepared in accordance with the Council's desire. For the data and results of experience reported in this paper the author is indebted to the following chief engineers:—M. Lancrenon, of the Est; M Maréchal, of the Paris-Lyons-Méditerranée; M. Nadal, of the State; M. Asselin, of the Nord; M. Solacroup, of the Paris-Orléans; and M. Herdner, of the Midi, Railways, who with the greatest liberality provided him with all the necessary information.

With the exception of some "Atlantics," which are not likely to be reproduced, all engines built for this service since 1904 are six-coupled, either ten-wheelers (4-6) or "Pacifics" (4-6-2). Superheated steam is largely used, especially in the latest constructions. With a few exceptions the Schmidt standard superheater§ has been adopted. Owing to the large tubes necessary to receive the superheating pipes, it frequently happens when a superheater is fitted in a locomotive boiler that the proper heating or vaporising surface is greatly curtailed; in many engines the total of the heating and superheating surfaces is less than the heating surface which might have been obtained without superheating. The figures in Table I. give some examples of this reduction.‖

Without superheaters, the heating surface equals 72 to 77 times the grate area in the four first engines (narrow fire-boxes), and 60 to 62 times in the case of the last (wide fire-boxes). With superheaters, the ratio of proper heating surface to grate area is as low as 50 and does not exceed 60; and, with the exception of the two last engines and of Nos. 3601 to 3605 Paris-Lyons-Méditerranée, the

TABLE I.

—	Numbers.	Grate Area.	Heating Surface.	Superheating Surface.	—
		sq. m. sq. ft.	sq. m. sq. ft.	sq. m. sq. ft.	
Est (Eastern)	3103-3146 3191-3230	3.1607 (34.02)	234.91 (2528.59) 158.85 (1709.85)	37.25 (400.97)	47.37 sq. m. with "Mestre" suph. (509.90 sq. ft.)
P.L.M.	2606-2969 3601-3605 3691-3700	2.98 (32.072)	214.80 (2306.73) 160.90 (1731.89) 149.75 (1611-87)	57.15 (615.33) 33 63 (362.0)	With tubes of 70 mm. dia. (2.76 in.)
Etat (State	230, 571-230, 618 230, 619-230, 705	2.80 (30.14)	206.71 (2225.04) 159.50 (1716.88)	37.50 (403.66)	
Nord (Northern)	2641 2659	2.76 (29.71)	211.30 (2274.43) 164.13 (1766.7)	40.03 (430.89)	
P.O.	3501-3520 3521-3550	4.27 (45.96)	257.25 (2768.99) 210.97 (2270.84)	63.50 (683.53)	
Midi (Southern)	3001-3016 3051-3054	4.02 (43.27)	253.20 (2725.45) 216.29 (2328.12)	60.88 (655.33)	

total surface is reduced. Although the results in service are good in all cases of superheating, this large reduction of heating surface in some boilers cannot be entirely satisfactory.¶ No difficulty is reported to arise from the use of superheaters; they are easily kept in order; valves and pistons, properly lubricated with an efficient oil, do not give signs of undue wear, even with a high superheat, up to 340 deg. Cent. Except on one company, all engines for express service have four cylinders, with a large proportion of compounds; in a few cases, simple expansion in four equal cylinders is used, but the compound system appears altogether to be preferred. The one exception is the recent building, by the Midi Railway, of simple engines with only two cylinders, using superheated steam, for express service.* When superheaters have been added to the four-cylinder compounds, the diameter of the high-pressure cylinders has been increased, the low-pressure cylinders being left unaltered. Piston-valves are generally used on all cylinders, even on non-superheaters; but in a few cases—for instance, on Paris-Orléans engines—flat valves have been preserved on the low-pressure cylinders of superheaters.

The usual practice is to have four separate valve motions, of the Walschaert type, for the different cylinders of the compounds; the reversing-gear can operate at will the high-pressure and the low-pressure motions together, or only one of them. The starting device, when admitting steam directly to the low-pressure cylinders, opens a direct exhaust to the high-pressure. An exception is to be found on the Paris-Lyons-Méditerranée engines; the low-pressure valve-motion gives always the same admission (averaging 63 per 100) backwards and forwards; it is operated by the same screw as the high-pressure motion, but is only transferred from one position to the other when reversing. The high-pressure valve-motion being designed to give a very prolonged admission (up to 88 per 100), the starting device comprises only a cock admitting live steam into the low-pressure cylinders, without special exhaust for the high-pressure.

As regards details, it may be mentioned that, in some engines, the damper-box and doors that enclose in the smoke-box the collectors and ends of superheating pipes have been taken off. No inconvenience seems to result from this suppression. Trouble would arise from a prolonged use of the blower, which may be avoided. If further experience proves that this mechanism can be dispensed with, including the steam-cylinder for the automatic working of the damper, the saving in first cost and expenses for repairs will not be negligible, as well as the reduction in weight of about 300 kg. (660 lb.).† The driver's station, that used to be on the right side of the engine, has been transferred to the left. Bogie-wheels are, as a rule, braked.

TABLE II.—*Principal Dimensions of Recent 4-6 Locomotives, with Superheaters.*

—		Est. 3191-3230. Four-cylinder Compounds.	P.L.M. 2691-2700. Four-cylinder Compounds.	Etat. 230,781-230,800. Four-cylinder Simple.	Nord. 3538-3567, 3578-3597. Four-cylinder Compounds.	Midi. 3501-3516. Two-cylinder Simple.
Grate area	sq. m. sq. ft.	3.1607 (34.02)	2.98 (32.07)	2.78 (29.92)	2.76 (29.71)	2.78 (29.92)
Heating surface	sq. m. sq. ft.	158.86 (1709.90)	149.75 (1611.87)	136.07 (1464.65)	164.13 (1766.77)	160.75 (1730.27)
Superheating surface	sq. m. sq. ft.	37.25* (400.97)	33.63 (362.0)	43.03 (463.18)	40.03 (430.89)	49.32 (530.89)
Tubes, number and outside dimensions	mm. in. mm. in.	21 of 133 (5.23) 28 of 49 (1.93) 75 of 70† (2.76)	21 of 127 (4.99) 19 of 50 (1.97) 64 of 70† (2.76)	22 of 133 (5.23) 139 of 50 (1.97) —	22 of 133 (5.23) 20 of 50 (1.97) 60 of 70† (2.76)	24 of 133 (5.23) 143 of 50 (1.97) —
Length between plates	m. ft. in	4.400 (14-5)	4.000 (13-1)	4.300 (14-1)	4.300 (14-1)	—
Mean dia. of barrel	m. ft. in	1.550 (5-1)	1.500 (4-11)	1.600 (5-3)	1.456 (4-9)	1.533 (5.0)
Height of axis above rail	m. ft. in	2.690 (8-10)	2.600 (8-6)	2.800 (9-2)	2.630 (8-7)	—
Effective pressure	kg. p. sq. cm. lb. per sq. in.	16 (227.6)	16 (227.6)	12 (170.7)	16 (227.6)	12 (170.7)
Volume of water in boiler	cub. m. cub. ft.	5.770 (203.8)	5.420 (191.4)	6.150 (217.2)	4.960 (175.16)	5.440
Volume of steam in boiler	cub. m. cub. ft.	2.855 (100.81)	2.810 (99.2)	2.850 (100.65)	2.720 (96.06)	2.990
Diameter of coupled wheels	m. ft. in.	2.090 (6-10)	2.000 (6-7)	2.040 (6 8)	1.750 (5-9)	1.750 (5-9)
Diameter of cylinders	mm. in. mm. in.	390 (1-3.35) & 590 (1-11.93)	370 (1-2.57) & 540 (1.9.27)	430 (1-4.93) —	380 (1-2.96) & 550 (1-9.66)	590 (1-11.23) —
Stroke of pistons	mm. ft. in.	680 (2-3)	650 (2-2)	640 (2-1)	640 (2-1)	640 (2-1)
Weight empty	kg. tons	71,580 (70.7)	67,440 (66.4)	65,500 (64.4)	64,045 (63.0)	69,800 (68.7)
Weight, working order	kg. tons	77,950 (76.9)	73,200 (72.0)	71,500 (70.4)	69,705 (68.6)	76,300 (75.1)
Weight adhesive	kg. tons	53,110 (52.3)	51,000 (50.2)	48,900 (48.1)	49,680 (49.0)	54,000 (53.1)

* 45.37 sq. m. (488.4 sq. ft.) with Mestre's superheater.
† Serve ribbed tubes.

Two standard types of locomotives are used in France for express service, the ten-wheeler (4-6) and the "Pacific." Tables II. and III. give the particulars of the latest types of these two sorts of engines for the different railway systems.

Details on the practice of each railway system will complete this general view.

EST.

One hundred and thirty six-coupled express locomotives (4-6), four-cylinder compounds, with wheels of 2.090 m. (6 ft. 10.3 in.) diameter, are in service on the Est system. The two first (Nos. 3101-3102), erected in 1903, have been described in the 1904 paper on "Compound Locomotives" (page 362 and Fig. 10, Plate LIII.). They have been followed by:—

Nos. 3103-3128,	erected in	1906-7.
,, 3129-3150,	,,	1907-8.
,, 3151-3164,	,,	1909-10.
,, 3165-3190,	,,	1910.
,, 3191-3230,	,,	1912-13 (Fig. 1, page 47).

Nos. 3147 and following (eighty-four engines) are fitted with superheaters.

For the flat valves of the two first engines (Nos. 3101-3102), piston-valves have been substituted in all others. The diameters of the cylinders, 350 mm. (13.78 in.) and 560 mm. (22.05 in.), with 660 mm. (25.98 in.) stroke in these two engines, have been enlarged to 360 mm. (14.17 in.) and 590 mm. (23.2 in.). ; further, to 390 mm. (15.4 in.) for the high-pressure cylinders of the superheating engines (Nos. 3147-3230). Might not the low-pressure cylinders be enlarged, too, with advantage? But these cylinders, with their diameter of 590 mm. (23.2 in.), occupy the whole available space between the frames, and an increase of size would involve a radical change in the plan of the engine, which was not thought advisable.

Engines Nos. 3103-3164 have two steam-domes, but Nos. 3165 and following have only one.

Other systems of superheaters besides the Schmidt have been experimented upon. First, for fear of overheating the high-pressure cylinders, superheating in two stages was resorted to; high-pressure steam being moderately superheated, receiver steam passed a second superheater. This plan has been abandoned. A "helical superheater," on the principle of the Field tube, with ribs, was fitted to some engines, and was abandoned, too, on account of its insufficient surface and of the difficulty of cleaning its outside ribs. Another system is the Mestre squirrel-cage superheater, Fig. 2, page 47, which is working on some engines and gives ample surface.

It may be mentioned that in engines Nos. 3129-3146 the receiver comprises a number of large pipes in the smoke-box, with a heating surface of 7.736 sq. m. (83.3 sq. ft.), the object being to dry or even to superheat the low-pressure steam. This contrivance does not seem to have any well-marked effect. The ends of the superheating tubes, which are steel castings in Schmidt's system, come close to the fire-box, the distance being reduced to 550 mm. (21.7 in.). It has been found that these castings are rapidly covered with a slag deposit that protects them from a too intense heat. With the exception of the points mentioned, the several lots of these engines show but slight differences. The principal dimensions are given in Table II. The heating surface is computed on the side in contact with combustion gases; in the case of Serve tubes it is reckoned as the mean between the actual surface ribs included and the surface of a plain tube of the same inside diameter. The surface of the superheaters is the mean between their inside and outside surfaces.

As usual, the cylinders are provided with air relief-valves, which open automatically when steam is shut off; they are quite necessary with piston-valves unless Schmidt's by-pass be used. Some trouble having been experienced in the working of these valves, which must be large, they have been replaced by groups of six small ones (see Fig. 3, page 47). All wheels, bogie included, are fitted with brake-blocks. These engines have six-wheel tenders, holding 22 cub. m. (4850 gallons) of water and 8 tons of coal, weighing empty 20 tons.

Mr. Lancrenon, Chief Engineer of the Est Railway, declares these six-coupled engines give entire satisfaction. Although utilised mainly for fast trains, they can negotiate all passenger and even occasionally heavy goods trains. They attain easily the limit speed of 120 km. (74.6 miles) an hour, and run smoothly without injuring the track; the expenses for keeping up, as well as coal and water consumption, are moderate.

In addition to these express engines, the Est Railway's stock comprises 212 locomotives of a similar type, with wheels of 1.750 metres (5 ft. 8.9 in.), which may occasionally haul express trains. These engines have been mentioned in the previous papers on locomotives.* The "Atlantic" engines of the same company, described in the 1904 paper (Fig. 8, Plate 25), number only two, ordered for sake of comparison with the 4-6 engines.

As regards boiler pressure, the practice of the Est Railway is to reduce the maximum allowed by one unit, so as to be certain that this maximum is never exceeded. On boilers marked 16 kg. per sq. cm. (227.6 lb. per sq. in.) the safety-valves blow off at 15 kg. per sq. cm. (213.35 lb. per sq. in.).

PARIS-LYONS-MÉDITERRANÉE.

Since 1904 the Paris-Lyons-Méditerranée Railway ordered:—160 six-coupled bogie engines (4-6) from 1905 to 1909; 20 "Atlantics" in 1906; 177 "Pacifics" from 1909 to 1912; all with 2 m. (6 ft. 6.74 in.) driving-wheels.

To these may be added 170 ten-wheelers, with 1.80 m. (5 ft. 10.9 in.) wheels, ordered in 1910, and utilised on certain lines for express trains.

Of these 527 locomotives, 198 have superheaters; all have four cylinders, and are compounds, with the exception of 91 engines using superheated steam in four equal cylinders, on the simple expansion principle.

The 4-6 and the "Atlantic" locomotives were designed in 1904, with the same boilers and cylinders. Owing

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* Paper read before the Institution of Mechanical Engineers at Paris, July 7, 1914.

† Proceedings of the Institution of Mechanical Engineers, 1900, page 375.

‡ *Ibid.*, 1904, page 327.

§ A description of the Schmidt superheater will be found in Mr. Flamme's paper, "Superheaters Applied to Locomotives on the Belgian State Railways" (Proceedings of the Institution of Mechanical Engineers, 1905, page 409, and Plates 15, 16, and 17). See also Mr. Fowler's paper, "Superheating Steam in Locomotives" (Proceedings of the Institution of Civil Engineers, 1913-1914).

‖ In France the heating and superheating surfaces are generally computed on the side in contact with combustion gases, including the whole surface of the ribs in the case of Serve tubes. An exception on the Est Railway will be mentioned. All measures in the present paper are metric, with the abbreviations adopted by the International Committee of Weights and Measures (Proceedings of the Institution of Mechanical Engineers, 1900, page 394).

¶ This question has been mentioned in F. H. Trevithick and P. J. Cowan's paper on "Some Effects of Superheating and Feed-Water Heating on Locomotive Working" (Proceedings of the Institution of Mechanical Engineers, 1913, Part II., page 345), but treated from a different point of view.

* Simple engines on the same principle exist on other railways, but not for fast service.

† When the damper is shut, the superheater elements lose their heat quickly, and take some time to regain it; this practically reduces the advantage of superheating for trains frequently stopping. For this reason the Midland Railway designed an apparatus to keep the doors open when the regulator is shut, provided the blower does not come into operation.

* Proceedings of the Institution of Mechanical Engineers, 1900, Fig. 12, Plate 46; and 1904, Fig. 3, Plate 50, and Fig. 9, Plate 52.

to the very good results obtained from the six-coupled, which have over the "Atlantics" the advantage of a greater adhesive weight, the building of engines of this latter class has been discontinued. Of these 160 ten-wheelers (Nos. 2601-2760), 10 (Nos. 2691-2700) have been built with an ordinary Schmidt superheater; 5 engines (Nos. 2601-2605), built in 1905, received later on a special Schmidt superheater, with small tubes and two collectors; these engines having Serve tubes of 70 mm. (2.76 in.) outside diameter, the superheating tubes found room in tubes of the same diameter without ribs.

In Nos. 2691-2700 (Fig. 4), built with superheaters, the diameter of the high-pressure cylinders has been increased from 340 mm. (13.39 in.) to 370 mm. (14.57 in.), the low-pressure cylinders remaining the same—540 mm. (21.27 in.). Of the five engines, fitted later on with superheaters, three only had their high-pressure cylinders increased, in view of comparative experiments. Table II. gives the principal dimensions of these engines.

A more powerful engine being wanted, a "Pacific" was designed in 1908, and 177 were put in service, in different lots, showing some differences. The main question to be resolved was whether, with superheated steam, simple expansion and a moderate boiler pressure and the net coal consumption (deduction made for lighting up) from 1.35 kg. (2.98 lb.) to 1.59 kg. (3.5 lb.). In some cases as much as 700 kg. (1543 lb.) of coal were shovelled in per hour and square metre (10 764 sq. ft.) of grate.

Compound locomotive 6204 hauled trains of 646 tons at an average speed of 80 km. (49.7 miles) to 90 km. (55.9 miles) an hour from Laroche to Blaisy; 2425 horse-power (2391 British horse-power) was indicated, and 1604 horse-power (1582 British horse-power) registered by the dynamometer on the pull-bar. The water consumed per hour and indicated horse-power varied from 6.13 kg. (13.51 lb.) to 6.82 kg. (15.03 lb.), the gross coal consumption from 1.03 kg. (2.27 lb.) to 1.22 kg. (2.69 lb.), and the net coal consumption from 0.933 kg. (2.06 lb.) to 1.08 kg. (2.38 lb.). The rate of combustion never exceeded 537 kg. (1183.9 lb.) per hour and square metre (10.764 sq. ft.) of grate.

Mr. Maréchal, Chief Engineer of the Paris-Lyons-Mediterranée Railway concludes: "The experiments show the compound locomotives at the same time more powerful and more economical than the simple. In consequence we discontinued the building of simple engines."

The 170 4-6 engines (Nos. 2430-2599) have the same general lines as the 2601-2760, but with smaller wheels, 1.800 m. (5 ft. 10.87 in.) instead of 2 m. (6 ft. 6.74 in.),

TABLE III.—PRINCIPAL DIMENSIONS OF RECENT PACIFIC ENGINES.

		P. L. M.		ETAT.	NORD	PARIS-ORLEANS.		MIDI.	
		4-Cylinder Compounds. Nos. 6201-6285.	4-Cylinder Simple. Nos. 6172-6191.	4-Cylinder Compounds. Nos. 231-501, 231-556.	4-Cylinder Compounds. Nos. 3-1151, 3-1170.	4-Cylinder Compounds without Superheater. Nos. 3501-3520.	4-Cylinder Compounds with Superheater. Nos. 3521-3590.	4-Cylinder Compounds. Nos. 3051-3054.	2-Cylinder Simple. Nos. 3101-3104.
Grate area	sq. m.	4.25		4.27	3.22	4.27		4.02	4
	sq. ft.	(47.75)		(45.96)	(34.67)	(45.96)		(43.27)	(43.06)
Heating surface	sq. m.	202.13	219.31	210.97	212.98	257.25	211.07	216.29	201.40
	sq. ft.	(2175.3)	(2360.6)	(2270.84)	(2292.5)	(2768.99)	(2271.95)	(2328.12)	(2167.9)
Superheating surface	sq. m.	64.47	70.63	63.50	45.00	,,	62.60	60.88	71.50
	sq. ft.	(693.98)	(760.28)	(683.5)	(484.4)		(673.9)	(655.3)	(769.7)
Tubes, number and outside diameter	mm.	28 of 133		24 of 133	24 of 133	,,	24 of 133	24 of 133	28 of 133
	in.	(5.23)		(5.23)	(5.23)		(5.23)	(5.23)	(5.23)
	mm.	143 of 55		151 of 55	90 of 70*	257 of 55	151 of 55	145 of 57	122 of 57
	in.	(2.17)		(2.17)	2.76)	(2.17)	(2.17)	(2.24)	(2.24)
Length between plates	m.	5.500	6.000	5.900	4.500	5.900		—	—
	ft. in.	(18-0.53)	(19.8)	(19-4.3)	(14-9)	(19-4.3)			
Mean diameter of barrel	m.	1.661	1.681	1.680	1.641	1.680		1.680	1.696
	ft. in.	(5-5.39)	(5-6)	(5-6.13)	(5-4.61)	(5-6.13)		(5-6.13)	(5-6.77)
Height of axis above rail	m.	2.900		2.850	2.820	2.850		—	—
	ft. in.	(9-9.7)		(9-4.2)	(9-3)	(9-4.2)			
Effective pressure	kg. per sq. cm.	16	14	16	16	16		16	13
	lb. per sq. in.	(227.57)	(199)	(227.57)	(227.57)	(227.57)		(227.57)	(184.90)
Volume of water in boiler	cub. m.	7.630	8.220	8.500	6.500	8.620	8.220	8.180	—
	cub. ft.	(269.47)	(290.30)	(300.19)	(229.56)	(304.43)	(290.30)	(288.89)	
Volume of steam	cub. m.	3.360	3.580	3.600	3.760	3.800	3.800	3 790	—
	cub. ft.	(118.66)	(126.43)	(127.14)	(132.79)	(134.20)	(134.20)	(133.85)	
Diameter of coupled wheels	m.	2		1.940	2.040	1.940		1.940	1.940
	ft. in.	(6-7)		(6-4.41)	(6-8.28)	(6-4.41)		(6-4.41)	(6-4.41)
Diameter of cylinders	mm.	440	4 of 480	420	410	390	420	400	630
	ft. in.	(1-5.33)	(1-7)	(1-4.54)	(1-4.14)	(1-3.35)	(1-4.54)	(1-3.75)	(2-0.80)
	mm.	and 650		and 640	and 600	and 640	and 640	and 620	—
	ft. in.	(2-1.59)		(2-1.20)	(1-11.62)	(2-1.20)	(2-1.20)	(2-0.41)	
Stroke of pistons	mm.	650		650	660	650		650	650
	ft. in.	(2-1.59)		(2-1.59)	(2-1.98)	(2-1.59)		(2-1.59)	(2-1.59)
Weight, empty	kg.	82,560	83,460	86,000	78,185	81,400	84,200	82,170	80,000
	tons	(81.3)	(82.14)	(84.7)	(76.9)	(80.1)	(82.9)	(80.9)	(78.7)
,, in working order	kg.	91,210	93,060	95,000	85,570	90,400	92,800	91,300	89,000
	tons	(89.8)	(91.6)	(93.6)	(84.2)	(88.9)	(90.7)	(89.9)	(87.9)
,, adhesive	kg.	55,500		54,000	49,170	52,500	52,950	54,000	54,000
	tons	(54.9)		(53.1)	(48.4)	(51.7)	(52.1)	(53.1)	(53.1)

* Serve tubes.

were not as advantageous as the compound system with a higher pressure.

The two first "Pacifics," delivered in 1909, were a four-cylinder compound (No. 6001), to which a Schmidt superheater was added in 1913, and a four-cylinder simple (No. 6101), with superheater and pressure reduced to 12 kg. per sq. cm. (170.7 lb. per sq. in.); afterwards seventy similar simple engines (Nos. 6102-6171) were ordered, but it must not be inferred that the question of simple expansion *versus* compound was definitely settled, as the orders in 1912 comprise eighty-five four-cylinder compounds (Fig. 5, page 48) with superheaters (Nos. 6201-6285), and twenty four-cylinder simple engines (Nos. 6172-6191). In these last engines the boiler pressure was increased from 12 kg. to 14 kg. per sq. cm. (170.7 lb. to 199.1 lb. per sq. in.), as it was noticed that in the first engines the drop of pressure from boiler to steam-chest amounted frequently to 3 kg. per sq. cm. (42.67 lb. per sq. in.), owing to the presence of the superheater.

All "Pacifics" have plain tubes, without ribs, with an outside diameter of 55 mm. (2.17 in.), in relation with their great length, 5.50 m. (18 ft. 0.5 in.) and 6 m. (19 ft. 8.22 in.). The principal dimensions of these "Pacifics" will be found in Table III., above.

A tender holding 28 cub. m. (6180 gallons) of water and 5 tons of coal, carried on two bogies, has been designed for the "Pacifics." It weighs, empty, 28 tons.

Comparative trials of No. 6102 (simple) and No. 6204 (compound) took place between Laroche and Dijon, the line rising from Laroche to Blaisy (distance 132 km.) (82 miles) with long continuous grades of about 5 mm. per metre (1 in 200).

With trains weighing as much as 487 tons, locomotive 6102 (simple) indicated 2051 horse-power* (2022 British horse-power), the utilised power on the draw-bar being 1364 horse-power (1342 British horse-power). The water consumed per hour and indicated horse-power varied, in the different experiments, from 8.67 kg. (19.1 lb.) to 9.77 kg. (21.5 lb.), the gross coal consumption, including lighting up of fires, from 1.55 kg. (3.42 lb.) to 1.81 kg. (4 lb.),

* 1 French horse-power equals 75 kilogramme-metres (542.5 ft.-lb.) per second (32,550 ft.-lb. per minute).

boilers a little more powerful (grate area, 3.08 sq. m. (33.2 sq. ft.) against 2.98 sq. m. (32.1 sq. ft.)), heating surface, 239.64 sq. m. (2579.5 sq. ft.) against 214.30 sq. m. (2306.7 sq. ft.), cylinders of 370 mm. (14.57 in.) and 590 mm. (23.23 in.) against 340 mm. (13.39 in.) and 540 mm. (21.27 in.) with same stroke of 650 mm. (25.59 in.). The object was to have a powerful engine to haul express trains on difficult profiles, where the permanent way could not allow the running of "Pacifics." It will be noticed that these engines have no superheaters.

ETAT.

The express engines ordered by the State railways (formerly Ouest) since 1904, include 10 "Atlantics," built in 1905, 273 4-6 engines, and 108 "Pacifics."

The "Atlantics" are four-cylinder compounds, with cylinders of 360 mm. (14.17 in.) and 600 mm. (23.62 in.) by 640 mm. (25.20 in.), wheels of 2.040 m. (6 ft. 8.31 in.), grate area 3.10 sq. m. (33.4 sq. ft.), and heating surface 239.40 sq. m. (2576.9 sq. ft.).

Of the 4-6 engines, 108 (Nos. 230,511-230,618), built from 1904 to 1908, are similar to Nos. 2701-2720, described in the 1904 paper on compound locomotives (page 355 and Fig. 2, Plate 50), with unimportant differences; 87 (Nos. 230,619-230,705), built in 1908 and 1912, have a larger grate area, 2.80 sq. m. (30.14 sq. ft.), and Schmidt superheaters, the diameter of the high-pressure cylinders being enlarged to 380 mm. (14.96 in.). The heating surface is 158.50 sq. m. (1706.1 sq. ft.), and the superheating surface 37.50 sq. m. (403.7 sq. ft.).

Another lot comprises 58 engines (Nos. 230,801-230,858), built from 1908 to 1912, on about the same lines, but with smaller wheels, 1.850 m. (6 ft. 0.83 in.), instead of 1.940 m. (6 ft. 4.38 in.), a somewhat larger boiler and bigger cylinders, 360 mm. (14.17 in.) and 600 mm. (23.62 in.) by 640 mm. (25.20 in.), without superheat.

Nos. 230,781-230,800, with superheaters, Fig. 6, page 48, are simple-expansion engines, with four equal cylinders, 430 mm. (16.93 in.) by 640 mm. (25.20 in.). The principal dimensions are given in Table I.

Of the "Pacifics," two (Nos. 231,001-231,002), built in 1908, are four-cylinder compounds without superheaters, with wheels of 1.940 m. (6 ft. 4.38 in.). The fifty following ones (Nos. 231,011-231,060), equally four-cylinder compounds without superheaters (Fig. 7, page 48) have smaller wheels, 1.850 m. (6 ft. 0.83 in.), and date from 1910. The fifty-six, Nos. 231,501-231,556, four-cylinder compounds with superheat, are not yet in service. The wheel diameter of 1.940 m. (6 ft. 4.38 in.) has been reverted to. Piston-valves are used on the high-pressure cylinders and flat valves on the low-pressure. The same shape of grate as on the Paris-Orleans (Fig. 13, page 50), is used, narrow in front, wider in the back part, but with a half cylindrical outer shell, flush with the barrel, instead of the flat Belpaire top. The principal dimensions are given in Table III.

No precise experimental data, referring to the types of engines mentioned, are available. As regard the comparison of simple four-cylinder engines *v.* compounds, all with superheaters, the impression of some officials of the State railways seems to be in favour of the compound principle. Troughs for picking up water have been established close to Arnières, 115 km. (71.5 miles) from Paris on the Caen line, and 121 tenders are fitted with scoops; 56 more are in preparation.

NORD.

The locomotives used for fast trains on the Nord since 1904, all four-cylinder compounds, are:—

Thirty-five "Atlantics," the last fifteen of which (Nos. 2661-2675) have been built in 1904-5; 150 4-6 engines (Nos. 3513-3662), erected from 1909 to 1912; two "Baltic" engines (4-6-4), Nos. 3,1101-3, 1102, built in 1911; twenty "Pacifics" (Nos. 3,1151-3, 1170), built in 1912.

TABLE IV.

	"Atlantic" No. 2641 (Saturated Steam).	"Atlantic" No. 2659 (Superheated Steam).
No. and date of train	179, August 22, 1900	179, April 19, 1913
Weight of train	322 tons	356 tons
Average speed on level	107 km. an hour (66.5 miles)	113 km. an hour (70.21 miles)
Average speed on 5 mm. per m. (1 in 200) incline	90 km. an hour (55.9 miles)	93 km. an hour (57.8 miles)
Mean indicated power on level	1235 h.-p. (1217.7 h.-p.)	1435 h.-p. (1414.9 h.-p.) (increase 16, 2 p. 100)
Mean indicated power on 5 mm. (1 in 200) incline	1295 h.p. (1276.9 h.-p.)	1510 h.-p. (1488.9 h.-p.) (increase 16, 6 p. 100)
Water consumed per km. (0.621 mile) per ton-km.	Not measured	91.5 l. (20.13 gals.) 0.257 l. (0.057 gal.)
Coal consumed per km. (0.621 mile) per ton-km.	Not measured	16 kg. (35.27 lb.) 0.0449 kg. (0.099 lb.)
Duration of run, Paris-St. Quentin (153 km.) (95.1 miles)	1 hr. 35 min. 45 sec.	1 hr. 35 min.

Of the "Atlantics" twenty were in service before 1904, and have been described in the Proceedings of the Institution of Mechanical Engineers (1900, page 400, and Fig. 11, Plate 46; 1904, page 334, and Fig. 1, Plate 50*). To the new ones superheaters have been added; the heating surface, 211.30 sq. m. (2274.4 sq. ft.) was reduced to 164.13 sq. m. (1766.7 sq. ft.), with a superheating surface of 40.03 sq. m. (430.9 sq. ft.); the high-pressure cylinders have been enlarged from 340 mm. (13.39 in.) to 390 mm. (15.35 in.), the low-pressure remaining at 560 mm. (22.05 in.); pistons have been substituted for flat valves. Steam is admitted in the centre of the piston-valves of the high-pressure cylinders, and the valve-rods are at a greater distance from the piston-rods than with the flat valves. For these reasons the motion derived from the Walschaert gear is transmitted to the valve-rod by a combination of levers (Fig. 8, page 48), which may appear somewhat complicated, the motive being the desire to change as little as possible the design of the old engine. By a modification of the compensating beams, the adhesive weight has been increased from 33 tons to the new limit of 36. The results in Table IV. prove the advantage of superheating. With the normal weight of 250 tons for this train, the consumption per kilometre was 11.9 kg. (26.24 lb.) of coal and 83 litres (18.26 gallons) of water (0.0476 kg. (0.105 lb.) of coal per ton-km.), with superheat, against 13.7 kg. (30.20 lb.), and 109 litres (23.98 gallons) without (0.0548 kg. (0.121 lb.) per ton-km.). Thus the new engine shows an economy of 13.1 per 100 on coal, and 23.85 per 100 on water.

The 4-6 engines, with 1.750-m. (5-ft. 8.8-in.) wheels (Fig. 9, page 50), have been designed for express trains, weighing 350 tons and more, with frequent stoppages. They have the boilers of the "Atlantics," and the frames and motions of former 4-6 engines, Nos. 3078 3354.* The small diameters of wheels resulted from the necessity to keep down their weight, as a compensation for the increase due to the boiler; narrow limits per axle and per metre of length were not to be exceeded; at that time some bridges on the main lines, not yet renewed, could not allow heavier engines. Experience has proved that, even with that diameter of 1.750 m. (5 ft. 8.8 in.), provided the cylinder ports were large enough, speeds of 110 km. (68.4 miles) to 115 km. (93.2 miles) an hour were quite easy. These engines take frequently the place of "Atlantics," even with the faster trains, the only practical difference being a difficulty to attain a speed of 120 km. (74 6 miles) an hour.

The 57 first engines have cylinders of 350 mm. (13.78 in.) and 550 mm. (21.66 in.) by 640 mm. (25.20 in.) as the old Nos. 3078-3354, but the ports are 30 and 24 per 100 larger, being 35 mm. (1.38 in.) by 350 mm. (13.78 in.),

* Proceedings of the Institution of Mechanical Engineers, 1900, page 404, and Fig. 13, Plate 47.

instead of 35 mm. (1.38 in.) by 270 mm. on the high-pressure cylinders, and 40 mm. (1.58 in.) by 520 mm. (20.48 in.) instead of 40 mm. (1.58 in.) by 420 mm. (16.54 in.) on the low-pressure cylinders.* Balanced flat valves are used. The wheels have no splashers, the running-board extending above; a transverse foot-plate, as low as possible, behind the crank-axle, facilitates the visit and lubrication of the inside motion. A door is provided in front of the cab, on the right-hand side.

The 25 first engines use saturated steam; the 125 following (Nos. 3538-3662), erected since 1911, have Schmidt superheaters; their high-pressure cylinders have been enlarged from 350 mm. (13.78 in.) to 380 mm. (14.96 in.), and fitted with piston-valves of 200 mm. (7.87 in.) diameter, the valve motion being altered as on Fig. 8, page 48.

The principal dimensions of these engines will be found in Table II., page 45.

The six-wheeled tenders of some of these engines have been designed with a view of reducing, as far as possible, the firemen's work. As seen in Fig. 9, page 49, the coal-tank is entirely in front, with a bottom sloping at an angle of 45 deg. On both sides auxiliary tanks are provided for briquettes, which are also close at hand.*

Owing to the moderate diameter of the wheels, these engines may be used for every kind of service; they negotiate heavy goods as well as fast passenger trains. This has proved a great convenience on the Nord, where in autumn the goods traffic is enormous, whilst in summer and on holidays a large number of supplementary expresses, all heavy, have to be run. The figures in Table V., page 51, give a fair idea of the results obtained.

* In his paper on "Compounding and Superheating in Horwich Locomotives," Mr. George Hughes advocates large ports (Proceedings of the Institution of Mechanical Engineers, 1910, page 423).

* A description of this tender will be found in *Revue générale des Chemins de fer et des Tramways*, August, 1909, page 99, and Plate XIV.

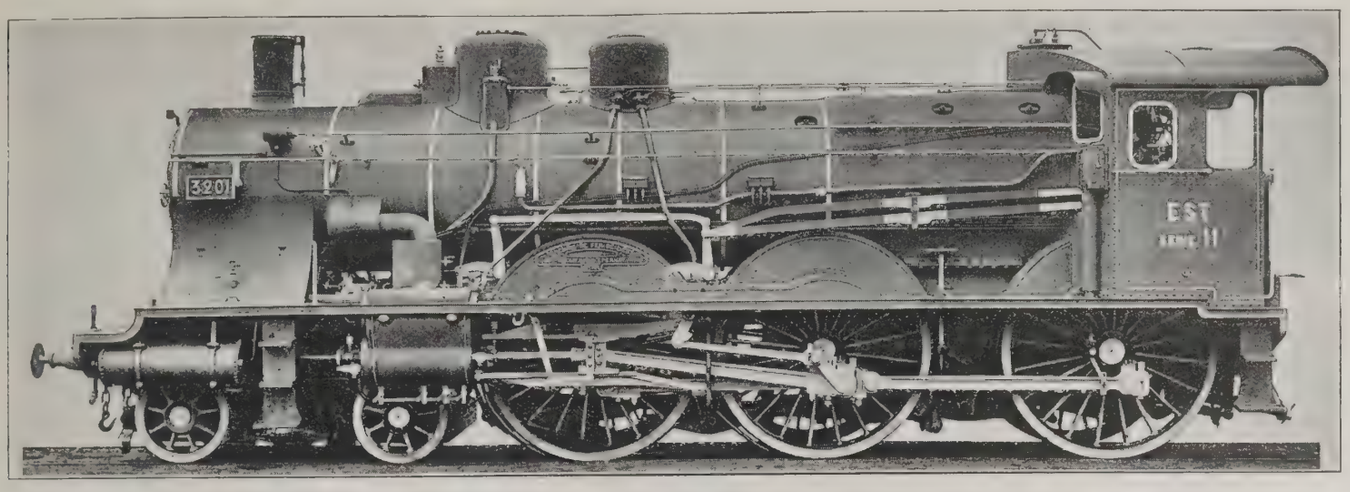


FIG. 1. LOCOMOTIVES NOS. 3191-3230; EASTERN RAILWAY OF FRANCE.

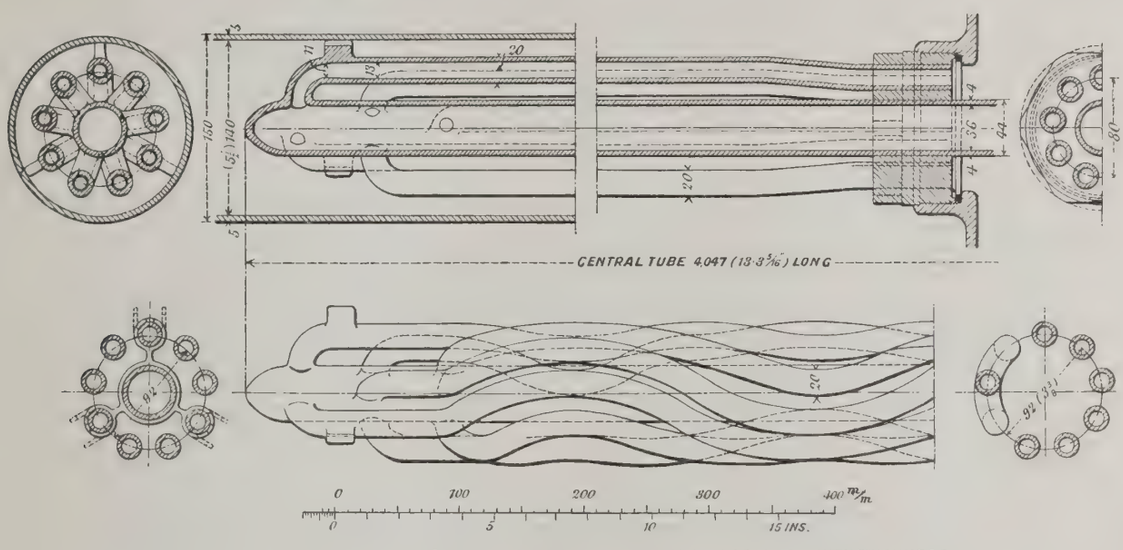

CENTRAL TUBE 4,047 (13·3 5/16") LONG
0 100 200 300 400 m/m.
0 5 10 15 INS.
TOTAL LENGTH OF CENTRAL TUBE 13 FEET 3 5/16 INCHES LONG × 1·42 INCH INSIDE DIAMETER × 0·16 INCH THICKNESS.
165 780 (2' 6 11/16") 165
SKETCH SHOWING JUNCTIONS IN THE 9 SURROUNDING TUBES.

FIG. 2. MESTRE SQUIRREL-CAGE SUPERHEATER.

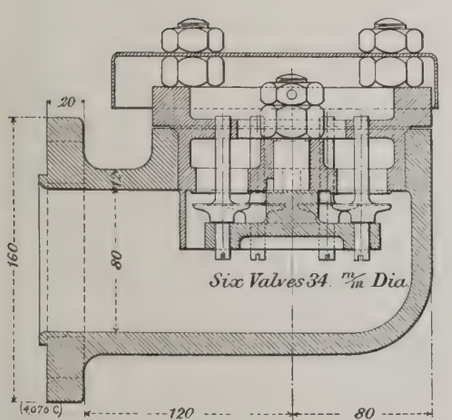


FIG. 3. SEXTUPLE AIR-RELIEF VALVES; EASTERN RAILWAY OF FRANCE.

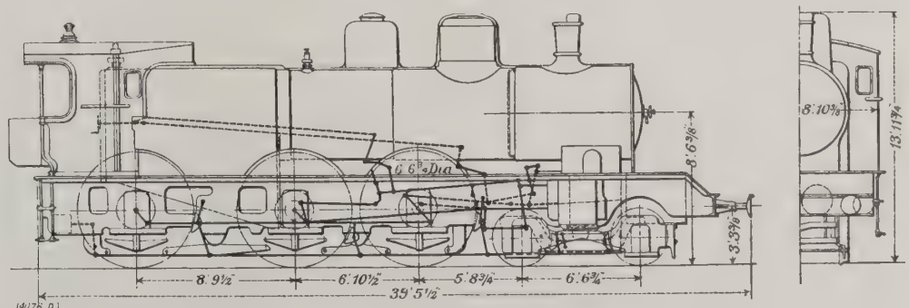


FIG. 4. LOCOMOTIVES NOS. 2601-2605 AND NOS. 2691-2700; PARIS-LYONS-MÉDITERRANÉE RAILWAY.

The two experimental engines, Nos. 3,1101-3,1102, called "Baltic," have been designed (in 1911) to haul weights of 400 tons at speeds of 120 km. (74.6 miles) an hour on the level, and 95 km. (59 miles) on 5 mm. (1 in 200) on their high-pressure cylinders instead of air-relief valves. After the results of experiments on the first of these engines, the section of the steam-pipes, the length of ports of high-pressure cylinders, and the travel of

The indicated power in regular working attains 1900 to 2000 horse-power (1972 British horse-power); 2120 horse-power (2090.52 British horse-power) has been registered once. With a train of 422 tons the speed has been in-

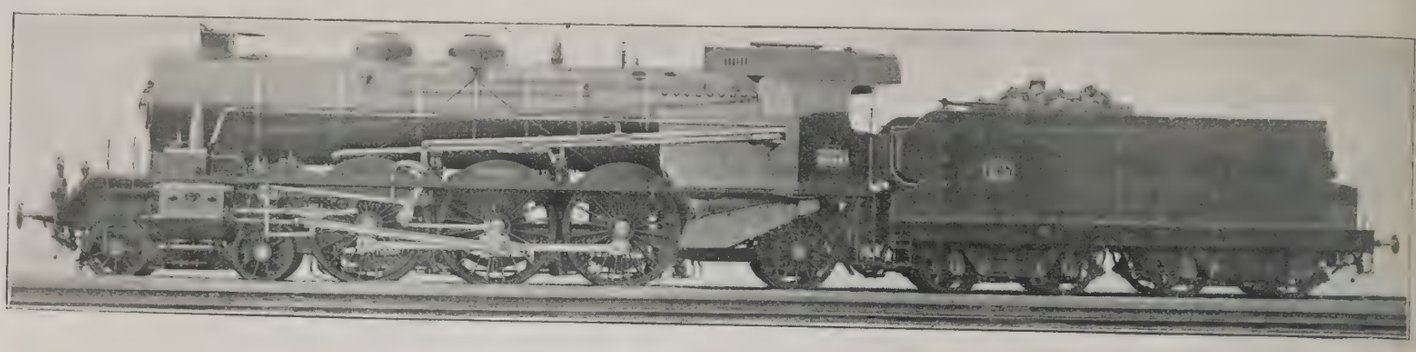


FIG. 5. LOCOMOTIVES NOS. 6201-6285; PARIS-LYONS-MÉDITERRANÉE RAILWAY.

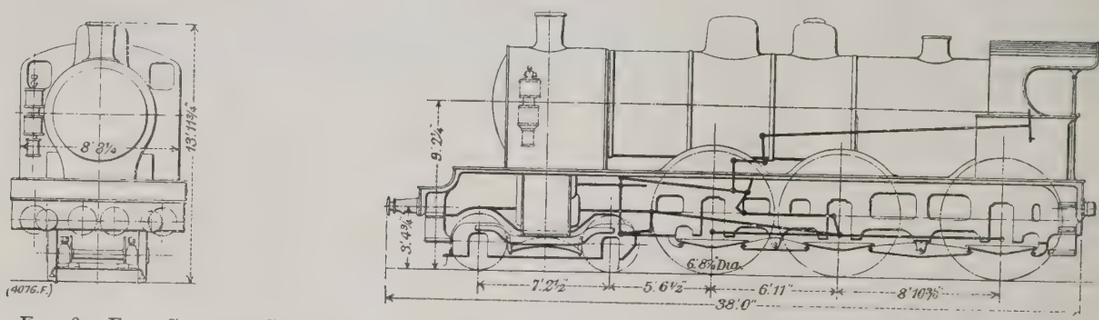


FIG. 6. FOUR-CYLINDER SIMPLE-EXPANSION LOCOMOTIVES NOS. 230,781-230,800; STATE RAILWAYS OF FRANCE.

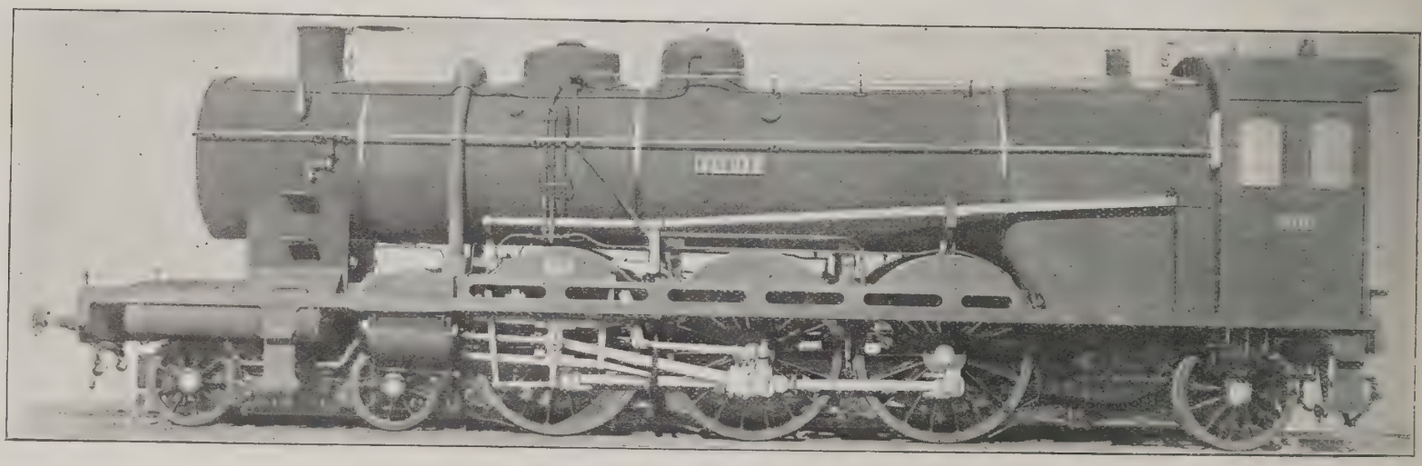


FIG. 7. "PACIFIC"-TYPE LOCOMOTIVES NOS. 231,011-231,060; STATE RAILWAYS OF FRANCE.

grades. These performances require an indicated power of 2200 horse-power (2170 British horse-power). The engine is carried on two bogies and six-coupled wheels of 2.040 m. (6 ft. 8.3 in.) diameter, Fig. 10, page 49. The lateral play of the front bogie is 50 mm. (1.97 in.), and of the rear bogie 120 mm. (4.72 in.). The principal dimensions are :—

Grate area	4.28 sq. m. (46.07 sq. ft.)
Heating surface ...	316.08 sq. m. (340.2 sq. ft.)
Superheating surface ...	70.00 sq. m. (753.5 sq. ft.)
Diameter and stroke, high-pressure cylinders	450 mm. (17.72 in.) by 640 mm. (25.20 in.)
Diameter and stroke, low-pressure cylinders	620 mm. (24.41 in.) by 730 mm. (28.74 in.)
Weight empty	103,200 kg. (227,510 lb.)
Weight in working order	113,010 kg. (249,140 lb.)
Weight, adhesive ...	55,510 kg. (123,380 lb.)

The two low-pressure cylinders inside the frames are, owing to their large diameter, one in front of the other, the distance between their axes being 385 mm. (15.2 in.) only.

The tender, carried on two bogies similar to the engine bogies, weighs empty, 25,210 kg. (55,600 lb.), and holds 26 cub. m. (918.2 cub. ft.) of water and 7 tons of coal. Table VI., page 51, gives the results obtained. It was not thought advisable to build more "Baltics" before a longer experience; for this reason 20 "Pacifics," Fig. 11 (page 49), began service at the end of 1912 with same diameter of wheels that the "Atlantics" had, but with a greater power and more adhesive weight. The principal dimensions of these "Pacifics" are given in Table III.

One peculiarity of these engines is the use of by-passes valves have been increased, with a notable gain of power. Two of the best performances, shown in Table VII., page 51, may be compared with the "Baltics."

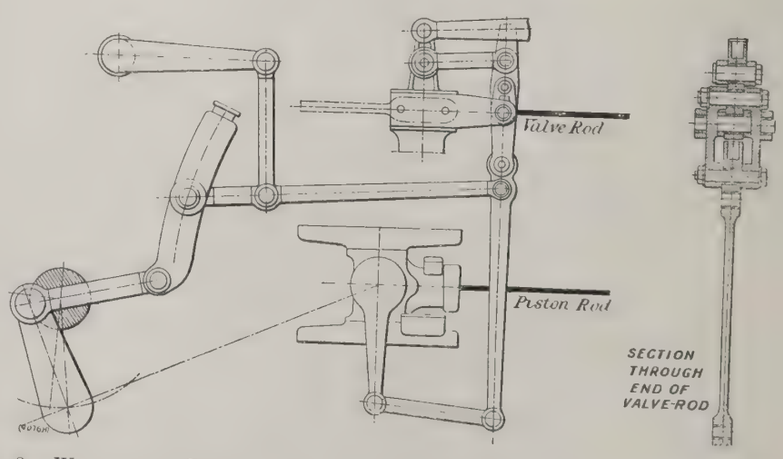


FIG. 8. WALSCHAERT GEAR FOR PISTON-VALVES WITH CENTRAL ADMISSION; NORTHERN RAILWAY OF FRANCE.

creased from 35 km. (21.7 miles) to 92 km. (57.2 miles) an hour on the 5 mm. (1 in 200) grade from St. Denis to Goussainville. On the 8-mm. (1 in 125) grade from

Marquise to Caffiers,* 8 km. (4.97 miles) long, the speed fell from 104 km. (64.6 miles) to only 75 km. (46.6 miles) an hour, with the same train.

As regards superheating, it has been adopted for all enced. The Nord engineers are of opinion that superheating and compounding must be combined.

The author cannot conclude better than by reproducing the terms of a letter from M. Asselin, chief engineer of 'Atlantics' by the addition of a superheater. Although taking heavier trains, these engines with superheaters showed an economy of at least 1.5 kg. (3.3 lb.) of coal per kilometre (0.62 mile).

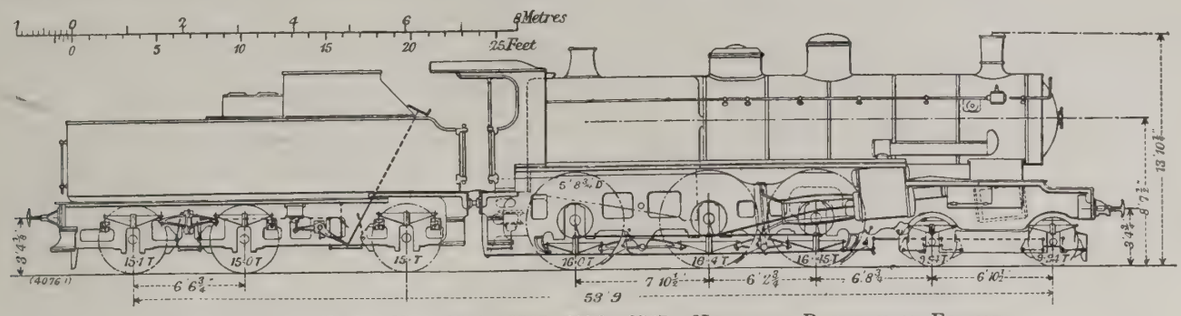


FIG. 9. LOCOMOTIVES NOS 2538—3567, 3578—3597; NORTHERN RAILWAY OF FRANCE.

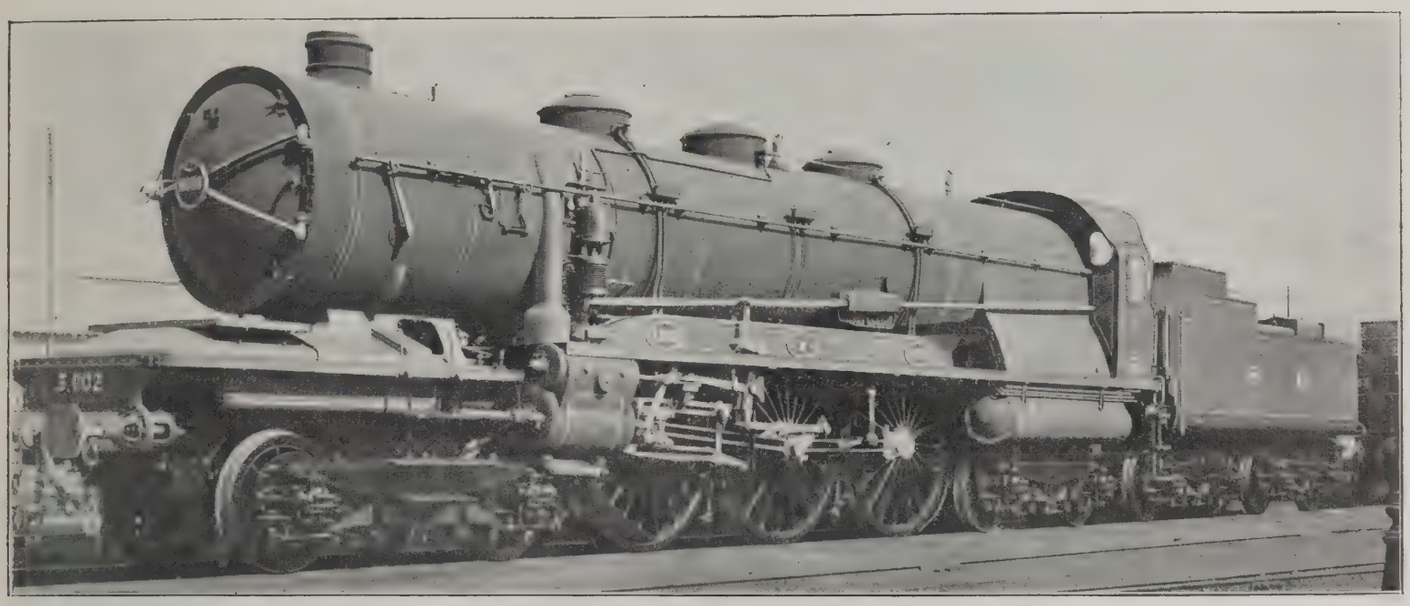


FIG. 10 "BALTIC"-TYPE LOCOMOTIVE; NORTHERN RAILWAY OF FRANCE.

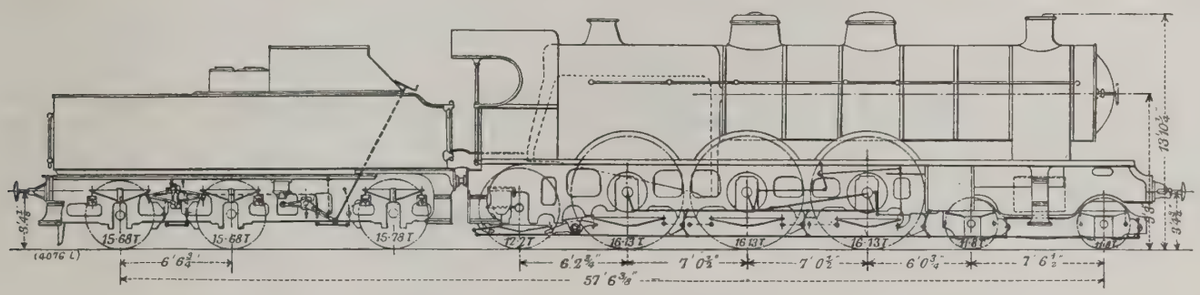


FIG. 11. LOCOMOTIVES NOS. 3,1151—3,1170; NORTHERN RAILWAY OF FRANCE.

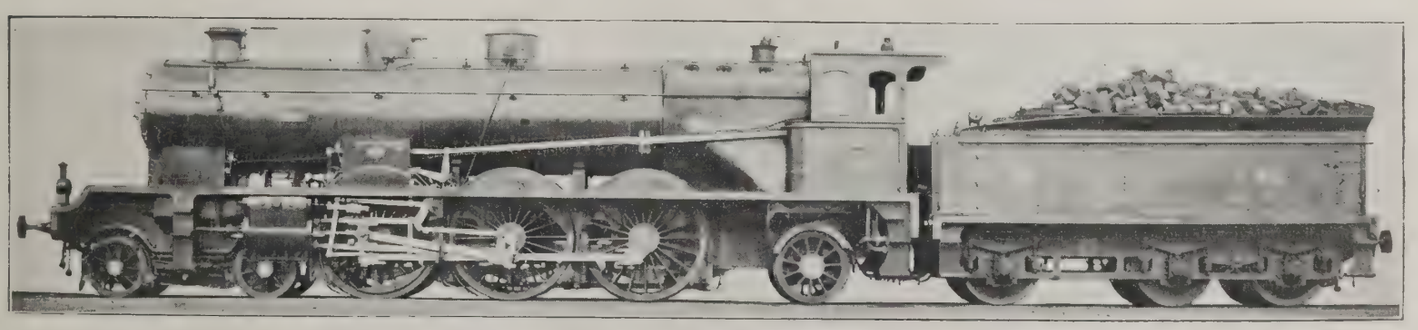


FIG. 12 LOCOMOTIVES NOS. 3501—3590; PARIS AND ORLEANS RAILWAY.

recent Nord engines, and will be continued in future engines; with steam temperatures of 300 deg. to 340 deg. Cent. no undue expenses for repairs have been experienced. The Nord engineers are of opinion that superheating and compounding must be combined.

The author cannot conclude better than by reproducing the terms of a letter from M. Asselin, chief engineer of the Nord Railway, in which his experience is recorded in a perfectly clear and definite manner.

"Until 1904 our fast engine was an 'Atlantic' without superheater, four-cylinder compound, with a power of 1400 horse-power (1380 British horse-power).

"The first step was to increase the power of these 'Atlantics' by the addition of a superheater. Although taking heavier trains, these engines with superheaters showed an economy of at least 1.5 kg. (3.3 lb.) of coal per kilometre (0.62 mile).

"The second step was to build 'Pacifics' of about 1900 horse-power (1873 British horse-power). It is remarkable how these 'Pacifics' proved economical. With the same weights they consume practically the same quantity of coal as the 'Atlantics' with superheaters; and with heavier weight than the 'Atlantics'

* See Profiles in Proceedings of the Institution of Mechanical Engineers, 1904, Plates 55 and 56.

could manage without superheaters they burn less coal.

"I don't mention our two 'Baltic' engines, which are mere experiments. I cannot as yet consider any extension of that type of engine. As regards power they are far in advance of the 'Pacifics,' but far less economical. However, before long I shall be obliged to design locomotives more powerful than the present 'Pacifics.' The weight of our fast trains, which did not exceed 300 tons with the 'Atlantics' without superheaters, attains to-day regularly 400 tons, and frequently more—up to 450 tons. I must very soon examine the possibility of hauling 500-ton trains with the actual speeds.

"Will the new engines be 'Pacifics' or 'Baltics'? I cannot say. But it will be necessary to increase the boilers of the present 'Pacifics,' their grate area, and the diameter of the cylinders. The size of the boiler is limited chiefly by the weight allowed to each axle by the permanent-way department.

"To enlarge the grate area, the length of the grate will be increased to 3.50 m. (11 ft. 5.8 in.) or 3.70 m. "Pacifics" with 1.850 m. (6 ft. 0.8 in.) wheels (Nos. 4501-4600), and ninety with 1.940 m. (6 ft. 4.3 in.) wheels (Nos. 3501-3590), Fig. 12, Plate III. All are four-cylinder compounds; thirty of the first series and seventy of the last have Schmidt superheaters with enlarged high-pressure cylinders.*

The shape of the fire-box is quite peculiar; it extends over the back trailing wheels, but is contained between the last pair of drivers, Fig. 13, the object being to avoid a shallow box. Reports of the working of this style of fire-box are quite satisfactory. Owing to the great length of the tubes, 5.900 m. (19 ft. 4 in.) between plates, plain ones without ribs have been adopted, with an outside diameter of 55 mm. (2.17 in.). The necessity of increasing the diameter of very long tubes is obvious; but the reason why they are not of the Serve system is not evident. It may be that a sufficient heating surface being obtained with plain ones, it is better to avoid the increase in cost and weight of the ribbed tubes.

Piston-valves are used on the high-pressure cylinders, and flat valves on the low-pressure, even with superheated steam, and no trouble is reported. The main dimensions of these engines will be found in Table III. (page 46). They have six-wheeled tenders holding 20 cub. m. (706.3 cub. ft.) of water and 6 tons of coal.

Indicator diagrams on the superheating "Pacifics" made apparent a too high compression in the high-pressure cylinders, although the clearance was 13 per 100. This clearance being enlarged to the mean value of 20 per 100 for both sides, a smoother running was obtained without any increase of steam consumption†. Experiments with fast and heavy trains showed an indicated power up to 2180 horse-power (2099.5 British horse-power), and 1266 horse-power (1208 British horse-power) on the pull-bar behind the tender.

An interesting comparison was made in actual running of twenty "Pacifics" without and of fifteen with superheaters, taking in turn the same trains. The mean coal consumption per 100 ton-km. was, in winter, including steam heating of the trains:—

3.92 kg. (8.64 lb.) for engines without superheaters;
3.51 kg. (7.74 lb.) for engines with superheaters;

and in summer respectively:—

3.53 kg. (7.78 lb.) and 3.17 kg. (6.99 lb.).

These figures show an economy averaging 10 per 100 in favour of the superheat.

Special experiments on one engine with superheater showed a consumption of 0.97 kg. (2.14 lb.) to 1.12 kg. (2.47 lb.) of coal per indicated horse-power per hour. One kilogramme of coal evaporated from 7.87 kg. (17.4 lb.) to 6.82 kg. (15 lb.) of water, with rates of combustion of 299 kg. (659.2 lb.) to 430 kg. (948 lb.) per sq. m. (10.76 sq. ft.) of grate an hour.

M. P. Conte (in the paper mentioned in the footnote in previous column) gives an interesting record of the coal consumption of engines hauling the Paris-Bordeaux fast trains in successive years (see Table VIII., page 51).

The 340-ton trains hauled by "Pacifics" are fitted with Stone's lighting system, which increases slightly the coal consumption. It is well worthy of remark that in a period of fourteen years, although the weight of the train has been doubled, the coal consumption has remained nearly the same.

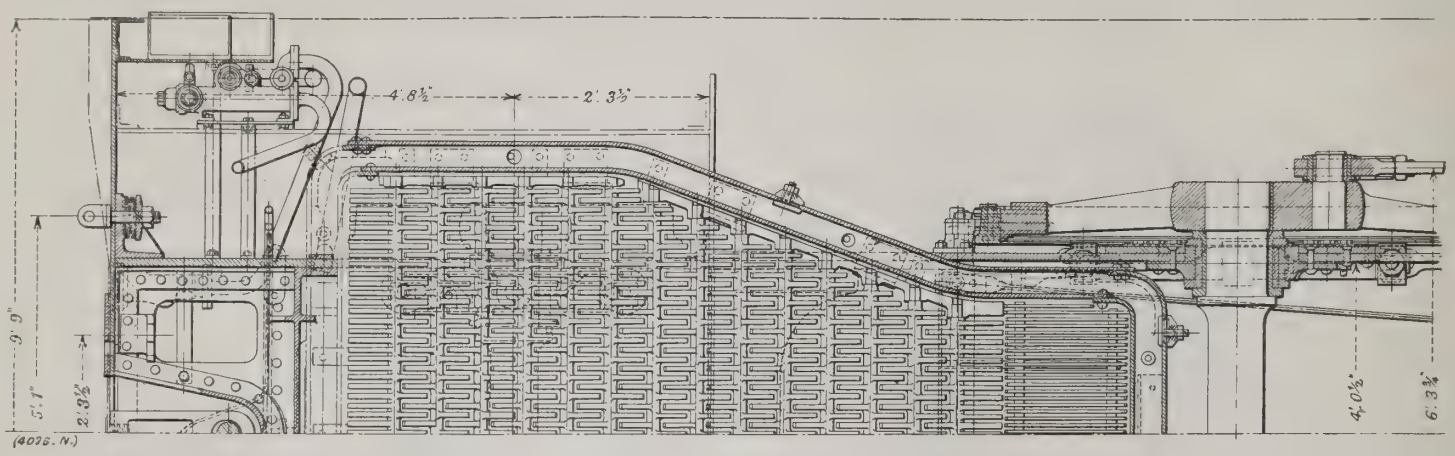


FIG. 13. HALF PLAN OF FIREBOX OF "PACIFIC"-TYPE LOCOMOTIVE; PARIS AND ORLEANS RAILWAY.

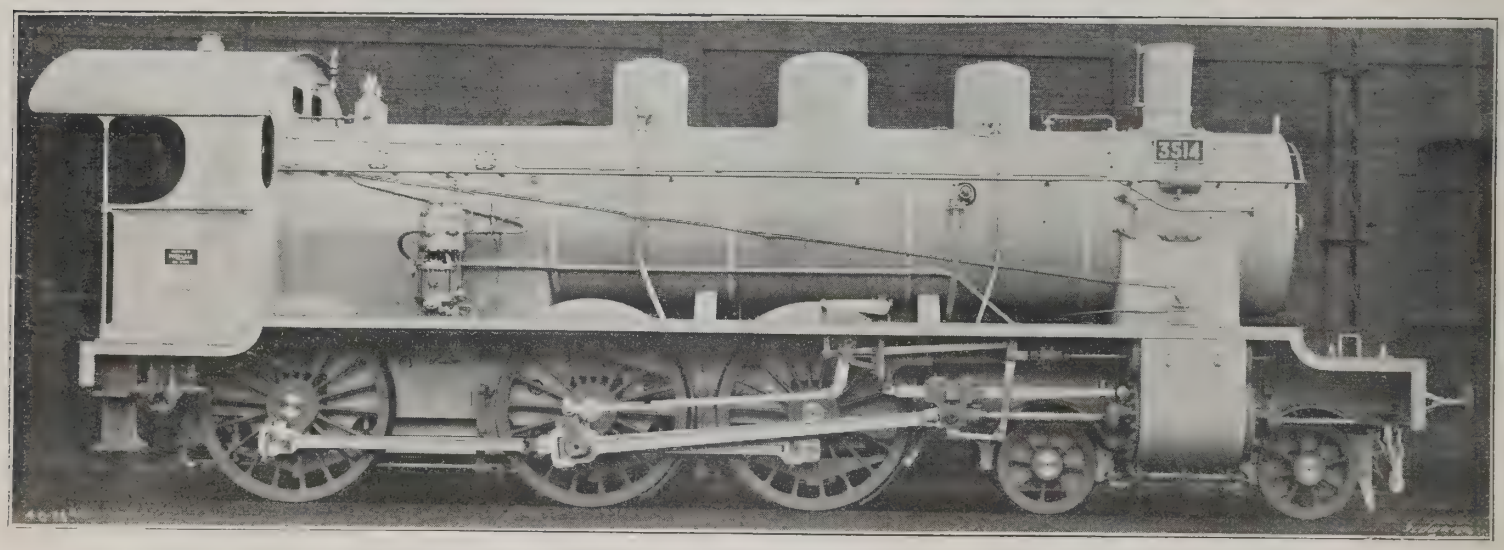


FIG. 14. TWO-CYLINDER SIMPLE LOCOMOTIVE WITH SUPERHEATER; MIDI RAILWAY.

* Reference can be made to Mr. G. J. Churchward's paper on "Large Locomotive Boilers" (Proceedings, Institution of Mechanical Engineers, March, 1906, page 165).

* An account of experiments on the superheaters by M. P. Conte has been published in the *Revue Générale des Chemins de fer et des Tramways* in June, 1912.

† Compare Mr. G. Hughes's opinion, who advocates shorter periods of compression in preference to increased clearance volume (Proceedings of the Institution of Mechanical Engineers, March, 1910, page 401).

PARIS-ORLÉANS.

Since 1904 the Paris-Orléans Railway has ordered 100

MIDI.

During the last decade the Midi Railway has added to its stock the following numbers:—

In 1905, six "Atlantics," Nos. 1911-1916, four-cylinder compounds, similar to the ten engines mentioned in the 1904 paper (page 333); four of these engines will receive a Schmidt superheater.

In 1906-1907, fourteen other "Atlantics," Nos. 1921-1934, with a longer grate, 3.08 sq. m. (33.2 sq. ft.), instead of 2.78 sq. m. (29.9 sq. ft.), and same cylinders, 340 mm. (13.39 in.) and 560 mm. (22.05 in.) by 640 mm. (25.20 in.).

In 1908-10, sixteen "Pacifics," Nos. 3001-3016, four-cylinder compounds, with the following dimensions:—

Grate area	... ...	4.02 sq. m. (43.3 sq. ft.)
Heating surface	...	253.20 sq. m. (2725.5 sq. ft.)
Steam pressure		...16 kg. per sq. cm. (227.6 lb. per sq. in.)
Cylinders, diameter	...	370 mm. (14.57 in.) and 620 mm. (24.41 in.)
Cylinders, stroke	... ...	650 mm. (25.59 in.)
Driving wheels, diameter	...	1.940 m. (6 ft. 4.3 in.)

In 1910, four similar "Pacifics," Nos. 3051-3054, with the addition of a Schmidt superheater of 60.88 sq. m. (655.3

sq. ft.), reducing the proper heating surface to 216.29 sq. m. (2328.1 sq. ft.), this proportion being ampler than in many cases mentioned before; the diameter of the high-pressure cylinder has been enlarged to 400 mm. (15.8 in.).

TABLE V.

Numbers of Engine (Superheater).	3541.	3538		3634	
Number and date of train	115 July 4 1912	109 Dec 14 1912	122 Dec 14 1912	Y B Feb. 4 1913	Y A Feb. 7 1913
Weight of train tons	312	282	346	733	1020
Average speed on level km. per h. miles	110 (68.4)	110 (68.4)	100 (62.1)	50 (31.1)	45 (28.0)
Average speed on 5 mm. (1 in 200) incline km. per h. miles	90 (55.9)	90 (55.9)	80 (49.7)	35 (21.75)	25 (15.5)
Average speed on 8 mm. (1 in 125) incline km. per h. miles	90 (55.9)	90 (55.9)	80 (49.7)	30 (18.6)	25 (15.5)
Water consumed per km. l. per t-km. l.	No measurement	No measurement	No measurement	117 (25.74 gls.) 0.160 (0.035 gls.)	145 (31.9 gals.) 0.142 (0.031 gls.)
Coal consumed per km. kg. per t km. kg	Do.	Do.	Do.	15.4 (33 95 lb.) 0.021 (0.046 lb.)	19.9 (43.87 lb.) 0.0195 (0.043 lb.)
Duration of run, Paris-St. Quentin, or *vice versa*, 153 km (95.1 miles)	1 hour 36 min	1 hour 35 min	1 hour 43 min	—	—

The two last were coal trains from Lens to Paris, following two different routes.

TABLE VI.

No. and date of train	No. 5, April 29, 1913	No. 115, June 7, 1913
Weight of train .. .. tons	401	382
Average speed on level km. per hr.	110 (68.35 miles)	113 (70.21 miles)
Average speed on 5 mm. (1 in 200) incline .. km. per hr.	94 (58.41 miles)	94 (58.41 miles)
Water consumed per km. l.	117 (25.74 gals.)	No measurement.
Water consumed per ton-km. l.	0.293 (0.064 gal.)	
Coal consumed per km. kg.	16 8 (37.04 lb.)	No measurement.
Coal consumed per ton-km. kg.	0.042 (0.093 lb.)	
Duration of run, Paris-Calais, 298 km. (185.2 miles)	3 hours 16 min. (including 5 min. stop at Abbeville	—
Duration of run, Paris-St. Quentin, 153 km. (95.1 miles)	—	1 hour 35 min.

TABLE VII.

No. and date of train	No. 5, Feb. 26, 1914	No. 115, Feb. 28, 1914
Weight of train .. .. tons	430	356
Average speed on level km. per hr.	110 (68.35 miles)	112 (69.56 miles)
Average speed on 5 mm. (1 in 200) incline .. km. per hr.	90 (55.92 miles)	90 (55.92 miles)
Water consumed per km. l.	118 (25.96 gals.)	No measurement.
Water consumed per ton-km. l.	0.275 (0.061 gal.)	
Coal consumed per km. kg.	19.2 (42.33 lb.)	No measurement.
Coal consumed per ton-km. kg.	0.0446 (0.098 lb.)	
Duration of run, Paris-Calais, 298 km. (185.17 miles)	3 hours 15 min. (including 5 min. stop at Abbeville)	—
Duration of run, Paris-St. Quentin 153 km. (95.07 miles)	—	1 hour 36 min.

In 1910-1912 comes in service a new type of 4 6 engines, Nos. 3501-3516, where advantage is taken of the superheater to reduce the boiler pressure to 12 kg. per sq. cm. (170.7 lb. per sq. in.), and to revert to simple expansion in two cylinders only of 590 mm. (23 2 in) by 640 mm. (25.2 in.), Fig. 14, page 50. The diameter of wheels is reduced to 1.750 m. (5 ft. 8.8 in.); the principal other dimensions will be found in Table II. (page 45). Owing to the good results obtained from these engines, four "Pacifics" on the same plan, Nos. 3101-3104, have been designed, and are in course of construction, with a boiler pressure of 13 kg. per sq. cm. (184.9 lb. per sq. in.), two cylinders of 630 mm. by 650 mm. (24.80 in. by 25.59 in.), and wheels of 1.940 m. (6 ft. 4.3 in.), Table III.

We may mention here, as used for express trains on mountain lines, six tank engines, Nos. 4501-4506, put in service in 1913, with four-coupled axles and bogie, having the following dimensions:—

Grate area ...	...	3.19 sq. m. (33.37 sq. ft.)
Heating surface	...	163.16 sq. m. (1756.2 sq. ft.)
Superheating surface	...	45.26 sq. m. (487.12 sq. ft.)
Boiler pressure ...	...	12 kg. per sq. cm. (170.68 lb. per sq. in)
Cylinders (2), diameter		630 mm. (24.80 in.)
,, ,, stroke	...	640 ,, (25.20 ,,)
Diameter of wheels	...	1.600 m. (5 ft. 2.9 in.)
Weight, empty...	...	74,000 kg. (72.8 tons)
,, in working order		93,500 ,, (92 tons)
,, adhesive	...	70,500 ,, (69.4 tons)

The author is indebted to M. Herdner, chief engineer of the Midi, for the comparison of simple superheaters and compound non-superheaters, Table IX. This comparison results from practical working of the same trains during periods of nine to ten months, and is specially interesting in the second case, where similar "Pacifics" ran in parallel. In the first case the "Pacifics," weighing 90 tons, with their grate area of 4.02 sq. m. (43.3 sq. ft.), ran against 4-6 engines of 76.3 tons, with grate area of 2.78 sq. m. (29.9 sq. ft.), which were likely more appropriate to the not very heavy trains.

In his elaborate paper, "Compounding and Superheating in Horwich Locomotives,"* Mr. G. Hughes comes to similar conclusions.

As pointed out by Mr. J. A. F. Aspinall † and by Mr. G. Hughes in his 1910 paper, the coal bill is only one item of expense in locomotive working, although the rise in the price of coals makes it more and more important; the economy of first cost in the case of two-cylinder simple engines must be taken into account. It will be of great interest to analyse in the long run as far as possible the new practice of the Midi.

TABLE VIII.

Date.	Type of Engine.	Weight of Train.	Coal Consumed from Paris to Tours. Per Ton of Train.	Total.
		tons		
1897	Forquenot, 2-4-2	175	18 48 kg. (40.74 lb.)	3235 kg. (7130 lb.)
1902	Four-cylinder compound, 4-4	219	15.63 kg. (34.46 lb.)	3424 kg. (7549 lb.)
1906	"Atlantic," four-cylinder compound	234	12.83 kg. (28.28 lb.)	3002 kg. (6618 lb.)
1911	"Pacific" without superheater	340	11.28 kg. (24.87 lb.)	3835 kg. (8454 lb.)
1911	"Pacific" with superheater	340	10.54 kg. (23.24 lb.)	3583 kg. (7899 lb.)

TABLE IX.

Engines.	Average Mileage per Month.	Average Weight of Train Alone.	Coal Consumed. Per Kilometre.	Per Ton-Kilometre of Train Alone.
		tons		
Simple superheaters, Nos. 3501-3516	8262 km. (5133 miles)	225	11.646 kg. (25.662 lb.)	0.0522 kg. 0.115 lb.)
4-cylinder compound non-superheaters, Nos. 3001-3016	8181 km. (5083.4 miles)	235	13.866 kg. (30.57 lb.)	0.0623 kg. (0.137 lb.)
2-cylinder superheater, "Pacifics," Nos 3051-3054	8150 km. (5064.2 miles)	255	14.100 kg. (31.09 lb.)	0.0563 kg. (0.124 lb.)
4 cylinder compound non-superheater, "Pacifics" Nos. 3001-3016	8140 km. (5058 miles)	252	14 616 kg. (32.22 lb.	0.0591 kg. (0 130 lb.)

The above descriptions make apparent the large increase in the power of express locomotives, which is characteristic of recent constructions; nevertheless, a further increase will be required in a near future. To meet the severe requiremets of traffic, larger boilers have been designed and fitted with superheaters. This state of affairs seem to be the same in Great Britain and in France. In both countries special experiments as well as ordinary practice have proved that superheating confers an important increase of power without causing trouble or undue expenses. Another point on which experts agree is that superheating alone is equal to or even better than compounding with saturated steam.

One point that seems open to further discussion is whether superheating and compounding must be superposed. In general, French practice as regards express engines is in favour of this superposition, with the interesting exception of the Midi Railway.

APPENDIX.

Descriptions and tracings of some of the locomotives mentioned above will be found in the following periodicals:—

Est, No. 3165 (superheating in two stages), *The Engineer*, 1910, 2, page 416.

Paris-Lyons-Mediterranée, Nos. 2601-2605, ENGINEERING, 1905, 2, page 704.

—, "Pacific," Nos. 6101-6171, ENGINEERING, 1911, 2, page 317; *The Engineer*, 1911, 2, page 322.

—, "Pacific," No. 6001, ENGINEERING, 1913, 1, page 666; *The Engineer*, 1913, 2, page 430.

Nord, "Atlantic," Nos. 2641-2675, ENGINEERING, 1906, 2, page 488.

—, "Baltic," *The Engineer*, 1911, 1, page 149, and 1911, 2, page 241.

Paris-Orleans "Pacific," No. 4501, ENGINEERING, 1909, 1, pages 409 and 588.

Midi, "Pacific," Nos. 3001-3011, *The Engineer*, 1910, 2, page 312.

COMPOUND ARTICULATED LOCOMOTIVES.‡

By ANATOLE MALLET, of Paris.

THE author asks permission to recall that at the summer meeting of the Institution, held in Paris in 1879, he explained the applications which he had made of double-expansion to locomotives He is pleased he is able (35 years afterwards) to explain a particular type of compound locomotive at a similar meeting.

If rack lines, whose total length is not over a thousandth of that of railways all over the globe, be neglected, one may say that traction takes place solely through adhesion—that is, through friction between the rails and the tyres of the wheels under the action of the weight bearing on the axles. Friction is, after all, the universal principle of self-propelled locomotion on earth. Animals are able to walk because their feet have a grip on the ground, while others crawl on their stomachs. If the gradient is too severe, animals, such as those which Nature has provided with claws, make use of them to support themselves without fear of slipping—a process which has been copied in the rack. The only thing is that in beings the progress in intermittent, whereas mechanical progress takes place in a continuous way, by means of wheels.

The tractive force of a locomotive is equal to the weight brought to bear on the rails by the tyres of driving and coupled wheels multiplied by the coefficient of friction for the parts in contact. This total weight is equal to the product of the number of coupled axles and the load on each axle (the latter load depending upon the conditions of settlement of the track) This weight, which was 3 tons per axle in 1825 on the Stockton to Darlington line, when railways were first started, increased to 8 tons in 1842, 14 tons in 1855, 16 tons in 1890, and has now reached about 20 tons (on the more important lines, of course). In the United States the weight goes up to 25 tons and more. For a long time, three was the maximum number of axles coupled together, whereas now four and even five axles are coupled, and only recently (though it was exceptional) six axles were reached. One can give a striking idea of the increase in weight and tractive power of engines for the last 85 years, from the point of view of utilising the track, in this way. (The author believes that this has not been published before.)

In 1829 an engine with two axles coupled, running on rails 17 kg. per metre (34.2 lb. per yard), weighed 5 tons, which was equal to 300 times the weight of rails per metre.

In 1846 an engine with three axles coupled, weighing 22 tons, ran on rails 35 kg. per metre (70.52 lb. per yard). This came to 630 times the weight of rails per metre.

In 1880 an engine with four axles coupled, weighing 56 tons, ran on rails 42 kg. per metre (84.6 lb. per yard). This came to 1330 times the weight of rails per metre.

In 1911 a six-axle-coupled Golsdorf engine, weight 96 tons, on rails 48 kg. per metre (96 77 lb. per yard), gave a ratio of 2000. In 1911, as well, in the United States, a Mallet engine with ten axles coupled, weighing 245 tons (adhesive weight), represented a ratio of 4600 times the weight of rails of 55 kg. per metre (111 lb. per yard); but this ratio, which is very high, is due, to some extent, to an exceptional weight per axle which is not to be found outside the United States.

If adhesive force be taken as one-sixth of the weight, it will be found that the ratio of the tractive force at wheel tread to the weight of rails per metre has varied according to the values: 50—105—225—333—750.

The number of coupled axles, when coupling by outside rods requires that the axles must be absolutely parallel, is limited by the minimum radius of the curves on the line. In fact, for a certain radius there is a maximum distance between extreme parallel axles which must not subtend an angle greater than about 1 deg. Beyond this, friction between the flanges of the wheels and the edge of the rails gives rise to severe wear of the surfaces in contact, and there is a chance that the flanges might jump the rails and cause derailments. It is true the flanges can be greased, but that is rather a poor solution of the problem.

When the required tractive force necessitates an adhesive weight which, in view of the profile of the line and of other conditions, is greater than what the maximum number of coupled axles could bear, special assistance is required, such as pushers, two engines, motor driving wheels on tenders, twin-engines or articulated engines. In articulated engines one can easily obtain the same adhesive weight (that is, the same tractive force) as with two engines, by distributing the axles on two frames coupled together, but capable of moving at an angle to one another, on curves. Such an engine with six axles will, for example, take the same curve of minimum radius as would fit an ordinary engine with three axles coupled. This type of engine comprises rather a large number of different models, all of which have, as a common characteristic, an absence of enforced parallelism between the two groups of axles. But these types can be arranged into distinct categories, which rest partly on the number of cylinders driving the wheels and partly on the disposition of the frame of the wheels, so that, if these different categories be taken two by two, one gets the following four classes:—

1. Locomotives with two movable trucks and only one set of cylinders.
2. Locomotives with two movable trucks and two sets of cylinders.
3. Locomotive with only one truck and one set of cylinders.
4. Locomotive with only one truck and two sets of cylinders.

The author will examine classes 2 and 4, because categories 1 and 3 are based on the use of certain mechanical transmissions, which, alone, would be a subject for a special paper.

Locomotives with two trucks and two sets of cylinders first appeared in the United States in 1832 in a somewhat primitive form, due to Horatio Allen. But at the Soemmering competition in 1851 locomotives of this type were seen built on a practical plan. These engines were: the Seraing, built by the Belgian firm of the same name, with two barrels and two central fire-boxes, weight 56 tons; and the Wiener-Neustadt, built by W. Gunther, of Vienna, with a single boiler, weight 61 tons, with full supply of fuel and water. The Seraing happens to be the prototype of the Fairlie engine, so far as essential

* Proceedings of the Institution of Mechanical Engineers, March, 1910, page 399.

† Ibid, 1900, page 408.

‡ Paper read before the Institution of Mechanical Engineers at Paris, July 7, 1914.

dispositions are concerned, in the same way as the Wiener-Neustadt is the prototype of the Meyer engine. It is absolutely necessary to distinguish clearly between the characteristics of these different engines. In fact, the author has had occasion to note that mistakes are made daily with regard to this, and they are even found in well-known works. Thus we read in a book on locomotives, published in London in 1907, that the Mallet engine is nothing but the Meyer engine, which appeared in 1867, to which M. Mallet had applied double expansion in 1884!

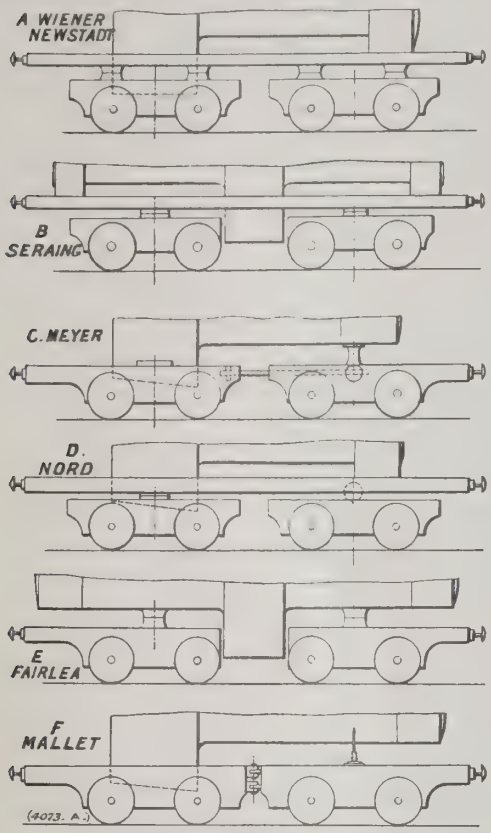


FIG. 1. CHARACTERISTICS OF SEVERAL TYPES OF TWO-TRUCK ARTICULATED ENGINES.

So that the author thinks he should give diagrams, Fig. 1, showing the essential characteristics of each of these types, including the engine of the Chemin de fer du Nord, constructed in 1904 by the late M. Du Bosanquet. The author will only casually mention the Garatt engine, which is characterised by the very great distance between the two driving-trucks, thus allowing the boiler to be lodged between them, so that it may be fixed much lower, and have a greater width than in the other types, where it is above the trucks.

The characteristics of the engines are as follow:—

(A) *Wiener-Neustadt.*—Main frame, carrying buffing devices and driving apparatus, and resting on the trucks on supports shaped horizontally like circular arcs—single boiler.

(B) *Seraing.*—Main frame, carrying buffing devices and driving apparatus, and resting on the trucks on lateral supports; the central points are independent of the coupling device. The boiler has a double central fire-box and double cylindrical barrel.

(C) *Meyer.*—No main frame—the buffing devices and driving apparatus are carried by the trucks—the single boiler rests on the back truck on lateral supports, and on the front truck on a spherical pivot; the two trucks are coupled by means of an arrow.

(D) *Nord.*—Main frame, carrying buffing devices and driving apparatus, and resting on the back truck on lateral supports, and on the front truck on a spherical pivot. Single boiler.

(E) *Fairlie.*—No main frame—the buffing devices and driving apparatus are fixed on the trucks—and the boiler, which has a central fire-box and two cylindrical barrels, rests on the trucks on circular supports, which also serve as couplings and have a certain elasticity laterally.

(F) *Mallet.*—This engine differs essentially from the others in that it has only one truck, placed in front, and joined at the back to the main frame of the engine by a king-pin. The front of the boiler rests on the truck on supports in the shape of arcs, whereas the back is fixed to the main frame.

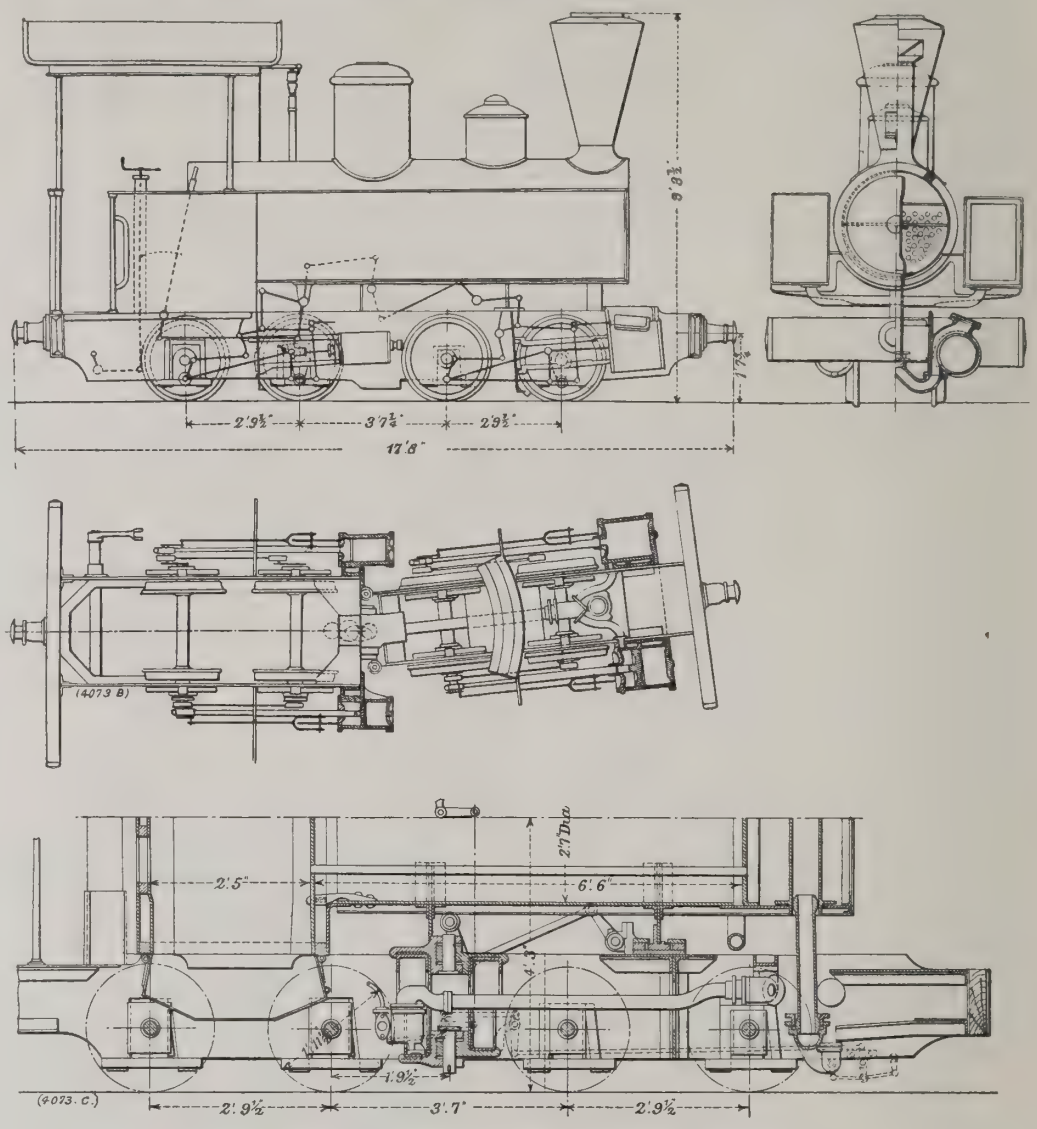
The author, in studying this type, reasoned on the following principle:—An engine, with two axles coupled, driven by two cylinders, and resting in front on a bogie with two axles as well, takes curves easily, but only part of its weight can be utilised for adhesion, and it cannot therefore exert a tractive force corresponding to its whole weight.

If the wheels of the truck be driven by a pair of low-pressure cylinders of convenient size fixed to the truck, and if these cylinders be fed by the steam coming from the back high-pressure cylinders, a simple method will have been arrived at, giving the three following results:—

1. The engine will have been allowed the full benefit of its weight for adhesion, and at the same time it will have great flexibility.

2. The main difficulties which arise in the case of the Fairlie and Meyer types, and other types with two trucks, will have been removed in so far as the movable tubing of the new engine (which tubing is, after all, much less intricate than the other) will only take steam which has already been expanded to a pressure of 3 kg. to 4 kg. per sq. cm. (42 lb. to 57 lb. per sq. in.) at most.

3. A rather simple type of locomotive will thus have been created which is justified by several advantages, to be referred to later.



FIGS. 2 AND 3. LOCOMOTIVE FOR DECAUVILLE RAILWAY.

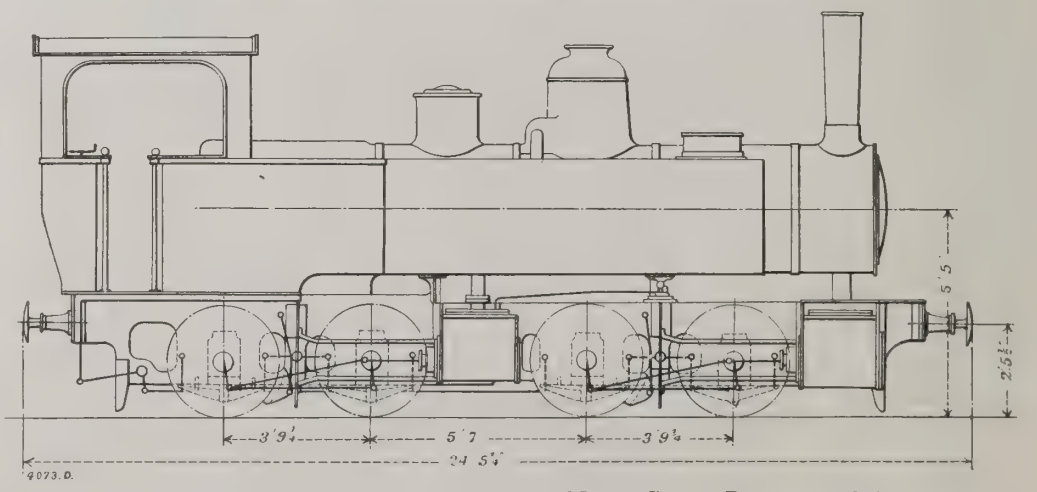


FIG. 4. LOCOMOTIVE FOR DEPARTMENTAL METRE-GAUGE RAILWAY, 1888.

This system, which the author advocated as far back as 1884, fulfilled the following conditions laid down by the Decauville firm in 1887 for locomotives running on 0.50 metre (1 ft. 11½ in.) tracks:—

The engine had to take grades up to 1 in 12.5 and haul weights nearly equal to its own, take curves of 20 metres in radius, and not weigh above 3 tons per axle, or 12 tons for four axles.

Figs. 2 and 3, above, show this engine. It is carried on four axles, two at the back under the fixed portion of the engine and two in front under the Bissel truck, which articulates round a vertical hinge. The barrel of the boiler rests on the truck in a slide working in a circular groove carried by the truck as shown in plan in Fig. 2. The back cylinders work at high pressure, and the steam comes direct from the boiler. After having done its work, the steam goes to a central box containing a pipe curved in the shape of a swan's neck, Fig. 3, which can turn round in that box, and the horizontal part of which proceeds to the front, where, through an up-take to be seen on the plan, it carries the steam to the low-pressure cylinders placed on the fore truck.

The steam then escapes from these cylinders through a vertical pipe, which carries a knee-cap socket at its base, so that, with the aid of this combination, the high-pressure steam goes through fixed tubes only as in ordinary engines, and the pipes with movable joints take expanded steam only. This is very satisfactory, so far as tightness of joints is concerned, and presents great facilities for the use of superheated steam in those engines. The success of that first engine was complete, and the Decauville firm built a large number of them, which were sent to different countries to be used on agricultural farms, and on mining and forest works, but the most important application was at the Universal Exhibition of 1889 in Paris, where six of those engines

did the traffic on the Inner Circle of 0.60-metre (1-ft. 11½-in.) gauge laid down by the Decauville firm. They covered a total distance of 113,000 km. (72,000 miles), and carried more than 6,000,000 passengers with regularity and without accident.

The author wishes to recall that on July 6, 1889, he had the pleasure of showing, at the "Petit Bourg" on four axles, weighing 60 tons (in running order), and one on six axles, weighing 85 tons. These tank-engines built for a normal gauge were intended: The first for the Swiss Central Railway, and the second, Fig. 5, for the St. Gothard Railway. This second engine was then the heaviest engine in the world—the United States excepted.

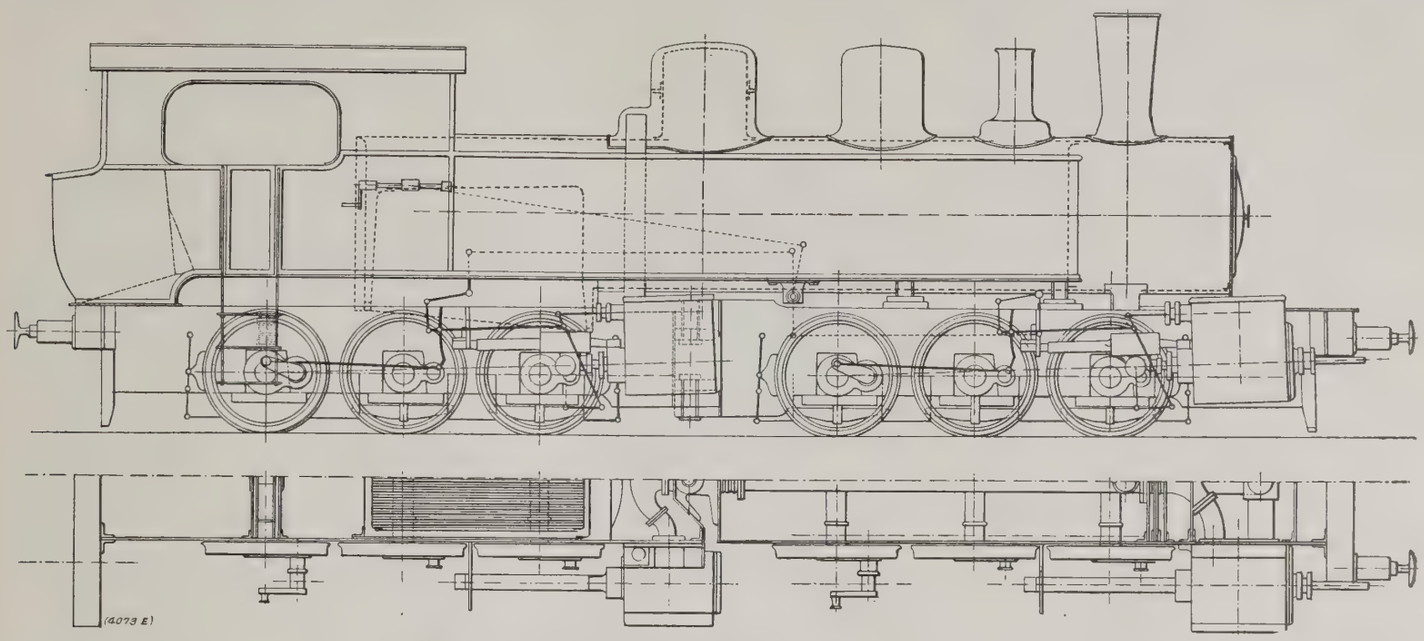


FIG. 5. LOCOMOTIVE FOR THE ST. GOTHARD RAILWAY, 1889.

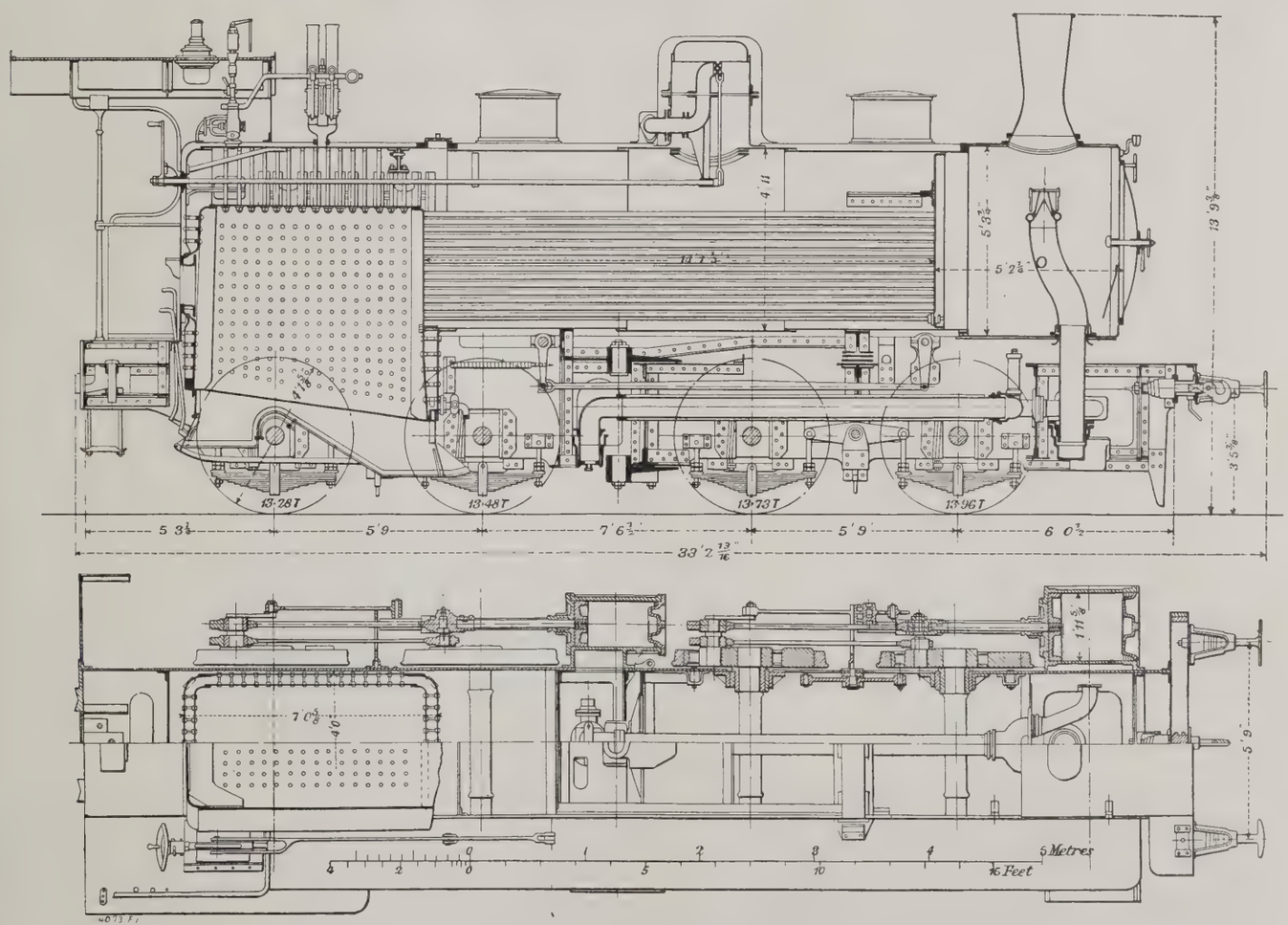


FIG. 6. LOCOMOTIVE FOR THE PRUSSIAN STATE RAILWAY; 56 TONS, 1894.

works, one of those small engines, and of explaining its mechanism to a number of English engineers who had been invited over by M. Paul Decauville. Mr. John A. F. Aspinall was at the head of the party.

As far back as 1888 the system had been applied (see Fig. 4) to tank locomotives with four axles, weighing 24 tons, running on the 1-metre (3 ft. 3.4 in.) gauge on one of the departmental railways in France, and in 1889 the "Maffei" firm of Munich constructed four engines

In 1894, engines on four axles and separate tender, weighing 56 tons, were built for the railways of the Prussian State, Figs. 6 and 7, on the present and following pages. As can be seen, the essential features do not differ materially from those of the first engine of 1887. Many similar engines were built for various German railways and for the Hungarian railways.

In 1895 six-axle engines with separate tender were built by Messrs. Borsig, of Berlin, and later by the Pontiloff firm, at St. Petersburg, for the 3-ft. 6-in. gauge of 850 km. (528 miles), from Vologda to Archangel, Fig. 8, page 54. It is interesting to note that it was not for flexibility that the system was adopted, since curves were not less than 350 m. (1148.3 ft.) radius, but it was for the light weight of rails, 18.5 kg. per metre (37.2 lb. per yard). This meant that a large number of axles must be coupled together, so as to obtain the required tractive power.

In 1898 another Russian line—the Moscow-Kazan line—had engines built on six axles, weighing 79 tons. One of these engines was exhibited at Vincennes at the time of the Universal Exhibition of 1900. A great number of these have been built, and superheated steam has been applied to the most recent engines. The director of that important company, Mr. Noltein, said at the Railway

Congress at Berne in 1910 that the Mallet locomotive is better than any other when it is desired to drive an engine of considerable weight over light rails. Under such circumstances it cannot be replaced by any other type with parallel axles.

The example given by the Moscow-Kazan Railway was soon followed by the Trans-Siberian Railway, to which the system was particularly suitable, given the lightness of the track: 24 kg. per metre (48 lb. per yard) rails. Two type-models of these engines, one for passenger trains with four driving axles and a carrying axle in front, weighing 56 tons in running order, and the other for goods trains with six driving axles, weighing 81 tons, were built with the intention of using them as patterns. These engines proved of great value during the Russo-Japanese War.

Large tank-engines on six axles were built in 1902 by Borsig, of Berlin, for the coal traffic on the Chemin de Fer Central d'Aragon. Gauge 1.676 m. (5 ft. 6 in.). These locomotives weighed 108 tons in working order, and were the heaviest built at the time, except in the United States. This company uses many engines of the same type but with separate tenders, weighing only 72 tons. Some of them, only recently built, by Henschel, at Cassel, are provided with Schmidt superheaters. As will be seen in Fig. 9, superheated steam comes from the smoke-box to the rear cylinders through two pipes placed outside the boiler. One can see how easily superheated steam may be applied to this type of engine where its use is as simple as on ordinary engines.

In conclusion, the author refers to the engines with six axles coupled with separate tenders, built in 1908, for the Chinese line from Pekin to Kalgan, by the North British Locomotive Company of Glasgow, which are the first engines of this type built in Great Britain. They weigh 98 tons, and pull trains on long 30 per cent. gradients, round curves of 152 m. (499 ft.) minimum radius. The author is glad to say that when he was revising this paper he learnt that the firm of Maffei, in Munich, the builders of the first normal-gauge Mallet engine, had recently constructed a huge tank-engine of the same type, with eight axles coupled in two groups. The engine weighs 122.5 tons in running order, and is, of course, the heaviest locomotive in the world, the United States excepted.

Table I., annexed, shows the principal dimensions of a few engines for narrow gauge, and Table II., page 55, gives those for wide gauge. The first engine of this type was built in 1887, as pointed out. In 1892 there were 110 of them in existence, and over 400 early in 1900. Since then the number has increased rapidly, and at present reaches about 2500. They are to be seen in about fifty countries distributed all over the world, and belong to about 150 different railway companies or administrations, some owning but a few, whereas others have from 50 to 350. It was in 1904, however, that the type made unexpected strides onwards. This was due to the following circumstances:—

There was then in the United States a very pronounced tendency towards reducing the cost of transport of goods by means of very heavy trains, so that powerful engines were required. The power of an engine is limited by the space between extreme axles and the weight which the wheels carry to the rails. Moreover, the following was unsatisfactory:—On many sections the track was very severe so far as grades and curves went. In 1902 the biggest American engine was an engine with five axles coupled and two carrying axles, weighing 120 tons, of which 106 tons was adhesive weight. It could give a tractive force of 28 tons. This engine belonged to the Atchison, Topeka and Santa Fé Railway, and was a compound tandem engine. For higher tractive forces three engines had occasionally to be coupled to one train. This was a costly, ungainly, and sometimes even a dangerous solution to the problem. The author had long come to the conclusion that the States, with their wider loading-gauge, their heavy weights per axle, and their method of coupling which made provision for an enormous tractive force, was just the ideal ground for the application of his system. He had entered into communication with an American firm, but without success. At last, in 1903, the American Locomotive Company constructed for the Baltimore-Ohio Railway a Mallet engine with six axles, weighing 152 tons (running order)—*i.e.*, 25.3 tons per axle—which was exhibited at St. Louis in 1904 (see Fig. 10). This engine was greatly criticised, and several engineers agreed to look upon it as a model—which would probably remain unique—of a monstrous locomotive, difficult to handle for everyday traffic, and being serviceable only as a pusher on very broken lines, or on lines of determined gradients. There was also a doubt as to the way the coupling of the two trucks and the movable tubing would behave in practice. When the engine started to run, after the Exhibition, it was found that those criticisms were based on nothing serious, and that the hopes of its success had not been exaggerated.

Two years later, in 1906, the Baldwin firm, which had already built a few similar engines for the narrow gauge of Porto Rico, delivered five engines to the Great Northern Railway, U.S.A., with six driving axles and two carrying ones—one in front, the other behind—weighing 162,000 kg. (159.4 tons), of which 144,000 kg. (141.7 tons) was adhesive weight (Fig. 11). These engines, like the first one, played the *rôle* of "pushers," but the excellent results they gave prompted the company to use them for road service—that is, for pulling goods trains—and twenty-five like engines, weighing 130,000 kg. (128 tons), of which 113,000 kg. (111.2 tons) was adhesive weight, were ordered. These engines pulled 1300 tons at a speed of 16 km. (9.9 miles) per hour on a gradient as high as 1 per cent., on which the consolidation engines only took 1000 tons, using the same amount of coal; this meant a saving of 30 per cent. In 1907 a further step was taken in increasing the number of driving-axles when the Erie Railway ordered three locomotives on eight axles, weighing 185,500 kg. (173.7 tons), entirely for adherence. These engines were intended to haul trains of 3000 tons over the 12-km. (7.5 miles) section on a gradient of 13 per cent. between Susquehanna and Golf Summit. This was done successfully, and a considerable saving in staff, coal, and time was the result. From that time many American lines started using this new type.

Another interesting fact to consider was that the introduction of the new engines, which were very powerful, caused the ordinary engines to be discarded. Mr. George H. Emerson, of the Great Northern Railway, conceived the idea of combining his consolidation engines, two by

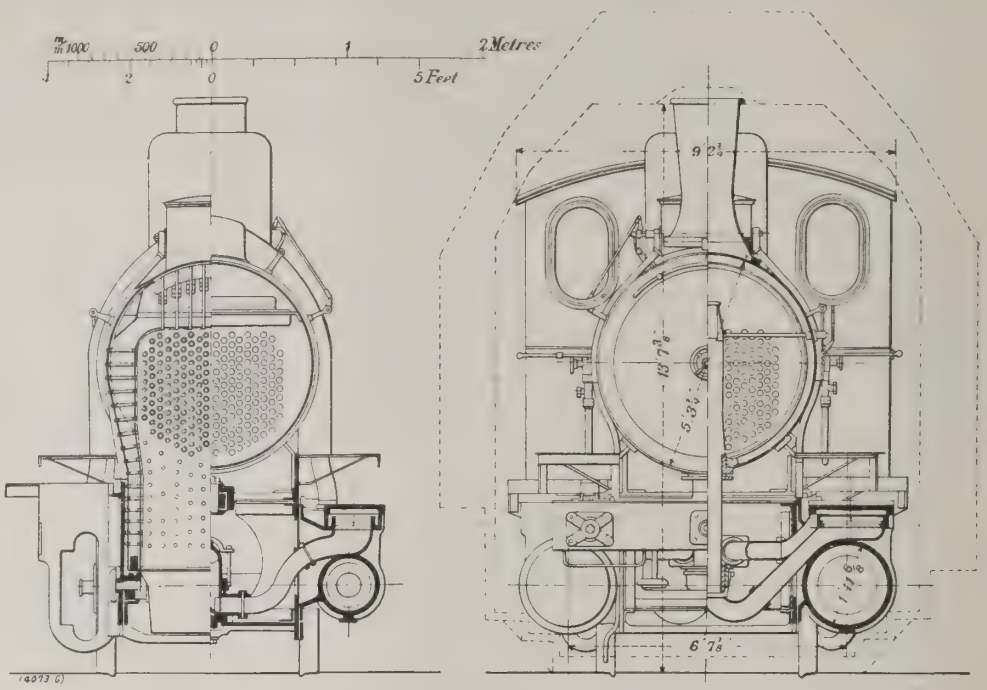


FIG. 7. LOCOMOTIVE FOR PRUSSIAN STATE RAILWAY, 1894.

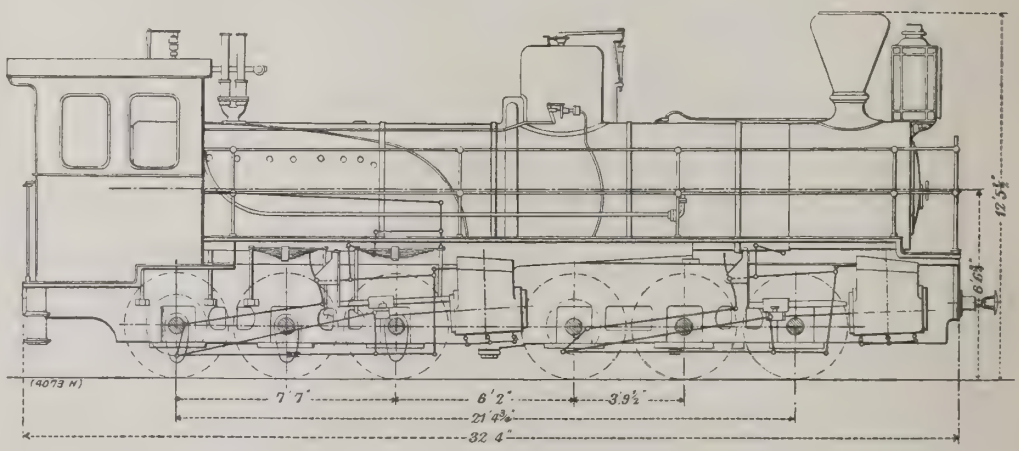


FIG. 8. LOCOMOTIVE FOR OSLAW-VOLOGDA-ARCHANGEL RAILWAY; 3 FT. 6 IN. GAUGE, 1895.

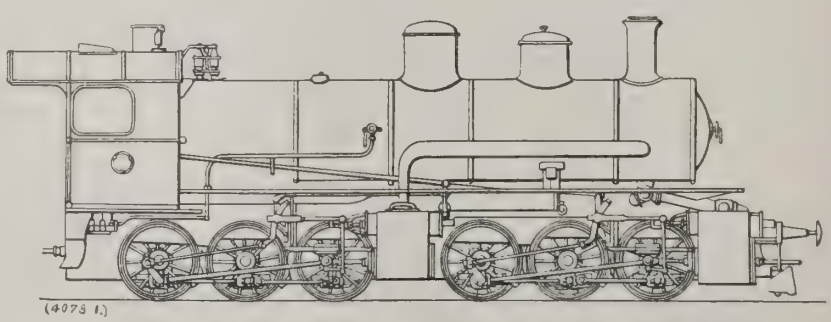


FIG. 9. SUPERHEATED-STEAM ENGINE; CENTRAL ARAGON RAILWAY.

TABLE I.—SHOWING A FEW TYPES OF MALLET ENGINES FOR NARROW GAUGE.

—	Vologda-Archangel 1.067 Metre. Poutiloff.	Hedjaz 1.050 Metre. Henschel	Departmental 1.000 Metre. Winterthur.	Bone-Guelma 1.000 Metre. Batignolles.	Arica-La Paz 1.000 Metre Hanoverian Society.	South African 1.067 Metre. North-British Locomotive Company.	South African 1.067 Metre. American Locomotive Company.
Number of axles	0-3 + 3-0	1-2 + 3-0	0-3 + 3-0	0-3 + 3-0	0-3 + 3-0	1-3 + 3-0	1-3 + 3-0
Diameter of cylinders in.	13.8-17.7	12.6-20.0	12.0-19.0	15.0.22.8	15.8-24 0	17.5-28·0	18.0-28.5
Piston stroke ,,	22	23	22	22	22	26	26
Diameter of wheels ,,	43	42	40	43	43	46	46
Distance between parallel axles ,,	91	—	87	96	102	100	100
Total distance between extreme axles in.	·257	326	252	272	291	401	492
Grate area sq ft.	20	29	16	16	30	43	50
Total heating surface ,,	1243	1744	926	1092	1798	2616	3391
Steam pressure in boiler lb. p. sq. in.	171	171	199	213	199	199	199
Working weight tons	46.2	52.2	45.2	60.5	59.1	95.5	100.4
Adhesive weight ,,	46.2	44.3	45.2	60.5	59.1	86 6	86.6
Weight of tender, full ,,	23 6	37.9	tank engine	tank engine	39.4	43.3	56.1
Total weight ,,	69.8	90.1	45 2	6),50	98.5	138.8	156.5
Tractive force—compound ,,	6.5	7.1	7.4	10.9	11.8	16.7	18.0

two, and turning them into Mallet engines with the introduction of new boilers. This transformation gave good results, and locomotives of the Prairie type were treated in the same way. But the most remarkable transformation was that carried out by the Atchison, Topeka and Santa Fé Railway using locomotives with ten wheels coupled, already referred to.

In 1902 they were the largest engines in the United States. The frames were utilised for the rear portion of the new engines, and the original low-pressure cylinders of 0.813 m. (2 ft. 8.01 in.) diameter were fitted with inside liners so as to reduce the diameter to 0.711 m. (2 ft. 4 in.) and transform them into high-pressure cylinders. A front truck was added, carrying the low-pressure cylinders of 0.965 m. (3 ft. 2 in.) diameter, and a new boiler

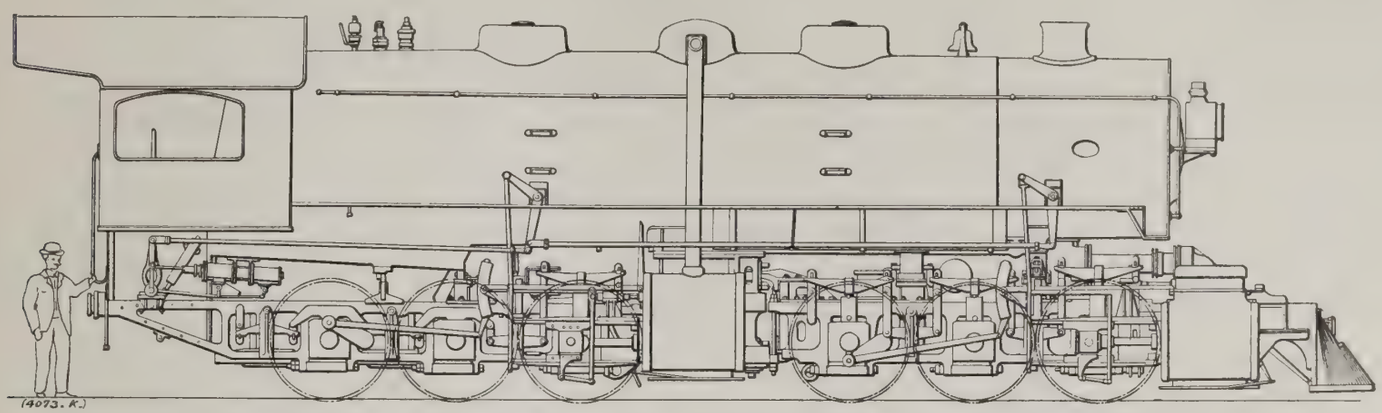


FIG. 10. LOCOMOTIVE FOR THE BALTIMORE AND OHIO RAILROAD; 25.3 TONS PER AXLE, 1903.

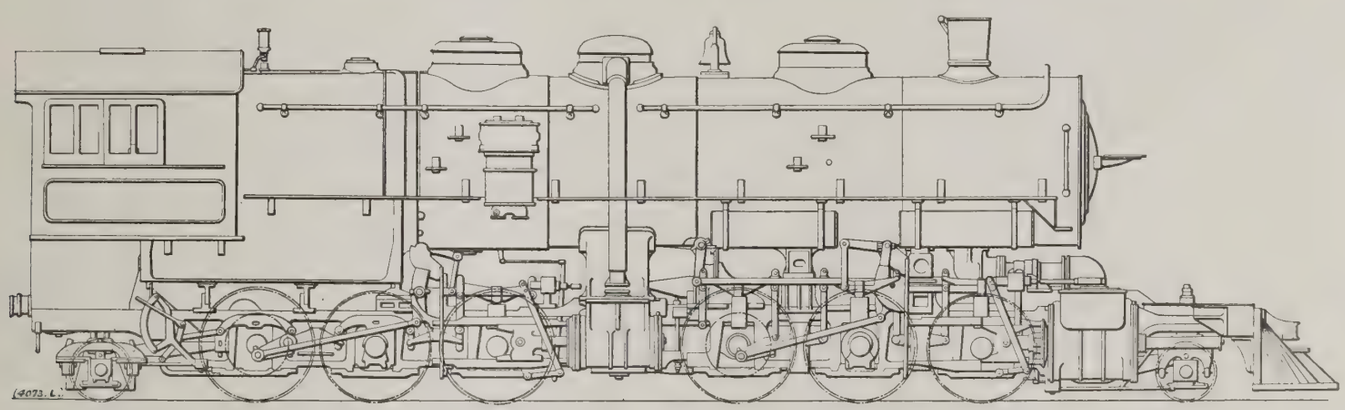


FIG. 11. LOCOMOTIVE FOR THE GREAT NORTHERN (U.S.A.) RAILWAY; 159.4 TONS, 1905.

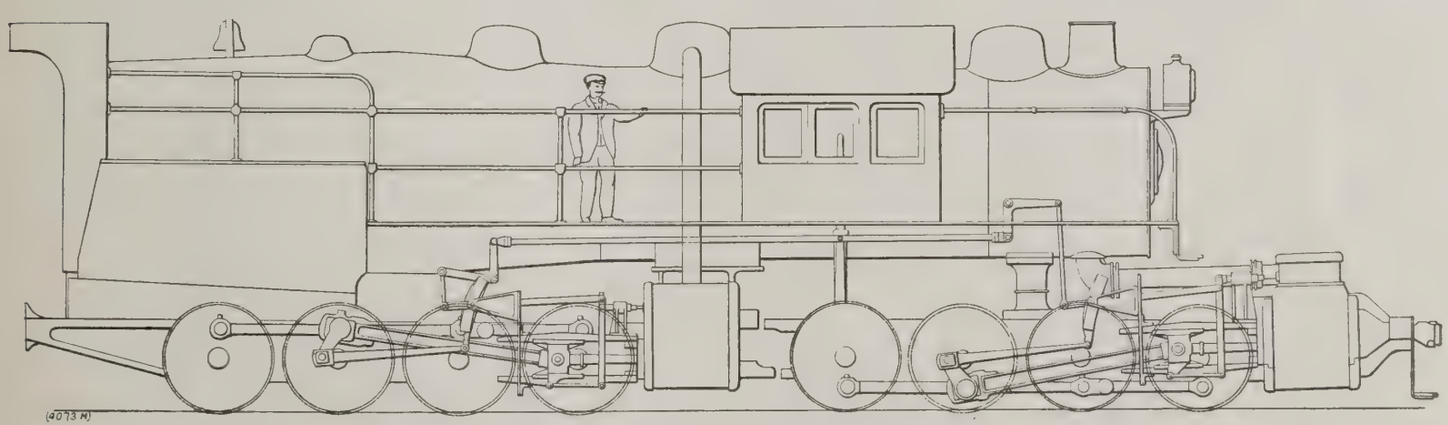


FIG. 12. LOCOMOTIVE FOR THE ERIE RAILROAD, 1907.

TABLE II.—SHOWING A FEW TYPES OF MALLET ENGINES FOR WIDE GAUGE.

—	Gothard, 1.435 Metre. Maffei.	Prussian State 1.435 Metre. Alsacian Society.	Hungarian State. 1.435 Metre. The Co's. Workshops.	Trans-Siberian, 1.525 Metre. Kolomna.	Central Aragon, 1.676 Metre. Borsig.	Pekin-Kalgan, 1.435 Metre. North British Locomotive Company.
Number of axles	0-3 + 3-0	0.2 + 2-0	0-3 + 3-0	0-3 + 3-0	0-3 + 3-0	0.3 + 3-0
Diameter of cylinders in.	15.8-23.8	15.8-23-6	15.8-24.4	18.7-28.0	18.5-28.0	18.0-28.8
Piston stroke ,,	25	23	24	26	24	28
Diameter of wheels ,,	48	50	48	46	43	51
Distance between parallel axles ,,	106	69	106	102	118	116
Total distance between extreme axles ,,	320	228	315	303	343	352
Grate area sq. ft.	24	21	24	39	37	45
Total heating surface ,,	1669	1529	2530	2196	2368	2605
Steam pressure in boiler lb. per sq. in.	171	171	228	171	171	228
Working weight tons	74.8-85.6	55.1	70.9	79.8	86.6-106.3	96.5
Adhesive weight ,,	74.8-85.6	55.1	70.9	79.8	86.6-106.3	96.5
Weight of tender, full ,,	tank engine	39.4	—	44.3	tank engine	—
Total weight ,,	74.8-85.6	94.5		124.1	86.6-106.3	—
Tractive force—compound ,,	9.9	94.5	10.3	124.8	15.8	17.7

was fixed containing, owing to its length, a superheater, a steam re-heater going from one group of cylinders to the other, and a re-heater for the feed-water. These newly-transformed engines scaled the enormous weight of 227,000 kg. (223 4 tons), of which 200,000 kg. (196.9 tons) was adhesive weight, distributed over ten axles.

The company has, besides, constructed others on the same model, heavier still, weighing 280,000 kg. (275.6 tons), of which 250,000 kg. (246 tons) is adhesive weight, and which give them, when working compound, a tractive force of 50,000 kg. (50 tons) at tread of wheels.

Table III., page 56, gives the main dimensions of some of these engines. It will be seen that for a few the diameter of low-pressure cylinders is equal to, if not greater than, that of the boilers of sixty years ago.

There are actually on American railways the following types of Mallet engines:—2-4-4-2, 4-4-6-2, 0-6-6-2, 2-6-6-2, 2-6-8-0, 0-8-8-0, 2-8-8-0, 2-8-8-2, 2-10-10-2. These engines are to be seen at the present day on some forty lines in the United States. They are used for various purposes, either on easy lines for very heavy trains or

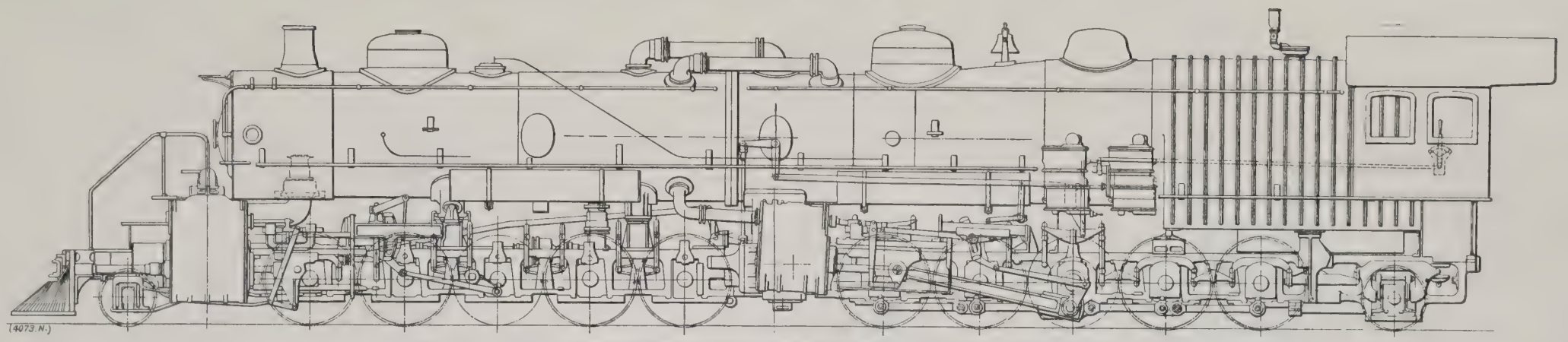


FIG. 13. 2-10-10 2 LOCOMOTIVE FOR THE ATCHISON, TOPEKA, AND SANTE FÉ RAILWAY, 1911.

with less loads on severe gradients. According to American engineers, the adoption of this system is justified by the following advantages :—

1. Distribution of adhesive weight over a great number of coupled axles.
2. Diminution of weight on the wheels, reducing the deterioration of track and bridges.
3. Considerable distance between extreme axles and reduced distance between parallel axles.
4. Great flexibility of the engine, reducing the wear of rails and flange.
5. Advantages arising from the use of double expansion and superheated steam where economy is concerned.
6. Division of the mechanism into two sets.
7. Small relative weight of the pieces of the mechanism and decrease in repairs.
8. Reduction in the repairs of the boiler as compared to those of the engine, owing to there being only one boiler for two engines.
9. Ease and simplicity of driving.

To these advantages it may be added that the use of double expansion reduces the slipping of the wheels considerably. Articulated locomotives, with double high-pressure cylinders independent of one another, often give rise to difficulties in running, due to the fact that when they are working at full pressure on an incline it is nearly impossible to make both cylinders give the same hauling power, and either the one or the other starts to slip. Trains frequently stop on severe gradients for that reason. Such is not the case with articulated compound locomotives on account of the reliability of the two sets of cylinders working on the same steam. If the high-pressure group start to slip, the cylinders of that group exhaust their steam in the receiver quicker than the low-pressure cylinders can use it, and the pressure at the receiver as it goes up stops the slipping. In the same way, if the wheels of the front group start to slip, the low-pressure cylinders discharge steam quicker than the high-pressure cylinders can feed them, and the pressure goes down at the receiver, so that the wheels cease slipping. If slipping take place in both groups at the same time, action can be taken accordingly as with ordinary engines.

The arrangement of articulated frames used by the author has been criticised. It means this advantage, however, as was pointed out in a pamphlet published by the Baldwin firm ; so long as the effort exercised by the driving connecting-rod on the crank-pin is not at a dead end, the pressure of steam tends to push the bottom of the cylinder and the frame in opposite directions. In articulated engines this is according to an arc of a circle described with the axis of articulation as centre. If the pistons on both sides worked together the two actions would balance one another, but the crank-pins are placed at 90 deg., so that during one turn of the wheel there is a point when the pistons are moving in opposite directions, and twice in every revolution they are tending to turn their separate frames, first one way then another. All engines have a certain amount of play, either between the rails and the flanges of the wheels, or in themselves, so that movement may take place laterally for an amount equal to the sum of these oscillations. But before this displacement is reached it is first of all counteracted by inertia, then by friction of the flanges against the rails, and by more friction like that of the journals in the axle-boxes, &c. The sum of these resistances multiplied by the radii x and y, Fig. 14, at the end of which the resistance takes place, represents the resistance of the engine against transverse displacement. This resistance is greater for the Mallet than for the Fairlie engine, on account of the greater length of the lever-arm. In the two types the reaction on the crank-pin is tangential to an arc of a circle having for its radius c the distance of the axis of articulation from the axis of the cylinder and the moment of rotation is the product of the reaction by this radius. From which it follows that the Mallet engine is more stable than the Fairlie ; for with equal loads on the driving-wheels and the same distance between axles, it opposes a greater moment of resistance to the displacing factors.

Lateral stability is a very important item, for if the moment is insufficient the engine will continually oscillate and bring about a rapid wear of the flanges and excessive play. This is opposed to safety, and in any case means very costly upkeep. A few engines of this type have been constructed with cylinders of equal capacity (all working at high pressure). The author does not advocate this scheme, in which one is deprived of the advantages to be realised by the adoption of double expansion both for simplification of piping and reduction in slipping. This system is only justified in the case of a loading gauge which does not allow the adoption of low-pressure cylinders of convenient diameter.

The author believes he could not do better than conclude with an extract from a paper read at the Franklin Institute on January 16, 1910, by Mr. Grafton Greenough :—

"We find that wherever continuous heavy road service or heavy pushing service is required, the Mallet compound articulated locomotive has more than done what was expected of it. We also find it, because of the articulated features, adapted to lighter work where rigid base wheel engines are not practicable. In all heavy service, of a nature which enables an engine to work a considerable portion of its time to anything like maximum efficiency, we find that, in addition to being more effective than other types of engines, the Mallet locomotive is by far the most economical design of locomotive yet devised. Without doubt its advent has eliminated the necessity—for a time at least—of widening the gauge of our railroads, and has, in many instances, postponed the laying of additional tracks, because of the reduction in the number of train movements it makes possible. Furthermore the introduction of the Mallet type of locomotive has justified the retention of steam locomotives as motive power on economical grounds alone, where, in a number of instances, electricity generated by water-power bids fair to invade.

"That the solution—for a time at least—of the apparently insurmountable difficulties attending the hauling of heavier trains, has been obtained with practically no change in roadways, is due primarily to the common-sense design of locomotive, developed by Mr. Anatole Mallet, seconded by the untiring energy and perseverance of the railroads officials, who in conjunction with the builders of locomotives had the temerity to give these engines a fair trial, and so mould their particular features to comply with modern railroad conditions that their efficiency is no longer an experiment, but a positive accomplishment."

The author deems it his duty to bring forward the above opinion of American engineers to the notice of European railway engineers and locomotive builders (the latter numbering about thirty), to whose initiative and ability the results which have been set forth in this paper are greatly due.

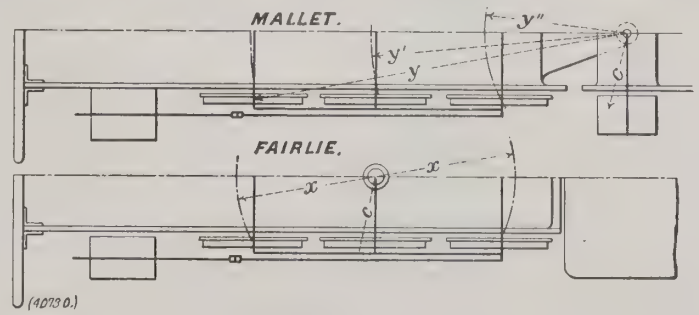


FIG. 14. COMPARATIVE STABILITY OF THE FAIRLIE AND MALLET ENGINES, UNDER THE ACTION OF THE PISTONS.

TABLE III.—SHOWING A FEW TYPES OF MALLET ENGINES IN THE UNITED STATES.

(See Figs. 10 to 13, page 55 and present page.)

—	Baltimore-Ohio, 1904. American Locomotive Company.	Great Northern, 1906. Baldwin.	Erie, 1907. American Locomotive Company.	Baltimore-Ohio, 1911. American Locomotive Company.	Virginia Railway — Baldwin.	Atchison, Topeka and Santa Fé — Baldwin.
Number of axles	0-3 + 3-0	1-3 + 3-1	0-4 + 4-0	0-4 + 4-0	1-4 + 4 1	1-5 + 5-1
Diameter of cylinders .. in.	20-32	22-33	25-39	26-41	28-44	28-38
Piston stroke .. .. ,,	32	32	28	32	32	32
Diameter of wheels .. .. ,,	56	55	51	56	56	57
Distance between parallel axles .. .. ,,	120	120	168	180	180	240
Total distance between extreme axles .. ,,	368	535	470	487	478	797
Grate area .. .. sq. ft.	72	78	100	100	84	82
Total heating surface .. .. ,,	5587	3907	5318	5533	6922	3918
Steam pressure in boiler .. lb. per sq. in.	228	213	213	213	213	228
Working weight .. .. tons	149.6	158.5	182.0	205.7	204.7	274.6
Adhesive weight .. .. ,,	149.6	140.7	182.0	205.7	184 6	245
Weight of tender, full .. .. ,,	62.9	65 9	73.8	80.7	78.8	101.4
Total weight .. .. ,,	212.5	224 4	255 8	286.4	283.5	376.0
Tractive force—compound .. .. .. ,,	26.5	28.5	36.4	44.3	43.3	49.2

WEST PARISIAN TRAMWAYS.—The working of the West Parisian Tramways last year was attended with a loss of 3436*l*. This carries the aggregate debit balance with which the company has to deal to 123,872*l*.

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With One Two-Page Plate and Four One-Page Plates of the ALEXANDRA DOCK EXTENSION AT NEWPORT.

ENGINEERING.

FRIDAY, JULY 10, 1914.

PROTECTION AGAINST FIRE ON BOARD SHIP.

IT is a remarkable fact that, notwithstanding the great developments that have taken place in every detail in the design of merchant steamships, little or no progress has been made towards the effectual protection of the vessel against fire excepting, perhaps, in the direction of improvements in the pumps and in the distribution of pressure water from them. In the case of warships it has for some years been realised that one of the dangers to be met in naval engagements is fire, due to the action of the explosive contents of the shells which may penetrate into the interior of the ship, and progress has been made in the direction of ensuring that the whole of the interior fittings shall be of a non-combustible material. It cannot be said that there has been great loss in decorative effect, although in this matter the warship is in an entirely different position from the modern liner. No attempt has been made, even in warships, to introduce furniture made of metal which will resist fire, the theory being that, before an engagement is entered upon, all wooden furniture, as well as all portable combustible material, &c., will be jettisoned.

In the merchant service there is not the same risk of fire as with warships in action, but statistics show that during the past eight or ten years there have been annual averages of over 300 outbreaks of fire on board ship, either in port or at sea, while the number of ships completely destroyed by fire averages over twenty per annum. This may not seem a large figure when one remembers that on the register of the United Kingdom alone there are nearly 21,000 ships, and that probably throughout the world there are 50,000 ships continuously in service. At the same time the possible loss of life, and the probable destruction of property consequent on fire, should encourage careful consideration of all possible methods not only of preventing an outbreak, but of quickly and effectually arresting it in the initial stages. Undoubtedly in the case of passenger - ships the publication of the fact that something had been done towards this end would have an effect on the bookings corresponding to that resulting from the evidence given of the possession of lifeboats for all. In the new Hamburg-Amerika liners Imperator and Vaterland Grinnell sprinklers have been introduced, and this fact alone justifies a consideration of the effectiveness of this method of combating fire on board a ship.

The extent to which such automatic sprinklers are used in mills, factories, warehouses, stores, halls, theatres, &c., and the disposition of fire insurance companies to grant rebate on the premiums of fire insurance policies when sprinklers are fitted, is evidence in favour of the efficacy of the same system on board ship. The conditions, particularly in the passenger quarters, are most favourable, because here the space is so minutely divided up by iron decks, transverse bulkheads, and even by cabin and alleyway walls, that the initial outbreak of a fire is confined within a limited area, and were automatic sprinklers immediately brought into action, the fire would the more likely be quenched. As to the freezing of the water in the pipes—an argument sometimes used against the system—the dry-pipe system has proved an effective preventive. In this system, so-called pressure tanks are provided, containing sufficient water for a primary supply, and this water is held in check by a specially designed differential valve, having water pressure on one side and air pressure on the other. When the rise in temperature, due to the starting of a fire, melts the solder of the sprinkler, the opening of the head liberates the air, reducing the pressure, and the valve is opened by the water-pressure above it exceeding the air-pressure under it. Thus the water flows freely through the pipes and out of the open heads. The inspection department of the Associated Factory Mutual Fire Insurance Companies of America, which has been responsible for the fitting of sprinklers to quite a number of American ships, including coasting, river and lake passenger-steamers, estimates that with any sprinkler system on board ship the heads would be spaced about 10 ft. apart, each protecting 100 sq ft., and that the cost of such an installation would average about 16s. per head, excluding the cost of the pumps. In land practice the cost is only about 12s. per head, but the ship installation would probably cost more.

The treatment of holds where cargo is carried involves a special application, particularly where the cargo is of a material with a tendency to spontaneous combustion. It would be difficult for sprinklers, and even for a hose, to subdue a fire of this nature, although it might postpone serious consequences sufficiently long to enable the ship to reach port. The authority already quoted has adopted a system of introducing carbon dioxide into warehouse compartments, which are analogous to ships' holds. The carbon dioxide is purchasable in a form liquefied under pressure and contained in drums. The liquid gas is passed through pipes and exudes through openings at the top of the warehouse or hold, its specific gravity causing it to sink, and thus to penetrate the interstices of the cargo during its descent; the result is that combustion is rendered impossible, and the fire is either held in check or completely extinguished, the gas ultimately being driven out or sucked out by fans. The difficulty is that the carbon dioxide, though not explosive or directly dangerous to life, tends towards asphyxiation. But a man can live for a limited time in an atmosphere containing 10 to 15 per cent. of it, and it is computed that from 30 to 40 per cent. is sufficient to extinguish a fire. It is not dangerous to merchandise, and the quantity required is about a 50-lb. cylinder per 1000 cub. ft. of air. Sulphur dioxide has been used, but the authority quoted found it objectionable, as men could not live in an atmosphere containing any appreciable amount of the gas; moreover, it is injurious to certain kinds of merchandise.

In addition to this means of extinguishing an outbreak consideration should be had, in merchantship practice, to the adoption to a larger extent of metal in preference to wood. It is true that so-called fire-resisting paints are largely used, but there is doubt of the efficacy of the great majority of such paints. In preference to wood a light steel might be used, especially if lined with non-combustible insulating material in order to secure a more equable temperature within the cabins in climates where extreme weather conditions prevail. In recent years there has been considerable development in the simulation of wood-carving and decorative effect generally in the production of metal furniture; but, even so, we are a long way from achieving the artistic effects which can be got from wood. In the modern liner, however, plaster-of-paris and other such materials are being more and more relied upon for decorative purposes. Indeed, in some of the newer ships it is difficult to grasp the fact that one is not in a room on shore, because of the treatment of the ceiling and walls. If this plaster-of-paris work proves to be lasting, a way is opened up for the use of light-steel partition walls with insulating materials in preference, or in addition, to the plaster-of-paris.

The question is largely one of expense. The substitution of steel and plaster for wooden decks, cabins, &c., in medium and large passenger vessels would involve an increase in expenditure up to 10 per cent. of the cost of the entire ship, excluding even the extra cost of steel furniture, if such were used. This is a serious addition to the price of a ship, and when to it there has to be added the cost of automatic sprinklers, it will be obvious that the shipowner will have to consider whether the advantage accruing from increase in favour with the public, and consequently more consistently full passenger lists, with the addition of a reduction of insurance rates, can compensate him for the expenditure. There can be no question that a ship so treated would be more immune from the risks of fire than an ordinary vessel depending only upon the fire-pumps; but the final answer is, we fear, one concerned with the relation of safety, and its influence on earning power, to the cost involved. The matter is one that will be decided finally by the public. If they make it clear that they are ready to pay for increased security, then it is certain to be attained, for manufacturers will vie with one another in discovering new materials, and in devising novel methods of treating old ones to render them durable and artistic. Shipowners have shown such

readiness to add to the comfort and speed of their vessels that there is no doubt they will meet all demands that are commercially practicable.

EXPLOSIONS IN ELECTRIC MAINS.

The unanimous report of the Departmental Committee on Electric Mains Explosions, just published,* should tend to allay the apprehension which has arisen in many quarters as to possible danger from the use of bituminous or pitchy compounds for the insulation and protection of buried electric mains. Explosions have occurred chiefly in separate mains carrying continuous current, insulated with vulcanised bitumen, either drawn into bitumen conduits or laid solid in troughs filled with bitumen. But the Committee does not find any sufficient grounds for recommending the Board to prohibit this system of laying, as it is probable that accidents which have occurred through it could also be partly assigned to other contributory causes.

The particular points requiring attention are: the method of making bends, which should have easy turns; the proper shape of the troughs, which should be filled in after the straights have set; the means for taking off the services, which should be armoured cables and be gas-proof from main to house; and the danger of covering with an impervious pavement. The following features are exonerated from blame as the cause of serious explosions :—Alternate-current supply, concentric cables, three-core cables, lead-covered paper-insulated cables, cables laid solid in pitch compound. It is noted, however, that bitumen has been so much more extensively used than pitch compound that a proper comparison between the two cannot be made. With regard to troughing, the Committee finds no superiority in iron or stoneware over wood, except where the soil is proved to be unsuitable for wood. It is recommended that separate mains be laid, each in a separate trough, with at least 2 in. of tightly-packed earth or sand between.

Considering the hundreds of miles of mains laid solid in bitumen under streets, the actual number of accidents arising from them is relatively very small, some two deaths only being caused, and some sixteen or seventeen persons injured by them, during the last eleven years. The immediate cause of the explosion is the ignition of gases evolved from volatilisation or destructive distillation of the bitumen insulation and packing round a fault in the main. It is shown that bitumen deteriorates from (1) contact with coal-gas; (2) injury inflicted after laying, or original defect, on a positive main, permitting a small leak to earth, causing corrosion and ultimate failure of the conductor; (3) an earth on a negative main, decomposing the insulating material, and producing a leak from positive to negative, ending in short circuit. In such cases an arc forms, which may either be quenched by the bitumen it melts, or may persist, decomposing the insulating vulcanised bitumen and also the packing. These are circumstances of greatest danger, for at a high temperature large volumes of very inflammable gases are given off. The gases take the line of least resistance, possibly into a house or manhole. It will easily be seen that the most favourable conditions concur with several cables at different pressures in the same trough.

It is admitted that bitumen and pitch compounds offer the only practical alternatives as filling material for cable-troughs. The bitumen should liquefy freely between 250 deg. and 350 deg. Fahr., weld readily to adjacent layers, adhere to cables and bridges, and retain such viscosity in the ground as to allow it to bend slowly and to reunite if fractured. It should not be heated above 400 deg. Fahr. The alternative pitch should be coal-tar pitch, softened with pitch or creosote oil. In some cases whinstone dust is afterwards added to strengthen the mixture. Two such mixtures are quoted—namely, (1) 3 tons pitch, 2 tons stone-dust to 10 gals. pitch or creosote oil, and (2) 10 cwt. pitch, 10 cwt. limestone dust to 10 gals. tar oil. This is cheaper than bitumen, runs at 260 deg. Fahr., and has specific heat 0.5, while that of bitumen is 0.8. Thus the pitch compound causes much less heating of the cable when filling. The pitch compound also adheres well to unglazed stoneware bridges, and is not affected by coal-gas or creosote.

Considerable attention was given by the Committee to the question of testing and localisation of faults. Vulcanised-bitumen-insulated cables are the most difficult in this respect. It appears that the allowable leak depends on the size of the undertaking, but varies greatly. In one town with a peak load of 35,000 amperes a leak of 10 amperes is taken to indicate a fault, while in another the normal leak is 20 amperes on a peak load of 8000 amperes. No suggestion is made for a general standard, but evidence was taken on the advisability of dividing large networks into districts interconnected by fuses or circuit-breakers. The most workable unit would seem to be a district taking about 600 to 800 amperes.

Not the least interesting part of the report is the special report from Dr. R. V. Wheeler, of the Home Office Experimental Station, Eskmeals, to decide the following points :—

1. There is no tendency to spontaneous combustion or self-heat on the part of the finely-divided carbon from gaseous hydrocarbons decomposed at a high temperature.

2. Gas from bitumen at 1000 deg. Cent. is explosive when present in the air between the limits of 5.4 to 20.5 per cent., and gas from pitch compound between 10.7 and 47.5 per cent. Up to this temperature, therefore, the gases from pitch compound are the more dangerous, as remaining explosive within a greater range of mixture, but if the gases are "cracked" or broken up by passing over a very hot surface, this difference largely disappears, the limits of inflammability of both being widened, but more in the case of bitumen gases than pitch gases.

3. There is very little to choose between the bitumen and the pitch compound in the matter of the volume of inflammable gases evolved up to 1000 deg. Cent., Callender bitumen giving 3.1, Glasgow pitch 2.5, and pitch compound 2.8 cub. ft. per lb., reduced to normal temperature and pressure, but, considering the wider limits of inflammability of pitch gases, the latter would be more dangerous, subject to the remark on cracking in the last paragraph.

The report goes on to give the nature of the gases evolved, in which hydrogen and carbon monoxide largely predominate, especially when cracked. It also gives details of the experiments made and apparatus used, and will well repay study on the part of those who are concerned with the behaviour of volatile oils and solids, as well as of those who are directly interested in the question of electric mains protection.

* Report of the Committee of Inquiry appointed by the President of the Board of Trade. London: Wyman and Sons, Limited. [Price 3d.]

FACTORY BUILDINGS.

FACTORY buildings are of all kinds. In certain cases the adoption of cheap corrugated iron sheds may be fully justified by certain special conditions, whilst in other cases the erection of more elaborate and more expensive structures may be truly economical, the higher first cost being more than counterbalanced by a much lower expenditure in maintenance. Until recent years such permanent buildings were almost always of brick and steel, but of late ferro-concrete has met with much favour, and its advocates claim that under normal conditions a ferro-concrete building is considerably cheaper than one of brick and steel, even if the latter is provided with a roof of corrugated iron, which, of course, involves a considerable expenditure in maintenance. In one case, recently referred to in a paper before the Concrete Institute, it was stated that competitive tenders showed that a factory constructed throughout of ferro concrete (roof included) would cost 12 per cent less than an alternative design in brick and steel, with a roof of corrugated iron. The local conditions were in no way specially favourable to the ferro-concrete, the aggregate having to be brought 25 to 30 miles by rail. The building in question was constructed throughout of ferro concrete, but generally it is cheaper to execute the panels in brick, the reinforced material being then reserved for the columns, beams, floors and roof. Such a structure is, of course, remarkably permanent, since even the indifferent concrete-making materials which were available to the Roman architect and engineer have shown an extraordinary endurance. There is, of course, a popular misconception that ancient cements were incomparably superior to our own, a belief mainly attributable to the characteristic ignorance of literary men and antiquaries. Claims of this kind are, in fact, always being made, amongst the latest being one that in domestic sanitation the Minoan age was fully abreast of the best modern practice. In all probability the archæologists responsible for this opinion could not define the difference between a wash-down and a wash-out closet. Nevertheless, their views get into the public Press, and thus become almost ineradicable, owing to an apparently inexpugnable desire on the part of certain popular writers to belittle the achievements of modern applied science.

Many engineers prefer to use steel rather than ferro-concrete stanchions, owing to the ease with which attachments can be made to them at any future time. Mr. P. M. Fraser, the author of the paper referred to, claims that in this respect the advantage lies with ferro-concrete, since an inch-hole, for example, drilled into a ferro-concrete beam or column, reduces in general the gross section by a smaller percentage. This may be quite true, but whilst, with a reasonable exercise of judgment, an attachment to steel-work may be made almost anywhere without serious risk, there is always the possibility that in drilling ferro-concrete the drill may encounter some of the concealed reinforcement. It is of importance to allow for a very ample factor of safety in designing columns, whatever be the material used. In erecting a new factory building it is often quite impossible to foretell with certainty what loads the columns may be required to carry in future years. The same consideration also applies to the design of the floor, and we have known instances, in printing works in particular, in which weights have been piled on galleries very much in excess of what had been anticipated by the designer. In this respect steel would appear to have a considerable advantage over its rival, since, if need be, a steel beam can be strengthened by additional plates, whilst a corresponding operation would hardly prove satisfactory with ferro-concrete.

It is sometimes claimed that ferro-concrete is specially suitable for engine foundations, but the conditions in which this may become necessary must be somewhat rare. What is generally required in such foundations is weight rather than great strength, and this is so commonly recognised that there is at times difficulty in preventing some contractors omitting from such foundations much of the cement specified, their view being apparently that anything that will stick together is good enough for an engine foundation.

Incidentally in his paper Mr. Fraser made some criticisms of English methods which are, we think, far from being justifiable by experience. The latter shows that slightly inconvenient buildings are not always as heavy a handicap as Mr. Fraser contends. For certain trades, particularly those in which articles are built in large quantities to stock, only extremely low annual charges may make feasible competition with firms more conveniently housed. Nevertheless, as is well known, firms with old machinery and old factories are by no means always unsuccessful, the reason being that the cost both of buildings and plant has been completely written off many years ago, and hence somewhat higher working expenses do not necessarily preclude effective competition. Where a varied class of work is done, hardly two jobs being alike, conditions are still more equal, since the newer factory cannot then have as effective an organisation as it may have in more specialised fields. Other things being equal, a well-arranged building is, of course, an enormous asset to the manufacturer. Many small firms have, however, to put up with what they can afford rather than with what they would prefer, and they manage to make profits in spite of certain inconveniences.

THE JOINT MEETING OF NAVAL ARCHITECTS AND ENGINEERS AT NEWCASTLE.

THE joint summer meeting of the Institution of Naval Architects, the Institution of Engineers and Shipbuilders of Scotland, and the North-East Coast Institution of Engineers and Shipbuilders, which is being held at Newcastle-on-Tyne, opened auspiciously on the 7th inst., when the various institutions were welcomed by the Right Hon. the Earl of Durham, K.G., as the chairman of the local reception committee. The official welcome took place in the King's Hall of the Armstrong College, and in addition to the Earl of Durham, the Right

Hon. the Lord Mayor of Newcastle-upon-Tyne, and Sir Charles Parsons, as President of the North-East Coast Institution of Engineers and Shipbuilders, delivered brief addresses of welcome. There was an excellent attendance, although the Marquis of Bristol, in replying for the Institution of Naval Architects, pointed out that many who would have attended from Scotland were prevented from being present by the visit of His Majesty the King to Glasgow. It was hoped, however, that most of these gentlemen would be able to come to Newcastle for the closing days of the meeting.

The Chairman announced that he had just received from Holyrood Palace a telegram sent by His Majesty the King, expressing his interest in their gathering. This telegram was as follows:—"The King is much interested in the meeting, now assembled at Newcastle, of the three Institutions representative of the shipbuilding and marine engineering of the Empire, and wishes it every success." The reading of the telegram was received with warm applause, as was also the proposal of Lord Durham that the grateful thanks of all present should be conveyed to the King for his gracious message.

Before dealing with the technical part of the proceedings, which is our proper province, we desire to express our sympathy with the Marquis of Bristol in the personal bereavement which prevented him taking other than a formal part in the meeting, and deprived the social features of the gathering of the presence of Lady Bristol.

BATTLESHIPS AND SUBMARINES.

The technical papers on Tuesday last, the first day of the meeting, were presented by members of the Institution of Naval Architects. The first, which was taken in the King's Hall before the whole of the assembled company, was by Professor Sir John H. Biles, and was entitled "On the Protection of Battleships against Submarine Attack." We reprint this paper in full on page 65 of our present issue. It was read by Sir John, who stated that it was really a stop-gap paper, prepared to take the place of one on the subdivision of ships, which was to have been read by Professor Welch, who had, however, been obliged to go to Canada in connection with the Empress of Ireland inquiry.

Lord Brassey opened the discussion. He said that as a veteran and old president he had been asked to do so. He thanked Sir John Biles for his most valuable paper, but did not feel competent to answer the four points which appeared at the end of it. It might be possible to build such ships as the paper proposed, but one thing which seemed clear to him was that it would not pay to put too many of our eggs in one basket. We might accept the inference that a given speed and armament were necessary, but that did not necessarily imply acceptance of a given size of ship. The same total armament might be distributed over a greater number of ships. An equal armament might cost more under these conditions, but the proposal could not necessarily be scouted on that score.

Mr. C. E. Ellis, the next speaker, said that Sir John Biles had hoped that Sir Andrew Noble would say a few words in connection with the questions of armour raised by the paper, but Sir Andrew had unfortunately been unable to attend, and had asked him to speak in his stead. A worse man could hardly have been chosen. Whatever knowledge might exist on the question of the resisting power of armour against torpedo attack did not reside with him or with any other armour-maker. No doubt the Admiralty had some knowledge in reference to the matter, but he had not. He was glad he had not. If he had, he might feel it necessary to give the meeting the benefit of his knowledge, and that would hardly have been permissible, as obviously any data on the subject must be based on Admiralty experiments.

All he would say was that any armour developed for protection against under-water attack might well be of somewhat different type from that at present used. It might be that a lighter protection would be sufficient. That was for the expert to decide. The history of armour showed that on the whole it had been capable of meeting the attacks of its enemies. It had fought the gun, and, he thought, on the whole, had fought it successfully. It had also given a good account of itself against torpedo attack on the water-line, and he thought it would prove capable of providing defence against this insidious attack below water. As a final point, he would say that in the last few years the armour-makers had found it necessary to provide armour of shapes which previously they could not manufacture. They had done this with success, and there was little doubt that in the future they would be able to furnish armour of any shape likely to be required.

Admiral Sir Reginald Custance, who continued the discussion, said there were a large number of questions raised by the author, and it was necessary he (the speaker) should confine himself to what he considered the gist of these questions. That was:—What was the war value of the Whitehead torpedo? In the first instance, it was necessary that one should not be misled by the results of peace practice. They were entirely different from those furnished by war. In the Russo-Japanese war there were four engagements in which torpedoes were employed. These were the first surprise attack outside Port Arthur, the first sortie of June 23, the second sortie of August 10, and the battle of Tsushima. In all, some two to three hundred torpedoes were fired, and of these about 5½ per cent. resulted in hits. Even so, many of these concerned ships at rest or moving very slowly, and only about 2 per cent. of the torpedoes fired at ships in motion reached their mark. This was a great falling off from the results of peace practice. It should further be noted that no ship sank immediately on being struck by one torpedo. The ships that foundered at once had been hit by three or four torpedoes, and had further been much damaged by gun-fire. These figures suggested that there was a very fair probability against a particular torpedo doing much damage.

What was the explanation of the low percentage of hits? At the time of the Russo-Japanese War a torpedo could travel at 50 ft. a second. Now they could travel at 75 ft. a second. When a torpedo was fired at a ship in motion it had to be aimed a considerable distance ahead of her; and as her speed and course were not known, great difficulty was introduced. Further uncertainty arose from the fact that one was not certain about the speed of his own torpedo; also it was necessary to fire it at the exact moment when the sights were on. This was not easy. Then questions of imperfect management crept in. The torpedo was set for short range, and fired for long range, and so on. Again, torpedoes might be erratic, and sometimes turned round and came back at the boat that had fired them. Not very often perhaps, but still it might be in 1 per cent. of cases. When all these difficulties came in, and had to be allowed for on a dark night under gun-fire, when the enemy was suddenly sighted, the wonder was that torpedoes ever hit their mark at all. Besides, all this went on at very close range—within 400 yards—when gun-fire became a very serious matter.

Errors in the course and speed of torpedoes also depended on the speed ratio. This was the ratio between the speed of the torpedo and the speed of the ship. From the point of view of this ratio, nothing must be taken off the speed of the ship. In the Russo-Japanese War the cruisers had a speed of about 17 knots, and the battleships a speed of from 13 to 8 knots, or even less. The speed ratios varied from $\frac{5}{3}$ to $\frac{4}{1}$. The ratio had not changed at the present day, as the increased speed of the torpedo had been offset by the increased speed of the ships. Errors of torpedo course also depended on the direction of attack—whether it was on the beam or right ahead, and it was difficult on a dark night to know if one was on the beam or not. Chances of hits were further dependent on the length of the ship and the angle she subtended. From this point of view, long ships were a disadvantage. The broad results of the experience of the Russo-Japanese War was that the gun-armed surface vessel had successfully neutralised the torpedo-armed surface vessel. That could broadly be said of the effect of the destroyer on the torpedo-boat.

These being the known war facts of the torpedo-armed surface-boat, the question arose, How did they apply to the submarine? There was no war experience of the submarine, but she carried the same weapon, and the same errors were possible. Some people might say that the submarine was safer for those on board than was the surface boat, and that their mental equilibrium would be less disturbed. But this was a peace idea. In peace manœuvres the man on the submarine knew that the man he was attacking would do him no harm. In war, he knew he would do his best to destroy him. This introduced an incalculable factor, and one must guard against drawing too definite ideas from peace practice. One must reserve judgment. The struggle was really one between weapons—between the gun and the torpedo—between a gun-armed surface vessel in motion and a torpedo-armed submarine, which must come to the surface at times and so expose herself to gun attack. He might suggest a simile. A fight between the gun-armed surface vessel and the torpedo-armed submarine was rather like a fight between a man in the open with a repeating rifle and a man under cover with a blunderbuss, who had occasionally to poke his head up to see what he was about.

Sir Philip Watts, the next speaker, pointed out that the author had stated there could be only two forms of defence against submarines—destruction of the submarines and protection of the bottom of the ship by armour. He had not appeared to think torpedo-net defence worth mentioning, but this defence could be made fairly effective, especially so when ships were stationary. A certain amount of protection could also be obtained by fitting deep inner bottom spaces, backed with tough protective plating, so that the loss of buoyancy resulting from a hit could be reduced to a minimum. Sir John had shown what it would involve if we had to armour-plate the sides of our ships to protect them against torpedo attack. If we retained the same speed, armour and armament as in the Dreadnoughts built during the last ten years, as many thought we should, the displacement would go up from 3000 to 4000 tons. The additional cost would be chiefly the cost of the introduction of the armour, which would be about 200,000*l*. These ships would still be somewhat smaller and, he believed, less costly than ships building at present by certain foreign Powers.

With regard to the points for discussion enumerated at the end of the paper, he would say:—

1. He thought 4-in. armour would afford sufficient protection against torpedos if associated with suitable inner bottom spaces, but it could be increased in thickness if desired.

2. Up to the present time the submarine menace had not been considered of sufficient importance to justify the adoption of armour protection on the bottom. Although discussed from time to time, it had never yet been seriously fitted.

3. He could not think that the power of gun attack was now relatively less than that of torpedo attack, but the reverse, and the importance of bringing the greatest number of big guns into the line of battle at least cost remained the same, and the value of speed remained the same. Hence the argument in favour of the big fast ship appeared the same.

4. It was probable that the admissible best form adapted for fitting and carrying armour would offer greater resistance than ordinary forms; but he was disposed to think there would not be very much in this. Resistance was very much more influenced by the longitudinal distribution of the displacement than by its transverse distribution.

Professor Hovgaard, who was the last speaker in the discussion, said that the problem discussed by Sir John Biles in his interesting paper was one of extreme importance, for on its solution depends the future of the large sea-going battleship. The question of the obsolescence of the battleship is really one of gradual restriction in its field of usefulness. Many people think that the battleship will be suddenly and absolutely abolished, and this idea has been advanced on several previous occasions when new weapons have appeared, but he believed that if the battleship was ever abolished it would only be as the result of a gradual process, perhaps of long duration. The Russo-Japanese War showed that the battleship could not safely approach fortified harbours, because the dangers of attack by floating mines were at all times very serious. In fact, the greater part of the losses by submarine attack during the war took place near the fortified places. At some distance from the coasts the battleships were fairly safe, being well prepared to meet the attack of surface torpedo craft. With the advent of the submarine-boat, the field of operation of the battleship at once became more restricted, although it cannot yet be said to what extent, since there is no war experience to go upon. It seemed certain, however, that large battleships would not now venture into narrow seas or near the coasts of an enemy unless they were absolutely forced to do so. For instance, he did not believe that they would

venture into the Baltic if this sea was infested by the submarines of a powerful enemy, but, if they did, they must certainly operate with the greatest caution. The same remark applied to the Mediterranean, although with less force.

As yet the submarine did not threaten the battleship seriously on the ocean, and as long as this condition existed battleships must be built to control the ocean—that is, they must be of the largest class and armed with powerful artillery. When the ocean-going submarine is an accomplished fact our conclusion might be different, but we do not know when this will happen, and perhaps by that time we shall be better able to meet submarine attack. It would be premature now to anticipate a danger that does not exist, and commence to construct small, poorly-protected and weakly-armed vessels. Battleships should be constructed to meet existing conditions, and not conditions that may not be realised for a number of years. The question is then, How best to protect the large battleships against submarine attack?

There are two positive ways in which this may be accomplished. One is by means of armour, the other is by means of the so-called "elastic" bulkheads—*i.e.*, bulkheads of curved form. Bulkheads of this nature were referred to by Mr. Owens in his paper read before the Institution of Naval Architects last spring, and are used by the French in the battleships of La Bretagne class.

Armour was now, as far as he was aware, always placed inside the ship on a longitudinal bulkhead at a certain distance from the outer shell. It was easy to show, however, that as now ordinarily constructed, this form of protection is unsatisfactory. Usually the armour is of 1½-in. or 2-in. thickness, and is supported only by a system of light stiffeners, quite out of proportion with the strength and weight of the armour itself. Probably the stiffeners will give way under the explosive pressures long before the plating is seriously strained, and the bulkhead will be blown bodily inwards. But even if the stiffeners are of adequate strength, it is likely that bulkheads as now constructed will give way by opening at the seams and butts and along the boundaries. It is very difficult, heavy and costly, to give sufficient strength to these lines of weakness. Let it be supposed, however, that this is done; then the armour-plating itself, being plane, will ultimately give way by bending, cracking, or tearing at the stiffeners long before it has had a chance to offer a resistance proportioned to its great weight and strength. On the whole, armour is ill-adapted to resist gaseous pressures; it is much better suited to resist local forces of great intensity, such as those due to the impact of projectiles.

As regarded armour placed on the outer shell, Professor Hovgaard went on to say that in 1909 he wrote an essay on this subject to Jane's *Fighting Ships*, where he gave a full discussion of this problem, resulting in the conclusion that if armour is to be used at all, it should be applied externally rather than internally. An explosion tends to expend its energy chiefly along the line of least resistance, a principle that is well illustrated in a gun. There the energy is almost entirely expended in giving forward velocity to the projectile and to the gases. The work done towards the rear by the recoil, where the resistance is much greater, is comparatively small, and laterally—*i.e.*, normal to the unyielding walls of the barrel—no work is done. Analogous conditions exist when a mine or a torpedo explodes in contact with the outer shell of a ship. If the side is unprotected, it offers practically no resistance, and the explosive pressures will be relieved instantaneously by exhaust into the interior of the ship, where they may cause widespread destruction. If, on the other hand, we could offer a greater resistance at the outer shell than that due to the inertia of the water, the explosive energy would be entirely or largely expended upwards into the atmosphere, since the line of least resistance would then be found in that direction. We cannot, of course, prevent a hole being punched in the side near the centre of the explosion, but by fitting armour on the side we may limit the size of this hole in a great measure. Only experiments can tell us to what extent this is possible, and how external armour will compare with internal armour. As already stated in his aforementioned essay, it is of the greatest importance that such experiments should be undertaken. In 1910 he contributed another essay to Jane's *Fighting Ships*, in which he recommended to fit 4-in. external armour on the outer shell, and to make the bottom, as far as possible, plane or developable. He recommended a form of the bottom somewhat approaching to that of a flat-iron, in order to facilitate fitting the armour, but as Mr. Ellis now stated that this difficulty no longer existed, it is best in that case to adhere to ordinary ship-forms. Hence, by fitting armour on the outside there appeared to be a possibility of keeping the greater part of the explosive effects outside the ship by giving the gas pressures time to exhaust more completely into the atmosphere. There is the further advantage that a good support of the armour is obtained without extra expenditure of weight, since the system of transverse and longitudinal frames in the double bottom can easily be made to offer a very considerable resistance.

His conclusion was, then, that if armour is to be fitted at all, it should be fitted on the outside; but he believed that the "elastic" bulkhead offered a far better solution of the problem. A crude calculation and even a simple consideration would show that it is possible with light plating of curved form to obtain enormous strength against gaseous pressure. Plane surfaces are, of course, entirely unfit for this purpose. No one would think of constructing a steam boiler as a rectangular box with plane walls. Even with ¼-in. plating it is easy to construct a bulkhead that will resist a head of several hundred feet of water. Such a bulkhead might be fitted at a moderate distance, perhaps from 8 ft. to 10 ft. inside the outer shell, and still be sufficiently strong. One important condition is, however, that it shall be adequately supported by deep girders. The elastic bulkhead would, he believed, essentially solve the problem of under-water protection, but it might be advantageous, in addition, to give to the outer shell a substantial thickness—for instance, 1 in.—and to construct it of a tough, high-tensile material, capable of being caulked, and well connected at seams and butts. This, however, was again a question that could only be settled by experiments

The Marquis of Bristol, in calling on Sir John Biles to reply to the discussion, regretted there was no torpedo admiral present to give his side of the question. Sir Reginald Custance and he himself were both gunnery officers. It was clear from the paper that it would be possible to fit protective under-water armour, but the interesting question was, Would this armour give the protection aimed at? In any case, he was afraid it would be necessary to retain the present speed and armament in conjunction with the new armour. It appeared to him, in a practical sort of way, that one should have an inner skin and some sort of cushion which would more or less damp out the explosion before it reached the armour. Finally, he thought it the duty of the Admiralty to carry out experiments on this question.

Sir John Biles, in reply, said that the paper had had the effect he intended when writing it. It would be agreed that no opinion had been expressed that the battleship should be eliminated. He thought this a fact worth recording in connection with the meeting. A second point was that it seemed to be agreed that some sort of under-water protection was possible—say 4 in. outside, or 1 in. inside and some outside, or some such arrangement. A third point was the desirability of doing this. That, he thought, must be left an open question at present. None the less when one remembered the screen of destroyers and cruisers round a fleet could be completely penetrated by submarines, which it never could by destroyers, the question of such protection became of great weight. The question might become acute in the near future, and he agreed with Lord Bristol that it was the duty of the Admiralty to consider the question very seriously. The consideration of the Paper then terminated with the usual vote of thanks.

The Föttinger Hydraulic Transformer.

At this stage of the proceedings the meeting was divided into two sections, and in the King's Hall, Dr. Föttinger read a paper on "Recent Developments of the Hydraulic Transformer," which we hope to publish in an early issue. Results were given of recent installations, and this, the author claimed, led to the conclusion that the economy of this system of power transmission and reduction resulted in an economy higher than that of electric transmission, and only 4 to 5 per cent. lower than that of mechanical gearing for ahead motion for the same steam conditions. For reversing and manœuvring its power and economy were over 100 per cent. better. Furthermore, by eliminating the astern steam-turbine, a decisive step in economy was obtained by utilising high superheat on board ship. The chief features of the system were:—(1) Increased speed and economy for all service conditions; (2) increased size of units both in ships and engines; (3) increased comfort and luxury for passengers and crew, due to entire absence of noise and vibration; (4) increased safety against danger, due to rapid manœuvring; (5) increased life of turbine-blading, due to constant rotation and absence of water-hammer and boiler-priming. In so far as the turbine was concerned, temperatures of 650 deg Fahr. could be safely used, a temperature which was now common practice in large stationary power plants.

Mr. Summers Hunter, who opened the discussion, acknowledged the free and frank manner in which Dr. Föttinger had placed his valuable experience before the Institution, and observed that the paper bristled with suggestions and valuable information. There were a few points which appealed to him as one identified more with merchant engineering than with warship work. Reliability and efficiency were what they asked for. Warships passed their trials at high power, and after that it was only in the stress of battle, when the lives of those on board were at stake, that the machinery was run at its maximum rate. With the merchant vessel it was quite different. Day after day, voyage after voyage, long or short, continual speed must be maintained, and he was sure it must be the admiration of everyone to notice the regularity with which our largest Atlantic liners and long-distance vessels performed their work at what was practically their maximum power and speed. It might be that under sea-going conditions some efficiency might have to be sacrificed to secure the reliability for which shipowners asked. From the shipowners' point of view, the question of cost was of primary importance. He was afraid that it did not matter how much economy they offered the shipowner, he would like the vessel at the same cost as the preceding vessel. It was a difficult position to meet, but he ventured to say new conditions were prevailing, and that, as opportunities arrived, the shipowners who were up to date were not afraid to spend a little more money to get what was so desirable—economy and efficiency. These were the considerations which must be taken into account in appraising the value of power transmission systems. As regards superheating, although he had done much in its adoption in merchant ships, he feared that, for the present, 650 deg. Fahr. was an excessive temperature.

Mr. R. J. Walker said that Dr. Föttinger was to be congratulated upon the success which had attended his efforts in the development of hydraulic transmission. The high efficiency which he obtained bore testimony to the good work he had accomplished in the transmission of power on hydraulic lines. He (Mr. Walker) was afraid that time would not permit him to deal fully with the many points raised in the paper, and the arguments used by the author in support of hydraulic transmission when compared with direct coupling of turbine engines to the propeller shaft or with mechanical gearing, and he would therefore confine his remarks to the few more important questions.

As regards efficiency, he thought it was generally accepted that the loss due to transmission alone was at least 8 to 10 per cent. greater with hydraulic transmission than with mechanical gearing. Attempts were made to reduce this difference to about half the amount by certain estimates of losses and gains which might be summarised as follows:—(1) Windage losses of astern turbines when revolving in the ahead direction. (2) Loss due to thrust-block. (3) Increase in the over-all efficiency with hydraulic gears by using the heated water of the transformer to increase the temperature of the feed-water.

With regard to windage losses in astern turbines, Mr. Walker said this question was fully dealt with in the discussion on Sir Charles Parsons's paper on "Mechanical Gearing for the Propulsion of Ships," read at the spring meetings of this Institution last year; but he would like to refer to an experiment which had recently been carried out at the Turbinia Works, Wallsend, by Mr. Cook (one of his colleagues at the works), on the windage loss of astern turbines in a geared installation recently

constructed. The arrangement of machinery consisted of one high-pressure and one low-pressure turbine, with an astern turbine incorporated in the exhaust casing of the low-pressure turbine, the turbines being coupled to the propeller shaft by means of mechanical gearing. The total ahead power transmitted to the propeller shaft was 3600 shaft horse-power. The revolutions of the turbines were 1486 per minute, revolutions of propeller shaft 90, so that the ratio of gear was 16.5 to 1. The astern power was 60 per cent. of the ahead power (with the same quantity of steam). A new rotor was constructed carrying only astern blading and rotated in the fully-bladed turbine casing at varying speeds and vacua. The power was supplied by an electric motor and measured in the usual way. The results showed that with the turbines revolving in the ahead direction at a speed of 1500 revolutions per minute, the loss was $10\frac{1}{2}$ horse-power, or $\frac{3}{10}$ of 1 per cent., with a vacuum in the condenser of 28 in., and 21.5 horse-power, or $\frac{6}{10}$ of 1 per cent., with a vacuum of only 26 in., thereby confirming the figure given by Sir Charles Parsons in his reply to the discussion on the paper already referred to—namely, that when going ahead the astern turbines are revolving in the vacuum of the condenser, and under such conditions the loss was not more than $\frac{1}{2}$ of 1 per cent. This result also confirmed Mr. Allan's experiments on windage loss of astern turbines.

With regard to the second point, in the later ships fitted with mechanical gearing pivoted thrust-blocks were employed, thereby reducing the losses in thrust-block friction to about $\frac{1}{10}$ of 1 per cent., practically a negligible quantity. As to the third point, in most of the modern turbine vessels the exhaust steam from the auxiliary engines was utilised for heating the feed-water. The quantity of exhaust steam available was in most cases quite sufficient to increase the temperature of the feed-water to 200 deg. or 220 deg. Referring to the question of the regeneration of heat, Dr. Föttinger gave the increase in over-all efficiency of the transformer due to feed-heating as 1.5 to 2 per cent.—this implied a loss in the transformer of $7\frac{1}{2}$ to 10 per cent. of the brake horse-power of the turbine. It was also said that for poorer efficiencies even 3 to 4 per cent. more could be gained. By a simple calculation it followed that if it were possible to obtain more than double the increase in the efficiency due to this regeneration of feed-heating, there would be in these cases double the initial loss in transmission.

Referring to the question of propeller efficiency, it had always been admitted that with direct-coupled turbines some sacrifice had had to be made in propeller efficiency as well as turbine efficiency, and that it had been necessary to compromise between the two. It was true that in some large-powered high-speed vessels propulsive efficiencies with direct-driven turbine propellers had been obtained approaching that of vessels with piston-engines; but in making any comparison of propulsive efficiency, as naval architects well knew, a very careful examination of the conditions and factors affecting propulsive efficiency required to be made. An error frequently encountered in the early stages of the development of the turbine-engine was to compare the propulsive efficiencies between a turbine-driven ship and a vessel with piston-engines, taking the shaft horse-power in the former case, and the indicated horse-power in the latter, whereas a correction should have been made to bring the piston-engine to a common basis of shaft horse-power.

Generally speaking, it was quite possible with reduced revolutions of propeller to obtain an increase in propeller efficiency varying from 5 per cent. to at least 12 per cent. in the different classes of ships where the direct-driven turbine had hitherto been successfully applied. With mechanical gearing, where the ratio of gear was not limited as in the hydraulic transformer, then full advantage could be taken of this increase in propeller efficiency to reduce the shaft horse-power necessary for a given speed. This reduction of power, together with the increase obtainable in the efficiency of high-speed steam-turbines, permitted of a considerable reduction in boiler power, size of auxiliaries, and condensing plant.

With the ratio of gear to which the hydraulic transmitter was limited it would appear that it was confined to a somewhat narrow field of work, inasmuch as it was not possible to secure in the majority of cases the accommodation necessary between the speed of the turbine and the speed of the propeller for maximum efficiency of each. There was therefore, in addition to the loss in transmission, a further loss in the propulsive efficiency with hydraulic transmission when compared with mechanical gearing, and the difference in over-all efficiency, when referred to in "knots run per ton of fuel," had been found to be very considerable in designs for war vessels.

He did not think that Dr. Föttinger had established any of the claims set forth in his conclusions. The question as to whether larger units incidental and necessary with hydraulic transformers were an advantage he thought was very much open to doubt. The placing of turbines in series on a common gear-wheel, instead of an independent turbine, had many advantages in favour of its recommendation; it was more economical in steam consumption, and the units were much smaller and more accessible, and in the event of a turbine being temporarily deranged, suitable pipe connections could be arranged for the working of the other turbine. In recently-constructed gears, which had been cut on the "creep" principle, noise had been practically eliminated. There was no difficulty in arranging for an astern power of 75 per cent. that of the ahead, should it be desired; but for all practical purposes it had been found that 60 per cent. of the ahead power was ample for any condition of manœuvring, and all recent designs of geared turbines provided for an astern power of at least 60 per cent. of the ahead for the same quantity of steam. Dr. Föttinger had suggested that astern turbines were a source of trouble. This was not the case. No trouble whatever had been experienced by the heating up of the ahead blades when driven in the opposite direction at full speed. The ahead turbine was connected to the vacuum of the condenser when going astern. It was observed in the illustration accompanying Dr. Föttinger's paper that an additional transformer was required for astern purposes in lieu of the astern turbine.

There was no difficulty in using superheated steam in geared turbines, either ahead or astern, provided suitable materials were employed in the construction, such as cast steel, instead of cast iron, for the high-pressure parts of the turbines. As a matter of fact, there were several geared-turbine installations under construction, arranged for superheat of 100 deg. to 150 deg. Fahr.

Dr. Föttinger, in replying, asked if Mr. Walker had seen the transformer plant at work, to which Mr. Walker replied in the negative. Continuing, Dr. Föttinger said he was afraid that Mr. Walker spoke on figures which had now been surpassed by the new results. There were, he said, other ways of looking at an engine besides the 5-per-cent. economy, and that from this point of view the hydraulic system merited consideration. He did not claim that what he had propounded was the solution for all questions and problems, but he proposed to show in future that this contribution, though a modest one, was a positive contribution to international science.

This section then adjourned after a vote of thanks to the author of the paper had been passed.

Shipbuilding Practice.

In the Physical Lecture Theatre, to which part of the meeting had adjourned after the conclusion of the discussion on Sir John Biles's paper in the King's Hall, two papers were taken, Sir Philip Watts being in the chair. The first was by Mr. J. G. John, and was entitled "Shipbuilding Practice of the Present and Future." It was read by its author. We reprint the paper on page 68 of our present issue.

Sir William Smith opened the discussion. He thought the meeting was to be congratulated on having listened to such a very able paper. Mr. John had gone into his subject in a very exhaustive way, and had written a valuable chapter on the question of how to get value for your money, which was, after all, the main problem in most walks of life. Many people seemed to think that when the Admiralty was in question, any difficulty encountered could be met by getting a little more money; but things did not work out like that. In this connection he would say that during the time he was at the Admiralty he went fairly closely into the question of pneumatic riveting, which was dealt with in the paper. He agreed with the author that it could be satisfactorily done, even for large rivets, if the people doing it wanted it to be satisfactory. But if one wanted to scamp work, it was easier to do it with pneumatic than with hand riveting. Mr. John's reference to the joining of parts by riveting was an apt illustration of the thorough way he had considered things in writing his paper. He (the speaker), like many others, had taken the joining of parts by riveting as a matter of course, but, as Mr. John had showed, there was nothing fundamental in it.

Colonel Saxton White said the paper was a very important one. If anyone called upon to lay down a new shipyard had the paper before him, he would learn to avoid many things which he ought to avoid. Those present at the meeting would that afternoon have an opportunity of seeing a yard which, he thought, would appeal very favourably to shipbuilders. One feature of lay-outs which appealed very much to his mind was the avoidance of the crossing over of traffic. This feature had been adopted in the yard they were to see. On the question of pneumatic riveting, he admitted there were difficulties, but thought they would be got over. Power riveting must inevitably be more and more introduced. He was interested in Mr. John's idea of welding the shells of steamers. If one could erect the plates in position, with the edges suitably prepared, and then weld them all up, it would be a consummation devoutly to be hoped for. All the same, he thought we should long have to rely on our friend (some called him something else) the riveter.

The crane question had been dealt with in an interesting way in the paper. That afternoon the audience would not see any covered berths, but would see a crane equipment that had the valuable property that it could be transported within certain limits to a new position. This was a most important matter. Owing to the size and character of ships constantly changing appliances frequently became obsolete. He could refer to sheds over shipbuilding berths, not 100 miles from the Hall, which were now too small for the work it was desired to do. It was important that, as far as possible, shipyard arrangements should be made elastic. A builder who put down certain plant at once of necessity limited the size and type of work he could undertake.

Mr. Rowell wished to know if Mr. John could say rather more about the process of welding he had used than he had put in his paper. The reference to the elimination of riveting was most important. It seemed to promise greater efficiency than at present for the expenditure of a certain number of tons of steel. The question of a welded ship was a big one, but the welding of the butts of plate-seams did not seem an impossible one, and would be an important step. On the question of lifting appliances for shipbuilding berths, he would say that he went into the matter fairly fully some years ago, and the result showed that it was not possible to justify an expenditure of more than 4000*l.* per 100 ft. of berth. This seemed considerably below some of the figures in the paper. He was sorry he had not seen Mr. John's paper earlier, and so had more time to consider it.

Mr. P. A. Mudd, of West Hartlepool, wished to say something on the part of the paper which dealt with electric welding. For some time past he had been engaged in carrying out electric welding repairs, and might be able to make some useful remarks. Electric arc welding dated back to 1885, when Nicholas de Bernados, of St. Petersburg, took out his patent for carbon arc welding. At that time, 29 years ago, Bernados saw a number of uses for his process, and in his specification mentioned a variety of plate-joints to be made, without rivets, either by point or continuous welding. He also claimed the construction of iron and steel vessels, boilers, armour-plate, and hydraulic apparatus, all welded at the joints and without rivets. In the result, however, little progress was made with carbon arc welding. The reasons were the difficulties of excluding the atmosphere and avoiding oxidation during the weld, and also of obtaining proper heat regulation of the arc. The welded or fused metal resulting from the process was extremely hard and full of small pores.

In the last few years considerable progress had been made in arc welding with metal electrodes coated with a flux or slag-forming composition. In the "Quazarc" process the difficulties of oxidation and heat regulation were faced in this way. In addition to protecting the fused metal from oxidation, the slag which was formed acted as a secondary conductor, and appeared to damp down the heat of the arc more nearly to the welding

heat required. Too much heat caused the metal to run very liquid and fly about, increasing the oxidation difficulty. Too little heat meant the added metal did not unite to the mass of the work. In the repair-work with which he (the speaker) had been concerned a word had been coined to express the right heat, and when the work and the added metal ran together "treacly," then the welding heat was right. It was obvious that downward welding gave the best results—that was work in which the molten metal from the electrodes ran down on to the work and the slag could float on the top, and so prevent oxidation. Unfortunately, in practice only about half the work necessary could be carried out downwards, the other half being either vertical or overhead. Overhead work was the most difficult, and taxed the skill and patience of the welder to the utmost.

He would like to make a few remarks on the results submitted by Mr. John. He would ask if the test-pieces referred to were welded on the bench under the best conditions of downward welding. He presumed they were. In the A series, when the tensile strength and elongation were tested, there was no actual test of the solid bar given for comparison, and also there was no tensile strength and elongation of the electrode wire which had been used. It was obvious that if one welded a 29 to 30-ton tensile boiler-plate with 24 to 25-ton wire electrodes, one could expect to get only about 75 to 80 per cent. of the strength of the solid plate in the weld. The sketches in the paper showed camber at the weld increasing the section. He presumed this was machined off before testing. A further point was that it was not stated if the butt was welded from one side only or from both sides, and whether the added metal was hammered while hot. In practice it was not always possible to weld a butt on both sides, but when it could be done it made the best job. It would have been better had Mr. John given an average over more than two test-pieces, one of which broke at 22 tons and the other at 25 tons. These were both good results. The conspicuous feature of tensile tests of welding was the lack of ductility shown by the small elongation of 3 to 6.5 per cent. obtained, although in the bending tests of all the series given the results were good. Further tests were required to determine resistance to fatigue.

In recent years electric welding had been used extensively for repair work on boilers and ships, but was very little employed for new work. For repair work on boilers it was much used for building up landing edges of riveted seams which were leaking, for welding in new patch-plates, for welding cracks in plates, and for building up wasted and corroded parts to their original thickness. For ship repairs it was used for welding landing edges of leaky seams, such as box-keel plates to stern-posts, welding cracks in stern and rudder-posts, welding split rudder gudgeons and building up worn rudder pintles. In the application of electric welding to new work, the speaker believed there was a large possible field, commencing on small work, such as steel water tanks, oil tanks, exhaust tanks, welded steel-plate condensers, and welded steel-plate masts and derricks. In the main structure of a ship, when watertightness was required in certain parts liable to corrosion, the landing edges of the riveted seams should be welded solid to do away with the caulking, which in time became leaky.

Mr. T. G. John, in replying to the discussion, said that when considering the preparation of the paper he had been struck by the rarity of papers on the subject. He thought the subject could not have been discussed in a better place than Newcastle. Colonel Saxton White was in a happy position in laying out his new yard. Most people could not afford all that had been done in this case. Such things as movable tower cranes and the non-crossing of traffic were usually impossible owing to the exigencies of the site. He did not altogether understand Mr. Rowells's reference to the cost of crane plant. Many figures in the paper were below that which Mr. Rowell had quoted. In reply to Mr. Mudd, he would say that the test-pieces dealt with in the paper were welded when in a horizontal position. Vertical welding had been done, but the results were not quite so good. The welds were not hammered. Hammering would obviously have improved them. He would also say that the strength of a weld must clearly depend on the strength of the material deposited.

A vote of thanks was then passed to Mr. John for his paper, on the motion of the chairman, and consideration was turned to the next contribution. This was a paper by Mr. G. H. Millar, entitled, "Some Notes on the Design of Floats for Hydro-Aeroplanes." It was read by the author in abstract. The paper, which we hope to reprint later, dealt with recent work on the subject carried out at the National Physical Laboratory. We need not deal with the paper now, as, in the absence of time, there were no remarks on it, beyond some congratulatory sentences by Sir William Smith, who rose on the invitation of the chairman. This concluded the proceedings of the morning.

Excursions.

In the afternoon the ladies of the party had a trip by train to Alnwick Castle, the seat of the Duke of Northumberland, K.G., while a large number of the gentlemen proceeded to the new Armstrong Works of Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, which were described in last week's issue (page 1 *ante*). Luncheon was served, and Sir Andrew Noble, having proposed the loyal toasts, welcomed the members of the three Institutions Earl Brassey replied, and Sir Charles Parsons proposed the chairman's health. After inspecting the yard, the members proceeded by steamer to Messrs. Swan, Hunter and Wigham Richardson's works, being received by Dr. G. B. Hunter. The most important object of interest was a four-cylinder four-stroke-cycle single-acting Diesel engine, running on the test-bed and developing 600 horse-power. The fact that fourteen vessels, including a light armoured cruiser, a destroyer, and every type of merchantmen, were in progress on the stocks, and that four vessels were afloat being completed, served further to show the importance of the work being done by the firm.

In the evening a reception was given by Sir Charles Parsons, chairman of the Council of the North-East Coast Institution of Engineers and Shipbuilders.

Warships Built at Elswick.

On Wednesday the proceedings were arranged by the North-East Coast Institution of Engineers and Shipbuilders, and two meetings were held. That in the Lecture Theatre of the Literary and Philosophical Society was under the chairmanship of Sir Charles Parsons, President of the Institution, and the first paper read was by Mr. J. R. Perrett, the Naval Constructor of Sir W. G. Armstrong, Whitworth and Co., Limited. The title was "Some Notes on Warships Designed and Constructed by Sir W. G. Armstrong, Whitworth and Co., Limited." In it Mr. Perrett described the vessels designed successively by Mr. George Rendel, Sir William White, Sir Philip Watts, and himself since 1867, and built first at the Walker yard, and since 1884 at Elswick, and now also at the new Armstrong yard. It is scarcely necessary in the present day, and with the full knowledge existent of the influence of Elswick designs on the development of the warship as we know it to-day, to indicate the features of the large number of vessels built. It may suffice, as some indication of the extent of this influence, to state that since 1884 the firm have constructed, or have in hand from their own designs, 64 warships, 59 being on foreign account, whilst five were built for or acquired by our own Government. These 64 vessels included 15 battleships, 33 cruisers, five torpedo-boat destroyers, three armoured gunboats, six scouts, and two training ships. The Turkish Royal Yacht and State Barge were also designed and constructed at Elswick. The total displacement of the ships amounts to 365,463 tons, and the total horse-power of the machinery fitted in them to 756,706. Added to the remainder of the warship output, these figures become respectively 619,979 tons and 1,221,687 horse-power.

At one time—in 1896—the firm had simultaneously in process of construction twenty warships of different classes, fifteen being under construction at Elswick and five at Walker. This list included a 12,300-ton battleship, two first-class armoured cruisers, each of 9700 tons, one armoured cruiser of 8500 tons, one armoured cruiser of 7000 tons, two coast-defence armourclads, each of 3400 tons, eleven second and third-class cruisers, and two torpedo-boat destroyers. The aggregate displacement of these vessels amounted to 98,000 tons, and six of them were launched from Elswick during the year mentioned. At the present moment the firm have in hand ten war vessels, of a total displacement of 158,670 tons, comprising five Dreadnoughts, two coast-defence armourclads, two scouts, and one armoured gunboat.

Sir Charles Parsons, in inviting discussion, referred to the work done by the Tyne Commissioners in improving the river to enable increasingly large ships to be launched and navigated to the sea.

Admiral Sir Reginald Custance said that they all must be impressed by the greatness of the work accomplished at Elswick, and he thought the author might look with pride on the part he had taken in the work which had been done. His memory went back many years, and he knew of the difficulties which the celebrated men connected with the firm had had to contend with in striving to meet the views of the naval officers of the day. It was very difficult, because the questions were far from being thought out, and, in consequence, mistakes were made. For example, they might refer to the Victoria. There was no doubt that the design was faulty in principle in several particulars, and no one would dream now of producing such a design. Without dwelling on further mistakes of which they knew, he ventured to suggest that they might not be altogether right in everything they did at present. Distinguished men in the past made mistakes. Might not they now also be making mistakes? Might not the first general action bring out their errors, and might they not have to reconsider some points? He would not stop to speak of them, beyond referring to the contest between the gun and the armour. The gun had always been kept to the forefront by the Elswick firm. The late Lord Armstrong was a firm believer in it as against the armour, and he observed in the paper that had just been read that the Elswick firm was applying much thinner armour to the ships than the Admiralty. He believed the maximum thickness of the broadside armour of the Chilian vessels was 9 in. He compared that with the 13½-in. armour of the Malaya, and he congratulated the firm on this step. He ventured to point out that they were adhering to the ideas of Lord Armstrong, and they had his support very cordially.

Mr. Perrett pointed out that in the ship which they were now laying down for a foreign Government the broadside belt, as mentioned in the paper, was of 13½ in. in thickness.

Sir Philip Watts said he had been more or less closely associated with the Elswick shipbuilding department for most of the period covered by Mr. Perrett's paper, having first visited the works in 1870. Several of the most important advances in modern warship design had been due to Mr. Perrett. In the manuscript copy of Mr. Perrett's paper, which he had read, but which had been modified, comparisons were made between Elswick-designed ships and other ships built at the same time, which showed that Elswick had on occasions taken the lead in warship design. Mr. Perrett, no doubt, had his own reasons for not bringing up such points in the printed paper—comparisons they knew were odious—but they might, in this case, be made by anybody who was sufficiently interested in the matter to do so. When he became manager of the warship department at Elswick, in 1885, the new shipyard was pretty much in the same position as the new Armstrong yard now was. In arranging the new yard, Mr. Perrett and his assistants had set to work upon an excellent arrangement of berths and shops, with the most modern and improved appliances, and he believed the yard was second to no other yard in existence.

Mr. W. H. Whiting observed that Sir Reginald Custance, with his usual insight, had set his finger at once on the two important lessons which were to be derived from this paper. The first was the true judgment with which Lord Armstrong constantly emphasised the predominant importance of attack over defence, and his insistence upon the power of the gun, even, he must admit, in one or two cases where special considerations rendered his design open to criticism. Secondly, such a review as that given offered a warning that they needed at the present time to apply to current ideas the closest analysis and severest scrutiny, lest they might be found, perchance, to be following a similar course to their predecessors, and pushing on with ideas which a later judgment might throw great doubt upon. The only other point to which he wished to refer was the reference which Mr. Perrett made to the

great service rendered, not only to the firm and to the Tyne, but to the country, by Mr. George Rendel. The paper seemed to imply that Mr. Rendel's first essay in shipbuilding was the design of the first Esmeralda. His first effort was the gunboat Staunch, the first vessel produced at Walker, a very little vessel, with a 12½-ton gun mounted on a disappearing platform, and acclaimed at the time by a large body of opinion to be a great success. Large numbers of such vessels were built in succeeding years in Government and other dockyards.

Mr. G. J. Carter expressed the pleasure it had given him for so many years to be associated with Mr. Perrett in the work at Elswick. The work carried on there had certainly been of a very progressive character, and, he believed, under present management, would continue to be so.

Sir William Smith said that from the beginning of the warship construction at Elswick he was closely connected with the work from the Admiralty point of view. He could say, from contact with the officers of the Elswick firm, that while they were hard bargainers, they had not had any outstanding question but what could be settled by amicable discussion and without higher authorities having to be evoked. That, he thought, bearing in mind the supervision exercised by the Admiralty, and the way in which the work done by the Admiralty came under the review of the Public Accounts Committee, was an exceedingly good record for the firm.

Mr. A. Scholfield (Tyne Improvement Commission) said the Commission naturally took the very greatest interest in the development, not only of the Elswick Works, but of all the vast industries on the river. It was with no little anxiety that they used to watch the development of the enormous vessels at Elswick, more particularly with regard to their beam, because they realised that there would be difficulties in the passage under the high-level bridge and through the swing bridge. Therefore they were delighted at the developments at Walker, because it got rid of these difficulties. The shipbuilding companies generally might think the Commissioners were hard to get on with in regard to encroachments, but the river was extremely narrow, and they had what they called a "river line," and they would adhere to it in the interests of all.

Mr. James McKechnie referred to the great enterprise of the Elswick firm, and, in speaking of the new Armstrong yard and its admirable and extensive equipment, ventured to raise the question of the difficulty of finding experienced workmen to carry on operations under present conditions.

Professor Hovgaard pointed out the epoch-marking ships built at Elswick. There was the Esmeralda. Apart from her high speed and great gun-power, she was the first notable cruiser without sail power, and the first cruiser with a complete armoured deck from end to end. The Piemonte had the four-cylinder engine, and was the first cruiser with a complete installation of rapid-firing guns. The Amethyst was distinguished as the first turbine cruiser, and the Victoria marked, at the period, the highest achievement in large-bore guns. Now they were reaching the maximum in another similar cycle in guns. He referred to the close association of the Elswick Works with Japan, remarking that it was the 4.7-in. gun which had won the battle of Yalu.

Sir Charles Parsons, in closing the discussion and proposing a vote of thanks to the author of the paper, mentioned the fact that he had served his apprenticeship at Elswick, and then formed the opinion that Lord Armstrong was one of the greatest men of the day. Subsequent events had only tended to confirm him in that view.

Mr. Perrett, in reply, surprised the meeting by remarking that the paper was his maiden effort in that direction.

Progress in Marine Steam Machinery.

Mr. A. C. Ross read the next paper, giving "A Review of the Progress in the Marine Steam-Engine on the North-East Coast During the Past Fifteen Years." It was a comprehensive, although brief, review, and in the course of it he said that, by the introduction of an all-geared installation in light cruisers of high power, it was quite possible and practicable to reduce the total weight of machinery to about 60 lb. per shaft horse-power, and, by the adoption of oil fuel, to get as much as 140 shaft horse-power per ton of boiler. In the case of destroyers with three shafts and geared cruising turbines, the corresponding figures would be about 33 lb. total weight of machinery per shaft horse-power, and about 190 shaft horse-power per ton of boiler. In 1899 the corresponding figures were about 220 lb. for total weight of machinery per shaft horse-power, and about 24 shaft horse-power per ton of boiler using coal for cruisers; and 56 lb. total weight of machinery per shaft horse-power and 97 shaft horse-power per ton of boiler using coal for destroyers.

Mr. A. F. Yarrow, who opened the discussion, referred to the work of Sir Charles Parsons, and said his name would be linked in history with those of Faraday, Watt, and Stephenson.

Mr. William Boyd, the first president of the North-East Coast Institution, said, in regard to oil-fuel, that that was the subject of the day, and the company with which he was identified—the Wallsend Slipway—had been connected with the industry for a great number of years. Somewhere in the 'eighties they engined a large number of small vessels for what was then the firm of Charles Mitchell and Co., for use in the Caspian Sea. The peculiarity was that the water in the Caspian Sea being fresh water, there was no difficulty in regard to the use of steam for the spraying of the oil.

Mr. John Thornycroft referred to the great change in the modern engine-room.

Mr. R. S. Portham said that Mr. Ross had referred to the excellent results of the Port Kembla, with quadruple engines and superheated steam, and wondered why superheat had not been more largely adopted in British ships. This was largely due to the prejudice of the pioneer British experiences of marine superheating of forty years ago, with uptake superheaters and vegetable oil of low flash-point. Germany started with a clean sheet, using the Schmidt system of superheater and high flash-point (600 deg. Fahr.) mineral oil. In Germany over 1,000,000 indicated horse-power was now running on the Schmidt system, the latest ship equipped being the 30,000 shaft-horse-power North German Lloyd steamer Columbus, and her sister-ship, having twin-screw quadruple engines. British owners were slowly, but surely, following Germany's example, and the results of forty ships fitted with Schmidt superheaters, aggregating 150,000 indicated horse-power, showed a net saving of 15 per cent and low maintenance costs, as compared with saturated steam. With geared reaction turbines and impulse-reaction astern turbines and superheat, an economy of 30 per cent. was realisable, as compared with reciprocating saturated-steam engines, and he prophesied that this system will be more and more adopted in the near future.

Sir Charles Parsons said he did not think that at the present time they realised what an important probable future the superheater had. In the old days they had the difficulty of the ingress of salt, but that had been largely got over by improvements in the manufacture of the tubes themselves. Then there was the question of the arrangement of the safeguards, so that in the various functions of the machinery on board ship there would be no possibility of the superheater getting burnt. The chief departure initiated in the Schmidt system had been the placing of the superheated tube in close proximity to the water surface in the boiler in order that the tubes would not reach a destructive temperature. He believed that the success of the superheater justified them in saying that its use would extend to a large extent. He further mentioned that Sir Philip Watts had been the first to urge the adoption of wide-bladed or large projected surface propellers with fine-pitch ratio for turbine driving.

Mr. Ross briefly replied, and the proceedings of the section terminated.

Internal-Combustion Engines.

At the meeting held at the Institution of Mining last Wednesday morning, simultaneously with that above reported, the chair was taken by Mr. Summers Hunter, and two papers were read—namely, one by Professor B. Hopkinson, entitled "The Charging of Two-Cycle Internal-Combustion Engines," and the other by Mr. H. F. Fullagar, entitled "A New Type of Internal-Combustion Engine." Of this meeting we are compelled by the demands upon our space to postpone our report until next week, when we shall deal with these papers and the discussions upon them.

Excursions.

The ladies attending the Conference went on a motoring tour on Wednesday, and were entertained at luncheon by Lady Parsons at Ray, Kirkwhelpington, and at tea at Cragside, Rothbury, the residence of Lord Armstrong. The gentlemen of the party went on one of five alternative visits of inspection. (1) To the works of R. and W. Hawthorn Leslie and Co. and Messrs. Palmers; (2) To the North-East Marine Engineering Company's Works; (3) To the Wallsend Slipway and Engineering Company's Works; (4) To the works of the Fullagar Engine, Limited; or (5) To the Consett Iron Works. In all cases the guests were entertained to luncheon. In the evening a reception and dance was held at the invitation of the Lord Mayor of Newcastle-on-Tyne.

Yesterday (Thursday) was given up entirely to social functions. In the forenoon alternative visits were made to the Darlington Forge, or to Messrs. Doxford's Works at Sunderland; and in the afternoon a large company attended a garden party at Lambton Castle on the invitation of the Earl of Durham, K.G., and Lady Anne Lambton.

To-Day's Proceedings.

The concluding meetings of the Conference are being held to-day, the programme of papers having been arranged by the Institution of Engineers and Shipbuilders in Scotland. The papers to be read are:—1. "Influence of Varying Temperatures on the Strength and other Properties of Admiralty Gun-Metal," by Professor A. Campion and Professor John G. Longbottom. 2. "The Strength of Welds by the Oxy-Acetylene Process," by Professor A. Campion and Mr. William C. Gray. 3. "Some Experiments on a Diesel Engine," by Mr. W. S. Burns.

(*To be continued.*)

NOTES.

Durability of Taps for Benzine Tanks.

Professor Alexander Baumann, of the experimental station for aeronautics and automobilism of the Technical High School at Stuttgart, has made some experiments on the durability of taps, greased and ungreased, when exposed to the flow of benzine. He fitted new taps into two vertical pipes, each 3 metres high; the upper portions of the pipes consisted of glass tubes, 4 mm. in internal diameter, behind which cardboard scales were fixed. By the aid of a mechanism the two taps were opened and closed simultaneously, fifty times in each series, and observations were taken half-an-hour later of the sinking of the benzine level. The one tap was greased, the other not. It soon appeared that very little benzine escaped through the greased tap, but a great deal through the ungreased tap. The experiments were repeated, and the greasing was renewed after six or seven series. The loss of benzine in the greased tap amounted generally to a few millimetres only—five, or less—and did not increase as the series were repeated; the greased tap improved, in fact, in the consecutive series. In the ungreased tap the loss amounted to 145 mm. in the first series already, and it rose to more than 1500 mm., not regularly, but steadily, while the tap began to drip. The details of the experiments, which were apparently not varied, are scanty, unfortunately. In the account which Professor Baumann gives in the journal the *Motorwagen*, of May 31, nothing is said about the nature of the pipe, of the tap, and of the grease used; it is merely stated that the grease was, or should be, insoluble in benzine. There is no doubt about the main fact, however, that suitably greased taps keep benzine-tight, and ungreased taps do not, but deteriorate more and more when turned frequently.

Conversazione at the Institution of Civil Engineers.

The Institution of Civil Engineers held a conversazione on the 2nd inst. in their new building, when the guests were received by Mr. Lyster, the President, and Mrs. Lyster, and a very full musical programme was admirably rendered. Several of the rooms—the south reading-room, the council room, and the committee room—had been set apart for the exhibition of engineering models and scientific apparatus. The exhibits numbered forty-nine, and covered metallurgy and civil, mechanical, naval,

and electrical engineering. We do not propose to review all of these in this short note, but following the order we have just stated, we may mention a series of rail specimens taken from the London County Council tramways, showing corrugations. Close to this was an interesting series of rail sections from the Great Western Railway, illustrating the development of the permanent way on that system since the year 1840. Sir Bradford Leslie, K.C.I.E., showed a model of a cast-iron pedestal sleeper, carrying reversible rails, as laid on the Jullunder-Doab extension of the Southern Punjab Railway. This pedestal sleeper does away with the notching of the lower head of the rail produced by bearing on the chair, and enables the rail to be reversed when the upper head is worn, thus doubling the life of the rail, the pedestal itself being practically imperishable. The pedestals are held together by a tie-bar provided with serrations for adjusting the gauge. Sir Bradford Leslie also showed a model of a cast-iron joint sleeper in which the rail ends are held. Another interesting specimen in the same room was the fractured tie-bar from the Charing Cross Station roof, showing the flaw in the centre, exhibited by Messrs. David Kirkcaldy and Sons, who also had an interesting series of fractured mechanical parts showing the growth of flaws. Mr. E. W. Timmis exhibited a model illustrating his system of bogie-lead and outside suspension swinging-bolster arrangements with bearing springs differentially loaded (see page 488 *ante*). Close to this could be seen the Gardner vibration signal for railways, exhibited by Mr. S. B. Cottrell. The portable apparatus, such as can be used by platelayers, consists of a box-shaped transmitter and a portable alarm in a case containing the battery, the transmitter being connected together by a twin lead as is used in field telegraphy. When a train reaches the place where the transmitter is laid, the vibration causes the alarm to ring, and it will continue to ring as long as the train is passing over the transmitter. The apparatus is also designed to give level-crossing warnings, to render audible a signal invisible through fog or smoke, and automatically to record the passage of trains. The models of the new marine station at Dover, of several bridges and locomotives, of the Pennsylvania tunnel shield, of a medical air-lock for the treatment of caisson disease, and of a Temperley grab-transporter in action, and of cranes, attracted general attention. Among the crane models we may mention Messrs. Stothert and Pitt's electric luffing-crane, of which we gave an illustrated description in our issue of the 26th ult.; also two models of luffing-cranes shown by Mr. Arthur Musker, with jib balanced by weights in one case, and by the engine cylinders in the other. Messrs. R. Waygood and Co. had a nicely-finished model of one of their automatic electric lifts in action, illustrating the means which render it automatically safe in working. A working model of a lighting equipment for a "National" steam-omnibus, with grate section showing rocking-bars and coke-feeders, was exhibited by Mr. Thomas Clarkson. The equipment contains sufficient coke to allow for the vehicle a run of 50 miles, the coke surrounding the boiler. Mr. A. F. Yarrow showed models of his device to facilitate the coupling of cruising turbines, particulars of which were given at the Glasgow meeting, last year, of the Institution of Naval Architects (see ENGINEERING, vol. xcvi., pages 11 and 26). He showed also a model of his latest balance-flap fitted to the end of the tunnel in which the propeller works, for very shallow draughts. We gave an illustrated description of this device in a former issue (see ENGINEERING, vol. lxxv., pages 498 and 512). A Michell thrust-bearing, sent by Mr. H. T. Newbiggin, formed also part of the exhibits; this bearing we described in our last volume, page 179.

THE NORWEGIAN NAVY.—The Norwegian Parliament has voted a grant towards an extension of the dockyard at Horten for the purpose of there building two submarines and two hydroplanes and to commence the manufacture of Diesel motors, for which the Councillor of State in charge of the question stated that drawings had been obtained from a foreign firm.

FLOATING-DOCK AT WILHELMSHAFEN.—A floating-dock of 40,000 tons capacity has just been built at the Blohm and Voss yard, Hamburg, for Wilhelmshafen; it has been transported there in pieces, and Wilhelmshafen now boasts four large floating-docks. Another floating-dock of about the same dimensions is at present in course of construction at the same yard for the naval station at Kiel.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday there was a want of life in the Glasgow pig-iron market, and no dealings of any kind were recorded. At the opening session there were sellers of Cleveland warrants at 51s. 1½d. cash, 51s. 3d. one month, and 51s. 5d. three months, and at the close of the afternoon session these quotations were unchanged. On Friday morning the market remained in a dull condition, and no business was transacted. Closing sellers of Cleveland warrants quoted 51s. 1½d. cash, 51s. 3d. one month, and 51s. 5d. three months. A better tone prevailed in the afternoon, but only one lot of Cleveland warrants was put through at 51s. 2d. cash. Prices became a little firmer, and at the close sellers quoted 51s. 2½d. cash, 51s. 4½d. one month, and 51s. 6d. three months. On Monday morning the tone was again fairly strong, and 1000 tons of Cleveland warrants were done at 51s. 6d. three months, and closing sellers quoted 51s. 4d. cash, 51s. 6d. one month, and 51s. 7d. three months. In the afternoon the market was dead idle once again, but the tone continued firm, and sellers of Cleveland warrants named 51s. 4½d. cash, 51s. 6d. one month, and 51s. 7½d. three months. On Tuesday, the day of the State visit to Glasgow of their Majesties King George and Queen Mary, the market was closed. When business was resumed to-day (Wednesday) the tone was strong, values advancing 3½d. per ton in the forenoon, closing with sellers of Cleveland warrants at 51s. 8d. cash, 51s. 9d. one month, and 51s. 10½d. three months. Unfortunately, no doubt due to the disorganisation of all business during the Royal visit, there was nothing doing in the afternoon, prices nominally being 1d. to 1½d. lower. The closing price stood at 51s. 6½d. cash, 51s. 8½d. one month, and 51s. 9d. three months.

Sulphate of Ammonia.—The sulphate of ammonia market keeps fairly steady, with a moderately good demand. The current quotation for prompt lots is 11*l.* 1s. 3d. per ton, Glasgow or Leith.

Scotch Steel Trade.—The idea that any improvement would take place in the Scotch steel trade on this side of the stoppage for the annual Fair Holidays, next week, has now passed away, as the demand has lately been of a miserable nature. The great quantity of foreign material which has been imported, and which is being sold here so cheaply, has hurt the local makers to no little extent, and some of the works have only been able to keep running for something over half-time during the past week or two. Almost all classes of stuff, ship-plates, angles, black sheets, &c., are in poor request, and not only are the various establishments likely to close sooner than usual for the holidays, but the latter are more than likely to be of longer duration than either the masters or the workmen will care for. The export demand is not very heavy, although there is quite a fair amount going through. Prices are unchanged, but where not under official control, sellers are inclined to shade slightly to secure any business offered for immediate despatch.

Malleable-Iron Trade.—The West of Scotland malleable-iron makers are still very badly off for orders, and the approaching holidays will be gladly welcomed by many, as a breathing space is necessary to survey the condition of the trade. The past half-year has proved a very trying period for all connected with the industry, and the worst feature of all is that the outlook is indeed very gloomy.

Scotch Pig-Iron Trade.—The home demand for Scotch pig iron is very dull, owing to the quietness of the local steel and iron trades, and dealing is mostly confined to small lots. The number of furnaces in blast is now seventy, and a goodly proportion of the output is being exported. Hematite continues very dull. Prices are practically unchanged, and the following are the market quotations for makers' (No. 1) iron:—Clyde, 66s.; Calder, Gartsherrie, Summerlee, and Langloan, 66s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 70s.; Shotts (at Leith), 66s. 6d.; and Carron (at Grangemouth), 67s.

WAR-OFFICE TRIALS OF MOTOR-LORRIES.—The Secretary of the War Office announces that trials of type motor-lorries, under the provisions of the War Department subsidy scheme, will be held in October, 1914, under the same general regulations as for the trials held in May, 1914. Further details regarding these trials will be issued later. Any maker who desires to enter a vehicle of the War Department subsidy type for these trials should notify the Secretary, War Office, as soon as possible.

CANADIAN COAL.—The coal of the Bellz River formation and the Edmonton formation grades between lignites and bituminous. The coal which belongs to the Bellz River horizon is found over an area of about 25,000 square miles; of this area 5000 square miles are estimated to contain 13,000,000,000 tons of coal. The amounts of coal contained in the two provinces of Alberta and Saskatchewan have been estimated at 10,000,000,000 tons and 3,000,000,000 tons respectively. The principal coal-mines within this area in Alberta are near Lethbridge Taber and Lund Creek. The coal of the Edmonton formation is generally lignites, but in the foothills it grades up to bituminous. The total area of workable coal has been estimated at 12,800 square miles, with a probable coal content of 71,000,000,000 tons. The principal coal-mines within this area are near Edmonton. The coal-fields of Saskatchewan are situated in the southern portion of the province, and extend from the boundary of Alberta on the west to the Manitoba boundary on the east. The area underlaid by coal is estimated at 5500 square miles, containing in all about 18,000,000,000 tons of lignite.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has not shown any marked change. Tonnage arrivals over the week-end were heavy, and loading operations have proceeded briskly, supplies of coal in most cases being abundant. There was little activity, however, as regards fresh business, both buyers and sellers holding their hands for the present in view of the threats of the marine engineers to hold up trade. The best Admiralty coal has been scarce and firmly held, while other qualities have been plentiful, and somewhat unsteady as regards prices. The best Admiralty large steam-coal has made 20s. 6d. to 21s. 6d.; best secondary qualities 18s. 6d. to 19s. 6d.; other secondary descriptions, 17s. 6d. to 18s.; best bunker smalls, 10s. 9d. to 11s.; and cargo smalls, 7s. 6d. to 8s. 6d. per ton. The best household coal has been quoted at 19s. to 20s.; good households have made 17s. to 18s.; No. 3 Rhondda large has brought 17s. 6d. to 17s. 9d.; and smalls have been quoted at 12s. to 12s. 6d. per ton. No. 2 Rhondda large has realised 8s. 9d. to 9s. 6d., and patent fuel has brought 19s. 6d. to 20s. 6d. per ton. Special foundry coke has been quoted at 25s. to 27s.; good foundry coke at 20s. to 23s.; and furnace ditto, 17s. to 19s. per ton. As regards iron ore, Rubio has made 16s. to 17s. per ton upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Welsh Colliery Deal.—The purchase has been definitely confirmed of the Ynishir Standard Colliery by the United National Collieries, Limited. The transfer is to take place in August. The colliery, which has a mineral area of 500 acres and an output of about 400,000 tons per annum, is acquired, with 800 wagons, mostly 12-tonners.

The Bristol Channel.—The shipments of coal and other fuel from Bristol Channel ports in 1913 amounted to 41,048,791 tons, as compared with 36,296,911 tons in 1912. The shipments from Cardiff were 24,577,083 tons, as compared with 22,420,540 tons; from Newport, 6,134,194 tons, as compared with 5,287,910 tons; from Swansea, 4,499,867 tons, as compared with 3,808,600 tons; and from Port Talbot, 2,515,070 tons, as compared with 2,146,507 tons.

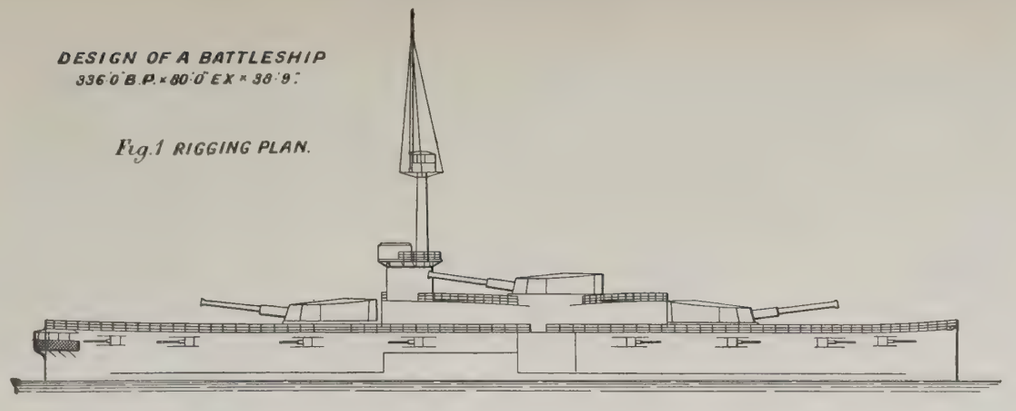
Tonyrefail.—Tonyrefail is growing rapidly. Already a town of recognised importance, Tonyrefail has nearly doubled itself in a few months. This is due to the laying down of a modern plant by the Coppée Company, Limited. The plant includes a full washery, to which coal is brought from the colliery screens. It is tipped by means of two electrically-driven tippers into the unwashed-coal bunker, there to be washed. It is then elevated by means of a bucket-elevator to the screens, where the coal is automatically classified.

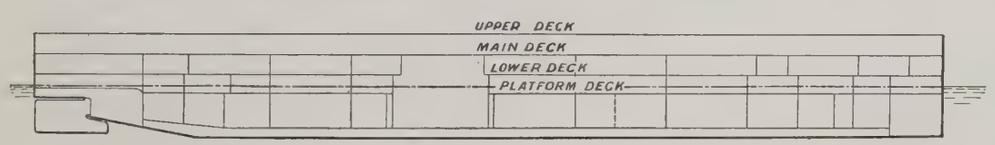
Wireless Progress.—Extensions at the naval wireless station at Horsea Island have been completed, and the poles have been secured. There are three of them, and they are 446 ft. high. They are of Californian pitch pine, and not of steel, as at Poldhu, the Cornwall station.

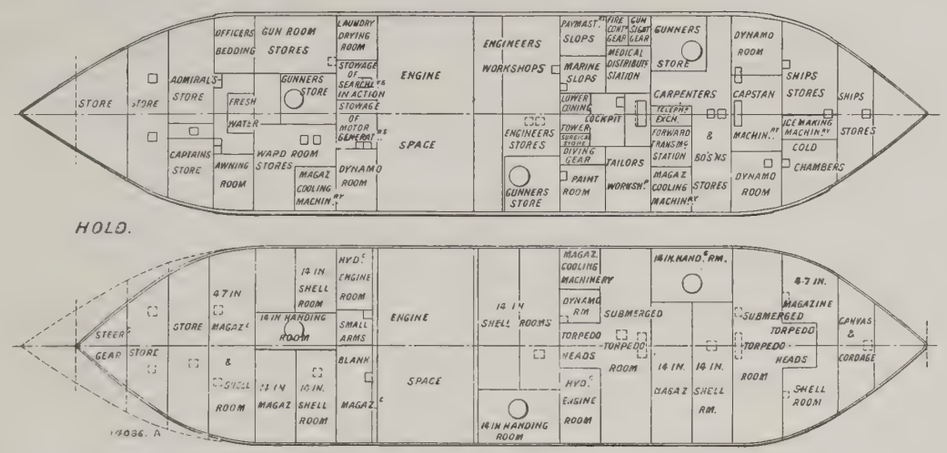
THE COPPER MARKET.—In their monthly report, dated the 1st inst., Messrs. James Lewis and Son state that the market for standard copper has shown little vitality during the past month, sales being limited to about 20,000 tons, prices receding to the extent of 2*l.* 15s. per ton—from 62*l.* 10s. for cash on the 2nd ult. to 59*l.* 15s. on the 26th ult.—recovering to 60*l.* 3s. 9d. on the 29th ult., and closing on the 1st inst. at 61*l.* for cash and 61*l.* 12s. 6d. for three months prompt. For refined copper the demand had been very limited, manufacturers both in Europe and the United States buying only for their immediate requirements. American electrolytic had fallen from 14⅛ to 13½ cents per pound, and from 65*l.* to 62*l.* 15s. per ton c.i.f. The reduction in price had so far failed to attract buyers to any material extent. The average price of standard for the half-year had been 63*l.* 19s. 6d. per ton, against 68*l.* 5s. 9d. for the whole of 1913. American exports for June were advised as 35,182 tons. Imports into Germany for the five months had been 99,788 tons, against 94,920 tons in the same period last year, and the exports 2969 tons, against 4353 tons. Stocks had decreased this year 468 tons, against an increase last year of 7701 tons, making the consumption 97,287 tons, against 82,866 tons—an increase of 14,421 tons, or 17½ per cent.

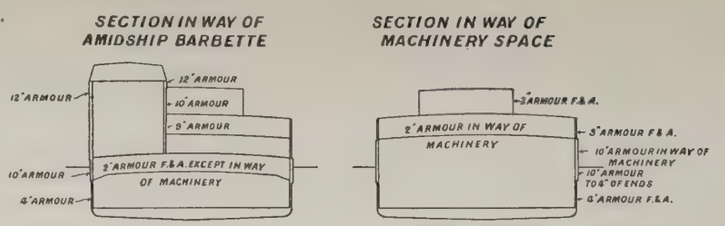
FILTERS AT CLYDEBANK.—By the pressure of a button on a stand erected at Messrs. Beardmore's Works at Clydebank, the King, on the 8th inst., opened the New Paterson Gravity Filtration Plant for purifying the water supply to the Burgh of Clydebank. The filtration plant in question comprises gear for the addition of a trace of coagulant for the removal of the marked discolouration of the water, and a small quantity of lime to correct the natural slightly corrosive tendency of the peaty moorland water; sedimentation tanks for the precipitation of the bulk of the impurities; and open gravity filters for the final purification of the water supply. The latter, eight in number, are the largest mechanical filtration units in the United Kingdom, each having an effective filtering area of 252 sq. ft. An interesting point in connection with the plant is the method of cleansing by compressed air. This operation is performed by first thoroughly agitating the filter-bed for a minute or two with sterilised compressed air at a pressure of about 5 lb. per sq. in. In this way the whole of the bed, even to the remote corners, is loosened and agitated and the impurities, freed from the sand grains, are flushed away into the waste gutter by a reverse current of wash-water. The plant was designed and constructed by the Paterson Engineering Company of London, the consulting engineers being Messrs. Warren and Stuart of Glasgow.

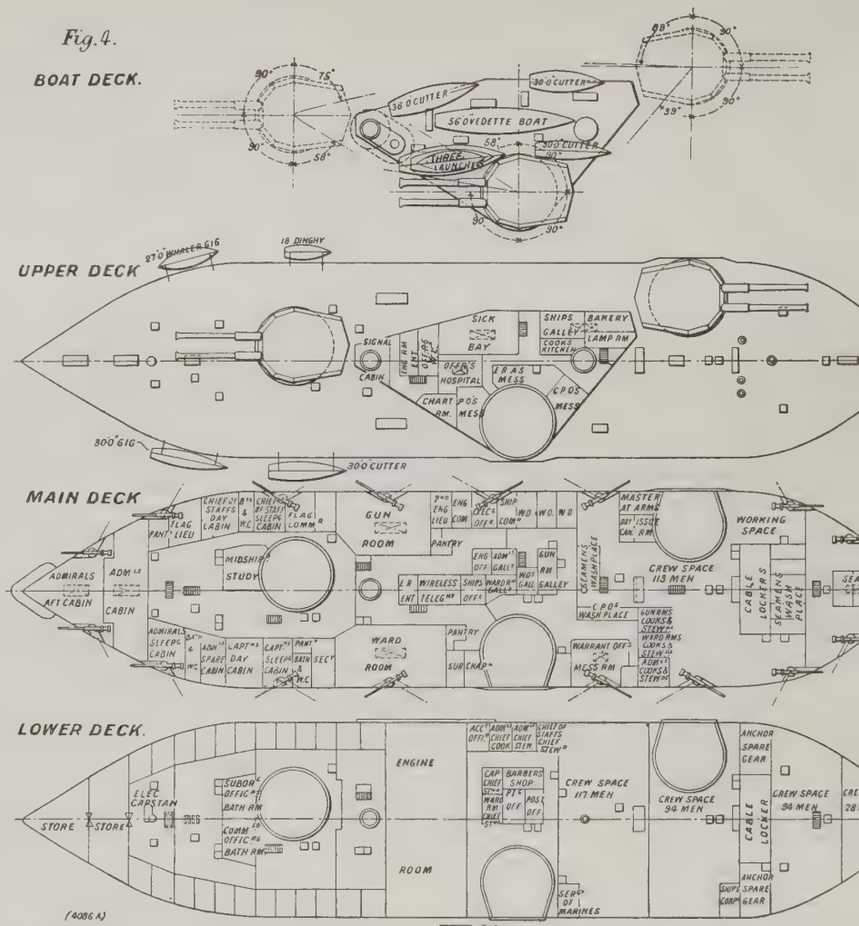
THE PROTECTION OF BATTLESHIPS AGAINST SUBMARINE ATTACK.











ON THE PROTECTION OF BATTLESHIPS AGAINST SUBMARINE ATTACK.*

By Professor Sir JOHN H. BILES, LL.D., D.Sc., Vice-President.

IN a lecture delivered in March last at the Royal Institution, I ventured to remark in relation to the War Navy that the "use of oil and turbines has so reduced the weight of motive power that much higher speeds can be got for the weight that was appropriated in the coal-burning earlier ships. It may be that some of this advantage may be made use of to reduce the size of ships and increase their number. It may be that armour may to some extent be sacrificed, and gun attack be allowed to be more effective in order that some compensation should be available for the effect of torpedo attack. It will thus be seen that the increasing destructive effect of the torpedo brings into the battleship problem the possibility of changes which may once again revolutionise warship design."

The *Times* opened its columns in May to a full discussion of the impending obsolescence of battleships and the coming of the submarine as the dominant fighting ship. In the discussion, it was generally assumed that if the submarine could get within striking distance the battleship must be destroyed. If my memory does not deceive me, it seems that the advent of the spar-torpedo and that of the almost-invisible small torpedo-boat was heralded in the same terms. Some of us have lived to learn the limitations of these cheap methods of destruction, and before too rapidly breaking up our battleships and building no more of them, it may be well to consider what, if any, defence can be given to these poor helpless ships.

In this Institution we have a meeting ground for the statesman, the naval officer, and the ship constructor. The first directs the second, and the third supplies the second with his weapon. We ship constructors are sometimes taken into the confidence of the naval officer, and we try to understand as much as we can of the nature of the onerous duties which he has to perform. We are told that the Navy exists to keep the command of the sea, and that command of the sea is necessary for its freedom. To keep the command it is desirable—some say, necessary—to discover and destroy the enemy's forces. Battleships, cruisers, destroyers, submarines, must all be caught and destroyed or captured, and, equally, all must be capable of resisting destruction or capture. In the two dimensions represented by the surface of the sea, with equal powers of vision, getting within destroying distance is a question of speed, and destruction is a matter of superiority of attack over the defence. The domi-

* Paper read before the Institution of Naval Architects at Newcastle, on July 7, 1914.

nating weapon of attack has been the gun, and the defence against it has been practically all above water, because there its attack has been made. The torpedo-boat and, later, the destroyer, have delivered their main attack below water, but the attacked ship is held to be quite capable of delivering a counter attack by guns above water, which is an adequate reply to the destroyer. The attack of the submarine is wholly below water, and so far the attacked ship has developed no effective reply of its own. The defence against the gun is armour and other guns. The defence against the destroyer's torpedo is the gun, which is quite ineffective against the submarine. The question of interest at the moment is, What defence can the surface ship have against the submarine's torpedo?

There can be only two forms of defence. First, the destruction of the submarine by other vessels, submarine, or others. Second, the protection of the bottom of the surface ships from the effects of under-water attack. The first, the destruction of the submarine, is obviously not the work of a battleship or large cruiser, but must be left to some vessel of the same order of size as the submarine. This destruction must be sought on the surface when the submarine is not submerged, for it seems improbable that a submarine will be able to chase another effectively under the water. In any case, the submarine will be dangerous to the large surface ship until it is destroyed, and, as the means of destruction are not yet certainly to hand, the question of effectively protecting the battleship against under-water attack seems to be deserving of consideration, unless someone is ready with a real reply to the submarine.

One naturally is first met with the question: What about the weight of such protection? The same question can, of course, be asked in the same attitude of mind about any weights used in a ship for the purpose of attack or defence. What about the weight of armour to keep out shot? The thickness and extent of protection ought to be proportioned to the liability to be hit and the damage done when hit. This principle is given effect to when distributing armour protection over a ship to resist gun fire. What is the relative damage done by a 15-in. shell and a 21-in. torpedo, and what is the relative liability to be hit by these projectiles? A distinguished gunner told you in this Institution in April that a modern battleship will be destroyed by gun fire in five minutes after fighting range has been reached. The submarine officer will tell you he can get a torpedo into any ship that he can see and can get within the range of his torpedo. The battleship can hit back at his enemy battleship, but can do nothing by himself against the submarine. What is the liability to be hit in the two cases? Can the submarine find the battleship as surely as the enemy battleship can? In other words, what is the relative liability to be hit by the two methods of attack? This is for the naval officer to tell us, if he can. If the relative liability to be hit is sufficiently great to warrant full consideration of the relative damage, we shall also want to know this. Assuming, as one reasonably may, that very serious damage will be done by the explosion of a torpedo, the next question is, What can be done to prevent or seriously to reduce this damage? Subdivision naturally suggests itself as one means of minimising the effect of this damage, but when all that is possible in this direction has been done, there seems to be no great certainty that a battleship will be still a formidable fighting machine after having received the successful contact explosion of a 21-in. torpedo. Can we do anything in addition to subdivision to preserve the ship for effective fighting purposes?

Armour on the bottom of warships has been proposed by responsible persons. Sir E. J. Reed and General Sir John Crease, R.M.A., during their lives made definite proposals of this character, but they have never been adopted on the outsides of ships, partly for the reason that, previous to the submarine, the torpedo-carrying vessel has been effectively answered by the gun, and partly because the resisting qualities of armour, when submitted to attack by torpedoes, have not been sufficiently well known. The effective advent of the submarine seems to justify a serious consideration of the question of applying armour to the bottoms of ships.

The question of the weight of such armour must be serious, and obviously the addition of such weight cannot be made without some changes and sacrifices. To some it may seem that the readiest way to approach this problem is to clothe the bottom of a 25,000-ton battleship of the latest pattern with armour, and to increase her fullness sufficiently to allow her to carry this armour, letting everything else remain unaltered. The only considerable effect will be to reduce the speed by 2 knots.

This is a direct and simple issue—is the gain in protection worth the loss of speed? This is for the naval officer to decide. The constructor will naturally find difficulties in the way of attaching such armour protection, but he has surmounted difficulties before, and if the naval officer thinks the result worth attaining, the difficulties will doubtless be overcome.

It is not always that the readiest way of approaching a

Fig. 5.

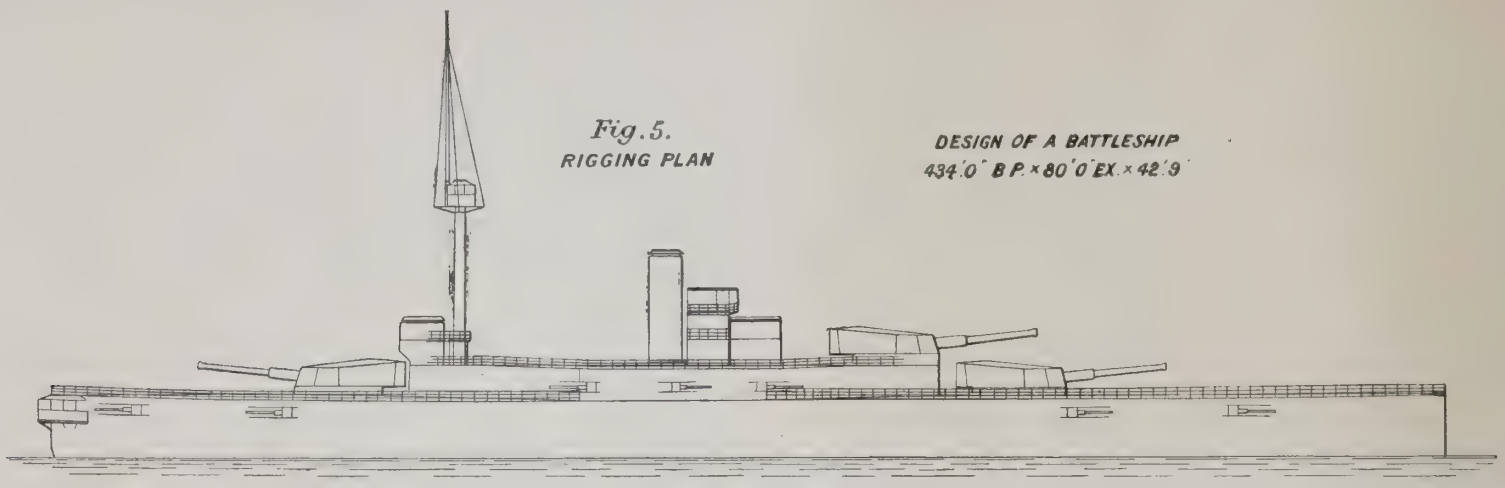


Fig. 6.

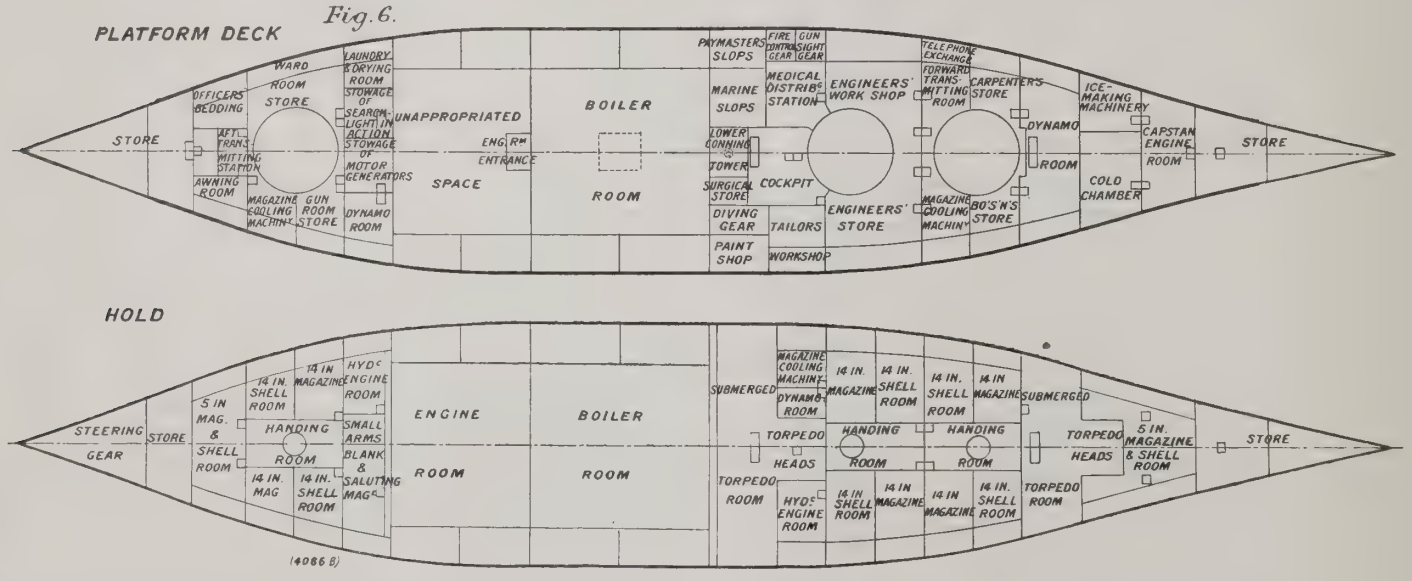
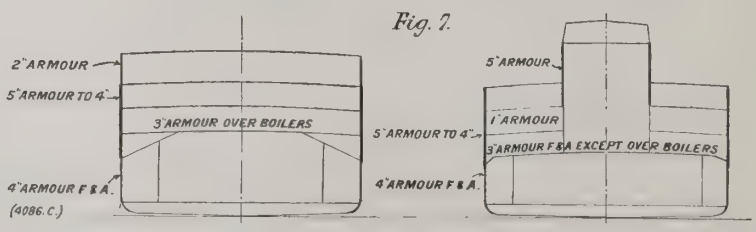


Fig. 7.

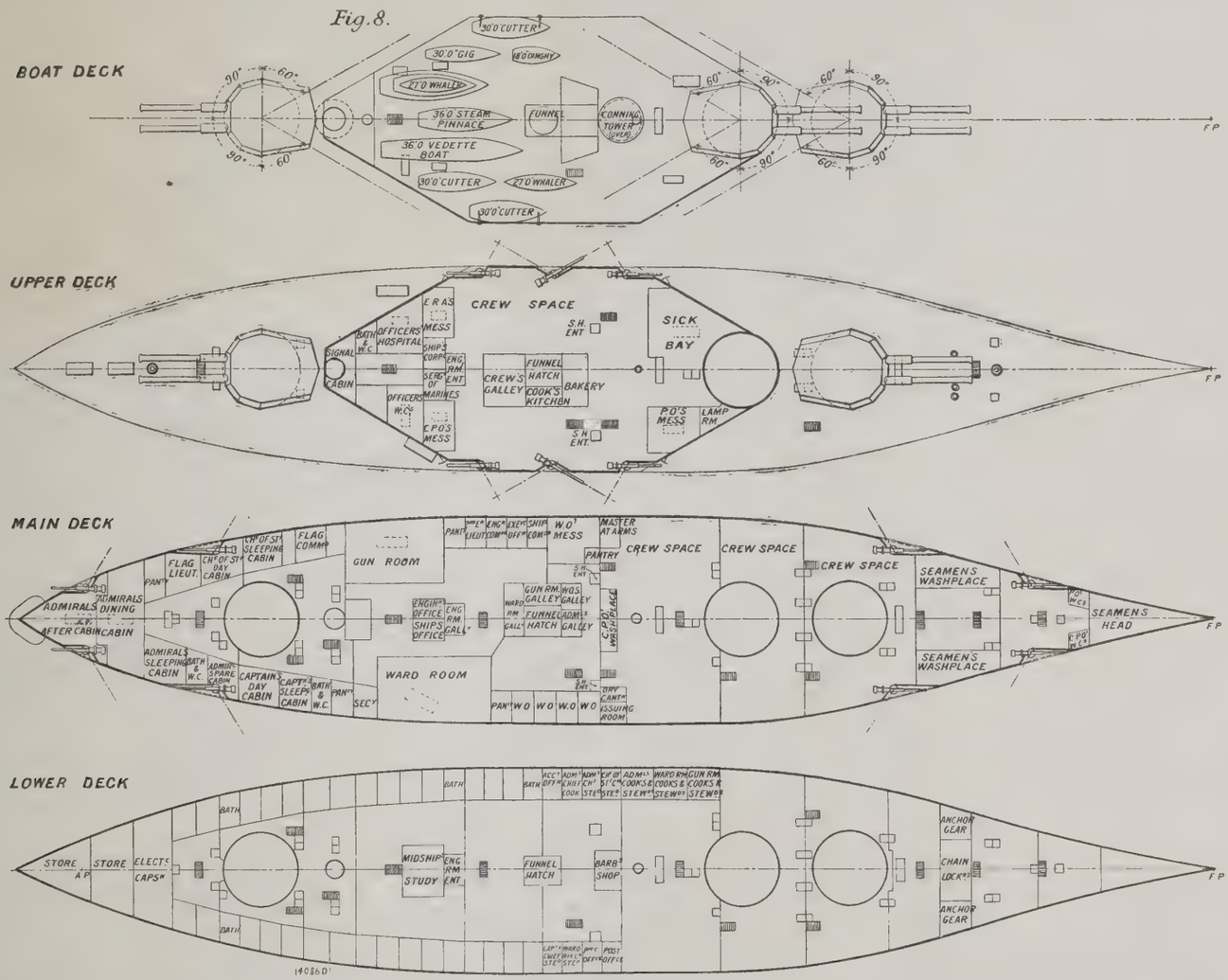

SECTION IN WAY OF BOILERS.
2" ARMOUR
5" ARMOUR TO 4"
3" ARMOUR OVER BOILERS
4" ARMOUR F & A.
(4086. C.)
SECTION IN WAY OF MIDSHIP BARBETTE
5" ARMOUR
1" ARMOUR
5" ARMOUR TO 4"
3" ARMOUR F & A EXCEPT OVER BOILERS
4" ARMOUR F & A.

problem gives the best result. One of the characteristics of our latest battleships is that their forms have a low resistance to forward motion. If a form is produced which is better adapted to fitting and carrying armour, though it may involve greater resistance or less speed, it may on the whole be better to adopt such a form. It may be interesting to give an instance or two of the application of this principle. Admiral Sir Reginald Custance has taken us into his confidence about some of his views on the principles which he thinks should underlie naval design. His appreciation of lower speeds and smaller displacements led me to work out what appeared to me to be a limiting case of his views, but combined with these characteristics was associated in this case an armoured protection from torpedo attack. The principal elements of the resulting design (page 65) were as follow :—

Armament	six 14-in., sixteen 5-in.
Thickness of armour :—	
On side at W.L.	5 in.
Above ,, ...	5 ,,
Below ,, ...	4 ,,
On casemate	2 ,,
On barbettes	5 ,,
Thickness of protective deck-plating	2 ,,

This vessel is of about the displacement of the Lord Nelson, which is, when purpose serves, called a Dreadnought. The armament is about the same as the first design, but the armour has been reduced so that it will only keep out 6-in. projectiles. Sir Reginald's view is that none of our ships have armour that will do more, and, that being so, this ship may be considered as sufficiently well armoured above the water-line. All the sections below the water-line are straight, with a circular arc at the end. This form has been adopted to simplify the armour construction of the bottom. It is fully recognised that such a design outrages the convictions of the economists, to whose ranks I want to belong, because ships of such size do not produce the greatest number of guns for a given expenditure. But if we are to be subjected to the ready loss of ships by submarines we may have to be prepared to sacrifice some gun power for our expenditure, and get our recompense in the greater number of ships and guns remaining afloat after the submarine has done its work. It is very rash on the part of a mere naval architect to attempt to reach any conclusion on this difficult question. The facts and figures are placed before this Institution, so that those who are competent to form an opinion may have the opportunity of doing so.

Fig. 8.



Length over all	358 ft.
Length between perpendiculars ...	336 ,,
Breadth, extreme	80 ,,
Draught of water	20 ,,
Displacement in tons	13,000
Speed	10 knots
Armament	six 14 in. ; sixteen 5 in.
Thickness of armour :—	
On side at W.L.	10 in.
Above ,, ...	3 ,,
Below ,, ...	4 ,,
On casemate	2 ,,
On barbettes	12 ,,
Thickness of protective deck-plating	2 ,,

This vessel may be considered as one which could not be expected to find the enemy unless he happened to be bottled up somewhere, but could be less careful than an ordinary battleship about coming out of port on account of the fear of submarines. The size and cost of this vessel should be small enough to satisfy the desires of Admiral Sir Reginald Custance, but it is doubtful whether she would be altogether satisfactory to him.

Anticipating some want of faith in this unusual vessel, a second design was produced having some of the characteristics of the first, but being produced with less disregard of convention. The principal elements are as follow (pages 66 and 67) :—

Length over all...	460 ft.
Length between perpendiculars ...	434 ,,
Breadth, extreme	80 ,,
Draught of water	24 ,,
Displacement in tons	16,000
Speed	18 knots

With a view to enabling those who do not believe in reducing the upper armour of a ship, nor in such a low speed as 18 knots, another design has been considered in which the bottom is armoured, and is of a form similar to the second design, but in which the speed, armour, and armament are of the same order as the Dreadnoughts. Such a vessel could take her place in the First or Second Battle Squadron, and would have armoured protection against torpedoes. The principal elements are as follow :—

Length over all...	600 ft.
Length between perpendiculars ...	570 ,,
Breadth, extreme	91 ,,
Draught of water	28 ft. 6 in.
Displacement in tons...	28,500
Speed	21 knots
Armament	ten 14-in., sixteen 6-in.
Thickness of armour :—	
On side at W.L.	10 in.
Above ,, ...	7 in. and 5 in.
Below ,, ...	4 in.
On casemate	2 ,,
On barbettes	12 ,,
Thickness of protective deck-plating	3 ,,

Briefly, the points for discussion are as follow :—

1. Is 4-in. armour sufficient protection against torpedoes to justify its adoption in battleships of the class of the later Dreadnoughts?

2. Is the submarine menace of sufficient importance to justify the adoption of 4-in. armour protection on the bottom?

3. Is the submarine menace of sufficient importance to justify the building of smaller, slower battleships of, say, 16,000 tons displacement, of 18 knots, having six heavy guns each instead of eight or ten as in the larger ships?

4. Is the method of applying armour to the bottom of sufficient value in itself to justify the adoption of a form of ship which offers greater resistance than the ordinary form?

These are some of the points which suggest themselves for discussion. The form and arrangement of existing ships, though not revealed to us by the Admiralty, may be considered, for this purpose, as sufficiently well known to many to make it unnecessary for a third design to have been embodied in this paper. If it should seem to be desirable further to consider this question of protecting battleships from submarine attack, it will be necessary to determine by experiment the effect of the explosion of a torpedo upon armour attached to a ship. If the submarine menace is judged to be really serious, the necessity for carrying out such experiments seems to be undoubted.

OIL FUEL IN CANADA.—Crude oil is being extensively used as fuel on the Pacific Coast for both steamships and locomotives, and the wide use of the gasoline motor has created a great demand for gasoline. The total imports of petroleum oils, crude and refined, in 1913, were 222,779,293 gallons, valued at 13,230,429 dols. The oil imports included 162,062,201 gallons of crude oil, valued at 5,250,835 dols.; 19,393,627 gallons of refined and illuminating oils, valued at 1,386,440 dols.; and 20,525,170 gallons of gasoline, valued at 4,822,941 dols. The imports of crude and refined petroleum oils in 1912 were 186,787,484 gallons, valued at 11,858,533 dols.

SHIPBUILDING PRACTICE OF THE PRESENT AND FUTURE.*

By Mr. T. G. JOHN, Member.

SHIPBUILDING practice of to-day is the outcome of many forces of varying magnitude, some of which may be said to be at war with one another. Amongst others may be mentioned science, experience, invention, skill, and even prejudice, but most important of all is the fundamental fact that shipbuilding practice results primarily from the necessity of making a profit out of the capital invested. The influence of the different factors at various times fluctuates considerably, but the one which has made most relative progress during recent years is that which may be termed the industrial force, by virtue of which the shipyard workman exercises a generic influence upon methods, efficiency, and cost of production, and incidentally it may be mentioned that this influence is probably stronger in the practice of present-day shipbuilding than in any other engineering industry.

Discussions on the comparative importance of these factors (except the last-named) have in the past filled many pages of the Transactions of this and kindred institutions. The exception has been partly because the subject enters more into the domain of the politician than of the scientist, and discussion of it can, therefore, scarcely be regarded as proper to a scientific institution such as this, although at the same time its relative importance to the industry is admitted to be very large. On the rare occasions when it has been mentioned—as our Transactions will bear witness—it has almost invariably been quoted as a factor more or less antagonistic to scientific progress. At the present time many shipbuilders are more of this opinion than ever, but when viewed in true perspective it must be admitted that its influence upon the ultimate scientific advancement of the industry can be but small, for the simple reason that, were it otherwise, the natural laws of economics would automatically adjust matters. This very debatable side of present-day shipbuilding practice will be referred to again, but this much has been mentioned now because at the present time many of the abilities and energies of our shipbuilders, and of the best of our workmen, are absorbed in solving the labour problems which are of almost daily occurrence, and the scientific advancement of the industry suffers accordingly.

Apart from the historic interest attaching to a study of the improvements which have occurred in shipbuilding practice during recent years, the subject to a certain extent, commands attention by placing various matters in more or less true perspective for forecasting the future.

Shipbuilding is one of our oldest, and still ranks as one of our most important industries, and in its scientific progress we have always taken, and still continue to take, a leading part. Nevertheless, many other spheres of engineering activity have been created since the inception of iron shipbuilding some eighty years ago, and in certain instances have developed so very rapidly that most shipbuilders at times feel a certain amount of regret that shipbuilding science and practice cannot be forced ahead at the same comparative rate of progress. On the other hand, perhaps, no branch of applied science gives rise to problems so varied and difficult as ship construction. Such subjects as structural strength, stability, elasticity, safety in damaged condition, &c., can only be dealt with by the designer with considerable mathematical approximation, and the factor of professional judgment enters very largely into his work. At the same time assumptions have to be made which, from the nature of things, must inevitably differ considerably from the conditions obtaining in actual practice—to say nothing of contingencies created by accidental damage. The finished ship, as built, is the combined result of assumptions, calculations, deductions from observations made on previous ships, together with a comparatively large factor of safety, which is included to give the necessary latitude in the foregoing assumptions and deductions, and particularly to cover the necessary uncertainty which must appertain to all material and to all mechanical operations. It is evident, therefore, that a very considerable amount of interdependence must exist between the shipbuilder and the designer, whose association is perhaps not always as close as it should be. Moreover, methods of manufacture restrict the ambitions of the latter in certain narrow grooves from which he can expand but little, and from this point of view it must be admitted that the improvements in appliances and methods of shipyard practice throughout the shipbuilding world have in recent years scarcely kept pace with the very great expansion of the industry. From the nature of shipbuilding the personal factor attaching to management figures more largely perhaps than in most industries, especially as regards profit earning, but even efficient management necessarily has a limited influence upon the development of shipbuilding practice, besides which, novelties in such practice usually entail a certain amount of risk of failure and consequent financial loss.

Our own shipbuilding industry may roughly be divided into two sections, comprising respectively those establishments which make a practice of building large numbers of medium or small-sized ships of almost standardised pattern, and those which do the better class of work appertaining to large passenger or war vessels. In other countries more variety frequently obtains in each yard, because of the smaller number of establishments. Obviously those of the former section need considerably less variety of equipment than those of the latter, and frequently they achieve good financial results notwithstanding that they use equipment which, for the purpose of the other section, might justly be called crude or inferior. Elaborate equipment being invariably productive of heavy establishment charges, it is not surprising that the large shipyard sometimes meets with difficulty when placing itself in competition for the class of work usually done by the small one. There exists, moreover, a subtle difference in the methods adopted by the respective establishments, but the best quality of work is demanded from all. While, for instance, a tramp steamer or a trawler has to last as long as possible, with more or less indifferent maintenance, on the other hand, a large passenger ship, or warship, becomes obsolete long before it wears out, yet at the same time needs during its comparatively short lifetime a very high standard of structural efficiency. Each establishment, however, whilst retaining its own characteristics, is built up on a strongly competitive basis, and there consequently exists every incentive to utilise whatever economy is available from improved equipment, machinery, and methods.

The Royal Dockyards constitute another class of shipbuilding establishment, but they are only semi-competitive in the above sense, and possess separate characteristics, more especially as regards the system of labour, which incidentally also goes to prove that, could our whole system of labour be entirely recast, a much better one could certainly be evolved. Although in output, cheapness, and quality of work this country still maintains its superiority in face of competition from other nations, and will, we hope, continue to do so, our shipbuilders have had, during recent years, to recognise the fact that several large Continental and American establishments have been extensively developed and equipped with very efficient plant, and that they will in future enter more largely into competition with ourselves. This has had its stimulating effect, but to a certain extent we have suffered handicap in this direction for having been the pioneers of the iron shipbuilding industry, as our establishments were formed and our methods developed when competition was much less severe than it is to-day or is likely to be in the future. It is also scarcely necessary to mention that the close connection which exists between methods and working customs, especially at the present time, limits very considerably the abilities of shipbuilders radically and quickly to alter existing practice.

At the same time it has to be remembered that the equipment and methods of such shipyards abroad have been considerably influenced by the existing local conditions. For instance, where skilled labour is scarce or very highly paid, then every possible labour-saving device is essential, and even in this country local conditions exert considerable influence upon the practice in different yards. Broadly speaking, it may be stated that such developments in our shipyards as have taken place during recent years have been chiefly due to two causes—viz. (1) the increase in dimensions of ships having to be built, with corresponding increase in the size of items of structure; and (2) the ever-persistent desire for economy, coupled with rapidity of production and good quality of work. New methods of manufacture have influenced the developments to a comparatively small extent.

The effect of these causes has been the expenditure of considerable sums of money in three directions, viz.:—

a. Alterations in the topography of the shipyard area.
b. Improvements in lifting and transporting equipment.
c. Improvements in general plant and appliances.

Before studying these in detail, one might mention the difficult position in which the shipbuilder is placed when he has to consider such expenditure owing to want of knowledge of the future requirements he will be called upon to meet, chiefly as regards size of ships and number of contracts. It is in this connection that the capital resources of an establishment tell heaviest, one with large capital, distributed perhaps over several branches of industry, being able to afford to take risks which another cannot. Then, again, the attitude of organised labour frequently deters the shipbuilder from embarking upon a large expenditure in improved plant because of a knowledge that in many cases he would receive a relatively very small return for his outlay, or perhaps none at all. At the same time, no equipment or machinery, however good, will pay for itself if it has only a limited amount of use, and, in any event, depreciation and obsolescence of shipyard equipment and machinery has become so rapid that the up-to-date builder must be prepared, even under present conditions, to scrap the greater portion of his most used machinery after less than fifteen years' service, which period is a continually decreasing one. As the increase in the size of ships is a factor which intimately concerns each of the three previously-mentioned subheads, it is well to remember that, compared with twelve years ago, the number of passenger ships now built per annum which have a tonnage exceeding 10,000 tons has nearly doubled, whilst the average launching weight of large warships during the same period has increased by more than 50 per cent.

ALTERATIONS IN THE TOPOGRAPHY OF THE SHIPYARD AREA.

In examining the development in this direction of most of our large shipbuilding establishments, one frequently gets the impression that, whilst the engineers who originally planned such establishments did so on exceedingly sound manufacturing principles, they at the same time considerably underestimated the requirements of the future. They designed their shipbuilding berths with what they considered to be an ample margin of length and breadth, they arranged their heavy machinery plant on the sound principle that the nearer the machine to the work the less the waste of labour, and then the rest of the yard followed suit. The trouble arises when the margin allowed becomes exhausted and alterations have to be made. This problem has faced many shipbuilders in recent years, and in most cases the solution has been a compromise between heavy capital expenditure and a certain amount of working inefficiency.

To meet present-day possible requirements the builder of the best class of work desires a slipway approaching 1000 ft. long and 100 ft. wide. Many thoughtful people, especially those of other engineering industries, frequently express surprise that the shipbuilder still continues to do most of his work exposed to the weather, but the question of roofed-in *versus* open slipways for large ships (which was a source of considerable debate and much diversity of opinion a decade or two back) seems to have been settled in favour of the open slipway, for at the present time there exists in this country but one roofed-in building in which a modern battleship or large liner can be built, and that one was erected about ten years ago.

At that period the relation which the first cost and maintenance of such a structure bore to its economic advantages was mostly the debatable point, but probably more than anything else the rapid advance made during recent years in the size of ships and the uncertainty of their future dimensions, has confirmed the opinions of most shipbuilders that, in this country, the advantages gained are incommensurate with the large expenditure and risk of obsolescence involved, which opinion may or may not be sound, and, if true now, may be reversed a short time hence, due to causes incidental to labour. In foreign countries also roofed-in slipways are not much in present favour, although in a few instances climatic conditions render them more or less a necessity.

Leaving out the question of cost, the old arguments, as regard advantages and disadvantages of the roofed-in slipway, still hold good—viz., time saved, better quality and cheapness of work, protection of mechanical appliances from the weather, and less expense in cleaning ships, whilst on the other hand there is the reverberating noise, draught, restricted light, &c.

To cover a slipway 1000 ft. long by 100 ft. wide with an iron shed on normal foundations, and having an average clearance from the ground of 140 ft., and, say, 15 ft. at each side, would cost in this country at the present time something like 150,000*l*., which sum does not include overhead lifting equipment, although it includes provision for such. With care such a shed ought to last thirty years, if not scrapped by the march of events before that time; but, assuming such duration of life and interest on capital to be 5 per cent., it appears that the yearly cost, excluding maintenance, will be about 12,500*l*. Whether the benefits are commensurate is, as stated above, open to doubt. For like reasons, except in one or two instances where concrete has perforce to be used as an adjunct to piling to obtain a safe foundation, the average shipbuilder still constructs his ships without the luxury of a concrete or granite slipway, although it involves him in considerably more trouble in fairing them and in carrying out their launching arrangements. In our Admiralty establishments, where all risks are eliminated so far as possible, and financial circumstances are different, such slipways are always used, and the degree of standardisation obtaining in the vessels constructed avoids subsequent disadvantage as regards area of building ground. After launching, *force majeure*, due mostly to their size, still compels the builder in frequent instances to complete his ships at a place more or less distant from the base of his operations. Such necessity is easily conducive to considerable waste of profit, besides entailing many other disadvantages, and with the large ships now obtaining the attendant difficulties are becoming more acute.

IMPROVEMENTS IN LIFTING APPLIANCES.

Slipway Equipments.—In no direction has such a variety of appliances been introduced into shipyards during recent years as in that relating to the overhead equipment of the slipway, and on no subject, perhaps, does more diversity of opinion exist than on the relative economic efficiencies of the various types. Many attempts have been made to calculate such efficiencies from a financial point of view, but it is probable that most estimates are more or less wide of the mark, owing to the problem really being incapable of exact solution; for, whilst such items as first cost, depreciation, and cost of maintenance and operation are fairly easily calculable, on the other hand, such advantages as they give in the direction of time-saving and quality of work are not capable of exact or even fairly approximate computation, and in addition, much depends upon the extent of the use of the appliances during their lifetime, and upon their ability to meet the unknown requirements of the future. Certain it is, however, that the deficiencies of many of those erected during the last decade but one are well realised.

The introduction of such elaborate lifting equipments is of comparatively recent date. Until about twenty years ago the time-honoured mast and derrick system, actuated from suitably placed winches by wire ropes and guys passing through leading blocks, reigned almost supreme, although in a few instances it was supplemented by steam or hand travelling cranes on gantries erected alongside the slipway. It may here be stated that a great proportion of our ships are still constructed under this system, including all warships built in our Royal dockyards. About that time, however, great extensions occurred in the shipbuilding industries of Germany and the United States, and several of our modern equipments had their origin in those countries, where, especially in the last-mentioned one, owing to skilled shipyard labour being able to demand comparatively high wages, every incentive was offered for the introduction of labour-saving devices, and the creation of new establishments furnished the necessary opportunity.

The problem of overhead lifting appliances is a fairly definite one. Briefly stated, material of a great range of weight, shape and size has to be transported to its allotted position in the ship with the minimum of cost

* Paper read before the Institution of Naval Architects at Newcastle-upon-Tyne, July 7, 1914.

and time, and the maximum of handiness, and the equipment should be economical as regards maintenance and working. The arrangement of it should be such that when any portion is delayed, as often happens, the remainder should not be impeded, and up to a certain extent, the greater the number of hooks available for the working squads the greater the efficiency. In view also of uncertainty about the future dimensions of ships, some degree of portability is an added virtue.

The best-known modern systems adopted in this country may be summarised into five types, in all of which each unit is self-contained as regards operative power, viz. :—

(*a*) The American cantilever system, in which two slipways are served by a cantilever crane which travels on a gantry erected between them.

(*b*) The travelling-carriage system, in which a single slipway is served by a number of carriages, either mono- or duo-rail, travelling on the sides or roof of a skeleton structure, and spanning the whole or different parts of the slipway.

(*c*) The wire-cable system, in which the slipway is spanned in the fore-and-aft direction by a number of cableways (usually three or four), which are supported by structures at each end, and which can be given transverse movement, trolleys running on the cables conveying the material.

(*d*) The tower-crane system, in which a number of horizontal jibs supported on independently stable tower structures, fixed or travelling, circumscribe areas over each of the two slipways which they serve.

(*e*) The lattice-built mast-and-derrick system, in which each unit circumscribes a specific area over a particular slipway.

Local variations occur in the details of the systems; but on general principles each system has certain merits and demerits, which may roughly be stated as follows:—

AMERICAN CANTILEVER SYSTEM.—*Merits:* Large range of lifting capacity at different radii: large area covered by a single unit; ability to pick up practically all loads from the heads or sides of slipway; ease of control.

Demerits: Heavy first cost; stability being dependent on weight, the travelling portion must be extremely heavy in comparison with the average weight lifted, thereby entailing large wasted expenditure of power; restricted access given to one side of each slipway at the midship portion; large amount of structure involved, much of which is difficult of access, thereby enhancing cost of maintenance; large area of yard occupied by gantries; inability to work in strong winds; operator far away from the work; non-portability, poor facilities for handling material and hydraulic riveting tools and inability to deal with sufficient loads in a stated time to anything like adequately meet the needs of two large vessels building under modern conditions.

TRAVELLING-CARRIAGE SYSTEM.—*Merits:* Large number of hooks available for handling, transporting and riveting operations, which number can, to meet exigencies, be quite easily increased even up to fifteen or sixteen per berth; ability to work in strong winds; quick transport; carriages can combine for heavy loads; operators have good view of their work.

Demerits: Very great first cost; installation limits expansion of breadth of slipway, and involves disadvantages as regards area of building ground; limited ability to pick up material from head or sides of slipway; expensive in maintenance and a certain amount of interference occurs with the carriages.

WIRE-CABLEWAY SYSTEM.—*Merits:* Comparatively low first cost; rapidity of conveyance; ability to take up loads from head of slipway; small ground area occupied by supports; small power absorbed; ability to work in strong winds; trolleys can combine to a certain extent for heavy loads.

Demerits: Very limited number of hooks available for handling material, &c., and these are not suitable for riveting machines; difficult to arrange for heavy loads; limited ability to pick up loads at sides of slipway; troublesome questions of tension and sag in cables.

TOWER-CRANE SYSTEM.—*Merits:* Comparatively low first cost; rapidity of conveyance; small power absorbed; ability to work in strong winds; breakdown of a unit has small effect; system lends itself to extension of length of ship served; semi-portability.

Demerits: Only certain cranes can take up loads from head of slipway; maintenance expenses somewhat heavy; operators far away from their work.

LATTICE-BUILT MAST-AND-DERRICK SYSTEM.—*Merits:* Small area of yard occupied; large number of hooks available for handling material and riveting machines; ability to work in strong winds; considerable portability, giving advantage of altering lines and areas of slipways.

Demerits: Obstruction caused by multiplicity of stays, with consequent difficulty in co-ordinating with any other existing devices; non-ability to pick up material from head of slipway; limited area of ship covered, involving a certain amount of laborious handling of material.

In selecting his equipment each shipbuilder, of course, will have considered the subject from the point of view of his own peculiar needs, and, in addition to other factors, will probably have had to contemplate the serious disorganisation of his work whilst the installation is being made.

Considered from the financial aspect, the cost of maintenance and working of most of the systems is, under normal conditions, comparatively a small item when judged by the amount of work they perform. Such costs necessarily vary according to temporary and local conditions, but on the other hand comparisons in capital costs per annum are fairly definite, and the following table has been compiled on the assumption that the life of the equipment is twenty years and interest on capital is taken at 5 per cent. The first cost is estimated on present-day prices, and the foundations and conditions of erection are assumed to be normal. Studied in conjunction with their relative merits and demerits, however, it seems safe to say that the efficiencies of the respective systems cannot be in the direct ratio of their costs, and it is more or less unsafe to say anything further.

Comparison of Present-Day Costs of Overhead Equipments Designed to Serve Efficiently a Slipway 1000 *Ft. Long by* 100 *Ft. Wide.*

Capacity at Maximum Outreach in each System is 5 Tons.

System.	Number of Hooks Available.	Total Cost per Slipway.	Capital Cost per Annum.
		£	£
American cantilever ..	½ to 1*	15,000	1500
Travelling carriage ..	15	95,000	9500
Wire cableway	4	10,000	1000
Tower crane	3 to 6*	13,200	1320
Lattice-built mast and derrick	16	24,600	2400

* Each hook is available for two slipways.

At the present time shipbuilding opinion is largely in favour of the tower-crane system, as may be deduced from the fact that during the past year or two a number of these have been installed in four large establishments in this country—viz., Messrs. Harland and Wolff, Limited, Belfast; Messrs. Workman, Clark and Co., Limited, Belfast; Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle-on-Tyne; and Messrs. Vickers, Limited, Barrow-in-Furness, the cranes having in each case been designed and constructed by Messrs. Sir William Arrol and Co., Limited. In foreign countries, besides in Germany, they have been installed in recent years in shipbuilding yards at Ferrol, Havre, Dunkerque, Genoa, Schiedam, and possibly in others. All are, of course, electrically operated. Opinion varies as to the most desirable lifting capacity, and as to the proportionate area of slipway which should be covered. As regards the former, it is interesting to note that plates weighing up to 8 tons are not uncommon in ships now under construction, and even this weight is frequently very much exceeded, whilst in moderate-sized vessels built on the Isherwood system items of framing weighing up to 10 tons have often to be dealt with.

A brief description of the installation now being erected in the shipyard of Messrs. Vickers at Barrow-in-Furness may be interesting.

The arrangement is shown diagrammatically in Fig. 1, page 70, and consists of two parallel rows of fixed cranes, containing five in the longer row and four in the shorter, with a clear width of 213 ft. between them, in this fashion serving four slipways, whose respective lengths are approximately 900 ft., 830 ft., 770 ft., and 720 ft., with possibilities of extension in each case. The crane at the lower end of each row is placed so that bulky materials may be lifted out of a barge afloat in the channel, thus obviating the congestion which inevitably occurs when cumbersome items have to be transported through the yard. Each crane has a jib of 120 ft. radius, seven of them are capable of lifting loads of 5 tons at the extreme radius; whilst the other two (the second from the forward end of each row) are designed to lift 15 tons at the extreme radius, and all will lift double those respective loads at half radius. The cranes have been given a large amount of overlap, and the heavy ones provided both to meet the increasing variety of heavy lifts now dealt with in modern big ships and in view of possible future requirements. With the two heavier cranes, boilers and heavy items of propelling machinery, &c., can be shipped on the slipway, and the great advantages accruing therefrom realised. The lowest jib of the whole installation is 95 ft. from the ground, and the highest 156 ft., thus providing a liberal margin for increase in height of ships beyond present-day requirements. The structural design of one of the 5-ton cranes is shown in Fig. 2, page 70. Owing to the units being a considerable advance in size and power from anything of the sort previously constructed, new difficulties were, of course, met with, both in design and working; for instance, owing to the comparatively large moment of momentum of the revolving structure with its load, the controlling arrangements had to be very carefully devised, and the limited experience already gained has shown the advantages to be realised by balancing them against wind pressure, wind sails, as shown in the diagram, having been added.

It will be noticed that the bases of the cranes have been arranged to permit of bulky loads, such as boilers, being conveyed to positions convenient for lifting on board ships.

Finishing-Berth Crane Equipment.—The equipment of the modern afloat berth presents a problem altogether different from that of the slipway. The small weight requiring to be placed in positions far apart still predominates, but the comparatively few heavy items are of ever-increasing weight, so that the modern large crane for such purpose needs a capacity of something near 200 tons, and this leaves very little margin for the future. It is significant that two of the most recently erected of such cranes have a working capacity of 250 tons.

The march of progress in this direction has been so very rapid that it is surprising to reflect that it is only eight years since the last heavy sheerlegs were erected to serve a finishing berth in this country, although at the present time such a type is regarded as entirely obsolete, giving, as it does, slow and very limited area of service, and necessitating frequent moving of the vessel. Owing to the concentration of pressures, the foundations are also often difficult to provide. Derrick cranes, actuated by hydraulic or electric power, have been installed in several instances at home and abroad, but modern opinion is largely in favour of the types known as the "Hammerhead" or "Giant" revolving cranes, electrically operated.

The problem of the light load at such berths has not yet been completely solved, but it has been partially met by subsidiary hoists working on the structures of the forementioned heavy cranes, by travelling-cranes with long outreach on the wharves, and by floating-cranes; and it is interesting to note that the maximum capacities of the two former types have recently increased from about 10 tons to the vicinity of 30 tons, the latter now being generally regarded as the most desirable range for subsidiary service of large vessels.

Other Transport Arrangements.—The remaining transport arrangements of modern shipyards call for little mention, as they are proceeding on fairly well-established principles. In the machine-sheds new problems in certain instances have had to be faced, both because of much heavier items of material having to be dealt with, and because more expeditious handling has become necessary. Overhead travellers have not in the past been as common as they might have been in such sheds, but in new ones they are in most cases being installed. As, however, in the first instance the shed usually needs to be designed, both as regards structure and head-room, to receive such an equipment, it is not often possible to make the improvement in existing ones. Overhead railways are in operation to a certain extent, and this system seems suitable for much more consideration from designers, with a view to further adoption.

IMPROVEMENTS IN GENERAL PLANT AND APPLIANCES.

As previously stated, these have been comparatively few, such as have occurred being principally due to such influences as a desire for increased output, reasons of economy, and new methods. There is no doubt that in this section great opportunities still exist for inventors and manufacturers of machine-tools and plant. As bearing evidence to the increased demands during recent years for the inclusion of exceptionally long and broad plates in ship construction, may be mentioned the difficulties experienced by builders with their bending and rolling machinery. Nine years ago bending-rolls capable of working a plate up to 30 ft. long by 2 in. thick when cold were generally considered sufficient to meet future needs. The next seven years witnessed the necessity of dealing with plates up to 40 ft. long by 2 in. thick, and at the present date rolls of even this capacity are proving inadequate to meet the demands of the ship-designer, plates having length and breadth up to 48 ft. and 11 ft. respectively being incorporated in ships now under construction.

The introduction of pneumatic tools some seventeen years ago for drilling, caulking, chipping and riveting, has led to their use on such an extended scale that it is difficult to imagine the difficulties which would arise in present-day shipbuilding if it were suddenly deprived of their assistance. Here, again, the economic results achieved by their adoption are not strictly capable of computation, for whilst the output per man using these tools is increased on an average about threefold, the outlay involved and costs of depreciation and maintenance of such tools is considerable; power has to be generated and by virtue of piecework agreements many of the benefits pass to the workman, by enabling him to earn higher wages, the deductions from which, for his increased output, vary in this country in the vicinity of 40 per cent. In this connection, however, it has to be remembered that the average workman is not so much concerned with the relative rates of pay as with his total earnings, and if pneumatic tools had not been introduced it is quite probable that the hand-work rates would have increased much more than they have done.

The chief advantages to the shipbuilder using such tools are in the greater output and better quality of work which they give him; and although, as stated, their financial effect is of a complex nature and not exactly calculable, it is not inconsiderable.

For the operations of drilling, reaming, caulking, and cutting, the utility of pneumatic tools is unquestionable, although the oxy-acetylene tool is coming much into use for the latter operation, but the extent to which pneumatic riveting is adopted varies considerably in different establishments in this country and abroad. Professional opinion, after seventeen years' experience, is still far from unanimous on the subject of pneumatic riveting, but most shipbuilders agree that, given efficient "holding up," pneumatic riveting, in the hands of a moderately-skilful workman, is at least equal in quality to and frequently excels hand-work, whilst at the same time the output per man is considerably increased. Its adoption in most yards is, in fact, limited by the sufficiency or otherwise of the power pressure available, by the willingness of the workmen to operate it, and by the extent to which holding-up appliances have been devised or are applicable. An added virtue possessed by all pneumatic tools lies in the fact that in the hands of an otherwise inferior workman they can be made to give quite a good quality of work, which in times of scarcity of labour would otherwise be lost. Hydraulic power has for a long time been used to a certain extent in shipyards in this country for riveting, and, until recently, considerably more so than in most foreign countries. Hydraulic riveting is nearly always of the best possible quality, and for certain important items of structure is almost a necessity, so that in every way its extension is much to be desired in ship construction.

The greatest difficulty in the way of extension of hydraulic riveting is due to the inordinate weight and size of the portable plant connected with it; for instance, a 6-ft. gap scissors machine, capable of closing 1¼-in. diameter mild-steel rivets, weighs something like 2¾ tons.

On this account special appliances, and often much labour, are needed to manipulate such tools, the work as a result frequently being slow and expensive. The hydraulic riveter in use to-day is in many respects a crude machine, and seems capable of considerable improvement in design for use in shipbuilding. It ought not, for instance, to be a necessity for the ship-designer, as is often the case, to have to narrow his plates so as to permit of hydraulic riveting by bringing the riveting-machine within manipulative weight and dimensions.

In connection with power riveting, it is generally realised that comparative results of efficiency of riveting taken from test specimens are often apt to be misleading. Machine riveting throughout a ship, whether done by pneumatic or hydraulic power, invariably approximates more closely to the selected test pieces than does hand work, owing to the personal factor of the average ability of the workman.

Other than for riveting, the only direction in which the use of hydraulic power in shipyards has been appreciably extended in recent years has been in connection with the manufacture of such items as plate collars, knees, brackets, &c., by die-stamping, besides which many fittings, previously made of forgings or castings, have been replaced by much less expensive stampings, notably pillar heads and feet, bollards, wells in flats and bottoms, &c.

Although in present-day shipbuilding each form of operative power acts more or less efficiently in its own sphere of usefulness, it may not be out of place to mention the great economy which would result if all these could be transmitted and utilised in one form. Multiplication of plant for generating power and its distribution over wide areas is an item of considerable expense in a modern shipyard, and anything in the nature of simplification is much to be desired. Of the prime energy systems, electricity seems the most suitable for unification, and whilst such an ideal is, perhaps, too much to hope for at present, it is not without interest that one can, even now, purchase an electrically-operated riveting hammer or an hydraulic riveter actuated by a self-contained electrically-driven pump, the latter being neither exceptionally bulky nor heavy.

Space forbids more than the mention of many minor appliances and machine tools which have recently been introduced into shipyard plant, such as friction saws, oil furnaces, &c., many of which have been in use for some time in other industries, but have either only lately been adapted to meet the shipbuilder's requirements, or else the requirements were not sufficiently pressing to warrant their adoption. The development of producer-gas plant also in recent years has given the shipbuilder opportunity of utilising it for his purposes, and the gas-furnace, with its attendant advantages of uniform heating, is now in common use in many shipyards.

As exemplifying improvements which are not altogether of the nature of plant, one may mention those in the direction of templating, &c., the constituent items of a ship's structure, and in this connection the exact relationship which the operations of the mould-loft bear to the subsequent work of the plating department remain more or less indefinite. It can readily be understood that in passing from the mould-loft, where all operations are dependent upon exactitude, to the different parts of the structure of a ship manufactured by workmen possessing varying ability, much opportunity occurs for wasted effort and poor execution. The template and batten system, emanating from the mould-loft with a maximum amount of standardisation incorporated, has been extensively used of late to eliminate such defects as much as possible. The system, however, to be successfully worked necessitates a considerable amount of co-operation on the part of the individual workman, together with keen supervision and frequent checking, even of the template, failing which, a mistake, occurring perhaps in the early stages of the work, is not discovered until a considerable amount of structure is involved, and is more or less costly to rectify. Different establishments work this system to a varying extent, but looked upon scientifically it is an excellent method, and its extension is much to be desired. Because of the above-mentioned reasons, however, "board work" continues to be used to a considerable extent, and although the method is slower, on the other hand the accuracy of the resulting work in most cases is more assured. Speaking generally, the factors which decide the method adopted are the facilities of the establishment, the price list, the urgency of the work, its desired extent of accuracy, and the individual ability of the workman to whom the work is entrusted.

In the same connection, the subject of standardising as much as possible the plate and angle-bar constituents of a ship's structure has been receiving some attention from shipbuilders, and the advantages of doing so, from a manufacturing point of view, are very evident. In the structure of floating docks the practice has for some time been extensively adopted, whilst it is also used to a certain extent in merchant and passenger ship work. In large warships, on the other hand, it is as yet almost non-existent.

Launching practice as applied to large and heavy vessels has undergone some modification in recent years. The time-honoured device which has been perpetuated since the days of the wooden shipbuilding industry, whereby the ship was released by the mechanical removal of two or more dogshores, has now given way to the more positive method of simultaneously releasing a number of triggers by electric or hydraulic power. The former system, however, still obtains in our Royal Dockyards, and in a few private establishments, although the much greater security and safety of the trigger methods seem more than sufficient to warrant their adoption. Another small detail regarding launching practice, which is worthy of mention, is the increasing custom in recent years of incorporating a horizontal layer of soft wood below the forward poppets in heavy vessels, with the object of distributing over as large an area as possible the pressure created when the stern lifts. Shipbuilding opinion is not unanimous as regards this practice, but it is prevalent, and has a tendency to become more so.

Fig. 1. PLAN OF PORTION OF SHIPBUILDING AREA

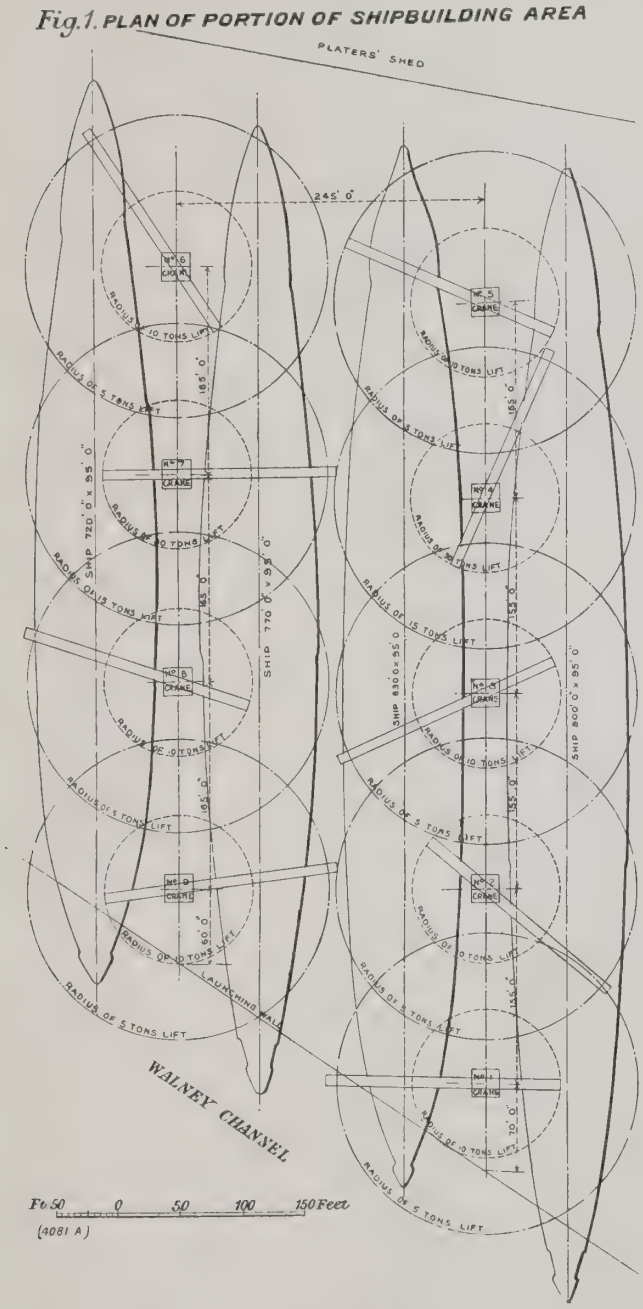
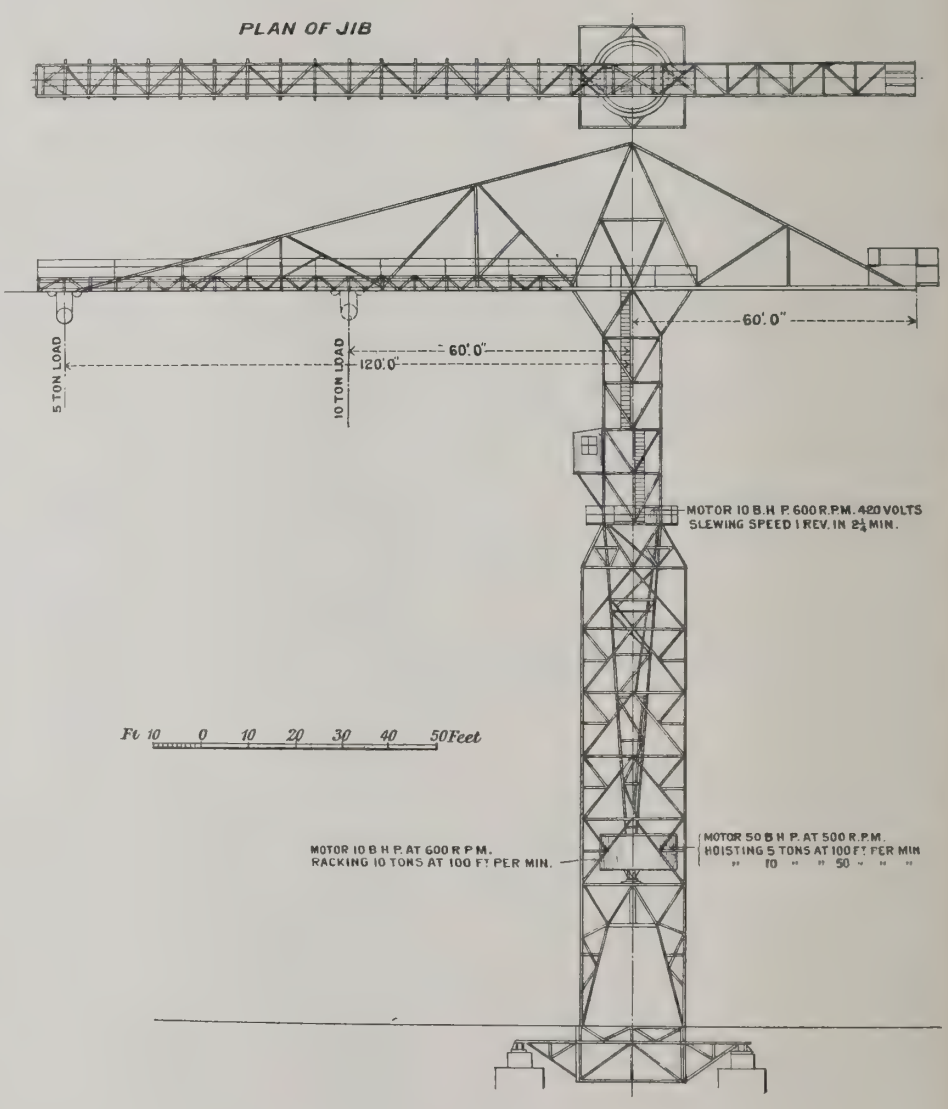


Fig. 2. OUTLINE VIEW OF 5 TON TOWER CRANE


PLAN OF JIB
60' 0"
60' 0"
120' 0"
5 TON LOAD
10 TON LOAD
MOTOR 10 B.H.P. 600 R.P.M. 420 VOLTS
SLEWING SPEED 1 REV. IN 2¼ MIN.
MOTOR 10 B.H.P. AT 600 R.P.M.
RACKING 10 TONS AT 100 FT. PER MIN.
MOTOR 50 B.H.P. AT 500 R.P.M.
HOISTING 5 TONS AT 100 FT. PER MIN
" 10 " " 50 " "
Ft 10 0 10 20 30 40 50 Feet

Regarding Future Developments.

One treads on very uncertain ground when approaching the future of a great industry like shipbuilding, and one has to bear in mind that the builder who is in advance of his times is penalised nearly as much as the one who is behind them. At the same time the desirability of intelligent realisation and anticipation by the shipbuilder of

the future needs of the industry requires no emphasis. The very fact of the existence of so many imperfections in shipbuilding practice is a sufficient guarantee that in process of time some, if not all of them, will be remedied, to the benefit of the shipyard and the ships.

Several instances have already been mentioned in previous parts of this paper where room exists for improvements upon present practice, and, of course, certain desiderata are, and always will be, present in the economics of the shipbuilding industry; for example, inexpensiveness and efficiency of materials, labour and methods, if not separately, then in combination.

The developments of the distant future are, naturally, too chimerical safely to debate, and obviously are dependent upon those of the near future. As regards the latter, certain presumptions are fairly positive—for instance, that the size of certain types of ships will continue to expand, and that economic competition will increase in severity, and at the same time become more world-wide. It is impossible to contemplate the future development of an industry such as this without appreciating how largely labour influences at home and abroad will certainly exert their pressure. It is unfortunate that trade unionism in shipbuilding practice, as in certain other industries in this country, has developed along such lines as to render the task of bringing the interests of the workman into line with those of the employer an almost impossible one. Notwithstanding much consideration having been given to this subject, and the trial and failure of the principle of co-partnership, the situation remains, to say the least, without tangible improvement. Whether and when any fixed basis for permanent settlement will be arrived at are highly speculative questions. But, on the other hand, two things are fairly certain: first, that certain sections of the shipbuilding industry in this country have grown up on such very different lines from most other engineering industries that the high degree of economical efficiency attained by the individual producer in the latter is not likely, for some time, at least, to be achieved in the former, not necessarily because of any marked difference in the efficiency of the average workman, but because of the fact that shipbuilding operations are not generally adaptable to highly standardised repetitive methods; and secondly, that in common with all skilled workers, the shippard workman will, as time advances, and his education increases, become progressively averse to heavy sustained manual labour. For the immediate future, therefore, the industry will have to place most dependence upon the inventor of more efficient methods and appliances for its continued progress. Incidentally, development along such lines should go far to remove the embarrassment caused both to trade unions and employers by the presence, at busy times like the present, of the inferior workman. Again, it is scarcely reasonable to assume that the steel ship of to-day—reached after development extending through less than a century —will be the prototype as regards structural details of the ship of a century heuce, and it is equally certain that the weakness of the ship of to-day lies mostly in its smaller structural details. Much of this is due to the want of improved processes—the resemblance which the great mass of structural details of our latest ships bear to those of Brunel's Great Eastern, besides bearing testimony to the genius of its designer, goes to prove this contention—and it can therefore be expected that many efforts in the future will go towards the improvements of structural details and of the methods by which such details are manufactured.

It is remarkable, for instance, to what an extent the rivet remains a fundamental unit in ship construction. It is certainly a very positive method of connection; but, owing to its employment, there exists a multitude of small added weights due to laps, butt-straps, angle-bars, doublings, corner-pieces, &c., and at the same time there is created a non-uniformity of strength and elasticity throughout the entire structure. Then again, very casual study of a typical water-tight bulkhead or flat in present-day shipbuilding serves to make one realise the necessary crudity of its design and construction, in association with the vital functions which it has to perform. The material is badly disposed for resisting the stresses to which it may be subjected, there is an absence of uniformity of strength, and when stressed it leaks and becomes more or less inefficient when only a very small proportion of the ultimate strength of its material is developed. These statements are made for the purpose of indicating the great need which exists in shipbuilding practice for the adoption of a reliable fusion process for connecting structural material, if only to reinforce the efficiency of the riveted joint. It is a far step from this to the abolition of the rivet itself in general construction work, but it is not so far to its abolition in such places as joints of bulkheads or flats.

It is not difficult to see that non-uniformity of strength is also principally due to the riveted formation. If the joints could be welded, the natural sequence would be for the ductility of the material to be more utilised, by adopting flanging or perhaps corrugation of varying intensity, to give the necessary uniformity of strength desired to withstand water pressure, or sustain loads, the specific area treated by such means depending, of course, upon its position in the ship and upon its relative functions. Incidentally, it is also remarkable to what small degree the ductility of steel is taken advantage of in ship construction. Sheet-iron and sheet-steel work have made such great progress in the industrial world during recent years that they afford many latent suggestions for ship construction on a bigger scale. It is not impossible that certain joints of the thinner flats, &c., in the future, may be made by a combination of the beaded joint with surface welding, and perhaps even the shell or deck joints may be made by giving the edges such configuration that they acquire the necessary strength when finally welded together, if such could not be obtained by the simple butt weld alone.

TABLE I.—RESULTS OF TESTS CARRIED OUT ON SAMPLES OF MILD STEEL WELDED ELECTRICALLY BY THE "QUAZARC" PROCESS.

Tensile Strength of Steel, 26 to 30 Tons per Sq. In.

No. of Sample.	Description of Joint in Test-Piece.	Dimensions of Section in Inches.	Area, Sq. In.	Tons on Sq. In.	Elongation per Cent. in 8 In.	Nature of Test.	Remarks.	Sketch of Welded Joint.
A 1	Butt weld	2×.5	1	25	6.5	Tensile	Clean fracture through weld	
A 2	Do.	2×.5	1	22	3	,,	Do. do.	
A 3	Do.	2×.5	1	—	—	Bending	Bent through 115 deg. over a radius of $\frac{5}{8}$ in. — broke through weld.	
A 4	Do.	2×.5	1	—	—	,,	Bent through 180 deg. over a radius of $1\frac{3}{8}$ in.—without fracture.	
B 1	Plates overlapped $\frac{1}{8}$ in., and welded on each side ..	2×.5	1	17.2	5	Tensile	Clean fracture at weld.	
B 2		2×.5	1	21.8	7	,,	Do. do.	
B 3	Do. Do.	2×.5	1	—	—	Bending	Bent through 57 deg. over $\frac{3}{4}$ in. radius without fracture	
B 4	Do. Do.	2×.5	1	—	—	,,	Bent through 180 deg. over $2\frac{1}{4}$ in. radius without fracture.	
C 1	Flat bar welded on, and then machined off before testing sample	2×.5	1	25.5	22.5	Tensile	Fractured outside the locality where flat bar was welded on.	
C 2		2×.5	1	24.5	23	,,	Do. Do.	
C 3		2×.5	1	—	—	Bending	Bent double between welds over $\frac{5}{8}$ in. radius without fracture.	
C 4	Do. Do.	2× 5	1	—	—	,,	Bent double at weld over $\frac{5}{8}$ in. radius, very slight fracture showing at part where flat bar had been welded.	
D 1	Longitudinal butt weld	2×.4	.8	28.2	18	Tensile	Clean fracture across weld.	
D 2	Do. do.	2×.42	.84	29.2	21	,,	Very minute signs of fracture along whole length of weld.	
D 3	Do. do.	2×.4	.8	—	—	Bending	Bent double over $1\frac{1}{2}$ in. radius—slight fracture at welded part.	
H 1	Two 7-in. × $\frac{3}{8}$-in. bars welded together to form angle	—	—	—	—	,,	Points of angle closed in—no fracture.	
H 2		—	—	—	—	,,	Points of angle opened out—fracture at weld commencing.	
H 3	Do. do.	—	—	—	—	Not tested		
F 1	Flanged plate welded to angle bar at heel and toe	4.5×.5	—	Breaking stress 43	4	Tensile	Clean fracture along weld.	
F 3		4.5×.5	—	39	3	Do.	Do. do.	
F 5	Flanged plate riveted to angle-bar	$5\frac{3}{8}$ ×.5	—	18 5	—	Do.	Three $\frac{3}{4}$-in. countersunk rivets — rivets pulled through holes	
K	Plates lapped and single-riveted —one seam welded	—	—	—	—	Bending	Bent through 35 deg. at joint —no fracture at weld	

(4081 B)

Until recently, also electric arc welding when used on detail work has given indifferent results, presumably owing to the oxygen of the atmosphere combining with the carbon in the steel, resulting in the disintegration of the latter and its consequent evils. A patented process lately evolved and passing under the name of the "Quazarc" process is engaging the attention of some shipbuilders at the present time, and promises better results. It may be described as an electric fusion process, in which the weld is obtained by the addition of molten metal. It has been the subject of recent experiments at the shipyard of Messrs. Vickers, and the tabulated results of some interesting experiments on test-pieces treated with it are set out in Table I. Unfortunately, this is an example of a process in which the result of work done on test-pieces has a limited value for gauging its applicability on a large scale to ship construction. At the same time, the experiments, so far as they have gone, and allowing for want of experience on the part of the operators, showed the ease of operation, the comparative cheapness of the process, and the efficiency of the results.

As might have been expected, the elasticity in the region of the weld is somewhat reduced, and, although not tested, it is only reasonable to assume that the resistance offered to fatigue stresses by a structure so treated would also be reduced, but probably not to a prejudicial extent. As in all electric arc-welding processes, both these defects could be improved, if not removed altogether by reheating and working the junction. This latter finishing operation would not necessarily be impossible to perform in ship construction, but the margin of safety without it would doubtless, in most cases, be sufficiently large to enable the deficiencies to be tolerated. On the other hand, the resistance to influences creating corrosion should be considerably increased by treatment similar to the "Quazarc" process.

The subject of the applicability of such a process to ship construction is extremely interesting, and, although much experience will have to be gained and many difficulties overcome before its adoption on any large scale could be entertained, it is only reasonable to assume, in the light of past and present knowledge, that sooner or later a process of this nature will exert a considerable influence over future shipbuilding practice.

In this relation it is not even certain that steel, at least as we know it, will be the material to be used in ships of the more or less distant future, although because of the abundance of iron in nature and its consequent cheapness, it is very likely that iron will be its basic element. The science of metallurgy has made such rapid strides in recent years that it is reasonable to assume that sooner or later a metal may be evolved possessing all the good characteristics of present-day steel in an accentuated form, and in addition be less liable to corrosion. The problem in this direction may perhaps be stated to be chiefly one of cost. As an example of such possibilities, although of a slightly different nature, might be mentioned duralumin, an alloy of aluminium, which can be made to possess most of the good characteristics of steel (except weldability) in an enhanced degree, while being only about one-third as heavy as that material. Unfortunately, duralumin, although meeting a definite need in engineering and in certain other industries, is at present prohibitive for ship construction on a large scale on account of its cost, being for shipbuilding purposes about twelve times dearer than steel. Sufficient, however, has been said to indicate the scope which exists in shipbuilding practice for the scientist, the inventor, and perhaps the philanthropist, and whilst waiting for the success of their efforts, the shipbuilder can but proceed in the direction of eliminating wasted effort, perfecting such details as he can, and taking full advantage of standardisation and repetitive work to reap whatever economy may result.

In conclusion, the author desires to express thanks to the directors of Messrs. Vickers, Limited, for permission to quote various details; to Messrs. Sir William Arrol and Co., Limited, for information supplied by them, and to several professional friends for helpful criticism and assistance rendered in the compilation of this paper.

BALDWIN LOCOMOTIVES. — During the last eighteen months the Baldwin Locomotive Works Company has been obliged to reduce the number of its employees from 19,500 to 8200. The hours of the day men have also been cut down from 55 to 40 per week, while those of night shifts have been reduced from 65 to 39.

OIL IN AUSTRALIA.—Considerable attention is being paid to prospecting for oil deposits in South Australia, and to radioactive ores. Licenses to search for oil have been granted, and bores are being put down in the southern part of Kangaroo Island, the south-west of Eyre Peninsula, and in the south-east. The Government has offered a bonus of 5000*l.* for the first 100,000 gallons of crude petroleum containing not less than 90 per cent. of products obtainable by distillation.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Tasmania: The Imperial Trade Correspondent at Hobart has forwarded an extract from the local Press stating that the Launceston Municipal Council has adopted recommendations to extend and duplicate the existing tramway lines at a cost of 60,000*l*.

Egypt: The Egyptian *Journal Officiel* notifies that tenders are invited by the Municipality of Alexandria for the construction of a drainage system for that town. The work comprises (1) the construction of a general system of sewers, (2) the erection of a pumping-station at Kaïd Bey, and (3) the construction of a main outfall into the sea. Tenders may be made for the whole or for part of the work. Sealed tenders will be received, up to noon on December 8, by M. le Président de la Commission Municipale d'Alexandrie, Alexandria. A deposit of £E10,000 (about 10,260*l*.), or the guarantee of an approved bank, must be sent separately to the Service de la Comptabilité-Générale, Alexandria.

Austria-Hungary: The *Licferungs Anzeiger*, Vienna, states that, of the sixty-one water-works projects for Innsbruck, necessitating a total expenditure of 6,380,000 kronen (about 266,000*l*.), thirty-eight of the most urgent have been passed by the Water-Works Committee of the Imperial Diet, and will be presented by this Committee to the Diet for official sanction. The carrying out of these projects will necessitate an expenditure of 3,345,000 kronen (about 139,000*l*.), and several years will be occupied in completing the works.

Italy: The *Gazzetta Ufficiale*, Rome, contains a notice inviting tenders on behalf of the Commune di Marano Marchesato for the construction of a conduit for the supply of drinking water. Tenders will be received, up to July 20, at the Casa Comunale of Marano Marchesato. The upset price for the cost of material and construction is put at 82,788 lire (about 3310*l*.). The *Gazzetta* also notifies that tenders will be received up to July 28, at the Ministero dei Lavori Pubblici, for the construction of an addition to the mole, as well as the construction of a wharf and a slipway for ships in the port of Riposto. The total upset price of the work is put at 1,118,300 lire (about 44,730*l*.). The *Gazzetta* further publishes a notice to the effect that tenders are invited by the Ufficio delle fortificazioni di Venezia Campo S. Angelo No. 3549 for the construction of a wet dock for the Direzione d'Artiglieria, in the island of S. Giorgio Maggiore, Venice. Tenders will be received at the above-mentioned address up to July 16. The upset price of the work is put at 246,000 lire (about 9840*l*.). Although the foregoing contracts will doubtless be awarded to Italian firms, nevertheless the carrying out of the works may involve the purchase of materials and accessories outside Italy.

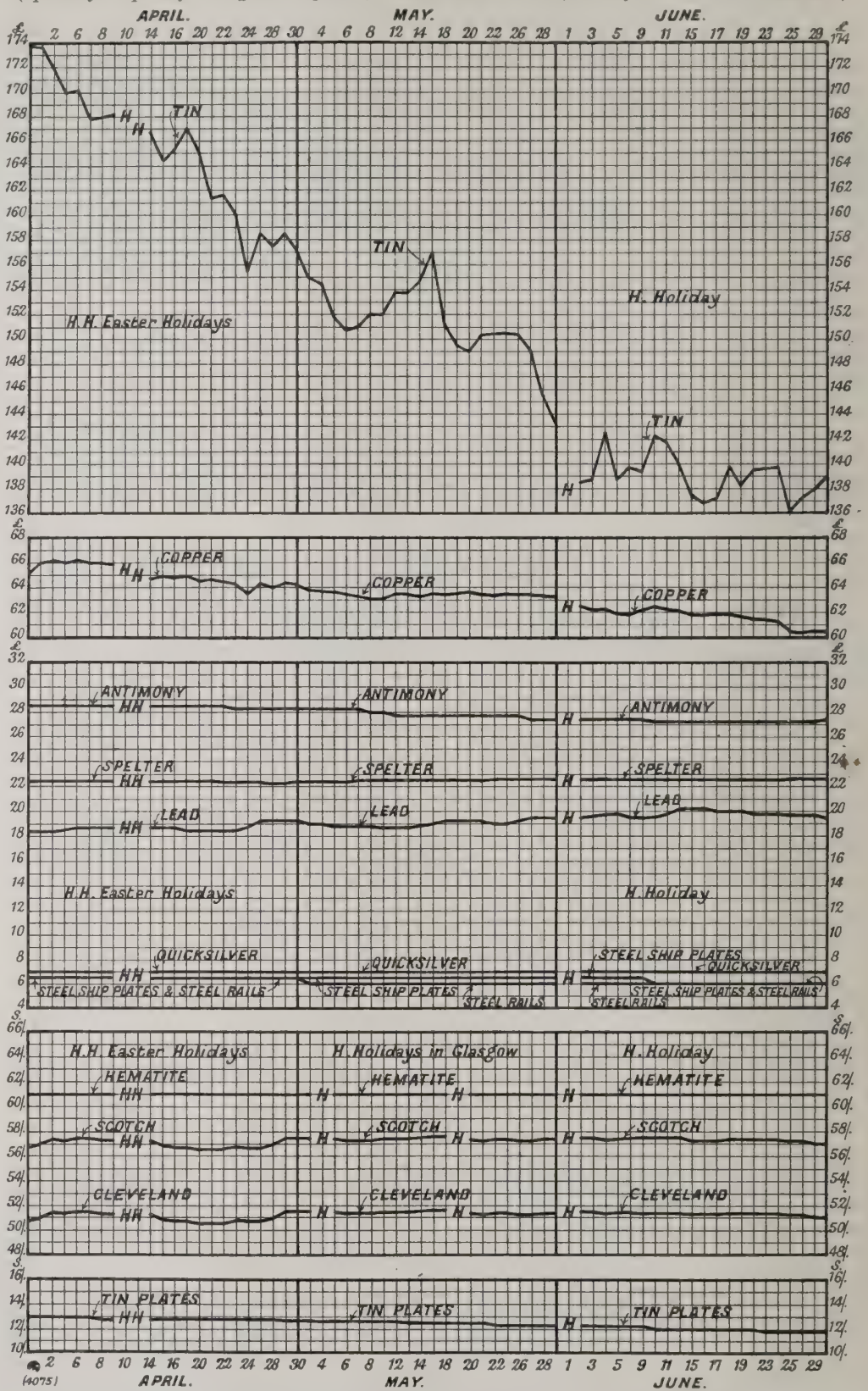
AMERICAN COAL FOR ITALY.—In the course of May three steamers brought 18,000 tons of American coal to Leghorn from Norfolk, Virginia. The coal was intended to be used upon the Italian State Railways, and it is the first brought to Leghorn from the United States for that purpose.

GERMAN RAILWAYS.—The German Government has been authorised to devote 25,310,550*l*. to the development and improvement of the German railway system. The Prussian Government has ceded the Wilhelmshaven and Aldensburg line to the Grand Duchy of Aldensburg for 1,150,000*l*.

TRIPLEX SAFETY GLASS.—On Saturday, June 27, some remarkable results were obtained, at Lord Stanhope's private range at Chevening Park, in testing the resisting properties of bi-triplex glass as manufactured by the Triplex Safety Glass Company, Albermarle-street, W. An Army service rifle and ammunition (mark VII.) were used at a range of 300 yards only, with the following results:—1. Bi-triplex, $1\frac{3}{4}$ in. thick. The bullet struck it almost in the centre, but only penetrated the first thin layer of glass $\frac{1}{10}$in. thick; the intermediate and back sheets were cracked; the back, however, remained perfectly smooth. 2. Bi-triplex, $1\frac{3}{8}$ in. thick. The bullet in this case struck the bottom left-hand corner, penetrating one layer of glass and one of xylonite, but without going any further. The back sheet of glass was slightly bulged. 3. Bi-triplex, $1\frac{1}{4}$ in. thick. This piece was somewhat badly damaged, but the bullet, as in the previous cases, did not go through. 4. This last was a piece of ordinary $\frac{1}{4}$-in. thick triplex safety glass (18 in. by 18 in.), such as is used in motor-coach work and wind-screens; the range in this case was 50 yards, with the same ammunition. Six bullets were fired through this piece of glass, making the same number of clean holes about the size of a threepenny-piece, but this even did not seem to make any difference to the strength of the glass as a whole. The wonderful properties of bi-triplex glass will surely make it invaluable for such purposes as look-outs in the conning-towers of submarines, port-holes, deck-house lights, and bridge-screens on destroyers, battle-ships, and no doubt for many other uses in the military, naval, and merchant services. In spite of the fact that this bi-triplex glass is built up of layers of glass and sheets of xylonite, the difference in transparency between it and ordinary plate-glass of the same thickness is so slight that it is difficult to distinguish the one from the other. Another important point is that although this glass may be very badly cracked, it still remains air-tight and water-proof on account of the sheets of xylonite, which do not crack, being between the layers of glass.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



IN the accompanying diagrams each vertical line represents a market day, and each horizontal line represents 1s. in the case of tin-plates, hematite, Scotch and Cleveland iron, and 1*l*. in all other cases. The price of quicksilver is per bottle, the contents of which vary in weight from 70 lb. to 80 lb. The metal prices are per ton. Heavy steel rails are to Middlesbrough quotations. Tin-plates are per box of I.C. cokes.

COMPLIMENTARY DINNER TO SIR JOHN SNELL.—A general desire having been expressed that the honour of knighthood recently conferred upon Sir John F. C. Snell, President-Elect of the Institution of Electrical Engineers, should be made the occasion of a complimentary dinner in the early autumn, a committee is in course of formation to make the necessary arrangements. Those wishing to associate themselves with the event—and there are certain to be many—are requested to send their names as soon as possible to any of the following:—P. F. Rowell, The Institution of Electrical Engineers, Victoria Embankment, W.C.; D. N. Dunlop, British Electrical and Allied Manufacturers' Association, King's House, Kingsway, W.C.; A. H. Dykes, Association of Consulting Engineers, 11, Victoria-street, S.W.; H. F. Proctor, Incorporated Municipal Electrical Association, The Exchange, Corn-street, Bristol; L. G. Tate, Electrical Contractors' Association, 20, Bucklersbury, E.C.

THE COOLIDGE LAMP.—It is announced at the Massachusetts Institute of Technology that the Rumford medal of the American Academy of Arts and Sciences has been awarded to William David Coolidge, assistant-director of the Research Laboratory of the General Electric Company at Schenectady. The award was made for his invention of ductile tungsten and its application in the production of radiation. The world will recognise in Dr. Coolidge the producer of the tungsten lamp, and near the end of last year the new X-ray lamp, which has greater penetrative power than the older, familiar form. The tungsten lamp produces light with so much less consumption of power that a well-known authority on the subject, speaking three years ago, said that the economic value of it was such that the electric lighting of the day was costing 240,000,000 dols. a year less than if it were done with the old four-watt carbon filament lamps of only ten years before.

THE INSTITUTION OF MECHANICAL ENGINEERS.

(*Concluded from page* 43.)

ON members reassembling in the hall of the Société des Ingenieurs Civils, last Wednesday morning, the chair was again occupied by Mr. Michael Longridge, Vice-President, and the first paper to be taken was one by Mr. Jules Niclausse, of Paris.

THE NICLAUSSE HIGH-DUTY MARINE BOILER.

This paper was entitled "The New Niclausse High-Duty Marine-Type Boiler." In the unavoidable absence of the author, Mr. A. Niclausse said a few words of introduction, after which the paper was abstracted by Mr. W. Y. Lewis. The paper is reproduced on another page of the present issue of ENGINEERING, and it is therefore unnecessary to summarise it here.

After a vote of thanks had been proposed by the Chairman, Mr. Michael Longridge, and passed, Mr. W. Hanning said he would like to make a few remarks on Messrs. Niclausse. Their boiler was widely used in France, and in the French Navy. It was greatly favoured, and the firm had therefore a wide experience, such as should recommend it for adoption in England. Mr. Niclausse had long been associated with British engineers, and was a great admirer of British practice, and he thought every support should be given to his efforts in the direction of progress.

Professor D. A. Low had a suggestion to make with regard to the figures at the close of the paper. He thought the performance should be given per square foot of grate area and per square foot of heating surface, so that reference to other tests would be facilitated.

The next speaker was Mr. W. H. Patchell, who said he had always been interested in the Niclausse boiler, and he was sorry that it had not secured a better showing in England many years ago. They were now being driven to water-tube boilers on account of questions of ground space. Niclausse was the first to use short tubes. The advantage of the first third of a tube compared with the last two-thirds had been amply demonstrated. He thought some additions might be made to the paper. The claim for such high efficiency, he thought, was probably correct, but there was nothing whatever in the paper by which to check it. An efficiency of 91.5 per cent. was pretty high, and he would like to know what happened to the other 8.5 per cent. How much of it went up the chimney, how much was lost in the ashes and in radiation? He thought there was hardly enough to divide satisfactorily between these losses. The boiler was one without a superheater. In that case it was possible that priming occurred, which would apparently improve the performance. The superheater was now almost regarded as an integral part of the water-tube boiler. He had tried to compare other figures with the 91.5 per cent. given in the paper, but he had nothing at all of the same order. The best figure he could lay his hand on was 74 per cent. for a test of a boiler and economiser combined. With a boiler, economiser, and superheater plant he had a figure of 86.7 per cent. for a semi-tubular boiler, and 86.43 and 87.9 per cent. for two Babcock boilers. Those were lower than the Niclausse boiler, although they included a superheater. An important feature of the Niclausse boiler was, he thought, the feed arrangement. Mr. Niclausse put the bottom rows of tubes in series with the upper rows. It was possible to obtain a better efficiency if a boiler were fed with hot water than with cold. If fed with cold, the natural circulation was often upset, but with hot that was not upset, and all the boiler was called upon to do was to evaporate. The Niclausse system gave a true counter-current circulation. The Bonecourt boiler claimed an efficiency of 95 per cent., but that boiler worked on gas, and if the 95 were multiplied by the efficiency of the gas-producer, the net figure was not nearly so high. It was well known that different efficiencies resulted from different conditions of working, and the paper would be improved if figures were given, so that the efficiencies stated could be checked.

Professor Ed. Sauvage, who was called upon by the Chairman, said he had no remarks to offer, except that the paper showed what could be done by careful and scientific treatment of the design and details, and the use in manufacture of the greatest accuracy obtainable with the very best machinery. It was difficult to get an absolutely precise figure for efficiency; but the rate of combustion was low, and the figure, he thought, about as high as it was possible to obtain.

Mr. Charles Hawksley said he thought the cost of the boiler ought to be stated, and also its duration or life, both of which were necessary to an estimate of its ultimate efficiency.

The Chairman, Mr. M. Longridge, said that the principal guide in adopting any type of boiler was the service for which it was intended. A type suited to the work to be performed should be chosen. The great points about water-tube boilers were economy of space and rapid evaporation. High-speed machines always required more attention than low. The high-speed boiler placed in the hands of a man used only to low-speed plant would inevitably give trouble, with the result that it would be condemned, as happened in England many years ago. He thought the improvements in recent designs of the Niclausse boiler to be the greater inclination and the shortening of the tubes. What was wanted for properly gauging performance was not coal per square foot of grate, but coal per square foot of heating surface, and a figure for heat transmission. He roughly figured it out that the test at the lowest rate of combustion mentioned in the paper gave ½ lb. of coal per square foot of heating surface, while in the high-rate test it was 1⅕ lb. The efficiency in the first case was remarkable, especially in view of the fact that radiation losses were often very large, and might in such cases amount to 15 per cent.; at any rate, 15 per cent. usually disappeared unaccounted for. He would like to know if any special arrangements were made with regard to the grate. How far was this below the tubes? Often grates were placed too close, and bad combustion resulted. As to cost, doubtless Mr. Niclausse would say something; but the durability of a boiler depended upon the character of the work and the class of attention, and could not be definitely stated.

Mr. W. Y. Lewis said that, as far as possible, all the information asked for would be given, as Messrs. Niclausse were quite prepared to disclose full details of the tests, &c. With regard to the evaporation per square foot of heating surface, he could not at the moment give that for the boiler alone, but could do so for the boiler and economiser. Working in one test from feed at 77 deg. Fahr., and producing steam at 256 lb. per sq. in. pressure, it worked out at 5.25 lb. In the high-duty test, burning 46 lb. of coal per hour per sq. ft. of grate area, the evaporation was 10.8 lb. per sq. ft. of heating surface, with feed at 77 deg. Fahr., and producing steam at 256 lb. pressure. These high rates were due to having the inner tube for feeding in one and the same direction. Mr. Niclausse had been able to make more use of the heating surface than was possible with other arrangements. The excellent figures were due to the unique features, which alone made it possible. He was in a position to give the balance figures asked for by Mr. Patchell. When he first saw the balance he thought the figures very high, but had submitted them to certain English engineers, and later some tests had been conducted, which, though of short duration, were accurately carried out with a flying start, and corroborated the result of the French Admiralty. The French Admiralty efficiency figures were based on the low calorific value of the fuel. In England the difference between the high and low values was not sufficiently appreciated. The high was the gross value, while the low was a value corrected for the heat which could not be taken up by the boiler owing to interaction of the hydrogen and oxygen. In the French Admiralty test the heat available per lb. of fuel was 14,000 B.Th.U. The heat transferred to the water was 12,800 B.Th.U., giving an efficiency of 91.5 per cent. The heat lost in products of combustion was 645 B.Th.U., or 4.6 per cent.; in excess air, 180 B.Th.U., or 1.3 per cent.; in evaporation and superheating moisture in the fuel, 17.4 B.Th.U., or 0.1 per cent. The balance, going in radiation, &c., was 356 B.Th.U., or 2.54 per cent. The boiler was compact, and there was not much radiation. Care was taken to insulate it effectively; the figure of 2.54 per cent. was not out of the way, and compared favourably with others of larger size and displacement. Another factor contributing to the high efficiency figure was the fact that the firing was done by hand and by first-class experts. The CO_2 records were excellent. There was a boy or man to open or close the door when any shovelling had to be done. This kept the excess air down. Mr. Patchell referred to the probability that some of the steam might be in the form of water, but the French navy experts were not to be easily taken in on such a point. They had tested the quality of the steam by the salt method, and at the normal rate of working the dryness was almost absolute, while at the high rate the dryness fraction was only 0.9 per cent., which was good. Corrections had been made for that amount. The boiler was fitted with separators, so that even when working at 105 per cent. above the normal rate the wetness was practically, say, 1 per cent. The feed-distributing features of the boiler were good. Testing with different feed temperatures usually affected results, because the circulation of the water was affected. In the boiler described the circulation was positive and always in the same direction, and the results did not differ greatly whether feeding with hot or cold water.

MARINE DIESEL ENGINES.

The next paper to be taken was one by Mr. M. Drosne, and was entitled "Development of Internal-Combustion Engines for Marine Purposes." This paper, which we give on page 99 of the present issue, was summarised by the author, after which Dr. H. S. Hele-Shaw reminded the meeting that two years ago the Institution had had a paper on the Diesel engine by Dr. Diesel himself. All engineers regretted the sad end of that distinguished man. He did not remember Messrs. Schneider's work being referred to in Dr. Diesel's paper. It had been important, however, for they had produced about thirty engines; while two years ago Messrs. Burmeister and Wain had only three, but now had about ten, averaging 1000 to 2000 horse-power. Engines of this type were now doing successfully at sea the work hitherto done by the steam-engine. He was present at a recent trial, at which he was much struck by the ease of manœuvring. Only on one occasion did he see anything like a misfire shown by a puff of smoke out of the funnel. Great difficulties had been encountered with the Diesel engine, and they had been overcome in a remarkable manner. By means of a lantern-slide, which was a cross-section of the Selandia, Dr. Hele-Shaw showed how designers had practically arrived at once at a permanent type of disposition or general arrangement for these engines on board ship. The great question of interest was the rivalry between the two and four-cycle systems. The Selandia and Messrs. Burmeister and Wain's engines were all four cycle. The point of great importance with two-cycle engines was increase of size. On the two-cycle system smaller cylinders were required for the same power. Of Messrs. Schneider's engines some twenty were two-cycle engines, and they were running up to large powers. The motor engineer was just now interested in the application of the two-cycle engine to the motor-bicycle, because it would tend to give equal power for less weight. He had great admiration for Messrs. Schneider, who had put down at great expense the two engines spoken of in the paper, with a view to mastering the requirements of the system, so as to be able subsequently to spring right into successful manufacturing. He thought some standardisation was needed with regard to terms. The internal-combustion engine, the term adopted in the paper, covered gas, oil, and petrol-engines. Dr. Diesel's paper was on the Diesel engines; this one was on the same subject, but the titles did not give that idea.

Mr. A. W. Green said that Dr. Hele-Shaw had forestalled him in remarks he had intended making with regard to the two and four-cycle engines. All the later Schneider engines were on the two cycle system, except one large one for land work, which was four cycle. It would seem that at first sight the two-cycle engine ought to be not only more compact, but also more economical. In that system the cylinder was always doing the work for which it was primarily designed, and the pumping was done in a separate and smaller pump, but the pressure against which the latter worked was higher. It would be interesting if figures could be given for the mechanical efficiency of two and four-cycle engines. He noticed that one engine (*d* in the paper) gave about 300 horse power per cylinder. He took it that the cylinder would be about 20 in. in diameter, which was about the limiting size. That size would require from 2¼ in. to 2½ in. thickness, and up to that it was possible

to work without trouble. He noticed that Messrs. Schneider used cast-steel cylinder-covers; other makers had tried that and abandoned it, reverting to cast iron. On the older engines, two-stage compression had been tried, but now three stage was used. The compressor had to be larger than was wanted for the injection air, in order to recharge the starting apparatus. In Fig. 11 a neat design was shown, but the replacement of a piston-ring would involve a lot of work. Was there any special way of accomplishing that? The scavenging-piston was shown without rings. Was that the case? The system of oil-cooling instead of water-cooling had advantages, since leakage from the cooling system became immaterial. Water leakage, of course, ruined the surfaces of the metal. He would like to know whether it would not be possible to use the forced-lubricating-oil system also for cooling. Why should it not be taken from the bearings up to the piston? It seemed to him that if that could be done, it would simplify matters. It would involve enlarging the passages, of course.

Mr. P. M. Baker said that however good the workmanship of the engine might be, this class of engine was up against a difficult proposition as regards fuel supply. In India, coal of 9000 to 10,000 B.Th.U. per 1 lb. cost from 21s. upwards. The Diesel engine did not pay there for itself unless oil could be purchased for 40s. He would be glad to know if any difficulty threatened in this respect, whether the cost of running made the game worth the candle, and at what sort of prices the Diesel engine would compete with the steam-driven ship.

Mr. H. C. Sparks said that with forced-lubricated steam-engines there used to be great trouble with the bearings getting dry, and some kind of priming arrangement had to be adopted for starting. With Diesel engines the pressures were greater, and he would like to know whether any similar arrangement had proved necessary. The oil consumption was given for fuel only. The lubricating oil was an important matter. Although the circuit was practically a closed one, there were certain losses. What was the amount of the make-up oil needed? He was aware that it was possible to get good guarantees, but there was no doubt that a certain amount of oil vapour did escape during work.

Mr. W. H. Patchell asked if there had been any cases of blood poisoning or illness by oil on ships. There had been such cases on land, where the cubic space was not nearly so restricted as it was at sea.

After a few words by Mr. Hanning on the excellent methods of the Schneider Works, Mr. Drosne replied, saying that the cylinder-covers of the Schneider internal-combustion engines were steel castings, which they had found much more reliable than cast iron, but it was necessary to use crucible cast steel for making the castings, so as not to have fractures, or fissures, which were frequently more dangerous than actual fractures, owing to the risk of water leakage inside the cylinder through such fissures. The price of such castings was high, as much as 1.75 francs per kilogramme. The exhaust-pipe was of drawn steel, surrounded by a welded-steel pipe, forming a water-jacket. The cylinders, casings and frames were also steel castings made with crucible steel. The crank-shaft was of nickel-chromium steel; the connecting-rods and the upper portion of the pistons were of nickel steel. In reply to Mr. Green, the air-compressor was a three-stage machine, so as to obtain for the whole engine satisfactory balancing. There were three cranks at 120 deg. for driving the air-compressor and scavenging-pump; otherwise a two-stage machine could very well be resorted to. The consumption of air for fuel injection was $2\frac{1}{2}$ times the fuel consumption. The air-compressor supplied a little more than was required; a small fraction was thus available to meet any leakage that might occur. The air-compressor could easily be dismounted by lateral doors which were not shown in the illustrations; these doors made it possible to inspect the pistons, piston-rings, and valves.

The oil for cooling followed a different circuit from that followed by the lubricating oil, and each had its own cooler: but the same oil was used for cooling and for lubrication, and this oil had a very high calorific capacity—$1\frac{1}{2}$ times that of ordinary oil. At 140 deg. Cent. it had a viscosity equal to that of water. It had a very high flash-point, and therefore a high degree of safety from the point of view of spontaneous ignition.

The oil consumptions per hour recorded in the case of a two-stroke-cycle engine were as follow:—

For a 1100-horse-power engine, two-stroke cycle, oil fuel: full load, 210 grammes; half load, 230 grammes; quarter load, 255 grammes, per effective horse-power; lubricating oil, 10 to 12 grammes per effective horse-power.

The consumptions in the case of the four-stroke-cycle type were for a 360-effective-horse-power engine:—

Oil fuel: full load, 195 grammes per effective horse-power; lubricating oil, 8 grammes per effective horse-power.

Messrs. Schneider used indifferently Texas or Baku oil. In the case of their cargo-boat France, which we described in a former issue (see ENGINEERING, vol. xcvi., page 491), the fuel consumption was much smaller than that of a steamer which could be compared with the France and which burnt Welsh coal.

BALANCING OF INTERNAL-COMBUSTION ENGINES.

The next paper was one by Mr. H. F. Fullagar, entitled "Balancing of Internal-Combustion Engines." In the absence of the author it was given in abstract form by Mr. W. Hanning. This paper we also print *in extenso* elsewhere in our present issue. It was followed by a very brief discussion.

Sir R. Paget said that people generally, and even engineers, had an idea that balancing might be beneficial, but few understood that it was of the fundamental importance it really was. Perfect balance involved the balance of all forces. In the Fullagar engine a force acted on two pistons, and the thrust was thus divided and balanced. The stresses were reduced. There was no fear of the cylinder-cover blowing off. The force necessary for compression was applied by a direct system of tie-rods. The force of the explosion was divided into two; the crank-shaft received nothing but direct, equal and opposite impulses, and could be made lighter. The engine weighed half the amount per horse-power of that of the ordinary engine. If the principle were applied to the Diesel engine, the weight could be halved.

IMPROVEMENTS IN MOTOR-LORRIES.

As time was rapidly advancing, the discussion on Mr. Fullagar's paper was closured, and a paper, which we shall publish in a future issue, by M. Brillié on "Improvements in Motor-Lorries; Self-Loading; also Driving and Steering Through all Four Wheels," was taken as read, the discussion on it being opened by Mr. L. A. Legros.

Mr. A. L. Legros said the paper dealt with two different types of vehicles. He believed that for the first one the number of platforms necessary was not stated; he thought that more than one platform would be required. The second vehicle was much more interesting than the first, but it was not entirely new, since one of a similar type was shown in 1904 at the Crystal Palace, built by Spyker. Mr. Legros then showed on the blackboard how trouble could occur by steering by both the back and front wheels, the vehicle being unable to leave a kerb unless there was ample room to allow of steering. It was necessary that there should be a differential on both axles and on the connecting-shaft.

Mr. Henry Fowler followed, speaking first on the movable platform described by the author. He thought that platform would add considerably to the weight, a question which they always had to keep in view in England. That would tell against its use there. Then the wheels were so small that he did not think it would be suitable for any but very level floors. He had had some experience lately with small electric lorries, of which the ease of manipulation was extraordinary. In one case a very unskilled man had in less than a week a wonderful control of the machine, and ran it in and out in shops among large machines without the least difficulty. In the large vehicle, however, these additional features increased the cost, weight, and complication, and then it was a question whether there was going to be any real advantage.

Dr. H. S. Hele-Shaw said he had had some experience with driving and steering on all four wheels, and the difficulty of getting away from the kerb mentioned by Mr. Legros was a real one. Nevertheless, the manœuvring capabilities of such machines were marvellous. They had found that it was impossible to drive two axles from a single drive. It had been tried, but the efficiency was about nil. Direct coupling was impossible for road work. Owing to the irregularity of the ground, the axles pulled against each other. If they were uncoupled and driven separately, the efficiency went up. He would like to know whether the machine described had a continuous drive right through to both axles.

As the time for adjournment had passed, the discussion was closed, and the usual votes of thanks were accorded to all who had contributed to the pleasure or the success of the visit, or would do so before its close. These votes included, of course, especial thanks to the Société des Ingénieurs Civils, Mr. and Mrs. H. Gall, Mr. and Mrs. W. Hanning, the various works, clubs, &c., and also to Mr. Eiffel, and to Mr. Sartiaux and the Chemin de fer du Nord and other railways.

In our account of the earlier proceedings, in our issue of last week, we made mention of the various events which took place on the Tuesday, Wednesday, and Thursday. It only remains for us to mention that the excursions arranged for the Friday were eminently successful. Members were divided in their interests, but the largest party left Paris on Thursday evening for Lille, where on the Friday morning parties were made up for different works. One party visited the general engineering works of the Compagnie de Fives-Lille, where they were cordially received by MM. Salmon and Richards. The works in question employ about 4000 hands, and have an area of 62 acres, of which $22\frac{1}{2}$ are under cover. The variety of the work in hand created a great deal of interest. It ranged from bridge-work and roofing to locomotives, turbines, gun-turrets, cane-crushing plant, &c. The finest shop was in the structural steelwork department, where one building has a length of 1308 ft. and a width of 148 ft. For a considerable portion of the length of this shop the floor is unobstructed by pillars, although it is virtually of two bays. Strong cross-girders span the shop and carry the roofing, carrying also lengthwise down the centre of the shop an overhead girder supporting rails for overhead cranes. One of the cranes is provided with a revolving jib, so as to enable it to deliver to, or pick up work from under, the neighbouring crane. At the conclusion of the visit the party returned to the Hôtel de la Paix, where it was joined at luncheon by MM. Salmon and Richards. After lunch several speeches were made thanking these gentlemen, the Compagnie Française Thomson-Houston, Mr. W. Hanning, and Mr. Walker, of Lille, for the courtesies extended by them to members of the Institution. Mention should also be made of the particularly genial co-operation of Mr. Sire, of the Northern Railway, a company who did everything possible in the way of providing railway facilities to add to the enjoyment of the trip. An additional excursion was arranged at the invitation of the Northern Railway for Saturday, and many members availed themselves of thus terminating the visit with an enjoyable day's sightseeing.

THE NATIONAL PHYSICAL LABORATORY IN 1913-14.

(*Concluded from page* 31.)

Heat (Messrs. J. A. Harker, D.Sc., F.R.S., G. W. C. Kaye, D Sc., W. Hugo, A. Blackie, B.A., W. F. H. Higgins, B.Sc., and B. Wilson, B.A.). *International Temperature Scale.*—This question, raised by the President of the Reichsanstalt in 1911, has been submitted to a sub-committee, consisting of Lord Rayleigh, Professor Callendar, and Dr. Harker, and recommendations are soon to be published by the national institutions at Berlin and Teddington, and also by those of Paris and Washington.

Emissivity of Matter at High Temperatures.—The phenomena of electric and thermal emissivity of matter, and of sublimation and cathodic sputtering, which are correlated, have further been investigated by Messrs. Kaye, Higgins, and Dr. Donald Ewen. We dwelt at some length upon these researches last year,* and in connection with Dr. Harker's Royal Institution lectures.† One of the new furnace arrangements is illustrated in Fig. 9. The carbon furnace tube has a length of 75 cm., a thickness of 4 mm., and an internal diameter of 30 mm.; the central portion only is heated up to 2000 deg.

* See ENGINEERING, July 4, 1913, page 3.
† *Ibid.*, March 27, 1914, page 290.

or 2500 deg. Cent.; as some of the fumes attacked the carbon, the furnace-tube proper was lined with a thin carbon tube, which was renewed occasionally. The graphite crucible has an internal diameter of 5.5 mm. Since almost every substance, carbon included, seems to give off charged (and also other) particles, electrons or ions, at high temperatures, a differential test was applied, the ionisations being first determined with the crucible empty and then with the crucible charged with material. The ionisation currents were measured both between the crucible and furnace-wall and between that wall and a special hollow carbon electrode, kept cool by water streaming through a brass tube within the carbon. The introduction of the powdered material into the hot zone of the furnace gave rise to a violent ebullition, and the smoke or flame issuing from the open furnace-mouth frequently showed a colour complementary

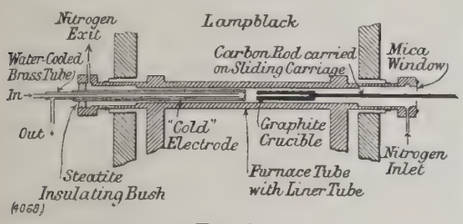


FIG. 9.

to the colour generally ascribed to the vapours; thus calcium oxide gave a yellow-green cloud (not reddish), barium oxide a salmon-pink (not green), strontia (characterised by a beautiful crimson colour) a beautiful green, aluminium a brilliant yellow, its oxide a green, &c. In addition to the substances stated, iron oxide, silica (silver sand), and the metals tin, copper, iron and brass were tried.

The vaporisation of all these substances caused a considerable increase in the ionisation currents. Those currents might be electronic, depending on temperature only, or they might be due to chemical reactions or to change of state, vaporisation or liquefaction; most likely all three causes come into play, and chemical combination plays a chief part. Carbides may be formed, and nitrogen—nitrogen was generally passed through the furnace—may react at high temperatures; solid magnesia seemed to melt into carbon at 1900 deg., as molten iron eats its way through a graphite crucible; oxygen, sometimes admitted, increased the electrode current. All the substances, except tin, emitted negative particles; the ionisation currents were strong, up to 4 amperes per sq. cm. It will be understood that the external electric current only served for heating the tube, no other external potential being applied. Yet that electric heating may have some influence; for Fredenhagen observed in similar experiments* that his ionisation currents produced by direct electric heating of the electrode went down to 1 per cent. of their value when the heating was indirect in a vacuum furnace. The ionisation currents increase as the temperature rises; and if that should continue at the same rate, the ionisation currents would account for Hale's powerful magnetic fields in the neighbourhood of sun-spots.

The experiments on the sublimation of hot metals were partly made with apparatus resembling that illustrated in July last, and partly by placing between the iron strip, directly heated by the current, and a screen, a shield of platinum provided with a central hole and further away with a platinum stop, so that the vaporised particles had to pass through two holes before being deposited on the screen. Like Reboul and de Bollemont, whose researches we have noticed, Dr. Kaye assumes that two kinds of particles are shot off: ordinary particles, probably neutral, shot off at all angles; and electrified particles, shot off at right angles only, and thus giving sharp shadow pictures, but only at a short range of about 1 cm. (for iron) *in vacuo*. The difference between the two kinds of particles may chiefly be one of size, however. At high temperatures the charges are always negative, as we mentioned before. When an aluminium cathode is volatilised in a helium tube, the disintegration of the aluminium proceeds only from the edges, whilst the directly heated strips of iron and platinum become pitted as if etched. In these latter experiments a vacuum is maintained, whilst those previously mentioned took place at ordinary pressure.

* See *Physikalische Zeitschrift*, 1912, page 539.

Thermal Conductivity of Heat-Insulators. Thermometer Glasses.—The apparatus described last year for determining the thermal conductivity of slabs of heat-insulators, 34 in. square (actual measurements being made on the central area of 10 in. square) has been successfully used by Dr. Kaye and Mr. Higgins for testing granulated cork, slag wool, and charcoal, but the results are, so far, confidential. The research on the secular behaviour of thermometer glasses, Jena 16^{III}, Jena 59^{III}, *verre dur*, Kew glass, concerns thermometers especially made eleven years ago, which for nine years had never been raised above room temperature. The temporary depressions of the zero were determined (Kaye and Wilson) corresponding to 30 deg., 50 deg., 75 deg., and 100 deg. Cent., and afterwards at every 50 deg. Cent. up to the temperature of annealing. The rates of change, studied previously by Mr Hugo, are very small. The analysis (by Mr. Withey) proved, however, that the *verre dur* (supposed to be free from lead) contained up to 6 per cent. of lead.

Petroleum.—Mr. Higgins has extended his comparison of the Engler and the Redwood viscosimeters to the Admiralty No. 2 type of the Redwood apparatus for oil fuel, so designed that the time of flow should be only a tenth of that required by the older pattern. The viscosities and densities of oils have also been determined for the temperature range 32 deg. to 120 deg. Fahr.; further the flash-points of mixtures, and the lowest temperature at which an oil will flash when tested in large vessels holding 5 gallons of oil.

Measuring Air Temperatures.—At the request of the Geodetic Survey of India the Laboratory designed an apparatus (made by Mr. R. Paul) for measuring air temperatures within 0.1 deg., at heights up to 150 ft. above the ground, at intervals of 15 ft., a question of importance with respect to the corrections to be made for refraction in geodetic work. As mirror galvanometers were out of question, Mr. Blackie made the following arrangement:—A manganin wire runs up the mast of 150 ft., and down again. On the latter side ten platinum resistance thermometers are inserted in series, and potentiometer leads are taken down from the two ends of each thermometer. Down below is a battery and a swamping resistance, which balances the other resistances at a certain temperature. The thermometer-frames are suspended vertically, and each is shielded above and below by screens of balloon fabric (aluminium coated) against solar radiation from above and terrestrial radiation from below: four of these screens are horizontal, and a fifth, above, is roof-shaped.

Mr. Blackie has also investigated, for the Advisory Committee on Aeronautics, the permeability of balloon fabrics to radiant heat with the aid of an apparatus which allows of the determination of secondary radiation, convection, and of the total emissivities of the fabrics in still air, at temperatures from 3 deg. to 30 deg. Cent. above the surrounding atmosphere.

New Furnaces.—The new equipment comprises a regenerative muffle furnace and a similar salt-bath furnace, in which temperatures of 1300 deg. and of 1000 deg. Cent. can be reached without blast. The former furnace is intended for black-body tests on pyrometers; the latter for the comparison of thermo-couples and resistance thermometers, which are inserted in iron tubes dipping into iron pots, $2\frac{1}{2}$ ft. deep, the salt-bath containing a mixture of sodium and potassium chlorides. In a third similar furnace a temperature of 1400 deg. Cent. can be attained without blast.

The new work projected comprises an investigation of the specific heats and latent heats of fusion of metals by the methods of Harker and Greenwood, a subject on which very little reliable information is available. Expansion coefficients and the properties of refractories are also to be investigated. For the expansion tests Dr. Harker uses tubes—*e.g.*, oxygen-cylinders inserted in baths, at various temperatures—and places in the tube first a rod of the metal in question, resting below on a footstep. On the metal he places a rod of silica which extends through the upper end of the tube, bearing against a micrometer screw; thus only the upper end of the quartz rod is exposed to cooling.

Thermometry.—To meet the transfer of the work from Kew, the Thermometry Department has been reorganised, and the work is now, under the superintendence of Dr. Kaye, carried out in three divisions (for high-precision, medium-precision, and clinical instruments), under Messrs. Hugo, G. Badderley, and A. C. Cooper. The baths, lagged with granulated cork, which we described last year, on page 3 of our issue of July 3, 1913, keep the heat very well. The capacities of the baths are 51,000, 26,500, and 17,500 cub. cm.; to cool them with the heating current off, but the stirrers on, from 90 deg. to 80 deg. Cent., took $1\frac{3}{4}$, —, $\frac{3}{4}$ hour; from 40 deg. to 30 deg. Cent., $11\frac{1}{2}$, $5\frac{3}{4}$, $6\frac{1}{4}$ hours; and from 30 deg. to 20 deg. Cent., 40, 18, 20 hours. Low-temperature testing is done with the aid of a vacuum-jacketed bath of acetone and solid carbon dioxide; oil circulating through a worm immersed in a freezing mixture of ice and salt is used for testing meteorological thermometers.

Radium Room.—The British National Radium Standard has been placed in charge of Dr. Kaye, in the new Radium Room, which has been fitted up with the assistance of Sir Ernest Rutherford. The international standard of radium chloride at Sevres was prepared by Mme. Curie; the British standard of 21.1 milligrammes of radium chloride—costing 354*l.*, the donation of Dr. G. T. Beilby, F.R.S.—was prepared by Stefan Meyer in Vienna, and was compared with her own standard by Mme. Curie. The outfit of the room comprises a 1000-volt battery by Klinkerfuess (formed lead strips in sulphuric acid in test-tubes, terminals with umbrella insulators), a Paschen galvanometer, Dolezalek electrometer, and three apparatus for standardising the radium salt in terms of metallic radium, which is the practice of the Reichsanstalt. The three apparatus are based upon the ionisation due to gamma-ray activity, which attains its maximum in sealed tubes after five or six weeks; the rays then measured have to pass through 5 mm. of lead. The first handy apparatus is simply an ionisation chamber, combined with an electrometer, the radium preparation being mounted on a carrier moving on an optical bench. The second apparatus, method of Rutherford and Chadwick, balances the ionisation produced against that of a deposited film of uranium oxide, after McCoy; the apparatus consists of a kind of photometer bench, an ionisation chamber of lead, and a lead tube (10 ft. long) leading from the chamber to the instrument-box; the tube is made long, so as to keep the radium away from the instrument, and is evacuated; calculations are based on the inverse square law. The third method is modelled on one due to Mme. Curie. An aluminium plate, 60 cm. in diameter, lies between two stout plates of lead, being separated from them by air-gaps of 2 mm. and ebonite blocks; the inner plate is insulated and joined to an electrometer; the two outer plates are charged to a high potential; the sample is laid on the centre of the upper plate, and the strong gamma-ray radiation is measured in the air-gap. More than 3000*l.* worth of radium have already been tested.

Metrology (Messrs. J. E. Sears, M.A., S. W. Attwell, H. L. P. Jolly, B.A., E. A. Owen, M.Sc., E. G. Constable, F. H. Rolt, F. A. Gould, B.A., V. Stott, B.A.).—The department has not only had to transfer the work from Kew, but the demands for Kew work so much exceeded those of previous years that a congestion arose; the increase in watches, chronometers, barometers, and hydrometers was very large, and the accommodation available is insufficient; thus an extension of the metrology building appears urgent. Serious—*i.e.*, long-continued—trouble has, moreover, arisen with respect to the maintenance of the standards; some comparative measurements made at Sèvres and at Teddington would not agree, and the silica metre bar, on which such great hopes had been placed, seemed to behave capriciously. The discrepancies involved were, of course, exceedingly small; but they could not be disregarded. Most of them have now been accounted for, and the reputation of the silica metre has been vindicated; but the report of Mr. Sears shows how much anxiety and labour those recomparisons have caused.

Pure Measurement. Line Measures.—As regards the 4-metre bars for the Laboratory and the India Office the determinations made at Sèvres and at Teddington were in excellent accord; the Laboratory bar had been sent over to Sèvres for verification in connection with the 24-metre wires. The accord of the measurements of the seven 1-metre bars (of nickel, 43 per cent. nickel steel, and invar) was also very satisfactory; but there were

puzzling discrepancies which were finally traced to the 1-metre comparator. The slide carrying the microscopes is rigidly bolted to the main framework, on ways cast solid with which the water-tank runs; any strains set up in the framework by moving the tank (weighing 300 lb. full of water) from one position to another was liable to produce distortion in the slide, and thus to disturb the axes of the microscopes. If this effect had been constant, either positive or negative, for measurements on the back girder or on the front girder of the comparator, it could have been eliminated by interchanging the bars after finishing half the observations This had, indeed, been Mr. Sears' practice. But some irregularity remained, and this has temporarily been cured by making the microscope slide, though still bearing on the framework carrying the tank, rest on a three-point support; but a new comparator is wanted. There were also discrepancies as to the expansion coefficients of the nickel bars of the National Physical Laboratory and of the India Office, the latter of which had been certified at Sèvres; both bars had to be sent over there, and it finally resulted that the India Office bar had changed. The invar bar continues to show a regular growth of 0.9 μ per year, the total measured growth now amounting to 17 μ.

End-Measures. Screw-Gauges.—A new set of end-gauges is badly needed; ordinary gauges are not sufficiently accurate, and the gauges will have to be especially made, and possibly have to be measured several times at the Laboratory during their manufacture before their standardisation. There is an increased demand for the measurement of ring screw-gauges to determine the five elements: full, effective, core diameters, pitch, angle—a task of great difficulty. The core diameter is now measured by means of Johansson gauges. The effective diameter is measured by small hardened-steel balls (from the Hoffman Company), which lie about half-way down the V on the thread, two balls being on one side of the gauge, separated by 3 or 5 threads, and one ball placed opposite; the distance between the balls is measured by the Johansson gauges. The full diameter is measured by a sharp point mounted on a piece having a well-finished base for the attachment of the Johansson gauge, completed with a rounded piece making contact on the crests of the threads opposite the point; the actual dimension measured is $\frac{1}{2}$ (full + core diameter). But special machines should be available for plug and ring screw-gauges, particularly as the Laboratory has to verify the international gauges for pipe-threads. Some Hirth minimeters and Aldis sphere spherometers have been standardised, the latter with the aid of sixteen steel balls ranging from $1\frac{1}{4}$ in. to $2\frac{1}{2}$ in.

Surveying-Tapes and Wires; 50-Metre Base.—The work on tapes and wires involved a research into the reliability of the two 24-metre catenary wires of the Laboratory, as to the standardisation of which Sèvres and Teddington differed. For this purpose the 50-metre invar tape was subdivided every 4 metres and standardised under 10-kg. tension in 4-metre catenaries by direct comparison with the 4-metre bar. The seven lengths of 24 metres (obtained by the addition of any six consecutive 4-metre steps) were then compared with the two 24-metre wires at the front of the 50-metre base. Finally the thermal expansion coefficients of the full lengths of the two wires (which had not been determined at the same temperatures at Sèvres and at Teddington) were redetermined in the 50-metre tank, one wire being placed into it at the time under a tension of 10 kg.; this latter absolute measurement was carried out by Mr. Attwell. It resulted that one of the wires (which, when placed on the floor, coils helically, whilst the other lies straight) is unreliable.

The 50-metre base itself, a curve of whose apparent changes in length we published last year,* has been kept under further observation, and it appears that the comparatively hot summers of 1910, 1911, and 1913 caused temporary increases in the length, whilst there was little increase during the cold summer of 1912. When the probable variations in length in different months and years (due to variations in surface temperature) are subtracted from the observed length, a wavy curve may be drawn through the cluster of points giving monthly means, and this curve has a general upward trend, indicating a very small secular growth of the bench independent of temperature changes, while the waves suggest summer and winter effects (due to general temperature changes in the body of the masonry apart from surface temperature).

Physical Test-Weights. Hydrometers.—It had been observed that the 1000 gramme-mass (copper-nickel, 50 per cent.) seemed to absorb moisture when immersed in water; determinations are therefore now made before and after immersion, and standard weights have been prepared of a special propeller alloy which seems to be free from this soakage difficulty. In determining the mean density of an ellipsoid of platinum-iridium (for dielectric measurements, of a volume of only 0.0958 cm.^{3}) to the fourth decimal, mercury displacement was found unsuitable, and weighing in water was disturbed by surface tension. The difficulty was overcome by suspending two glass carriers, one for the ellipsoid, the other for the weight, by platinum wires from the balance arms into distilled water, exchanging the loads, and by allowing also for the change in surface tension consequent upon the exposure of different lengths of suspending wires. The same difficulty of surface tension crept up in testing Sikes' hydrometers (for excise work) of glass and of metal. The two kinds cannot really be compared in liquids approximating the density of water, because these liquids do not wet metal stems, and metal hydrometers are unreliable for this reason. The trouble can, to a certain extent, be overcome by mixing the liquid with a little solution of sodium carbonate, and adding a little alcohol; but that method is not applicable for hydrometers of different sizes, and not for comparing hydrometers of glass and of metal.

Barometers. Barographs.—The ventilation and temperature control of the inner rooms of the metrology building, in which a constant temperature should be maintained, had been effected by sending a continuous supply of warm air into these rooms by a series of small fans. This arrangement, adopted when the building was erected some years ago, did not answer well when the rooms became crowded, and for the past two years the system has been reversed, cold air being drawn in through the outlet trunks. But fans are altogether out of question in rooms where mercurial barometers are tested, and other arrangements will have to be made in the projected extension. In connection with the international adoption of the "baromil," to which we have referred on other occasions, we should mention that a baromil is defined as the height of a column of mercury, which at 0 deg. Cent. in latitude 45 deg., at sea-level, produces a pressure of one millibar — *i.e.*, 1 kilodyne (10^3 dynes) per sq. cm; the equivalents are: 1 in. = 33.8632 baromils = 25.4 mm. The comparisons are not facilitated by the fact that inch scales are graduated at 62 deg. Fahr., and millimetre and baromil scales at 0 deg. Cent.

The method in which barograph curves obtained on flying-machines are tested is interesting. The instruments are received as used, except that the pointer is lifted from the paper. The clockwork is set going, and the instrument is placed in one of the glass cylinders used for testing aneroids at different air pressures. The pressure is then adjusted so that the pointer falls on the beginning of the curve and afterwards follows the curve, the corresponding standard pressure on a gauge barometer being read at intervals. If then the date, hour and place of ascent, its height above sea-level, and the difference between surface pressure and maximum pressure are known, the height to which the aeroplane rose can be calculated—to ± 200 ft. in the case of two barographs submitted

Chronometers, Watches, Clocks (Mr. Constable).—We have already mentioned that radiotelegraphic time signals are received from Norddeich and the Eiffel Tower; these two signals agree, whilst the telegraphic signal from Greenwich comes about 0.2 second later. The unit in watch-testing is now 0.1 second (against 0.25 second formerly), and the testing is done on lines more approaching the Swiss Observatory practice. The number of "especially good" watches had risen; the best marks were again obtained by a foreign watch, from P. Ditisheim, La Chaux-de-Fonds; of 184 chronometer movements 150 were certified.

Taximeters. Blythwood Machine (Messrs. H. A. Dear and J. K. Enock).—The work had been affected by the strike of 1912, but the number of new taximeters tested in 1913 was greater than in 1912; only one new type has been submitted. Two flexible shafts submitted failed; shafts need not be tested individually, but must be made to approved sample. Mr. Enock is also in charge of the Blythwood grating-ruling machine, which has been provided with new ways for the carriage; the carriage now runs on two cylindrical steel bars, with two V's on the front, and with a flat on the back bar; a finger projects downwards from the carriage on either side of the screw, and the motion is transmitted from the nut to the two fingers by means of a gimbal-ring, so that the carriage moves as though connected to the nut at a point on the axis of the screw; the nut is in two halves, and each half is independently prevented from rotating by an arm which rests on one of the way-bars. The machine rules (up to 14,400 lines to the inch) only on the forward stroke; special gratings, like those for Professor Bragg, which we mentioned recently, are produced by missing one or more strokes. The new gratings now appear free from the erratic errors given by the rolling carriage; but there is still some trouble with large rulings.

The Silica Metre.—It has already been mentioned that the apparent behaviour of the silica metre of the Laboratory suggested the need of a modified annealing. The trouble was, however, traced to the comparator, and applying the corrections to previous measurements, it is found that the fluctuation in length of 0.5 μ probably represents the average. But there is apparently a growth in length of 2 μ annually in the case of the silica metre for the India Office, which has not settled down yet to constant dimensions in the nine months during which it has been under observation.

Miscellaneous.—Rubber templates, it appears, may shrink by more than 1 per cent., chiefly in early life. The researches, undertaken for the Engineering Standards Committee, on British Association screw threads (neither the pitches nor the diameters of the tapped holes agree exactly with those of the taps), on bayonet-socket lamp-holders, and on sparking-plugs are being continued.

Optics (Messrs. T. Smith, B.A., R. W. Cheshire, B.A., and J. Guild).—The transference of the Kew works and the equipment of the new spacious rooms, which we briefly noticed last year, has left little time for research work. The question of improvement of the manufacture of optical glasses has suffered from the death of the chairman of that committee, Sir David Gill; but a report is now under consideration. The equipment has advanced slowly, not only for want of means, but also because the staff are modifying some methods of testing; they are preparing a revised edition of the test pamphlet, and proceed cautiously in innovations, wishing first to thoroughly study the theory of the Kew tests and the instruments used. Although, as we mentioned in our introduction, some of the simple test-work has fallen off, the higher class work for the Admiralty and others has become more heavy, fully justifying the expenditure on the new commodious quarters of the department. The iron bench is a semi-circle, 46 cm. in width, 145 cm. internal radius, resting on 6-in. iron pillars, through which the cooling and heating water circulate; the bench rests on concrete foundations 152 cm. above the floor, a convenient height. When it was completed the Kew collimators were mounted on it and bolted to the plane upper surface of the bench. The altitude circle for theodolite-testing is not yet completed; so far only the vertical iron horse-shoe can be seen. Scales of degrees have been fixed on the roof on the tank building (extending over 11 deg.) to the west, and in the meadow to the east of the building (extending over 20 deg.); all the posts are bedded in concrete, and the black lines denoting degrees and quarter-degrees are formed of boards nailed to the background boards, which are painted white. The test objects brought from Kew have been refixed, and at distances of 100 ft., 200 ft., 300 ft., 400 ft., and 500 ft. from the vertical scale phosphor-bronze rods have been embedded in the cement below the turf-level.

Ships' Lights.—In connection with the work of the Photometric Department on ships' lights for the Admiralty, lenses have been designed to fit the Navy lantern and to give the distribution of light from an oil-lamp desired by the Admiralty—viz., symmetrical illumination about a vertical axis through an azimuth angle of 135 deg., and in a vertical plane an illumination represented by the unit 1 from 5 deg. above to 5 deg. below the horizontal, diminishing uniformly both above and below the horizontal from illumination 1 at 5 deg.

* See ENGINEERING, June 27, 1913, page 860.

to illumination $\frac{1}{4}$ at 20 deg. Lenses made to this design have given satisfactory results.

The report describes the new optics building at some length. We noticed some of the chief features last year, when the buildings were opened, the general arrangements, the cream-tiled "dark" rooms, the double light-trap doors, with their peculiarly-recessed posts and doors, effectively to shut out all light, &c. An appendix to the report contains historical notes on optical tests at Kew Observatory, which, it appears, began in 1860, when sextants were tested with apparatus which Francis Galton bought at his own expense.

Tide Prediction (Messrs. F. J. Selby, M.A., and W. H. H. Brookes).—The department advised on modifications in a machine which Messrs. Kelvin, Bottomley and Baird constructed for the Japanese Hydrographic Office. Work on the Indian tide-tables for 1916 is advanced.

The Library (Messrs. Selby and Hodgson).—Mr. Selby, who acts as secretary to the National Physical Laboratory, is also librarian of the new White library, which should receive general liberal support; back volumes of the leading journals would particularly be welcomed.

THE JOINT MEETING OF NAVAL ARCHITECTS AND ENGINEERS AT NEWCASTLE.

(*Concluded from page* 63.)

TWO-CYCLE GAS-ENGINES.

AT the meeting held in the Institution of Mining at 10 A.M. on the morning of the 8th inst, Mr. Summers Hunter was in the chair. The first paper taken was by Professor B. Hopkinson, and was entitled "The Charging of Two-Cycle Internal-Combustion Engines." It was summarised by the author. We reprint the paper on page 100. The second paper was by Mr. H. F. Fullagar, and was entitled "A New Type of Internal-Combustion Engine." It was read by its author. We do not reprint the paper, but a description of the leading feature of the engine will be found in a paper read by Mr. Fullagar before the Institution of Mechanical Engineers at Paris, which is reprinted on page 103.

Professor R. L. Weighton was the first speaker in the discussion, which was taken jointly on the two papers. He said that having had little time to study either communication, any remarks he made would be of only a general nature. The first paper dealt with a subject that was at the root of the efficiency of internal-combustion engines. Professor Hopkinson had naturally had to make certain assumptions, and quite possibly the coefficients he suggested would have to be modified in the light of future experience. He did not think, however, that anyone could have carried the matter further mathematically than Professor Hopkinson had done, and he saw no reason to suppose that, when final coefficients were evolved, the method should not form the basis of a directly practical method of designing internal-combustion engines.

Turning to the Fullagar engine, he would say he saw it for the first time the day before, and anything he said must be taken as a result of first impressions. He must confess, however, that those impressions were very favourable. He thought the use of open-ended cylinders with double pistons was ideal. Mr. Fullagar seemed to have improved on the best type of Junkers engine. Junkers obtained a beautiful mechanism, by which what he might term the useless forces—the forces used in compression—were not transmitted to the crank-shaft. He required three cranks, however, and tandem pistons, leading to a very high engine. Mr. Fullagar seemed to obtain all the same advantages, without the disadvantages, merely by the use of his oblique rods. The only objection he could see which anyone might raise against the engine would be on the score of these rods; but he did not think they would necessarily weigh against the advantages.

The balancing of the engine was very perfect, and, from a practical point of view, it seemed to have all the elements of durability. It had no valves, except, of course, the fuel-valves, the cylinder construction doing away with either exhaust or admission-valves. This was a great simplification. There was a point in this connection, however, which he should mention. Anybody could devise a simple mechanism by which valves were eliminated by causing the piston to cover and uncover ports. It could be done for any sort of engine. He had done it himself for steam-engines, and was, perhaps, sorry afterwards. The arrangement worked all right, but was uneconomical. It was possible by analogy from steam-engines that there would be less economy in a valveless internal-combustion engine than in one having cam-worked valves of the usual type. Against this, however, Professor Hopkinson had found the Fullagar engine economical. It was quite possible the device would be economical, and would show the maximum degree of durability. If he might give some advice, he would suggest that Mr. Fullagar should run his engine continuously and as hard as possible, and should consider the construction of a Diesel on the same principle.

Mr. R. Allen was the next speaker. [We should state that the 500-horse-power Fullagar engine now running at the Gateshead station of the Newcastle Electric Supply Company was built by Messrs. W. H. Allen, Son and Co., Limited, of Bedford.] Mr. Allen said he would like to say something of the work he had been privileged to carry out with Mr. Fullagar during the last three years. Everyone engaged on experimental work knew how frequently it led to nothing but the scrap-heap. In this case, however, the inventor's confidence in his ideas had been justified. Mr. Fullagar had faith enough to build a fairly big engine right away, and his faith had been justified by success. Professor Weighton had spoken of the oblique rods in the engine. It was probable that anyone who saw the engine for the first time would raise this point. Everything else in it was absolutely simple, but this was at least a novelty. He must confess that much of the attention he had given to the engine had been directed to this point. He had been afraid of vibration at first, but Mr. Fullagar had convinced him that there would be no trouble, and finally the engine was built practically to Mr. Fullagar's original drawing. To prevent possible accident when the engine was first run, vertical guides were made for the oblique rods, which had a damping effect. The vibration was very small, however, and there was no trouble whatever. The engine had run perfectly successfully from the first time it was run on their test-bed, and had run for eighteen months since. Much care was taken with the balancing during construction, and each component of the reciprocating parts was weighed separately. The parts of each unit were then weighed together. He thought the success of the engine due to the few working parts, the remarkably low stresses, the small floor space, and the great saving in weight.

Mr. Stokes, the next speaker, wished in the first instance to deal with Professor Hopkinson's paper. He did not think the inferior output of two-cycle engines, compared with four-cycle, was due to loss of charge in the exhaust, as Professor Hopkinson stated. He thought it due chiefly to the fact that the effective stroke of a two-cycle was less than that of a four-cycle. In a two-cycle engine, 22 to 25 per cent. of the stroke was occupied with exhaust and charging. In a four-cycle the whole stroke was available for expansion. He did not think there was any loss through the ports of an Oechelhaüser engine, as air was first injected, then gas, and then further air. This gave some stratification and only air passed through. Another reason why there was a loss of efficiency in a two-cycle engine as compared with a four-cycle, was that two-cycle engines as at present constructed employed charging pumps, and these required work to drive them. Professor Hopkinson had referred to the waste of charging air. He (the speaker) did not look on this as an unmixed evil. If one worked things too closely, back-fire became possible. Some time ago Messrs. Beardmore had experimented on this point, and had reduced the loss until it was touch and go as to whether they got a back-fire. They now purposely arranged that some of the charge of air should go straight through. All the same, he was not impressed by an engine recently brought to his attention by the inventor, in which 50 to 60 per cent. of the air went into the exhaust, the inventor remarking that air was cheap.

The theory put forward and work done by Professor Hopkinson might be useful to designers, but he would like to criticise some of the methods used. In hearing of the care taken in analysing the samples of cylinder content he was reminded of the man who evaluated some quantity as 1.004 and got the 0.004 correct all right. Professor Hopkinson had measured the air by means of a diaphragm. To measure a large quantity of air was a tricky business, and he should like to have seen the result checked by a Venturi meter, or in some such way. It was suggested in the paper that the result might be right to within 3 per cent. He was inclined to suggest that this might be made 30 per cent. Again, he thought the method of taking the samples of gas for analyses not likely to lead to accurate results. The sampling-bottle was in constant connection with the cylinder, so that the quantity of material entering it at any time must have been proportional to the pressure. A disproportionate quantity must have got through at explosion. He suggested that a timing-valve should have been fitted and samples trapped at different parts of the stroke. Another point was that when a charge first enters the cylinder, it was expanded by the heat of the walls, so that the charge in a given volume was reduced. Then Professor Hopkinson had assumed the pressure in the cylinder during admission to be that of the atmosphere, but in some two-cycle engines one had a plenum in the cylinder at that time. To get over loss of charge in the exhaust he suggested that a sort of constriction might be introduced into the combustion-chamber, so that the incoming air would converge and drive out the products of combustion with little mixing.

Turning to the Fullagar engine, he would like to congratulate Mr. Fullagar on the remarkably simple appliance he had produced. He (the speaker) felt flattered that the Oechelhaüser principle had been adopted. He said this without any jealousy, since as far as his firm (Messrs. Beardmore) were concerned, the Oechelhaüser engine was dead. They would not build any more. This was not because the engine was not reliable. Two of their works were driven entirely by it. If the engines stopped, the works stopped. But the engines did not stop. He liked the double-acting cylinders of the engine and the absence of gland packings. By way of criticism, he might point out that the two cylinders of a unit were interdependent. If anything went wrong with either, both stopped. Another thing was that the two side rods of a pair were not the same. They were not interchangeable. A third point was that the construction made it impossible to carry the ports all round the cylinders; some were blocked off. He thought this a disadvantage, as the ports all round were a considerable help towards obtaining stratification.

Mr. E. Hall-Brown said that, in view of the short time available, he would make his remarks very brief. Apart possibly from the method of obtaining the samples of gas, he could see nothing that could be criticised in Professor Hopkinson's work. The theory of design was most valuable. No one had worked out even the basis of such a thing before, and designers had had nothing to go on. This could be seen in the very different sizes of scavenging-cylinders put in by different makers to do the same work. He had not yet had time to study Professor Hopkinson's paper thoroughly, but felt deeply indebted to him for it. The information in reference to the giving up of the manufacture of Oechelhaüser engines by Messrs. Beardmore, given by Mr. Stokes, was very interesting, but it was a pity the meeting had not been told the reason for it. [Mr. Stokes here interposed to say it was simply because the engines proved too costly to build.] Turning to the Fullagar engine, Mr. Hall-Brown said he thought the form of cylinder adopted, which eliminated all possibility of cross-strains, was an admirable point. The engine was very simple, but he would point out that in the diagram shown in the hall and included in the paper the scavenging and gas-supply pumps were not shown. These would, of course, make it appear rather more complicated. He would like an expression of opinion as to the probable efficiency of a Diesel engine built on the same lines. As a final point he might say that it was a moot question as to the size of gas-engine piston it was necessary to water-cool, and the cooling of the four pistons of a Fullagar engine would be rather a complicated job.

The Chairman, in winding up the discussion, said he thought the outstanding features of the Fullagar engine were its simplicity and the absence of initial strains and unknown stresses. In Diesel engine-building most of the difficulties were due to unknown stresses, due to high temperatures. The balancing of the Fullagar engine seemed to be excellent, judging by the way it ran. This should

105-HORSE-POWER AGRICULTURAL TRACTOR.

CONSTRUCTED BY THE DAIMLER COMPANY, LIMITED, COVENTRY.

(*For Description, see Page* 80.)

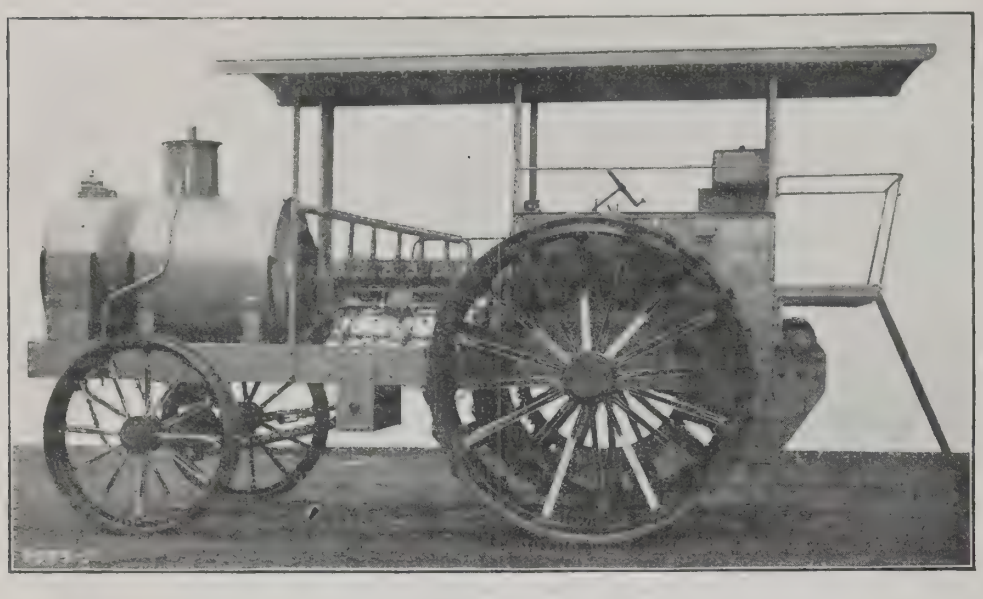


FIG. 1.

FIG. 2.

add to the life of the main bearings, which in a Diesel was frequently remarkably short. The meeting was most indebted to Professor Hopkinson for his valuable paper. He had done to their Institution a great honour in reading it before them. Needless to say, Professor Hopkinson's name was a household word, and they were all indebted to the valuable work carried out at Cambridge.

Professor Hopkinson, in reply, said it was always a pleasure for him to come to Newcastle, and he never left without having learnt a good deal. He had seen much of the Fullagar engine over six months, and at one time had pretty well lived with it for several days, and no one could do that without realising that it represented an important development. The engine at present was running on coal-gas, and it was possible trouble might arise when it was tried on tarry gases, but Mr. Fullagar was working on the question. He thought the engine a very important contribution towards the solution of the big-gas-engine question. A gas-engine with large cylinders seemed in a way against nature; the weight of the cylinders went up in proportion to the diameter, and the thick layer of gas radiated proportionately more heat to the cylinder walls. He thought it fair to say that few people had tackled the big-cylinder gas-engine without dropping money. To make a large-power gas-engine, and to make money at the same time, it seemed necessary to go in for a lot of cylinders, like the National Company, who fitted twelve. About 22 in. seemed to be the limit for cylinders without water-cooling, but with a large number one got a very large number of parts, valves, &c. The Fullagar engine could apparently be built with a large number of cylinders and still require only a moderate number of parts. This seemed to him to make it an important contribution to the big-gas-engine question

In conclusion, he would like to make a brief reply to Mr. Stokes's remarks on his paper. Mr. Stokes thought the loss in two-cycle cylinders was due to loss of stroke. No doubt there was something in this, but he would point out that his idea was in harmony with his work on the Fullagar engine, in which there was no loss of gas in the exhausting, the exhaust-port being practically closed before the charge entered. Mr. Stokes spoke of his measurement of the air by a diaphragm method, and suggested that the pulsations would make the result inaccurate. He thought he had made it clear that the pulsations were damped out by the large air-receiver. He really thought that he might claim an accuracy of more than 30 per cent. for his work. On the question of the method of taking the gas samples he admitted the matter was a difficult one, and that a timing-valve might have had advantages. All the same, he thought his procedure gave fairly reliable results, as reliable as the rest of the work done in the engine. One might at times get a certain amount of stratification, but it did not matter what one got in any particular sample as long as the average was correct. He thought, perhaps, Mr. Stokes had misconceived the object of the paper, and he was grateful to Mr. Hall-Brown for his remarks. All he wished to do was to initiate a method of design for two-cycle engines. The method might be sound—in general he thought it was; but, finally, of course, it must stand the test of experience.

Mr. Fullagar then replied very briefly to the discussion. He said the only difficulty they had had in connection with the running of the engine was caused by the long pipe connecting the air-receiver with the cylinder. This caused differences of pressure. The trouble was difficult to locate, but had been quite done away with. The matter was dealt with in Professor Hopkinson's paper. The meeting then adjourned.

DIESEL ENGINE EXPERIMENTS.

On Friday, the 10th inst., the technical meetings were resumed at 10 A.M., in the Lecture Theatre of the Literary and Philosophical Society. Three papers, submitted by the Institution of Engineers and Shipbuilders in Scotland, were down for reading and discussion. Dr. R. T. Moore, President of the Institution of Engineers and Shipbuilders in Scotland, was in the chair. In the course of some preliminary remarks thanking the North-East Coast Institution for their hospitality during the summer meeting, Dr. Moore suggested that an alliance between the two Institutions might be of value to both. The Institutions were interested in the same classes of shipbuilding and engineering activity, and an alliance involving common proceedings would enlarge the sphere of utility of the papers presented to both, and would have other attendant advantages. Dr. Moore then called upon Mr. W. S. Burns to read his paper entitled "Some Experiments on a Diesel Engine."

The paper dealt with some trials carried out by the author on a Diesel engine in the Mechanical Engineering Laboratory of the Royal Technical College, Glasgow. The subject of the trials was suggested by Professor Mellanby, and they were carried out as a research by Mr. Burns while holding a Beilby Scholarship. The trials were made with the object of discovering the effects of: (1) Variation of blast pressure; and (2) variations of jacket-water temperatures, on the running of a Diesel engine. In order to study the combustion part of the cycle more easily than was possible from an ordinary indicator-card, a rotary-card arrangement was fitted up, which greatly extended the length of the diagram. Many characteristic indicator-cards were given in the paper. The results of the experiments on blast pressure showed that on light loads the excess air in the cylinder and the inrush of blast air with a small quantity of fuel caused late ignition and slow combustion. As the load increased and the mixture of pulverised fuel and air became richer, there was earlier ignition and an increase in the rate of propagation of the explosion. At all loads, too low a blast pressure pulverised the oil imperfectly, causing late ignition and incomplete combustion, with increase of exhaust pressure and temperature above the normal. Too high a blast-pressure caused late, but violent, ignition, attended, again, by incomplete combustion. The general results of the jacket-water experiments showed that at all loads increase of jacket-water temperature did not seem to affect the point of ignition of the oil appreciably, but caused more rapid and more complete combustion with increased efficiency.

Professor A. L. Mellanby opened the discussion. He was asked to speak by the Chairman in the absence of volunteers among the audience. Professor Mellanby said that he had not intended to contribute to the discussion, and was rather surprised that no one had risen to criticise some of the methods described in the paper. The work had really been undertaken out of curiosity, owing to differences which had been noted in the working of the Diesel engine as the blast and jacket-water temperature varied. The ordinary indicator diagram showed very little of what was happening, owing to the record of pressure changes being crowded into such a small space, and the rotary diagram arrangement described in the paper had accordingly been devised. The opened-out diagram had taught them a good deal, and showed, for instance, that the ordinary text-book explanation, that the injected oil burned at constant pressure, was not accurate. Variations in the blast pressure made great differences, and in all cases there seemed to be a short period in which the oil did not burn, and during which the moving forward of the piston caused an increase of volume, and consequent fall of pressure. After this fall of pressure the oil seemed to ignite, giving a sudden explosion. It was usual to put this sort of effect down to inertia of the indicator, but he could not think that was the explanation in the present case. Frequently the explosion could actually be heard. The charges due to alteration in the blast pressure were well brought out in the diagrams, but it must be remembered that the results in any particular case would depend on the type of fuel valve and pulveriser used.

Professor R. L. Weighton, the next speaker, said the paper was concerned with a type of work well suited for research by a student. The results reflected great credit on Mr. Burns. There was one point to which he might refer, which was

5-TON SIDE-TIPPING TRAILER.

CONSTRUCTED BY MESSRS. RUSTON, PROCTOR AND CO., LIMITED, LINCOLN.

(*For Description, see Page* 80.)

FIG. 1.

FIG. 2.

FIG. 3.

brought out in Table II. of the paper. It would be seen that in Experiment 11 an increase in the temperature of the inlet jacket-water was accompanied by an increase in the temperature of the exhaust. In Experiment 12, however, the reverse was the case. He would like to know if this was correct, as the reason did not seem clear. He would also like to know what effect increase of temperature had on mechanical efficiency. If increased cylinder temperature meant increased economy, it would be easy to get economy, because it was easy to get temperature. The matter was important, and it would be interesting to know what the allowable limit of temperature was. A higher temperature meant saving in jacket-water, which was frequently of great importance. He supposed one could not well raise the jacket-water above the limit of vaporisation.

Mr. Summers Hunter asked if the experiments were all carried out with the same quality of oil.

Mr. J. T. Milton said that, like Mr. Summers Hunter, he wished to know something more about the oil used. In the analyses of the exhaust gases which were given in the paper there was no mention of hydrogen, which was practically always present. All the paper gave in reference to the oil was its specific gravity and its net calorific value, and these did not give any proper idea of its character. The viscosity of the oil at higher temperature was a most important point and might greatly affect the results. An analysis of the oil showing the hydrogen present should certainly have been given. Professor Mellanby had spoken of explosions in the cylinder. He did not believe any such effect properly took place. The matter was one of rapid combustion. Another point was that in many cases combustion did not seem to have been perfect, as carbon monoxide was present in the exhaust.

Mr. W. S. Burns, in reply, said that the point raised by Professor Weighton was to be explained by the fact that in Experiment 13 there was more efficient combustion of the fuel. The question of the oil raised by Mr. Summers Hunter and Mr. Milton was dealt with fully in a paper on "Oil Fuels," in the Transactions of the Institute of Engineers and Shipbuilders of Scotland, vol. lvii., page 195. The reference was given in his paper. Mr. Milton had further pointed out that there was no mention of hydrogen in the analyses of the exhaust gases which were given. These analyses were taken by engineers, and the results were not given in the detail which a chemist would perhaps have used. In general traces of hydrogen only were found—0.02 per cent. at most.

OXY-ACETYLENE WELDS.

The next paper was by Professor A. Campion and Mr. W. C. Gray, and was entitled "On the Strength of Welds made by the Oxy-Acetylene Process." It was read in abstract by Mr. Gray. We hope to reprint the paper later.

Mr. J. T. Milton was the only speaker on the discussion. He said that he believed certain governing bodies had at length recognised oxy-acetylene welding as a proper method of repair for boilers and other important structures. For himself, he entirely agreed with the final remarks in the paper to the effect that autogenous welds always represented a somewhat uncertain quantity, and there was no means, except by destructive tests, of ascertaining whether a weld was good or bad. This idea was consistently acted on by Lloyd's. They had, and still, refused to accept autogenous or oxy-acetylene welding for repairs, which, in case of failure, would result in possibility of serious damage or danger to life. For repairs in which failure would not involve serious consequences, he thought such welding very satisfactory and convenient, and it was accepted by Lloyd's.

For the shell-plates of boilers and such like repairs, for which it was recommended to them, however, they could not accept it. People had even suggested repairing crane parts in this way, and sticking together broken crank-shafts. Where tightness was required rather than strength, the system was admirable. The only point in reference to the paper he would mention was that all the experiments described had been carried out on comparatively small pieces, and that if large pieces had to be dealt with, it would be much more difficult to get uniform welds. He was afraid large welds might frequently show inferior results. Lloyd's had accepted oxy-acetylene welding for large parts in temporary repairs. There was a

case of a steamer at Messina at the time of the earthquake. Her stern-frame was broken, and was welded on this system. It seemed to have been a thoroughly good job, and apparently might have been left in. The owners, however, preferred a new frame, and the repaired one was taken out when the boat got home.

Mr. Gray, in reply, said that it had been the original intention of the authors to make some large welds and test them in tension, but the large college testing-machine was being used in connection with the work on gun-metal, which formed the other paper to be presented that morning.

This third paper was entitled "Influence of Various Temperatures on the Properties of Admiralty Gun-Metal." It was by Professor J. G. Longbottom and Professor A. Campion. In the absence of both authors the paper was taken as read, and the meeting then terminated.

PRESENTATION OF FREEDOM OF NEWCASTLE-ON-TYNE TO SIR CHARLES PARSONS.

The City Council of Newcastle-on-Tyne, on March 4 last, passed a resolution to confer the honorary freedom of the city upon Sir Charles Parsons, "in recognition of his distinguished services in the cause of science, particularly in the invention and development of steam-turbine engines," and on Sir Joseph W. Swan "in recognition of his distinguished services in the cause of science, especially in the inventing and perfecting of electric lamps and improvements in photographic processes." It was decided to defer the formal presentation to Sir Joseph Swan in the hope that he might be sufficiently strong to come to Newcastle in the summer, and also to postpone the formal presentation to Sir Charles Parsons until the meeting of the Naval Architects in the city. To the great regret of all, Sir Joseph Swan died before the formal ceremony could take place, but it was decided that the minute of the Corporation containing the resolution, printed on vellum, should be handed to Lady Swan and his family at the same time as the conference of the freedom on Sir Charles Parsons, and accompanying the formal resolution was a service of plate. Mr. Kenneth Swan, son of Sir Joseph Swan, in peculiarly appropriate terms, acknowledged the presentation. Sir Charles Parsons was presented with a silver-gilt casket, containing the document on which was engraved the formal resolution. The Lord Mayor, in making the presentation, and Sir Charles Parsons, in acknowledging it, appropriately reviewed the incidents connected with the development of the steam-turbine. Sir Charles was in a reminiscent mood, and acknowledged the assistance which he had received from many workers in connection with scientific work, and the encouragement and financial assistance from others in the development and application of the turbine.

THE DINNER OF THE INSTITUTION: BATTLESHIP *versus* SUBMARINES.

The guests attending the conference were entertained to dinner on Friday evening by the North-East Coast Institution of Engineers and Shipbuilders. Sir Charles Parsons presided, and the loyal toasts having been honoured, the Earl of Durham made the announcement that the King had consented to be patron of the North-East Coast Institution of Engineers and Shipbuilders. His lordship afterwards submitted the toast of "Our Royal and Merchant Navies."

Lord Charles Beresford, in reply, contributed what was practically a speech on the paper read by Sir John Biles at the inaugural meeting of the Congress on the protection of battleships against submarine attack. Referring to the controversy regarding the relative efficiency of surface and submarine vessels, he said that the discussion was not at all inopportune, but he thought that on this occasion it was unwise to jump to hasty conclusions.

Submarines and air vessels were no doubt new and most important auxiliaries in naval warfare, but at present he thought they must count these new forces more in the nature of defence than attack. Danger existed to our Navy and to the navies of other nations from submarines and aircraft, but no war was without danger. Whenever a new danger appeared, it was their duty to meet it and beat it. They had heard theories before, and many of the gentlemen present had, by their knowledge, energy, and enterprise, manufactured what was wanted. Referring to the ram, torpedoes, and mines, Lord Charles said he was always opposed to the ram. He wanted a straight stem to knock in the side of the other ship. He thought it would be foolish to cease building battleships because a new auxiliary of attack or defence had appeared in all countries. They must never forget that a French Minister went crazy over the torpedo-boat and destroyers, and for many years the French nation was displaced from the position of a first-class naval power on account of a fad. The submarine, Lord Charles continued, could only operate by day and in clear weather, and it was practically useless in misty weather. The submarine could not see the object it was going to attack. It must come to the surface to see; and because of its very limited vision it must come close to its object before it could fire its weapon, and when on the surface it was visible for miles. A machine-gun or a few bullets would put it out of action. It could not defend itself, and a great limitation was the time it could remain under water. Then there was the great anxiety as to whether they were going to sink a friend instead of an enemy. There was no means of communication with a submarine. We were going to have, it was stated, a new British tradition, a new British doctrine—that the fleets had to remain in harbour because there was some danger at sea. Our old tradition was that when we heard of a danger we at once went out to meet it. The idea of remaining in harbour was entirely foreign to the characteristics of our race. The true lessons of war in naval campaigns were never to run away from a danger. Wars were always won by attacks, and never by defence. Hard practical facts must be thought of as well as theories. How would he suggest the danger of the submarine should be met? He would meet it in two ways. He would build a sufficient number of small craft and speedy torpedo-destroyers and small cruisers, and he would keep round the fleet circles of these vessels. When a submarine came to the top, these craft would be on it as a whale-hunter would be on a whale. In the second place, he thought the naval architect was quite capable of armouring the under-water parts of ships, as proposed by Sir John Biles, to protect battleships against torpedoes, without greatly affecting other tactical qualities. They could not afford to gamble with experiments in regard to the defence of the Empire. The superiority of the submarine had not yet been proved in either peace or war. The fundamental principle of strategy at sea remained with the surface fighting-ships, and the battleship must remain the unit of naval defence at present. Lord Charles referred to air-craft as enormously useful both ashore and afloat as scouts, and paid a glowing tribute to the mercantile marine, pleading for better recognition for their "brothers of the sea."

Principal Hadow, of Armstrong College, proposed the toast of "The Guests," to which the Lord Mayor of Newcastle, Sir John Biles, and Dr. R. T. Moore responded. The health of the Chairman was proposed by Sir George Holmes, and Sir Charles in reply paid a thoroughly well-merited tribute to the thoughtfulness and organising ability of the Secretary of the North-East Coast Institution, Mr. E. W. Fraser Smith, on whom a large part of the success of the meeting depended. In some of the arrangements he had the co-operation of Mr. R. W. Dana, the Secretary of the Institution of Naval Architects, and Mr. E. H. Parker, the Secretary of the Institution of Engineers and Shipbuilders in Scotland. All three, and the Reception and Executive Committees at Newcastle, have the satisfaction of knowing that the arrangements made provided for all contingencies, and that the proceedings throughout the whole week were an unqualified success.

105 H.-P. AGRICULTURAL TRACTOR.

IN the account of the Royal Agricultural Society's Show at Shrewsbury, in our issue of the 3rd inst. (page 20 *ante*), we made mention of two tractors shown by the Daimler Company, Limited, Coventry. One of these, of 105 brake horse-power, we illustrate on page 78, in Figs. 1 and 2, showing respectively a side and end view of the machine. This powerful machine, capable of exerting a draw-bar pull of from 10,000 lb. to 12,000 lb., is mounted on four wheels, the leading pair being 5 ft. in diameter, with faces 1 ft. 2 in. across, while the main wheels are 8 ft. in diameter and 3 ft. 9 in. across the face. This tractor weighs about 12 tons. It is fitted with a six-cylinder sleeve-valve engine, with cylinders 150 mm. bore by 150 mm. stroke. All engine parts are lubricated by a multiple plunger-pump. The engine is started by means of a small single-cylinder auxiliary air-cooled engine which is first started up. The transmission from the main engine is through a cone clutch to a gear-box with which is combined the worm and differential gear. The main wheels are driven by spurs and pinions. When ploughing the drive is direct through the worm and main-wheel spur-gears. For higher speeds gears in the gear-box are thrown in. The gear-box gives two speeds (2 and 4 miles per hour) forward and one reverse (2 miles per hour), the engine running at 1000 revolutions per minute. The radiator is of the tubular condenser pattern. The water is circulated by a centrifugal pump driven off the engine. The front portion of the barrel-shaped tank on the machine is the fuel-tank. Air is passed through the radiator-tubes by a large fan driven by the engine. The solid front axle is pivoted centrally. The tractor has been designed for work on a large scale, and is capable of hauling a 14 or 21 disc plough cutting 6 in. deep and 8 in. wide. It will plough $3\frac{3}{4}$ acres per hour. It is also provided with a belt-driving pulley giving a belt speed of 2300 ft. per minute.

FIVE-TON TIPPING TRAILER.

IN our account last week of the Royal Agricultural Society's Show at Shrewsbury we referred to a new tipping trailer shown at the stand of Messrs. Ruston, Proctor and Co., Limited, of Lincoln. We now give, on page 79, illustrations of this trailer, which will afford a more adequate idea of its construction. This wagon is constructed to Constable's patents. In Fig. 1 the wagon will be seen tipped to the off side; Fig. 2 gives a view when tipping to the near side; while Fig. 3 shows the body returned to the normal position. The body is supported by twelve small wheels, four of which are fixed to the chassis and eight (in two lines) to the tipping-body. Channel-section rails are arranged for these wheels to run on. The body is first traversed and then tipped by one continuous movement. A shaft with bevels may be seen on the chassis. This gears with square-threaded screwed shafts running across the chassis. One of the latter is worked by a removable crank-handle, shown in position in Fig. 1. The operation of this crank thus drives both transverse shafts. On each screwed shaft is a toggle, the central pin of which runs in Z-bar rails attached to the tipping-body, while one end of the toggle has a screwed nut working on the shaft, and the other an idle nut sliding on the transverse shaft. To each idle nut is attached an upright lug, and as the flattened toggle is traversed across the chassis when the screws are turned, these lugs push the body over until they come to the far side of the frame. As soon as the traverse is complete, the sliding-nut can move no further, and the toggle closes up, causing the body to tip.

On the chassis in Fig. 1 will be seen two inverted stirrup-irons. The body tips about a centre formed by the kinks in these irons, in which are caught the pins of two of the carrying-wheels. The body tips to an angle of 40 deg. To return the body, the screwing movement is reversed, and the toggles are flattened out. Their central pins, running above the Z-bar ledges or rails, pull the body down, and when returned to the horizontal the same pins come into contact with stops on the rails, and pull the body over. The tipping gear is in duplicate, so that the body can be tipped on either side, always being worked from the opposite side. It is only necessary to turn down two stops on one side or the other before tipping. In the figures it will be seen that a horizontal rail runs across either end of the wagon, and that under this rail are hooked the ends of levers attached to the side doors which run the length of the wagon. As the body is traversed, the hooks of the door-levers come under this rail, and when the traverse is converted into a tipping movement, the doors are prevented from falling with the body. They are thus automatically opened, as shown in Fig. 2. Each door is fitted with four wedges, which engage and disengage of their own accord in sockets on the body. The doors are hinged to the side and flap outwards. The wagon is a one-man affair. Its tare is 52 cwt. and its load is 5 tons. It is made, however, in sizes up to 10 tons capacity. The wagon illustrated can be tipped in $1\frac{1}{2}$ minutes from starting the traverse. The load is deposited without shock to the wagon and well clear of the wheels, &c.

LOCOMOTIVE FOR THE P. L. M. RAILWAY.

IN 1894 the Paris, Lyons, and Mediterranean Railway Company placed in service, especially for the Paris to Marseilles main-line goods traffic, a 0-8-0 type of locomotive capable of hauling a load of 782 tons at a speed of 36 km. (22.37 miles) per hour. This class was followed in 1907 by a heavier design of the 2-8-0 type, scheduled to handle 1177 tons at a similar speed. The continued growth of the traffic has since rendered another development necessary, the demand being for a class of engine capable of hauling 1300 tons at a speed of 45 km. (28 miles) per hour. This has been met by the design of a class of 2-8-2 four-cylinder compound locomotive, of which we give drawings in Figs. 1 and 2, on Plate XV., with this week's issue of

FOUR-CYLINDER COMPOUND (2-8-2 TYPE) LOCOMOTIVE FOR THE PA

CONSTRUCTED BY THE SOCIÉTÉ FRANÇ

(*For D*

Fig. 1.

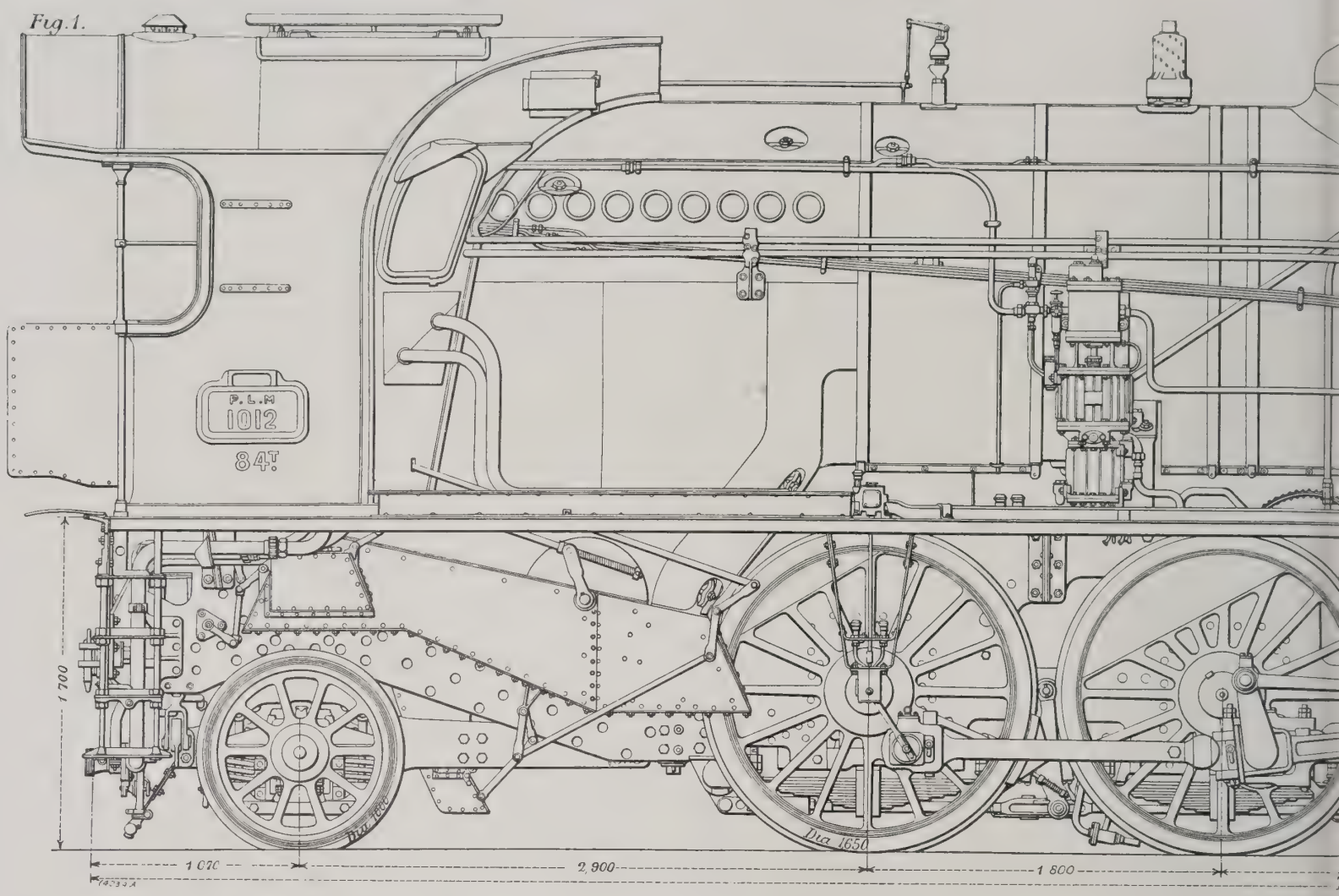
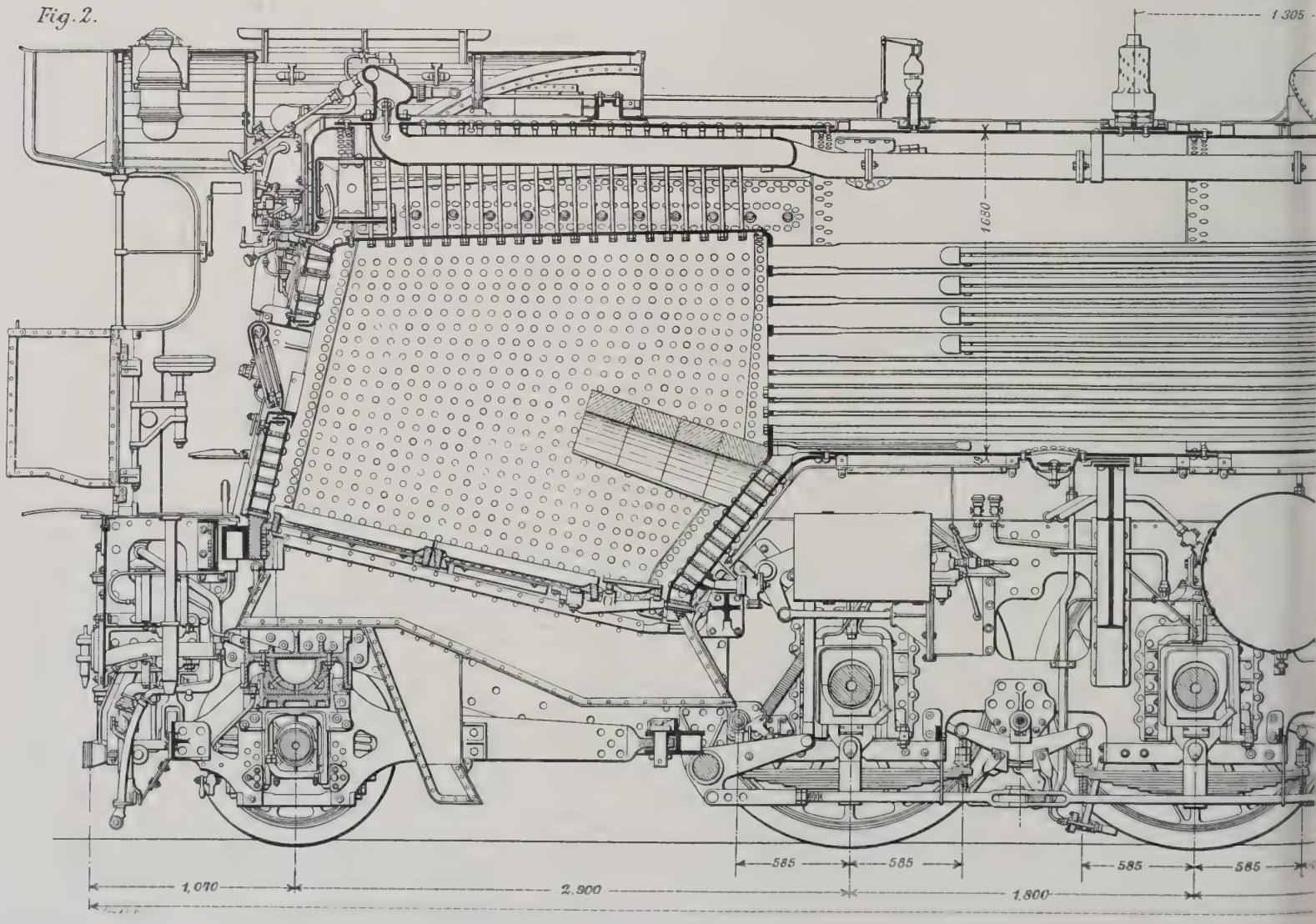


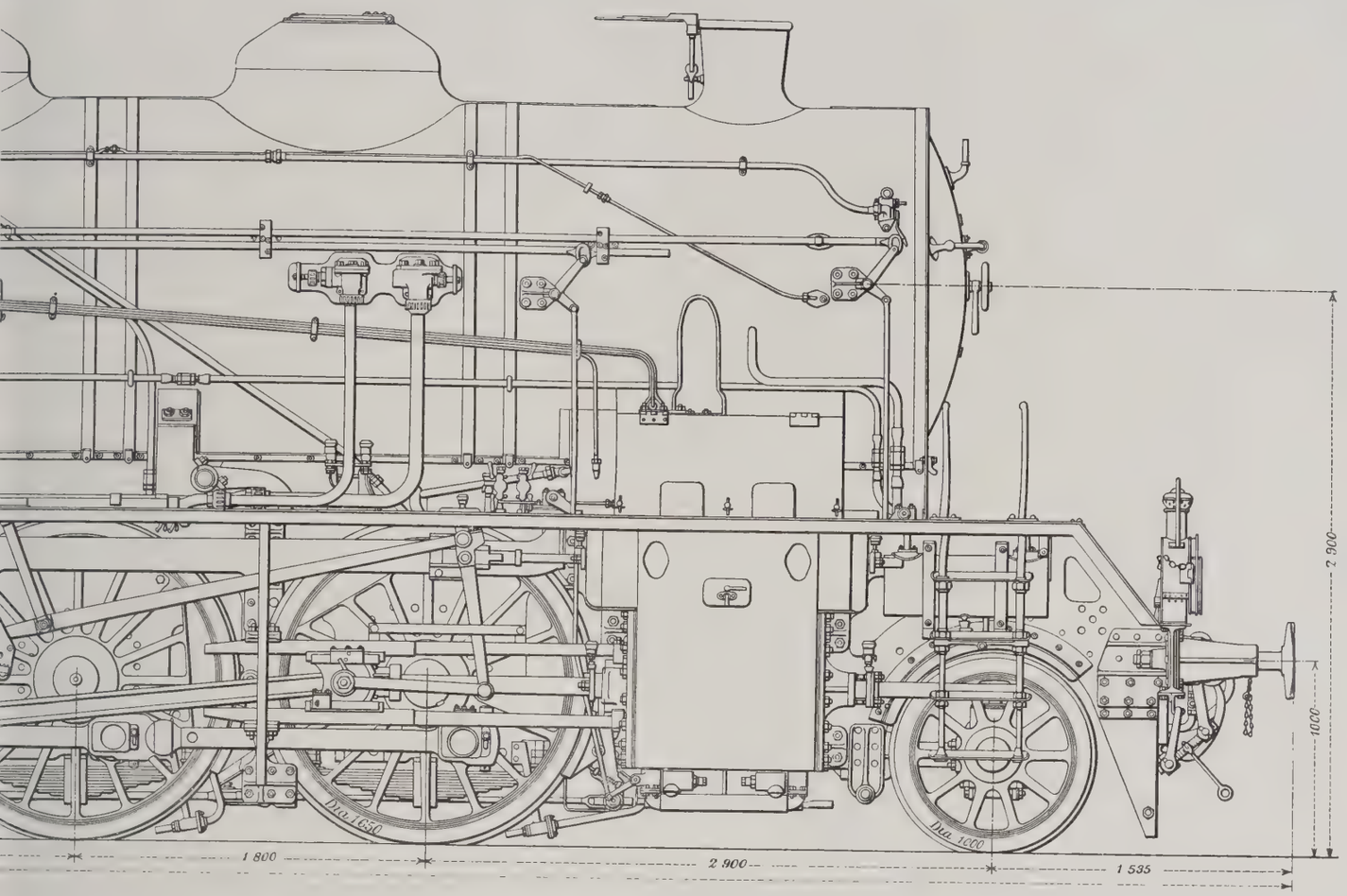
Fig. 2.

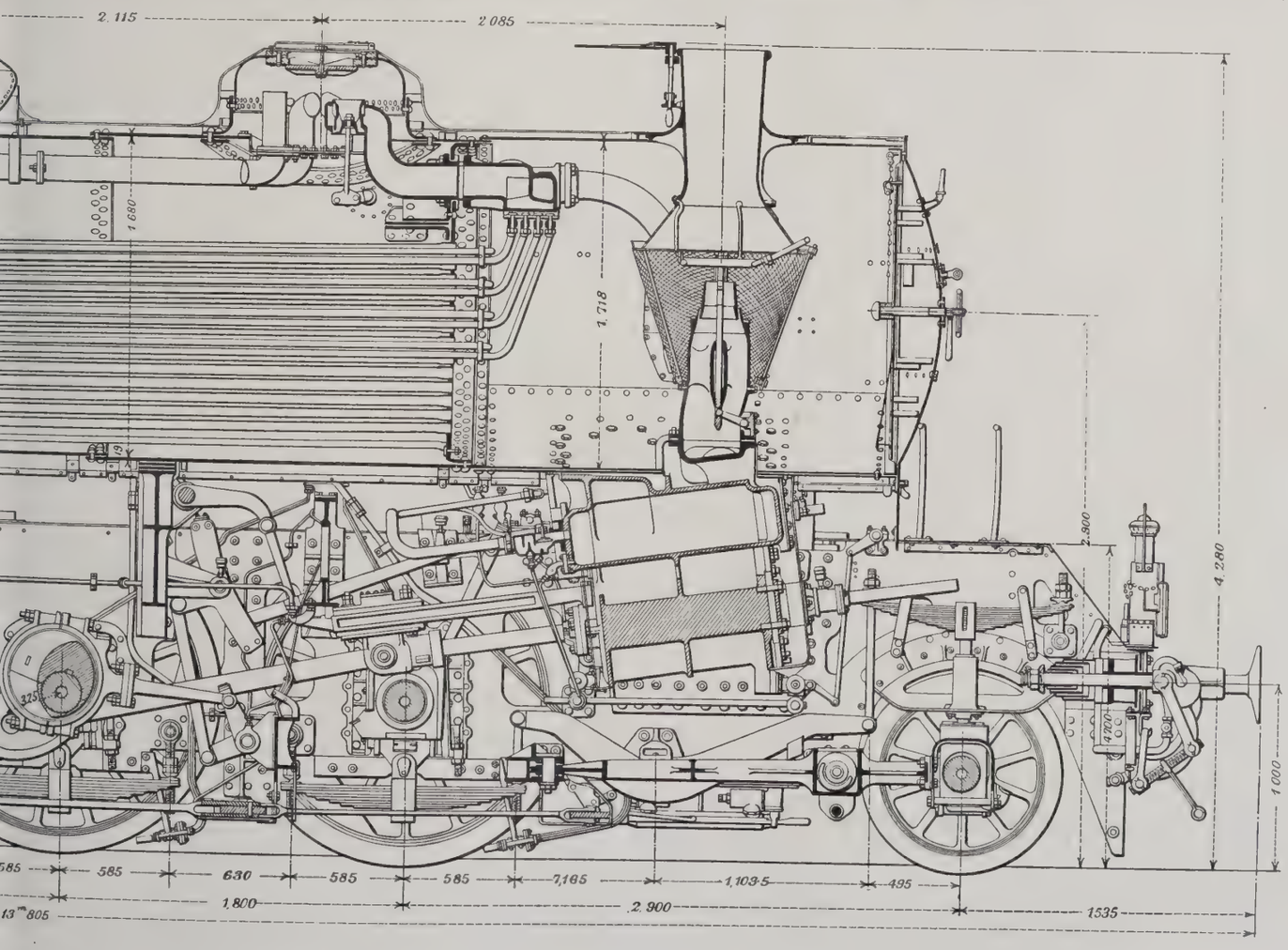


'ONS AND MEDITERRANEAN RAILWAY AT THE LYONS EXHIBITION.

'STRUCTIONS MÉCANIQUES, DENAIN, NORD.

Page 80.)





FOUR-CYLINDER COMPOUND (2-8-2 TYPE) LOCOMOTIVE FOR THE P. L. M. RAILWAY AT THE LYONS EXHIBITION

CONSTRUCTED BY THE SOCIETÉ FRANÇAISE DE CONSTRUCTIONS MÉCANIQUES, DENAIN, NORD.

Fig. 3.

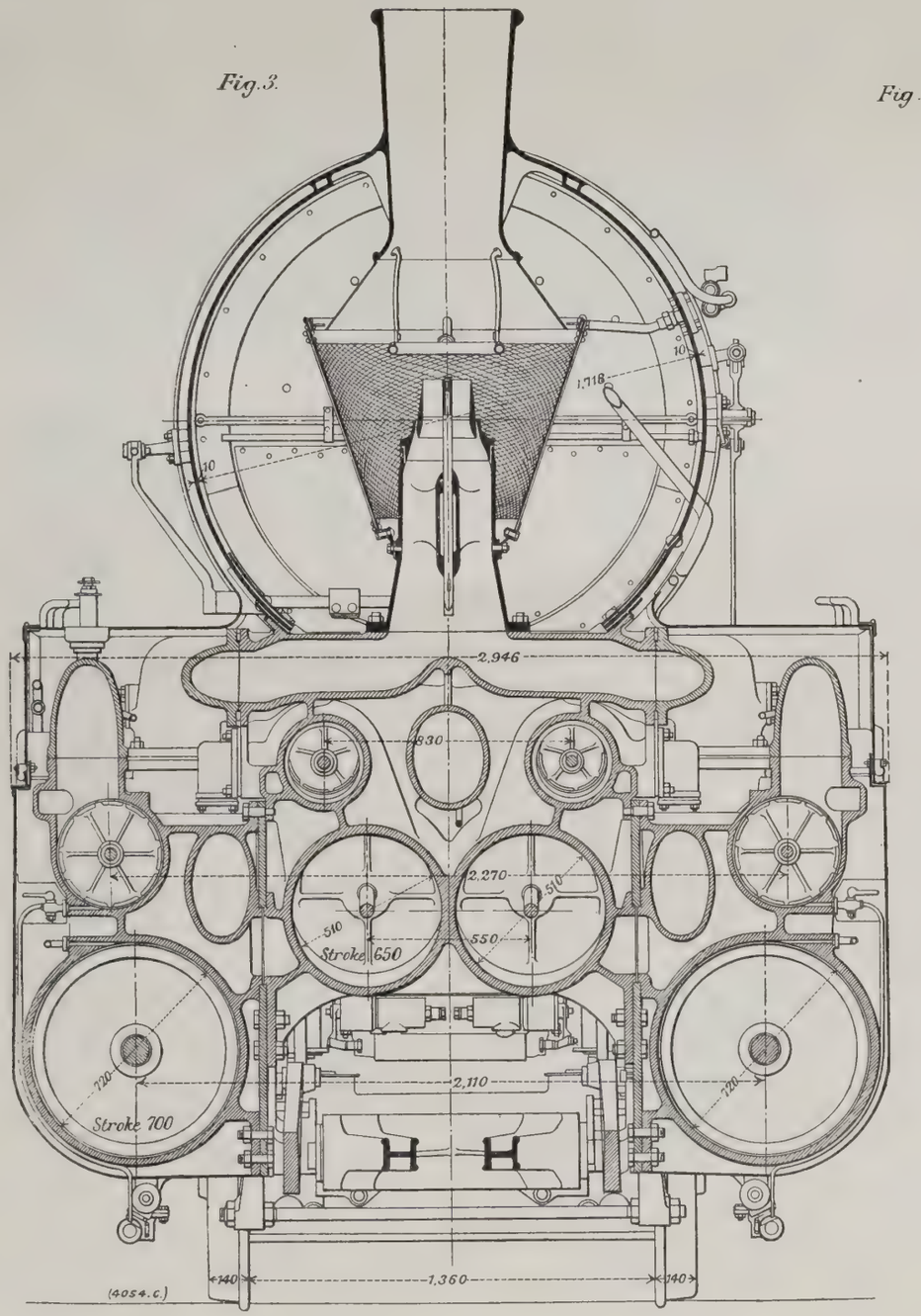
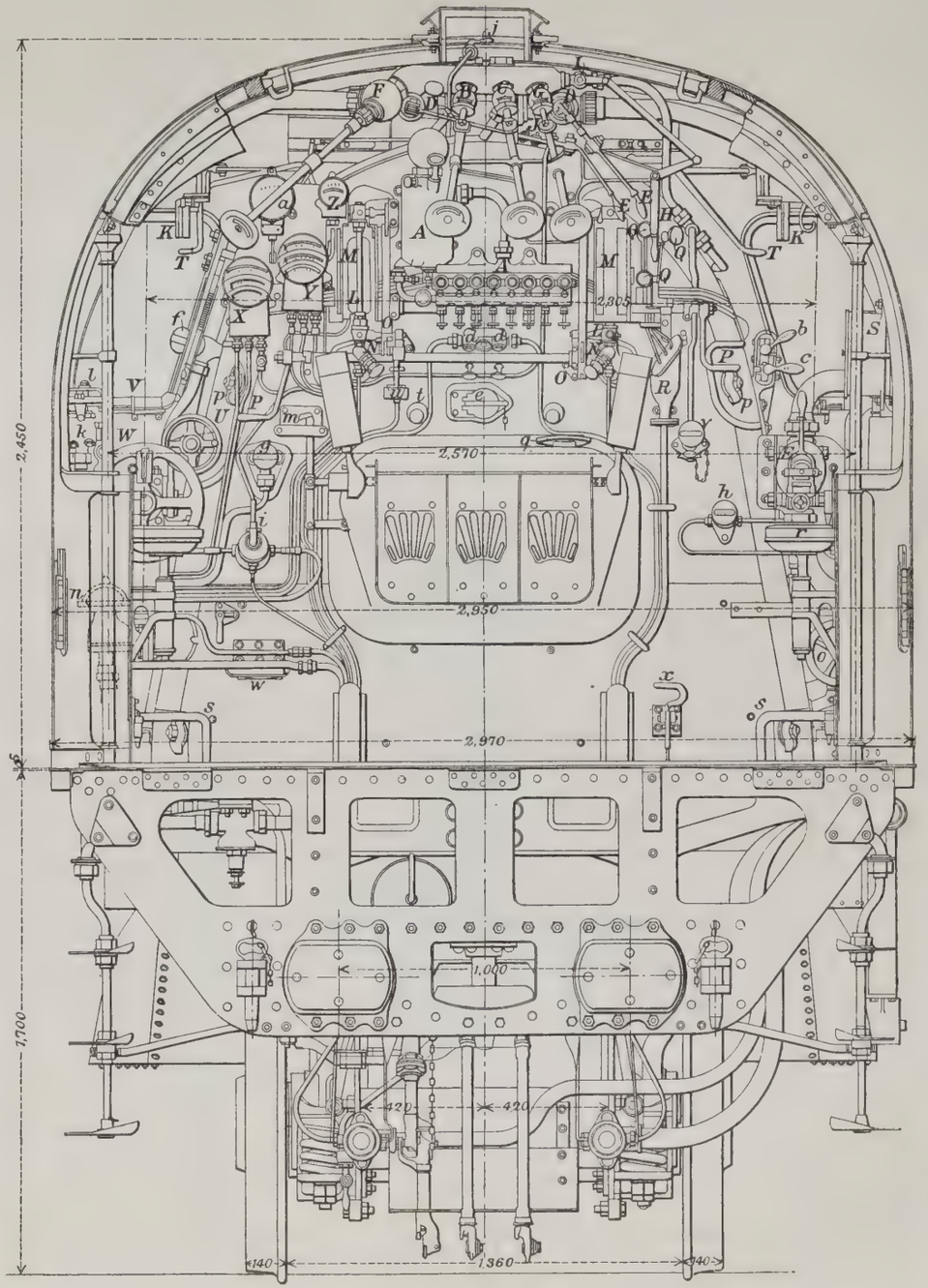


Fig. 4.



DETAILS OF TENDER FOR LOCOMOTIVE (2-8-2 TYPE) FOR THE P.L.M. RAILWAY.

CONSTRUCTED BY THE SOCIÉTÉ FRANÇAISE DE CONSTRUCTIONS MÉCANIQUES, DENAIN, NORD.

Fig. 5.

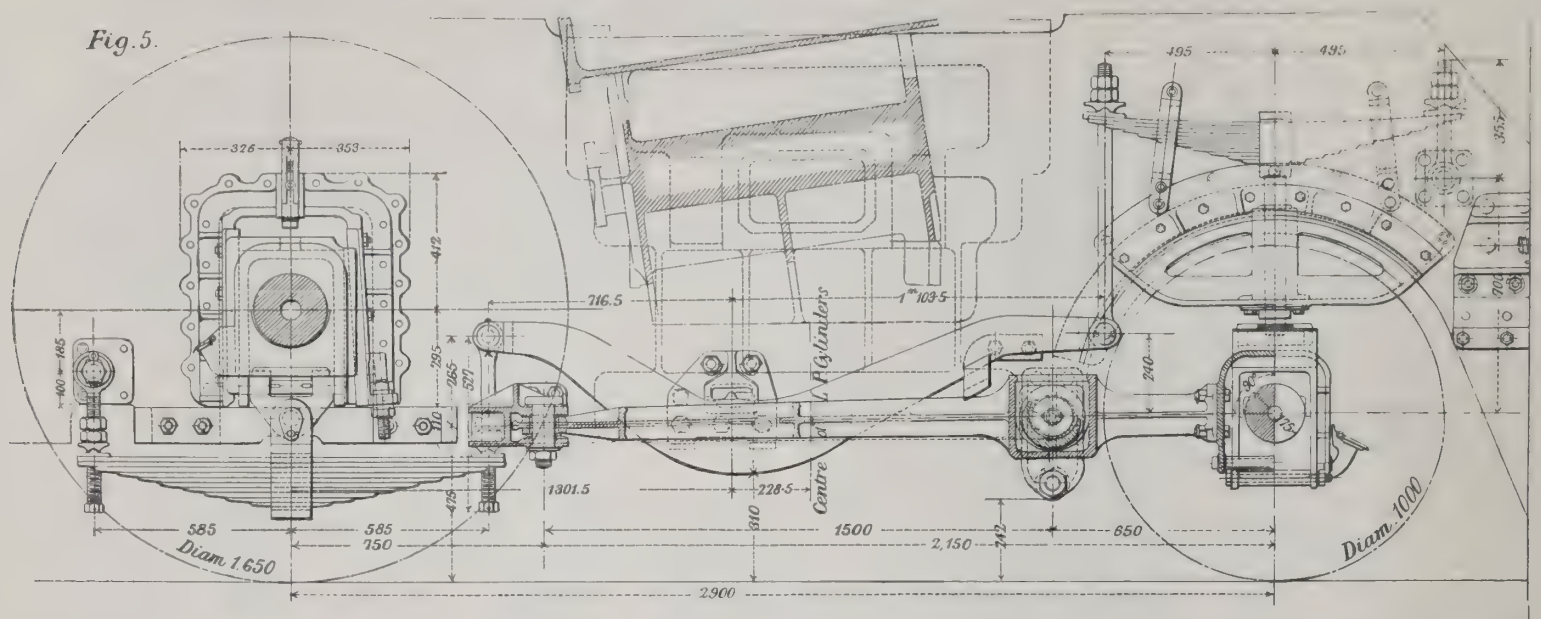


Fig. 6.

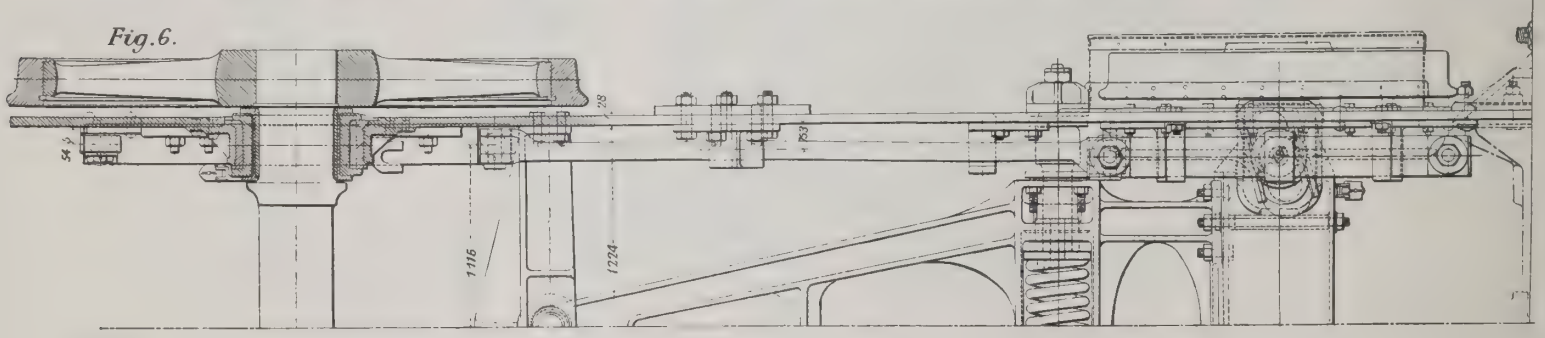


Fig. 7.

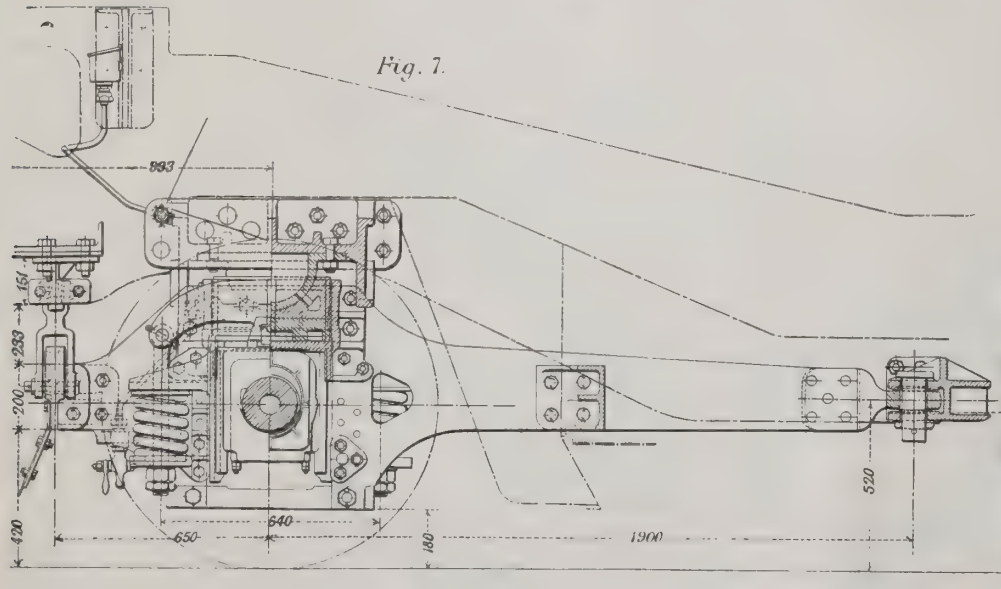


Fig. 8.

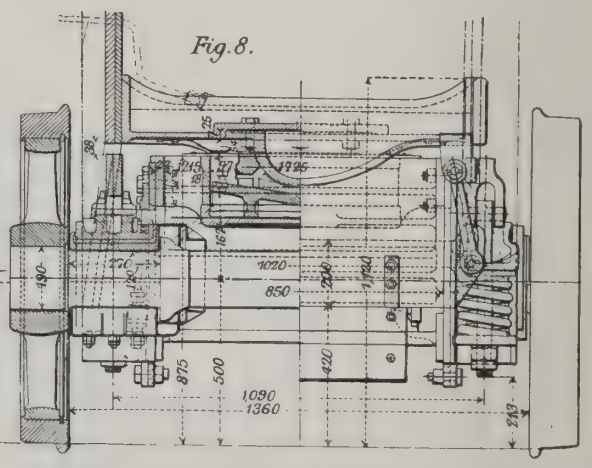
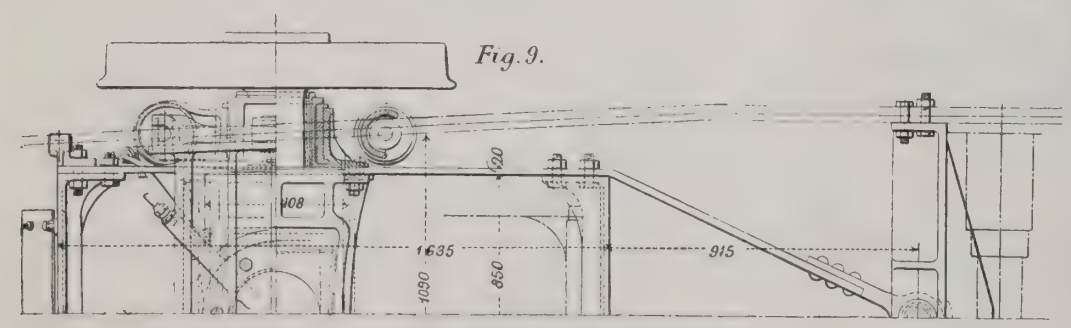


Fig. 9.



ENGINEERING, and in Figs. 3 to 12, on pages 81, 82, and 83. One of these locomotives, to the designs of Mr. L. Marechal, is to be seen at the Lyons International Exhibition. Of our figures the first two represent respectively an outside and a sectional elevation of the locomotive. Fig. 3 is a cross-section through the cylinders and smoke-box; Fig. 4 is an end elevation of the cab; Figs. 5 to 9 are details of the leading and trailing two-wheeled trucks; while Figs. 10 to 12 illustrate the construction of the tender.

The locomotive is of the compound type, with two inside high-pressure cylinders, 510 mm. (20.08 in.) in diameter and of 650-mm. (25.6 in.) stroke, and two outside low-pressure cylinders 720 mm. (28.35 in.) in diameter and 700 mm. (27.56 in.) stroke. The engine is also fitted with a superheater, as it is intended for long-distance traffic, while its coupled wheels are 1.65 m. (5 ft. 5 in.) in diameter, instead of the 1.50 m. (4 ft. 11 in.) of the earlier classes, with a view to making it more suitable for fast timing.

The boiler, except for the fire-box, which is of copper, is of mild steel. The fire-box is of the wide pattern extending over the frames. The fire-box shell is joined directly to the boiler barrel, and is formed of three plates. The fire-box crown is stayed to the shell by hollow steel stays. The upper part of the shell is stayed by a row of transverse stays of steel, drilled at either end for a length of 194 mm. ($7\frac{5}{8}$ in.). The fire-box is stayed to the shell across the water spaces, &c., by manganese-bronze stays. The tube-plate is connected to the barrel by means of ten steel palm-stays. The barrel is composed of three rings. The longitudinal seams are butt joints with double cover-plates, the transverse seams being double-riveted lap-joints. The fire-box door is arranged to hinge horizontally and to open inwards towards the fire-box. It is composed of three sections,

TENDER FOR LOCOMOTIVE (2-8-2 TYPE) FOR THE P.L.M. RAILWAY.

CONSTRUCTED BY THE SOCIETÉ ANONYME LES ATELIERS DE CONSTRUCTION DU NORD DE LA FRANCE.

Fig. 10.

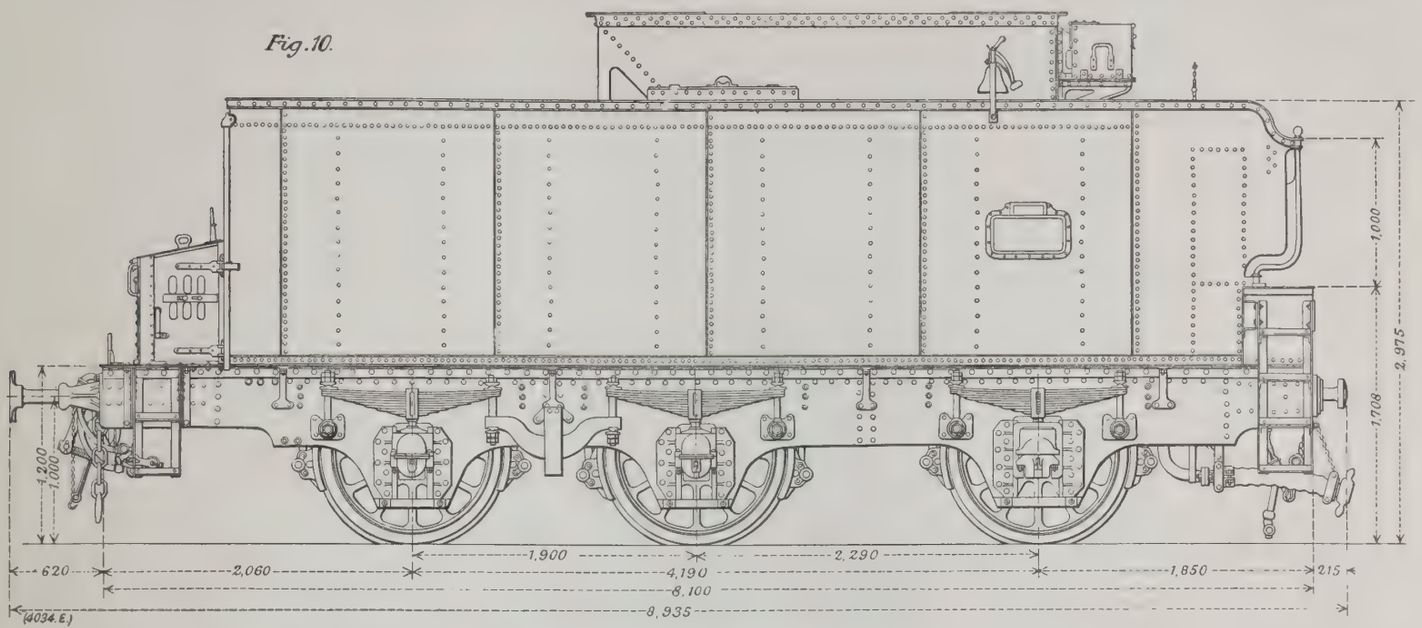


Fig. 11.

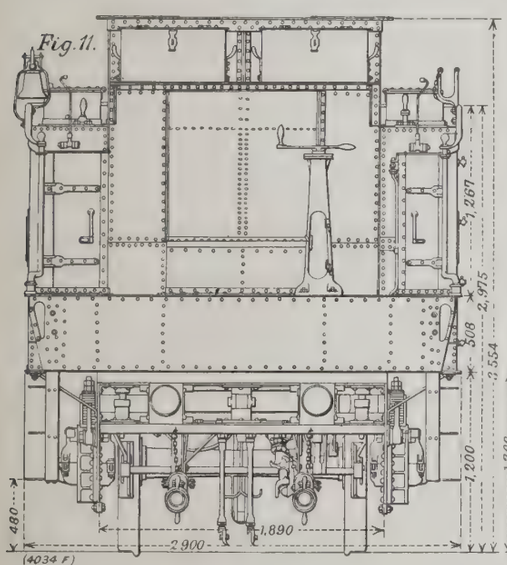
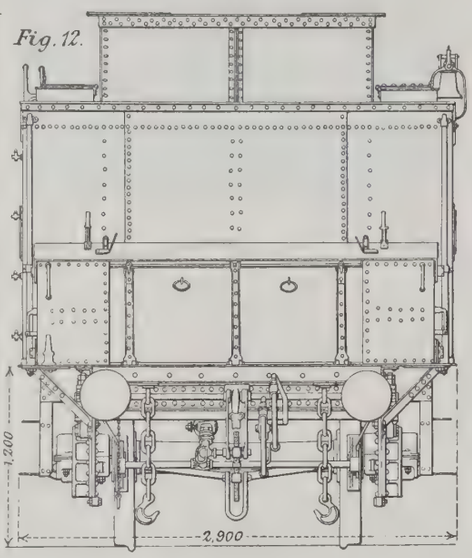


Fig. 12.



of which the two outside are operated by separate levers. The central section overlaps the other two, so that when either is worked the central one is also operated. Counterweights are provided sufficiently heavy to keep the door open, but not heavy enough to prevent it closing automatically in the event of a boiler-tube bursting. The superheater is of the Schmidt type.

The frames are of steel plate 28 mm. (1.1 in.) in thickness. They are stayed transversely by the leading buffer-beam of rolled I section, a box-shaped stay of plate and angles at the back end, by the inside cylinders, and also by eight intermediate stays of cast steel. The high-pressure cylinders drive on to the second coupled axle, the low-pressure cylinders driving on to the third. The outside cylinders are as large as could be adopted with the existing loading gauge, and the stroke of these cylinders was increased so as to bring the volume into correct relationship with that of the high-pressure cylinders. The cylinder proportions have been chosen with a view to the engine giving maximum power—that is, utilising all the steam the boiler can produce, at a speed of 60 km. (37.28 miles) per hour, instead of the 85 km. (52.8 miles) per hour of the previous class. The running gear, however, is designed so that a speed of 95 km. (56.23 miles) per hour can be maintained with a proportionately lighter load. The pistons are of cast steel, with forged-steel piston-rods. The cross-heads are of cast steel, with cast-iron slippers and white-metal lining. The slide-bars are of hard forged steel, of a tenacity of 55 kg. per sq. cm. (35 tons per sq. in.), and an elongation of 20 per cent. The connecting and coupling-rods are of steel, with brasses lined with white metal.

The high and low-pressure valve-gear is of the Walschaert type. Piston-valves with inside admission are employed. In the reversing-gear, the reach-rods of both the high and low pressure cylinders are brought to a single-screw frame in the cab. On the reversing screw works a screwed cross-head, to which the high-pressure reach-rod is connected. There is, in addition, a floating frame with pins, to which the low-pressure reach-rod is connected, this frame being moved by the high-pressure screwed cross-head, just referred to, after the latter has moved a certain distance. There are only two stable positions for the low-pressure gear—namely, in forward or back gear—but the high-pressure gear can be adjusted at will. A dash-pot arrangement, consisting of a cylinder containing a liquid, in which moves a piston pierced with holes, is provided for the low-pressure gear, the piston being connected with the reach-rod by means of levers. This is necessary, since the floating frame is not fixed to the screw-gear, and when reversing while running the low-pressure gear would be liable to fly over suddenly. The throttle is of the equilibrium type, from which steam passes to the Schmidt superheater of 28 elements. The blast-pipe is furnished with an adjustable cone top.

The leading and trailing two-wheeled trucks are illustrated in Figs. 5 to 9, page 82. The leading truck is built up of two steel castings, one forming the frame for the axle-boxes, and the other the radius-bar. The radius of the truck is 2.150 m. (7 ft. 0.64 in.). An horizontal helical control-spring is provided to return the truck to the central position. The extreme side movement allowed to the truck is 40 mm. (1.58 in.). Hardened-steel plates working in guides on the top of the truck-frame casting over the axle carry the spring load. The truck springs are equalised on both sides with the leading coupled axle. The trailing truck shown in Figs. 7 to 9 is built up of steel castings with steel plate radius-frame. The radius in this case is 1.900 m. (6 ft. 3.8 in.). The load in this instance is carried by the truck on the central sliding casting fitted with cup and ball, the latter being attached to a cross-bearer on the main frame. This centre is provided with crossed inclined surfaces, making the truck self-centring.

The axles are hollow. The axle-boxes are of cast steel fitted with bronze bearings lined with white metal. The horn-blocks are of cast steel with cast-iron liners. The engine is fitted with both the automatic air and the Westinghouse-Henry brakes, the latter giving direct non-automatic applications. The four-coupled axles are braked to 66 per cent. of the axle-load. In addition the cylinders are arranged for counter-pressure braking by reversing. A cock is provided in the cab for use in this connection, for admitting hot water from the boiler into the high-pressure exhaust, and another for admitting steam and water to the exhaust of the low-pressure cylinders. The cylinders are provided with the usual by-pass.

The tender, which is coupled to the engine above described, is, as already stated, illustrated by Figs. 10 to 12, on the present page. It was constructed by the Société Anonyme les Ateliers de Construction du Nord de la France, at Blanc-Misseron (Nord). It has steel frames 20 mm. (0.79 in.) thick. The wheels are 1.200 m. (3 ft. 11.24 in.) in diameter, with outside bearings. The axle-boxes of the leading journals are of cast steel furnished with wedge-plates and slippers, which allow a lateral displacement of 35 mm. (1.38 in.). The boxes of the middle and trailing axles are of cast iron. The horn-blocks of the leading wheels are of cast steel; in the other cases they are cast iron. The springs of the middle and trailing axles are equalised. The tender can accommodate about 6½ tons of coal. In order to provide room for this without stacking it too far back on the tank, the bunker sides are raised above the water-tank. If it is necessary to carry more than this, the fuel supply can be increased to 8 tons by stacking briquettes at the front end of the bunker. The tender is braked with two blocks on all wheels.

The following are the chief particulars of this engine and tender :—

Engine :

High-pressure cylinders (two inside), diameter	510 mm.	(20.08 in.)
Low-pressure cylinders (two outside), diameter ...	720 ,,	(28.35 ,,)
High-pressure cylinders, stroke	650 ,,	(25.6 ,,)
Low-pressure cylinders, stroke	700 ,,	(27.56 ,,)
High-pressure piston-valves, diameter	240 ,,	(9.45 ,,)
Low-pressure piston-valves, diameter	360 ,,	(14.17 ,,)
High-pressure valves, maximum travel	212.5 ,,	(8.36 ,,)
Low-pressure valves, maximum travel	126 ,,	(4.95 ,,

Exhaust maximum opening	0.0237 sq. m.	(36.7 sq. in.)
,, minimum ,,	0.0150 ,,	(23.25 ,,)
Wheels, leading, diameter	1 m.	(3 ft. 3.37 in.)
,, coupled ,,	1.65 ,,	(5 ,, 4.96 ,,)
,, trailing, diameter	1 ,,	(3 ,, 3.37 ,,)
Boiler barrel, length	...5.899 ,,	(19 ,, 4.25 ,,)
,, ,, diameter	...1.680 ,,	(5 ,, 6.14 ,,)
Fire-box, length inside	...2.078 ,,	(6 ,, 9.8 ,,)
,, width ,, front	2.086 ,,	(6 ,, 10.13 ,,)
,, ,, ,, back	1.922 ,,	(6 ,, 3 67 ,,)
Tubes, diameter	(143) 0.055 m.	(2.17 in.) and
-	(28) 0.133 ,,	(5.23 ,,)
,, length	6 m.	(19 ft. 8.22 in.)
Heating surface, fire-box ...	15.64 sq. m.	(168.35 sq. ft.)
,, ,, tubes ...	203.44 sq. m.	(2189 84 sq. ft.)
Heating surface, total ...	219.08 sq. m.	(2358.19 sq. ft.)
Superheating surface ...	70.63 sq. m.	(760.28 sq. ft.)
Grate area	4.25 sq. m.	(45.75 sq. ft.)
Working pressure	16 kg.	(227.57 lb. per sq. in.)
Wheel-base, driving ...	5.4 m.	(17 ft. 10.18 in.)
,, total	11.2 ,,	(36 ,, 8.9 ,,)
Weight on leading axle ...	11.08 tons	
,, first coupled axle	16.1 ,,	
,, third, fourth, and fifth axles (average) ...	17.8 ,,	
Weight on trailing axle ...	12.75 ,,	
,, total, in working order	93.33 ,,	

Tender:

Tank length	5.708 m.	(18 ft. 8.73 in.)
,, width	2.858 ,,	(9 ,, 4.52 ,,)
,, height	1.629 ,,	(5 ,, 4.13 ,,)
Wheels, diameter	1.2 ,,	(3 ,, 11.24 ,,)
Water capacity	23,100 kg.	(5093 galls.)
Fuel ,, ...	8 tons	
Weight in working order ...	51.4 ,,	

Engine and Tender:

Weight in working order ...	144.73 ,,	

The attached list gives the references to Fig. 4 :—

A. Sight-feed lubricator
B. Steam-cock for sight-feed lubricator
C. Steam-cock for heating apparatus
D. Steam-cock for injectors
E. Hand-levers for injector steam-cocks
F. Starting-gear steam-cock
G. Steam-cock for the pump
H. Handle for blower-cock
I. Blower steam-cock
J. Cock for steam sand-gear
K. Ventilator-handles
L. Water-gauge
M. Gauge-glass protector
N. Blow-through cocks for water-gauges
O. Lamp-brackets for water-gauge
P. Lever for working water-gauge cocks
Q. Pet cocks
R. Drain for pet-cocks
S. Speed-indicator
T. Whistle-lever
U. Exhaust-regulator
V. Throttle-lever
W. Reversing-gear hand-wheel
X. Pressure-gauge for boiler and steam-chests
Y. Pressure-gauge for brakes
Z. Pressure-gauge for heating apparatus
a. Pyrometer
b. Handle for high-pressure cylinder-cocks
c. Handle for low-pressure cylinder-cocks
d. Steam-heater for the injector water-feed pipes
e. Peep-hole
f. Cock for admission of steam and water to low-pressure cylinders
g. Cock for admission of water to high-pressure cylinders
h. Spraying-cock for smoke-box door.
i. Regulating-cock for sand gear
j. Cock for boiler-pressure gauge
k. Regulating-cock for automatic brake
l. Regulating-cock for non-automatic graduated brake
m. Handle for air-dampers in fire-box door
n. Heating apparatus regulating-cock
o. Drop-grate hand-wheel
p. Wash-out holes
q. Oil-can shelf
r. Seats
s. Foot-rests
t. Boiler pressure inspection seal
u. Funnel drain for sight feed lubricator
v. Tube-cleaner
w. Foot-step
x. Back ash-pan damper handle

CRACKS IN STEEL PLATES.

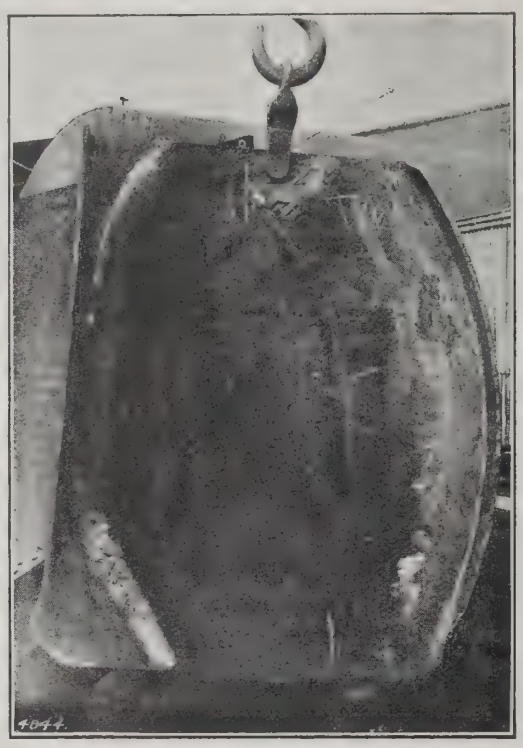
To the Editor of Engineering.

SIR,—I enclose a photograph taken about seven years ago from a tube-plate in course of manufacture for a marine boiler. It will be seen that the plate had gone through the first operations of forming the flanges to take the wrapper-plates of the combustion-chamber. It is one of several others which had been flanged on the same day, and it had been placed to one side with them in a stack. Shortly after starting up on the following morning a loud report was heard to come from the stack of plates, and on examination this plate was found to have cracked in two places. One crack is shown by the white line at the bottom towards the right near to the wood chock, and the other by the similar line near to the clamp to which the crane is hooked.

The plate was subsequently struck a few sharp blows with a heavy wood-flanger's mallet on the side reverse to that shown in the photograph, and out of curiosity as to whether the cracks would extend or others develop. The plate was then lifted, and to my astonishment I found the interesting, and, I believe, unique strain diagram which a careful examination of the photograph will reveal. The white lines at the cracks and all of the innumerable fine lines over the area of the plate are the clean grey steel surface of the plate showing between the overlying blue scale.

The whole area of the plate was apparently under a state of extreme stress, and the effect of the hammer-blows was apparently sufficient to increase the stress beyond the elastic limit, so that the material stretched in many directions, and the brittle scale broke. The measure of the extent of the stretching is the width of the lines, and varied perceptibly, the directions of the stresses are normal to these lines.

It will be noticed that at the edges of the plates, in way of the cracks, the white line is imperceptible. This is because there was no stretch at the edge, the material having broken short, but as the cracks extended inwards the material had stretched very markedly, and so increased the surface of grey steel exposed to view. Taking cross-sections through the plate across the cracks the reduction of thickness or area of section was very perceptible, and where it was greatest it was easy to make an impression upon the steel by means of a sharp knife-blade, but at the extreme edge of the plate where the cracks started the steel was as hard as glass.



The photograph is a poor one, and I much regret that a shower of rain prevented me obtaining a better record of the most beautiful stress diagram I have seen.

At about the same period my attention was drawn to a serious crack in a shell-plate for a large boiler, and which was revealed in a curious manner. The holes had been drilled, and when examining the quality of the work it was noticed that a minute piece of steel had broken off the edge of one hole. Further examination discovered a crack extending right through the plate and from the edge of the plate, across the hole, and for several inches into the plate. But for the chance of drilling the hole right across the crack it might not have been discovered until a very serious accident had happened.

Yours faithfully,

May 29, 1914. R. J. N. W.

[The cracks were somewhat difficult to follow in the photographic print we received, and although great care has been taken in the reproduction, they are still less visible in the engraving.—ED. E.]

WHAT IS HARDNESS?

To the Editor of Engineering.

SIR,—I have noticed that from time to time discussions have arisen, particularly in England, in regard to what hardness is and is not, and also as to what the different hardness-testing instruments show and cannot show. These have been somewhat misleading in the past, for two reasons: Firstly, lack of technical knowledge of the subject on the part of the discussionist; and secondly, the disparagement of one form of testing apparatus in order to advance the sales of another competitive device.

As in everything else, an erroneous discussion, while it often awakens new thought, can just as well mislead, and thus delay progress. It appears to have done the latter in England, for the statistics show that this country is fourth in the line of progress in the adoption and application of the hardness test. In a recent issue of a monthly journal issued by a firm of machine-tool makers, the following statement, among others, is made: "Testing of hardness is full of difficulties, the reason being that the word is used to cover a number of very different properties in materials."

As a matter of proof for these different properties, the relation of the resistance to cutting or machining is discussed. The writer goes on to say that different hardness-testing instruments show different properties. The scratch test, according to him, measures resistance to scratching, not necessarily hardness. The scleroscope, which depends upon the principle of the rebound of a small diamond-face drop-hammer after causing a permanent set in the metal after dropping from a certain height, he says "measures mainly what might be called bounceability," substantiating his claim by the fact that india-rubber, wood, and brass can cause a higher rebound than soft steel, while the Brinell machine measures the resistance to deformation. This, he considers, is the most correct test, although he does not claim that the test will show resistance to cutting in all materials.

Let us first ascertain the relation between hardness and resistance to cutting. Hardness at the present time is generally understood to be a state of rigidness in a body which imparts to it the power to resist penetration and necessarily also deformation. Hardness in metals is much like the integrity of their melting-points, when pure. Fusion, then, always occurs at a fixed and known temperature. This will, however, change with the addition of impurities or by alloying with such metals as may have a higher or lower melting-point. The tendency, then, is for a mutual adjustment between the two, so with the hardness of the metal in relation to its resistance to cutting or machining. A pure metal will show resistance to machining directly in proportion to the increase of hardness.

It does not matter what instrument is used to measure this so long as it indicates resistance to penetration, such as the scleroscope, and also the Brinell machine, when properly operated, does. But this uniform increase of resistance to cutting will only hold good when the clearance of the tool is perfectly adapted to the hardness of the metal; if it is not, all experiments will be misleading. This is, in fact, the first point necessary to understand in the practice of testing for hardness—to determine cutting qualities.

In dealing with alloys, complications necessarily arise, yet a simple rule holds good. The power required to remove chips will depend upon the tensile strength which is developed by any alloy. This is also indicated approximately by the hardness reading. Wear of the tool here is quite another thing, for this depends upon the hardness of the hardest particles in that alloy. The cutting-tool must scrape against these, which are therefore determining factors from the standpoint of tool wear.

A very good illustration of this point is a mechanical mixture of lead and emery. The emery does not impart greater tenacity and therefore physical hardness to the lead, so that it would still be possible to cut large chips therefrom with a steel tool with little power, but in a very short time this tool must wear out because of the grinding action of the emery. This illustration is rather crude, but serves the purpose quite well, and, in fact, may be used as an analogy describing the resistance of different alloys to machining or cutting with steel tools.

Let us first consider mild-carbon steel. This, of course, is an alloy of carbon and iron. Carbon can only combine with iron to form a carbide, Fe 3C, or cementite, which is a definite compound of considerable hardness and has a carbon content of 6 67 per cent. Pure iron then acquires an affinity for this carbide, so that if the total carbon is very low, it appears as a network of mere streaks. These streaks become more numerous as the carbon content increases. Hence, in machining mild steel, the tool is obliged to overcome the tensile strength of the iron and carbon alloy; while the edge, in scraping against the microscopic streaks of hard carbide, will be worn in proportion to the number of these that are contained in the steel. The wear of the tool is then almost directly in proportion to the total carbon content, if it is in the annealed condition, while the power required to remove the chips, as before stated, may be in proportion to the tensile strength or true physical hardness.

A very interesting example illustrating this point is the resistance to cutting offered by high speed steel, which has usually a low carbon content, but yet a high tensile strength, and therefore high hardness reading. The tungsten and chromium with which the iron is alloyed appear to impart hardness, and, therefore, strength, without the formation of gritty material, such as carbide of iron is, for, as we have seen before, this contains 6.67 per cent. of carbon. High-speed steel thus may be 50 per cent. harder than the carbon steel in the annealed state, and while it may take more power to cut, will not show nearly so much wear on the tool, just because the carbon content is lower, the number of carbide grains being less. It is said that these grains are as hard as hardened high-carbon steel; in fact, hard enough to scratch feldspar.

Another illustration of tool failures due to wear, independent of the hardness of the material, is found in the working of wrought iron containing slag grains. A drill may keep going all day without resharpening so long as no slag is encountered; while, on the other hand, it may fail at once if slag is struck, for this impurity is much harder than any hardened steel. It has been found that in connection with cast iron, silicon, which readily combines with iron, and is then easily cut, may be oxidised during the process of melting, and thus turn into particles of silica or stone. These do not impart greater strength or hardness to the iron, for the mixture is purely mechanical; but when an attempt is made to cut the iron having such impurities, the power required to do this is equal to the hardness of the iron, while the wear on the tool will be in direct proportion to the amount of silica or grit it contains.

Another very interesting illustration of this phenomenon is seen in manganese steel. This material usually shows a high resistance to wear at a low physical hardness, and this is evidently due to the fact that it contains particles of great hardness suspended in a cement medium, quite soft and ductile. Consequently such steel cannot be machined by any scraping action. This is because the hard particles, being harder than the tool, quickly scrape off the edge. A cold chisel, however, which has its scraping action reduced to a minimum, will easily cut into manganese steel, the resistance of which is quite exactly in proportion to its physical hardness. This phenomenon teaches a very valuable lesson, and shows how important methods of cutting are with regard to action, shape, and clearance of the tool.

There is another factor which enters into the cutting of

material which has greatly baffled many who have sought to gain the many advantages contained in the hardness test. This is the susceptibility to mechanical hardening under pressure. Let us take, for example, a brass casting 15 hard. This casting, by rolling or hammering, may readily acquire a mechanical hardness of, say, 40. The difference in resistance to machining here cannot invariably be expected to be in direct proportion to the initial hardness. The reason is very simple.

In machining such a casting, it can readily be understood that since pieces have to be cut or torn off, enough pressure must be used to overcome its elastic limit and ultimate strength. This will be great enough to cause considerable mechanical hardening, not only of the chip but of the area from which it is separated. Hence the power required will be greater than indicated by the initial hardness of the casting. The difference will be least where the tool has the greatest clearance, and where so little resistance is therefore offered to the cutting of the chip that but little mechanical hardening can result. As the tool becomes dull or more blunt, the casting will be more and more difficult to machine, not alone because the tool is not sharp, but also because the hardness of the casting will be raised practically to its limit—viz., 40 hard, for the sample selected. If the same casting, however, were first cold rolled, the power required to remove the chips would be in proportion to whatever hardness it was cold rolled at, provided, of course, the form or clearance of the tool is well adapted to the metal. There would be little difference between the initial casting and the same when cold rolled so far as the abrasive effect on the tool is concerned, for, as stated before, this would depend upon the hardness of the hardest particles of the alloy.

It is needless to discuss here the effect of speed, where the principal destructive factor is heat. The theory of hardness has been rather well explained under Professor Howe's analogy of the brick wall, where cement is used to unite the bricks on the one hand, while on the other no cement is used, the bricks being merely piled up to form a wall. The bricks in each wall are of the same hardness. The wall with the cement, which combines the bricks into one unitary mass, is capable of resisting deformation and penetration, and would therefore be considered a hard body, while the one without the cement, under the same mechanical forces, would collapse; therefore it is incapable of resisting penetration and deformation; and although its grains or particles are just as hard, it would be said to have a low physical hardness. We have seen that the cement medium in a body, therefore, is just as important as the particles which it unites.

In addition to hardness of these particles, their shape has much to do with mechanical properties such as those of metals and materials. The analogy of builders' sand and quicksand may here be taken into consideration. The former has sharp angles and surfaces, while in the latter the particles are roundish, and the sand is therefore incapable of supporting heavy weights. This indicates that friction between the crystals and the cement media is a very important factor, and, in fact, the trend of metallurgical investigation at the present time is in this direction, under the science of metallography and microscopic study of structure. When these are used in conjunction with the hardness test, there appear to be a few problems remaining between that test and its practical application, although it is more frequently necessary to use only a little common-sense in addition to the observation of the simple rules given in the foregoing.

I feel that when the readings of the scleroscope are compared with indiarubber in order to disparage that instrument in the eyes of the unwary, it is particularly unfair, for, as pointed out before, no hardness test can be made until permanent set can be caused, and it is certainly not possible to do this in india-rubber with either the scleroscope or the ball test.

The principle of the scleroscope was originally discovered as a result of mathematical studies of the law of conservation of energy. We may have differing opinions as to what relation elasticity may have to hardness in solid bodies; but, according to this doctrine, we can easily see that when a weight is lifted to a certain height against the force of gravity, work is done upon that body equal to the product of the weight by the distance lifted. When this body is allowed to fall again, this work is transformed into energy of motion; and when the body strikes an obstacle, the act of stopping the body causes it to give up its energy of motion, resulting in deformation or breakage and heat. Should, however, this body fall upon another one that is immovable, and that cannot be penetrated or deformed in any way, the energy of motion is not given up, but continues to remain in the falling body as energy of motion, meaning that in an absolute vacuum and absolute freedom from friction it will have to rebound as high as it fell, and thereafter keep vibrating almost for ever.

Under ordinary conditions, the rebound from such very hard materials is less than from the height it falls, because of the resistance of air and mechanical friction; and while the falling body keeps vibrating for a considerable time, the energy of motion is gradually converted into heat due to said mechanical and air friction.

Naturally, since the law of conservation of energy is so extremely exact and persistent, it would necessarily follow that the slightest deformation that can be caused between these colliding bodies will instantaneously detract from the rebounding effort, because of the work that had been done, until at last, when a soft metal, such as lead, is struck, practically all the energy of motion is converted into work, and the most insignificant rebound occurs. The scleroscope, therefore, is an instrument of strictly scientific origin. It obeys the laws of physics, and is deliberately designed toward that end. A properly-conducted hardness test by any correctly-designed instrument, like anything else, must necessarily become valuable, and more and more indispensable, as we learn not to waste time expecting the unreasonable.

In this connection I wish to take this as my opportunity to refer to oft-repeated unfair statements that the size or mass of the piece under test by the scleroscope cause variations of its hardness. It is perhaps needless here to refer to the manufacturers' regular instructions and provisions in the instrument design to clamp minute pieces so that they acquire the inertia of the heavy-enough clamp. In this manner hardened steel and softer metals, as thin as writing-paper, or rods less than $\frac{1}{8}$ in. in diameter, are regularly and faithfully tested.

In common scleroscope practice it is rather fortunate that when little pieces of metal are thus clamped or mounted for testing, the sound of the little drop-hammer will instantly warn the most careless operator as to the accuracy of his operations. When the clamping is satisfactory, so that the small piece has the same inertia as the large mass of the clamp, a dull thud is heard, or the note of a body that size. Smaller bodies have higher or shriller notes, and in order to be sure the clamping has been satisfactory, these must be subdued to correspond to that of the larger body. Only the most ordinary judgment is required to note these sounds, and the operator is therefore guided quite unconsciously.

Yours truly,

ALBERT F. SHORE.

555-557, West 22nd-street, New York, June 9, 1914.

"HYDROSTATIC CATENARY."

TO THE EDITOR OF ENGINEERING.

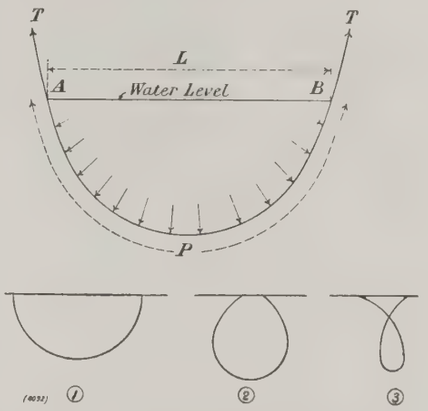
SIR,—I shall be much obliged if, through your columns, I can get a solution to the "hydrostatic catenary."

A flexible sheet, with no resistance to bending, of length P, is hung between two level supports A and B, distant a length L apart, and is then filled with water up to the level of A and B.

1. What is the equation to the curve or catenary in which the sheet hangs?

2. What is the relation between L, P, and T and the maximum ordinate?

3. What area does the curve enclose?



The pressure from the water is everywhere normal to the surface of the sheet, and hence the tension T is constant all round length P for any particular case.

The curve is the same as that assumed by a long column of uniform cross-section under an excessive load. This curve may take various forms in the general case as shown, but it is only case 1 which is used in practice. This section is a common one in light metal flumes for carrying water, and it has been adopted as the water section in a large reinforced-concrete aqueduct at present under construction.

Yours truly,

H. M. GIBB.

Irrigation Department, Brooks, Alberta, Canada, June 29, 1914.

"THE SUBSIDENCES IN THE STREETS OF PARIS."

TO THE EDITOR OF ENGINEERING.

SIR,—As an engineer and a reader of your valuable paper, and who, besides, has been in charge of the shield process of Berlier's Tube from 1906 to 1909, I note in your article "The Subsidences in the Streets of Paris" various points which I take the liberty of taking up as not being quite correct.

1. The line Villiers-Gambetta does not run parallel to No. 1. This line, called "No. 3," intersects the Nord-Sud at St. Lazare, not the Concorde, and runs through the highest level at Opera.

The second level is line No. 7 from La Villette-Opera, joining there No. 8, which runs to Auteuil, crossing the Seine below the Concorde Bridge, and again at Mirabeau, making a half circle on the left bank.

The third and lowest level is the new line, nearly completed, and going to the Palais Royal down the Avenue de l'Opera.

The line where the accidents were crosses No. 1 in the Champs Elysees.

Also, when the Seine invaded the works during the winter 1909-10, the flood came by the Nord-Sud, owing to the breaking of a big sewer running along Boulevard St. Germain, and which was not repaired in time, the tube being completed under the Seine.

The "Berlier Tube," as such was called the "Nord-Sud," was, contrary to your article on June 26, done by the shield under the Seine between the two stations "Chambre des Deputés" and "Concorde," and though great difficulties were experienced from subsoil, as rock was only found right under the river, it turned out a pretty good success for that method, but, except for that portion, all the remaining was done in masonry in the shape of *voûte surbaissée* or *anse de panier*, which was reckoned as being the one giving best results.

As to the stability of the whole, it is a known fact, though it has been criticised, that provided the masonry is made of good material, and thicknesses adhered to, no fears of collapsing can be entertained.

Hoping you will excuse me for interfering so on your time, but thinking it right to mention the above, leaving you to use it as you like.

I remain, yours very truly,

HRY. J. DE CORDEMOY,
Director of the Australian Section,
British Chamber of Commerce, Paris.

Paris, June 29, 1914.

[We thank our correspondent for his corrections, but we think he has not in all cases read our article quite correctly. We wrote, on page 840 *ante*:—"The line No. 3, now completed, is at the lowest level underneath a steel viaduct which carries, at the Place de l'Opéra, the line No. 2. This line No. 3 is known as the Villiers-Gambetta line, and follows a direction generally parallel to line No. 1; it intersects both the 'Nord-Sud' line and the central line which serves the Place de la Concorde, running thence to . . ." Line No. 1 is practically a straight line from the Place de la Bastille to the Porte Maillot, some 4½ miles. Line No. 3 starts at Père Lachaise and runs by the Place de la Republique, the Bourse, the Opera, the Gare St. Lazare, and the Avenue de Villiers to the Porte de Champerre. The two lines are equally distant for about one-third of their length at each end, but for the middle third are somewhat nearer together. It is, however, quite reasonable to describe them as generally parallel. At Gare St. Lazare line No. 3 intersects the Nord-Sud, and here we have evidently mistranslated the original article, which should read: "it intersects the Nord-Sud, which serves the Place de la Concorde." This point was made clear by the map in our second article on page 879 *ante*. The respective levels of the three lines intersecting at the Place de l'Opera are clearly shown on our two-page plate, published on July 6, 1906. No. 3 line is the uppermost.

We have expressly pointed out, and have shown in the drawings, the intersection at the Champs-Elysées of the broken line with No. 1. The inundations at St. Lazare in 1910 were not caused solely by the Nord-Sud, but also by the actual flow of the subterranean water of the subsoil; that is, we believe, accepted. As a matter of fact, M. Berlier constructed the two passages under the Seine with a shield, but the tunnels of the Nord-Sud were, as our correspondent says, built without shields.—ED. E.].

INFLUENCE LINES.

TO THE EDITOR OF ENGINEERING.

SIR,—An expression useful for working out influence lines for a girder divided into a large number of equal spans is as follows:—

Let A B, B C be two adjacent unloaded spans, then by the well-known theorem—

$$M_A l + 2M_B (l + l) + M_C l = 0$$

A	B	C
M_A	M_B	M_C

i.e.,

$$M_A + 4M_B + M_C = 0$$

$$M_A = -4M_B - M_C$$

Now if M_0 = bending moment at the first point of support = 0,

M_1 = bending moment at the second point, &c.

Then the moments at successive points of support until a loaded span is reached are given by—

$$M_n = (-1)^{n-1} \cdot \frac{(2+\sqrt{3})^n - (2-\sqrt{3})^n}{2\sqrt{3}} M_1.$$

Successive values (which are all whole numbers) being

$$M_1, \ -4M_1, \ +15M_1, \ -56M_1, \ \&c.$$

If there are an infinite number of spans—

$$\frac{M_n}{M_{n-}} = -(2+\sqrt{3}) = -3.732.$$

Yours truly,

G. P. MANNING.

102, Fordhook-avenue, Ealing Common, W., July 10, 1914.

P.S.—If you have seen this expression before, please say where it is to be found.

PERSONAL. — Mr. H. G. Humby, M. Inst. C.E., M.I.N.A., formerly consulting engineer to the Natal Government, and subsequently to the Government of the Union of South Africa, having retired, has opened an office at 20, Victoria-street, London, S.W., where he is practising as consulting engineer on matters relating to railways and harbours and their equipment, of which he has had extensive experience.—Mr. H. S. Rowell, A.R.C.Sc., B.Sc., Wh.Sch., has been appointed to the position of Senior Lecturer in Mechanical Engineering at the Bradford Technical College, and will commence his duties in September next. Mr. Rowell had a distinguished career as a student, obtaining successively a National Scholarship and a Whitworth Scholarship in Engineering, a double Associateship of the Royal College of Science (in Physics and in Mechanics) and the B.Sc. (Engineering) degree of London University.

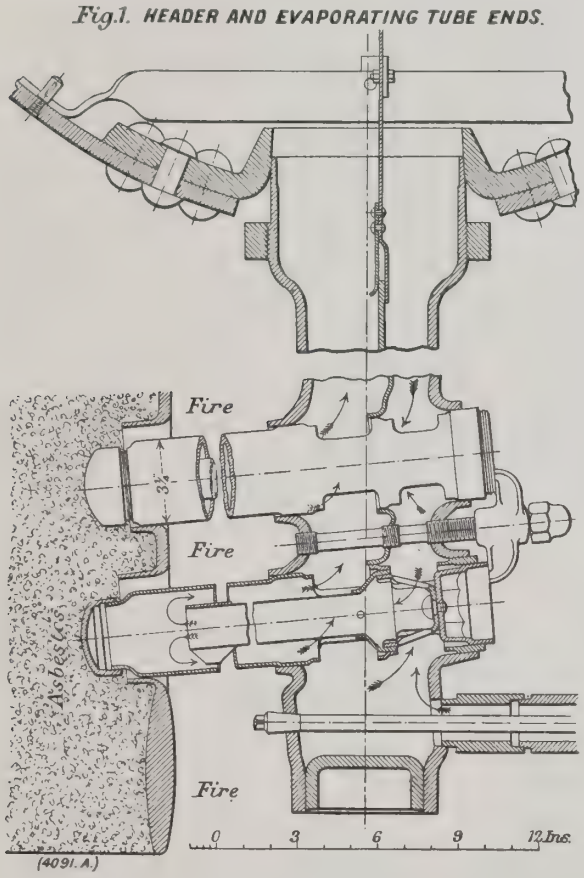
THE NEW NICLAUSSE HIGH-DUTY MARINE-TYPE BOILER.*

By JULES NICLAUSSE, of Paris.

THE Niclausse boiler, of which so many important installations have been made in practically all the navies of the world, in large power-houses, and in industrial factories, is too well known by engineers to require a description, so the author proposes to limit this paper to setting forth briefly the general features and latest improvements.

In the Niclausse boiler all the evaporating-tubes are fitted at one end only into the headers, and a perfectly tight joint is ensured by metal-to-metal conical joints. The other end is closed by a cap, and is carried by a supporting plate. The removal of any tube, either for cleaning or for replacement, is very easily and rapidly effected, so that a shut-down for any cause does not put the boiler out of service for more than a relatively very short time. The tubes being fixed at one end only, expansion or contraction takes place freely, giving complete security against troubles resulting from neglect of this important provision. It will be noticed from Fig. 1, herewith, that the old screwed-on lantern end has been suppressed, the tube being now solid-drawn throughout, with swellings to form the cones.

Fig. 1. HEADER AND EVAPORATING TUBE ENDS.



As shown in Fig. 1, each header is divided into two compartments by a vertical partition plate, separating the steam and water currents. The current of water flowing through the front compartment of the header is distributed to each evaporating-tube by an inner tube contained in the former. Windows cut in the header end of the evaporating tube enable the water to enter and the steam to depart in two distinct currents, so that positive circulation in only one, and that the correct, direction is ensured.

During the last two years, a number of improvements have been made in the details of the Niclausse boiler, without affecting the principles of its operation and construction. Some years ago the malleable cast-steel curved headers were replaced by headers constructed in solid-drawn pressed steel of increased and of rectangular section, and recently the firm introduced a special system of feed distribution to serve the lower tubes, which are those nearest the furnace, and are the principal evaporating tubes. For this purpose the steam and water drums are divided into two compartments by a longitudinal diaphragm plate in prolongation of the vertical partitions in the headers, as shown in Fig. 2; the feed, after passing through a trough C, wherein carbonates and other impurities are precipitated, and whence they are ejected by means of a blow-down valve D, enters at the front compartment, descends the vertical headers for a certain distance determined by a cross diaphragm E, passes into the upper evaporating tubes, and returns with the steam there produced into the back compartment of the drum, which consequently contains only hot and purified feed. The purified feed then descends by two tubes placed in front of the side walls, in the case of the high-duty boiler (see Fig. 3, opposite) into a square horizontal header located longitudinally in front of, and connecting by an elbow to, the bottom of each of the vertical headers.

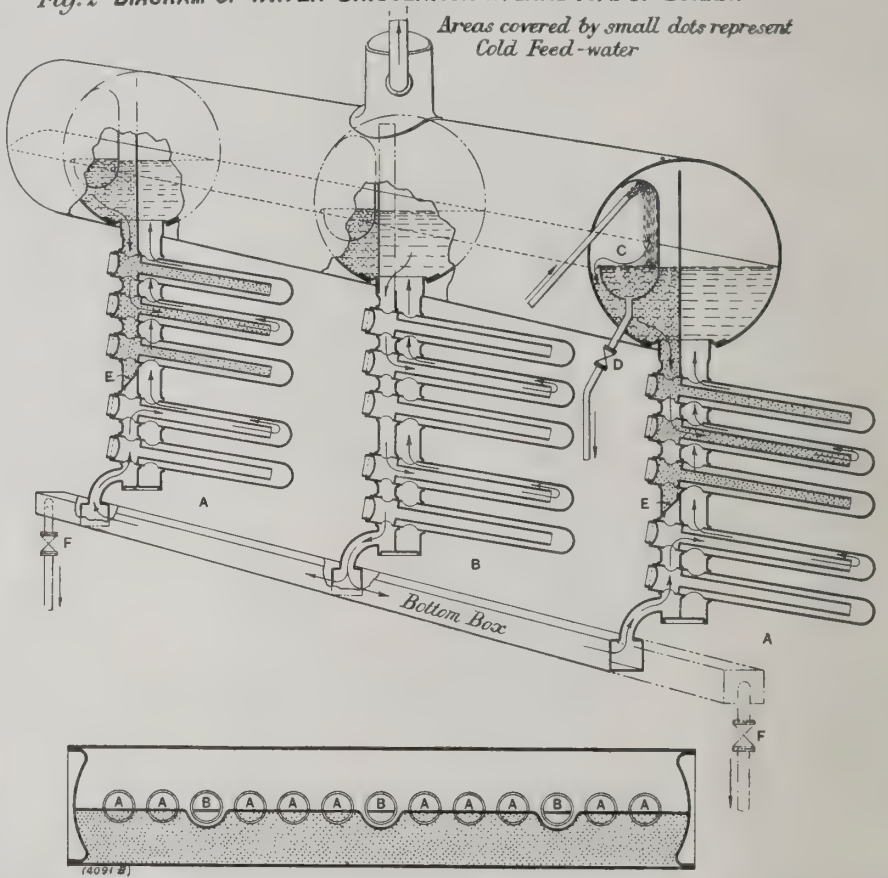
* Paper read before the Institution of Mechanical Engineers, at Paris, July 8, 1914.

The upper tubes are therefore fed by relatively cold feed-water, and the bottom tubes by the purified hot feed. The horizontal header also serves as a "bottom box," Fig. 2, whence impurities can also be rejected by blow-down valves F fitted at each end of it.

The lower tubes, which are most exposed to the heat of the furnace, consequently receive the feed at boiler steam temperature, and free from any impurities in the feed to the upper tubes are practically harmless, since the temperature of the gases surrounding them is insufficient to form a hard scale.

In the modern land-type boilers the system is simplified, without impairing its efficiency, by suppressing the vertical downtake pipes. These are replaced by one header out of every four or five, in which no cross-diaphragm is fitted in its front compartment, so that it serves to feed the "bottom box" and the lower tubes of all the headers fitted with the cross-diaphragm, whilst its own lower tubes are served direct. The arrangement will be quite clear from Fig. 2, A, A being headers having the cross-diaphragm in their front compartment taking impurified feed from the front side of the drum to feed the upper tubes, B being a downtake header taking its hot purified feed-water from the back side of the drum, the division-plate therein being suitably arranged for this purpose, as shown at B in plan.

Fig. 2 DIAGRAM OF WATER CIRCULATION IN LAND TYPE OF BOILER



In the new high-duty marine-type boiler the firm have still further increased the section of the headers, chiefly in the rear compartment forming the passage for the steam. This is about 4½ times larger than in the modern land-type headers. Furthermore, an inclination of 15 per cent. instead of 10 per cent. has been given to the tubes, in order to facilitate disengagement of the steam. Also, the outside diameter of the tubes has been reduced from 84 mm. to 60 mm. ($3\frac{5}{16}$ in. to $2\frac{3}{8}$ in.), a reduction which has been rendered practicable, with complete security against all forms of distress, by the above-mentioned improvements.

The new high-duty boiler is fitted with a feed-reheater placed above the tubes. The water circulates into this apparatus on the contra-flow principle—that is, in the reverse direction to the hot gases. The official tests referred to hereafter show the efficacy of this feed-reheater, as much from the point of view of the feed-water temperature as from that of the chimney-gas temperatures.

The high-duty marine boiler, having no superheater as usually arranged between the tubes in the land type, is fitted with a new system of gas-baffling, which doubles the length of the gas flow in the tube *faisceau*, ensuring improved utility and efficiency. This comprises plain open-ended tubes laid between the evaporating tubes, forming gas-passages, as will be seen from Fig. 3.

All the above improvements were comprised in the test-boiler recently tested by the French Navy experts. Full dimensions of this boiler are given in the Appendix, page 88, and in the drawing showing its general arrangement, Fig. 3. The tests of this boiler by the Committee of Naval Experts appointed by the French Admiralty, and carried out in September last, comprised:—

1. A six-hour trial at the combustion rate of 95 kg. of coal per square metre of grate surface (19.5 lb. per sq. ft.). The evaporation in pounds from and at 212 deg. Fahr. was 13.1 per pound of coal fired, the thermal efficiency being 91.5 per cent., and the capacity 20,000 lb. per hour from and at 212 deg. Fahr.

2. A six-hour trial at the combustion rate of 180 kg. of coal per square metre of grate surface (37 lb. per sq. ft.). The evaporation in pounds from and at 212 deg. Fahr. was 11.5 per pound of coal fired, the thermal efficiency being 79.8 per cent.

3. A 16-hour trial at the combustion rate of 225 kg. of coal per square metre of grate surface (46 lb. per sq. ft.). The evaporation in pounds from and at 212 deg. Fahr. was 11.4 per lb. of coal fired, the thermal efficiency being 79.3 per cent., and the capacity 41,000 lb. per hour from and at 212 deg. Fahr.

4. A 4-hour trial at the combustion rate of 135 kg. of petroleum per square metre of grate surface. The evaporation in pounds from and at 212 deg. Fahr. was 15.5 per pound of fuel burnt, the efficiency being 78.8 per cent.

5. A 5-hour trial, to demonstrate the elasticity of the boiler. Operation took place as follows:—Half an hour at the combustion rate of 95 kg. per sq. metre of grate surface; half an hour at the combustion rate of 180 kg.; half an hour at the combustion rate of 225 kg.; one hour at the combustion rate of 240 kg.; a quarter of an hour at the combustion rate of 180 kg.; a quarter of an hour stop; 10 minutes at the combustion rate of 95 kg.; three-quarters of an hour at the combustion rate of 135 kg. with oil fuel; a quarter of an hour at the combustion rate of 95 kg. of coal. This trial proved that the boiler made the change from these different rates with perfect success, and without any difficulty.

Further tests were made on January 6 last by a party of English engineers. The results fully corroborated those obtained by the French naval experts.

During the No. 3 trials, the percentage of water entrained was at maximum only 0.9 per cent. This was determined by the salt method with the Kennedy apparatus. The maximum temperature of the gases at foot of chimney was only 330 deg. Cent. (625 deg. Fahr.) during the sixteen hours' test at the combustion rate of 225 kg. per sq. m. (46 lb. per sq. ft.) when the evaporation was 105 per cent. above the normal. It must be added that the feed-water used was the ordinary town water, which was not in any way treated or purified, and which during the official tests was subjected to an addition of such a quantity of sea salt as to give 1 deg. of salinity to the water in the boiler. Valvoline was also added in the proportion of 175 grammes per ton of coal fired. On the results of the tests made by naval experts in September last, the French Admiralty placed with the firm an order for twenty-one boilers, aggregating 36,000 horse-power, for the 25,000-ton super-Dreadnought Bearne, laid down on January 1 of this year.

For land service the new high-duty boiler is arranged in much the same manner as in the Niclausse land type, and is fitted with superheater and mechanical stoker, both of the firm's design and make. The superheater is constructed of several serpentine sections interpolated and coupled to two headers, one at the entrance and the other at the steam exit. The serpentines, which are placed within the nest of tubes in the latter, are located above the *faisceau* in the new high-duty-type boiler for land service.

The Niclausse mechanical stoker comprises fire-bars in short sections interlocking with each other and carried in supporting bearers, which are given an intermittent to-and-fro motion, so that two adjacent bars always work in

THE NEW NICLAUSSE HIGH-DUTY BOILER.

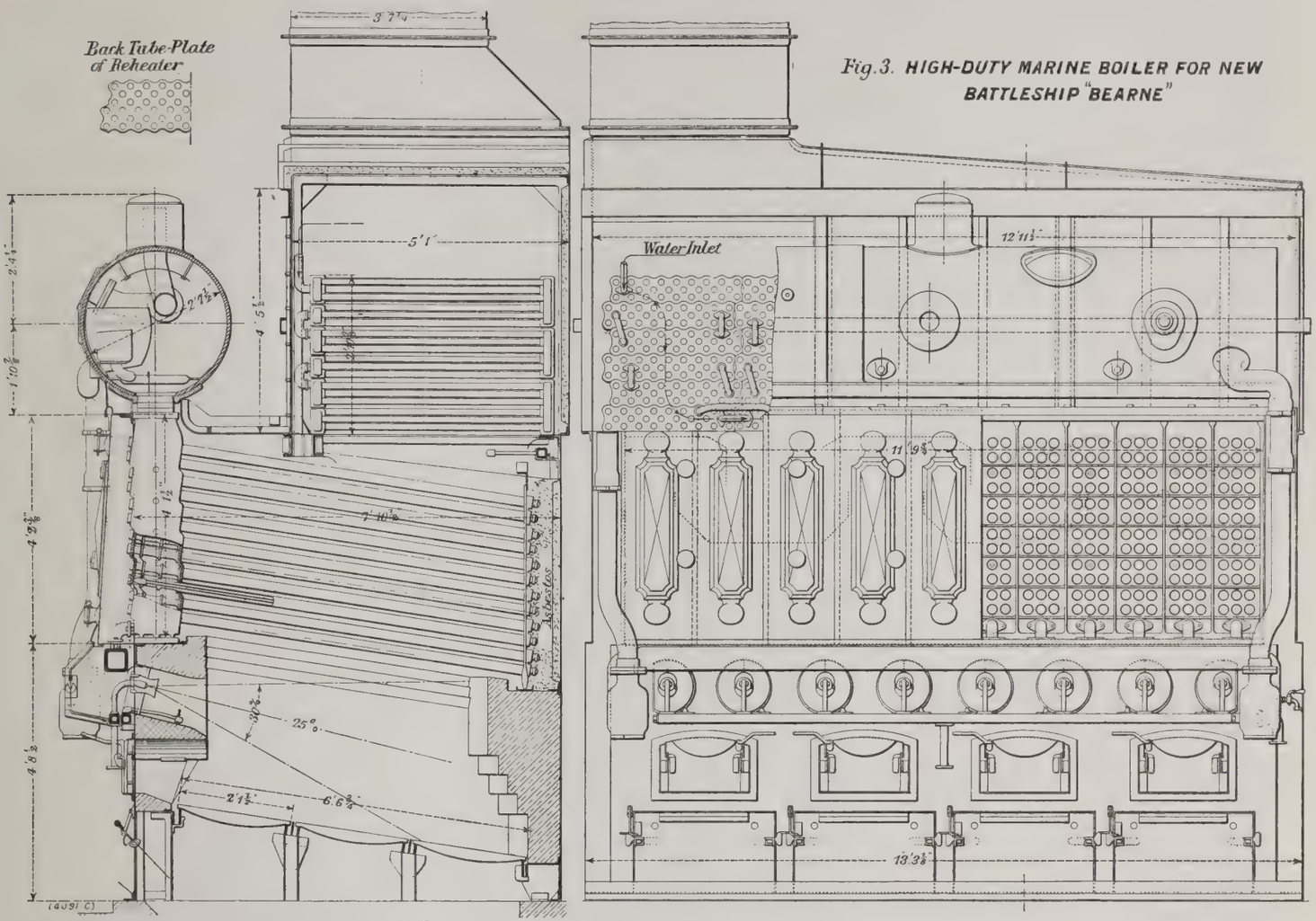
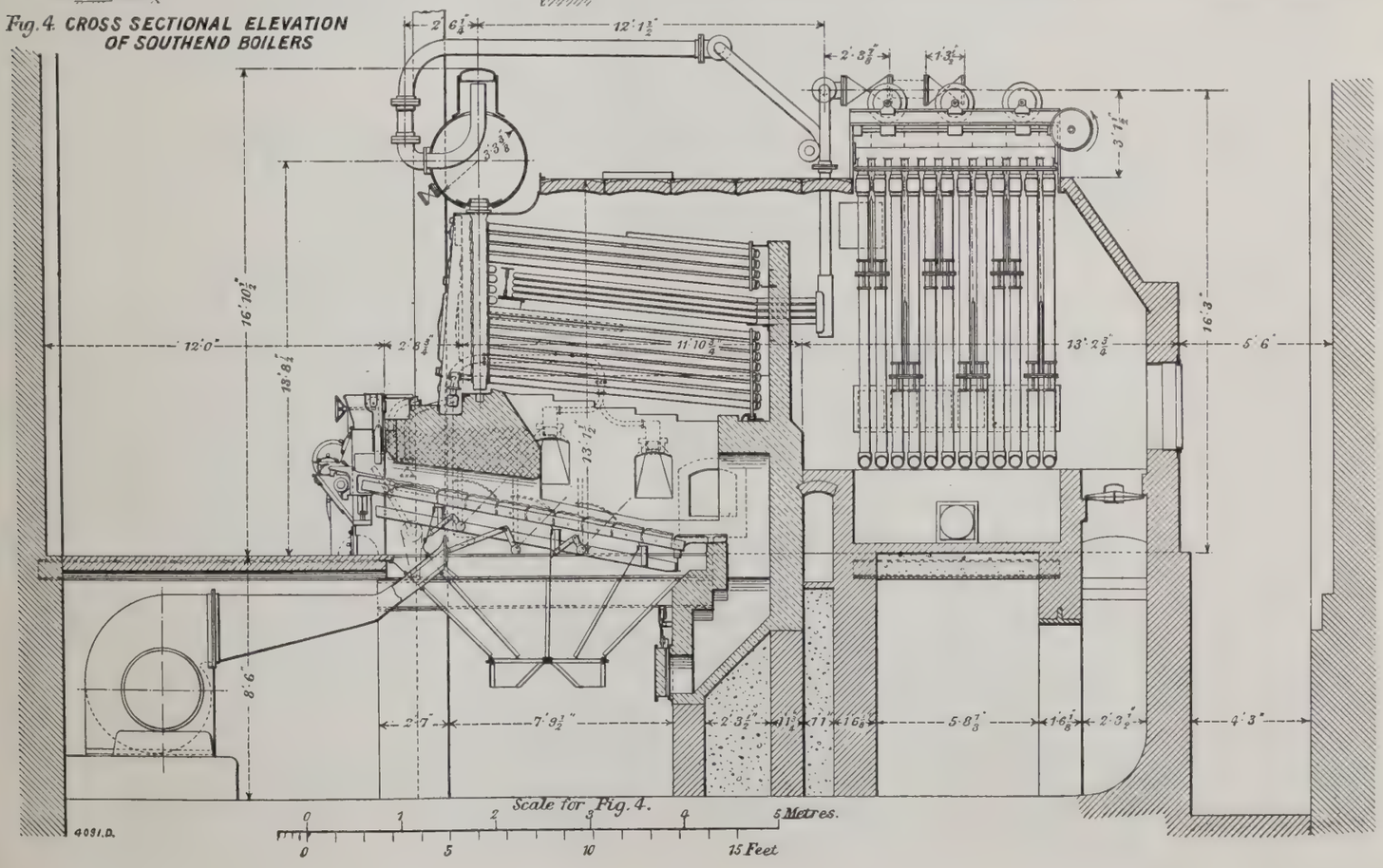


Fig. 3. HIGH-DUTY MARINE BOILER FOR NEW BATTLESHIP "BEARNE"

Fig. 4. CROSS SECTIONAL ELEVATION OF SOUTHEND BOILERS



opposite directions. There is a momentary pause between the movement backwards and forwards. The bar movement is effected by means of a slowly-rotating shaft fitted with hard-steel cams, which engage with hard-steel trip-pieces mounted on the bearer-heads. The speed of the driving-shaft can be varied from 1 to 6 revolutions per minute. Below the grate is fitted a series of hoppers serving as both air-ducts and ashpits. The air supply is furnished preferably by a forced-draught fan worked at low pressure, This system is very much more economical than either the induced or ejector-draught systems. The ashpit is divided into three compartments, in which the air supply is regulated independently to the different zones of the fire-bed, whereby perfect combustion with any kind of fuel is ensured. The ashpit compartments also serve to separate green fuel riddlings from the fine ashes, the former being trapped in the front compartment, and the latter in the rear compartment, whilst the clinkers are delivered into a capacious hopper under the end of the grate. The Niclausse stoker, of which there are over 200,000 horse-power at work, has been proved capable of burning all classes of solid fuel, from coke-breeze and coals having only 8 per cent. volatile matter to the coals richest in volatile matters. Recently, it has been tried in England with very high volatile Midland coal, and in South Wales with extremely low grade, low volatile, high ash Welsh coal, with successful results.

Fig. 4 illustrates the arrangement of the stoker, also the superheater, with respect to the boiler, as instanced in the recent installation of two 25,000-lb. to 35,000-lb. per hour boilers, complete with stokers, &c., at the Corporation Electricity Works of Southend-on-Sea, in England.

APPENDIX.

Particulars of the Boiler Submitted for Trials by the Navy.

The general arrangement of the boiler is shown in Fig. 3. Other particulars are as follows:—

Working pressure (gauge)...	18 kg. per sq. cm. (256 lb. per sq. in.)
Number of headers... ...	13
Number of evaporating tubes, upper	300 (thickness, 2½ mm.) (0.099 in.)
Number of evaporating tubes, lower	156 (thickness, 4 mm.) (0.16 in.)
Total number of tubes ...	456
Cleaning tubes	12
Outside and inside diameter of upper tubes, mm. ...	60 × 55 (2.36 in. × 2.16 in.)
Outside and inside diameter of lower tubes, mm. ...	60 × 52 (2.36 in. × 2.04 in.)
Height of headers	2.300 m. (7 ft. 6 in.)
Length of tubes projecting outside the headers ...	2.020 ,, (6 ,, 7¼ ,,)
Number of tubes in economiser	780
Length of economiser tubes (outside headers)	1.216 m. (4 ft. 0 in.)
Length of grate	2 000 ,, (6 ,, 6 ,,)
Width of grate	3.690 ,, (11 ,, 9½ ,,)
Grate area	7.20 sq. m. (77.5 sq. ft.)
Heating surface of outer tubes	...173.62 ,, (1870 ,,)
Heating surface of economiser	...119.22 ,, (1285 ,,)
Total heating surface	...292.85 ,, (3155 ,,)

The ratio of outer heating surface of the tubes (neglecting the header surface) to the grate surface is:—

Outer surface of evaporating tubes...	24.11 to 1
Outer surface of economiser tubes ...	16.56 to 1
Ratio of total heating surface to grate area	40.67 to 1

Space occupied by boiler = 114 sq. ft.; height to top of dome, 13 ft.

Hourly evaporation per square foot of ground space occupied:—

(*a*) At normal load, with rate of combustion of 19.5 lb. per sq. ft. of grate surface = 175 lb. per hour from and at 212 deg. Fahr.

(*b*) At overload, with rate of combustion of 46 lb. per sq. ft. of grate surface = 355 lb. per hour from and at 212 deg. Fahr.

50-FT. MOTOR PINNACE FOR THE BRITISH ADMIRALTY.—A motor pinnace of 50 ft. length, the first of the class, was delivered at Devonport Dockyard during the second week in July by Messrs. John I. Thornycroft and Co., Limited, making the non-stop voyage from Southampton—a distance of 130 nautical miles—under her own power in less than 12 hours. The type is very similar to the 50-ft. steam-pinnaces at present carried on battleships, and is, indeed, destined to replace them. The only important difference between the motor and steamboats is in respect of the machinery. The machinery consists of one Thornycroft S/6 type direct reversible paraffin engine starting on blow-lamp. The cylinders are six in number, 8½ in. in diameter by 12-in. stroke, and the engine develops 150 brake horse-power at about 550 revolutions per minute. The initial impulse is given to the engine by compressed air at 575 lb. introduced through non-return valves on the cylinder-head. The air is stored in three steel reservoirs in the engine-room. Reversing is effected by moving the cam-shaft longitudinally, thus bringing another set of cams into operation. There is a compressor driven by cam-shaft at the fore end of the engine, and also an auxiliary hand-driven compressor for the first charge in the reservoirs.

THE INSTITUTE OF METALS.

THE Autumn Meeting of the Institute of Metals will be held in Portsmouth on September 10 and 11. The meetings will be held in the Portsmouth Municipal College. On Thursday, September 10, there will be a general meeting, at 10 a.m., opened by the official welcome of the Institute by the Mayor of Portsmouth, Alderman J. H. Cooke, and the Chairman of the Education Committee, Alderman F. G. Foster. Afterwards papers will be read and discussed. In the afternoon a visit will be paid to H.M. Dockyard. In the evening a dinner will be held at the Queen's Hotel, followed by a reception by the President, Engineer Vice-Admiral Sir H. J. Oram, K.C.B. On Friday, September 11, in the morning, more papers will be considered, after which members will visit and take lunch at the works of Messrs. J. Samuel White and Co., Cowes. Alternative motor excursions have been arranged for the afternoons—namely, for Thursday to the New Forest or Arundel, and for Friday, to Carisbrooke Castle. The papers to be taken at the meetings will, it is expected, include the following:—"The Wiedmanstättian Structure in Various Alloys and Metals," by Captain N. T. Belaiew; "Ductile Tungsten and its Internal Structure," by C. Gladitz; "Tensile Tests on Copper at High Temperatures," by Mr. D. Hanson and Dr. G. D. Bengough; "The Critical Point at 460 deg. Cent. in Zinc-Copper Alloys," by Mr. O. F. Hudson; "A Note on the Annealing of Brass," by Mr. F. Johnson; "The Deposition of Metals by the Spraying Process," by Mr. R. K. Morcom; "The Effect of Hydrogen on the Annealing of Gold," by Mr. J. Phelps; "A Contribution to the History of Corrosion—Part III., Coke, Condenser Tubes and Corrosion," by Mr. A. Philip; "The Surface Tension of Molten Metals," by Mr. S. W. Smith; "The Behaviour of Copper-Zinc Alloys when Heated in a Vacuum," by Mr. W. E. Thorneycroft and Professor T. Turner.

THE MOTOR EXHIBITION.—At a recent meeting of the Society of Motor Manufacturers and Traders, Limited, the date of the Motor Exhibition at Olympia was fixed for November 6 to 14. From the applications for space received it was manifest that the coming Exhibition would be even more international in character than heretofore, and would demonstrate the fact that Great Britain is the world's market for automobiles.

COAL EXPORTS FROM CALCUTTA.—The exports of coal from Calcutta by sea during the half-year ended March 31, 1914, were 1,614,484 tons, as compared with 1,498,304 tons in 1912-13. For the whole of the year ended March 31, 1914, the exports were 3,036,353 tons, as compared with 3,104,834 tons for the year ended March 31, 1913. The exports to Bombay were 549,961 tons; to Karachi, 230,939 tons; and to Rangoon, 210,223 tons. Of the coal exported in the half-year ended March 31 this year, 1,296,225 tons were carried by the East Indian Railway, as compared with 1,100,688 tons in the corresponding period of 1912-13.

INTERNATIONAL MUNICIPAL CONFERENCE.—The Mayors of some of the most important cities of the United States, together with a number of ladies and gentlemen identified with municipal matters, will arrive in London at the end of the present week, and from Monday, the 20th inst., to Saturday, the 25th inst., will join in an International Municipal Conference at the Anglo-American Exposition, at the White City, Shepherd's Bush, London, W., with Viscount Peel, the Chairman of the London County Council, as President. Amongst the subjects to be discussed are:—The administration of Public Health, including regulations for housing and prevention of disease, and all matters connected with sanitation and sewerage, municipal trading, the supply of electricity, gas, and water by public bodies, and the arrangement for provision and control of traffic. Parks, open spaces, town planning, and recreation. The administration of justice, police, and protection from fire. Control of building operations and destruction of insanitary buildings, with reference to the protection of health and life. Housing, &c. Relief of the poor, hospitals and orphan asylums. Public welfare. Education. Control of licensing, and relation with central government concerning part of the revenue derived from such licences, and the question of subsidy. Care of children; female and child labour.

OFFICIAL FIRE-TESTS.—The British Fire-Prevention Committee conducted two series of fire-tests last week at their Regent's Park testing-station. The first of these dealt with a fibrous material suitable for partitioning and panelling, known as "Calno," which was put before the Committee by the Fireproof Fibre Building Boards, Limited. It was tested in panel form of various thicknesses, the thinner panels for duration and the thicker for the Committee's standard forty-five minutes' test, with a view to obtaining the classification for affording "temporary protection" (Class A). The second series was with a partition and with two doors of non-flammable wood, treated by the Timber Fire Proofing Company, Limited. The partition was submitted to the Committee's forty-five minutes' test, with a view to obtaining the classification for "temporary protection" (Class A), and the 2-in. doors to the one-hour test, with a view to obtaining the classification for "temporary protection" (Class B). The temperature throughout these tests had to range from 1500 deg. to a temperature not exceeding 1650 deg., and the fire-test was followed by the application of water from the steam fire-engine. The results of the tests will be submitted in the form of a report in due course. The next testing-day at the Regent's Park testing-station will be July 22, which will be devoted to a series of three glazing tests, among which will be wired-glass skylights.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was quiet, and Cleveland warrants fell away a little. The turnover was limited to 500 tons at 51s. 4½d. cash, with closing sellers at 51s. 5d. cash, 51s. 7d. one month, and 51s. 7½d. three months. In the afternoon the market was dead idle, the only change being in the prices of Cleveland warrants for the three months position, for which sellers named 51s. 7d. On Friday morning there was little doing, and the only business was one lot of Cleveland warrants at 51s. 4½d. cash, and closing sellers quoted 51s. 5d. cash, 51s. 7d. one month, and 51s. 7½d. three months. The afternoon session was again idle, and no change was made by sellers in the quotations for Cleveland warrants. On Monday morning a good tone prevailed, but buyers were absent, and no dealings took place. Sellers of Cleveland warrants quoted 51s. 6d. cash, 51s. 8d. one month, and 51s. 9d. three months. The afternoon session was also a blank as regards business, and no change was made in sellers' prices. The firmer tone again held good on Tuesday morning, and dealings amounting to 1500 tons of Cleveland warrants were put through at 51s. 7½d. August 25, and at 51s. 9d. and 51s. 8½d. three months. The closing quotations were 51s. 6d. cash, 51s. 8d. one month, and 51s. 9d. three months sellers. In the afternoon Cleveland warrants remained steady, but business was at a standstill. Sellers made no change in their prices, although buyers shaded their's. When the market opened to-day (Wednesday) there was once again little feeling for business, and while the tone was steady, no dealing took place. Closing quotations for Cleveland warrants were 51s. 6d. cash, 51s. 8d. one month, and 51s. 9d. three months sellers. In the afternoon another blank session was recorded, and a holiday feeling prevailed. There was little change in prices, and sellers of Cleveland warrants quoted 51s. 6d. cash, and 51s. 8d. one and three months.

Sulphate of Ammonia.—A firm tone prevails in the sulphate of ammonia market this week, and there has been a little better demand on shipment account. The current price is now 11*l.* per ton Glasgow, and about 11*l.* 2s. 6d. per ton Leith, for prompt lots.

Scotch Steel Trade.—At last the annual fair holidays are with us, and those responsible for keeping the works going are relieved for a little of some of their anxiety. No demand of any moment has been experienced of late, and there has consequently been no pressure for delivery of steel before closing down, except in the case of urgent lots; in fact, some establishments put up their shutters several days earlier than usual owing to the shortage of specifications. The quieter tone experienced in the shipbuilding industry during past weeks, or months, coupled with the inroad of foreign material, has told severely on the demand for the local manufacture of steel plates, &c. Makers of black sheets are also very quiet, and the outlook is really so poor that the holidays will be extended this year. Export orders, while fair, have lately been of rather limited tonnage, and not nearly so heavy as is generally expected at this time of year. Prices show no change, and are called 5*l.* 12s. 6d. per ton for ship-plates, 5*l.* 7s. 6d. per ton for angles, and 6*l.* per ton for boiler-plates, all less the usual 5 per cent. for Clyde delivery or equal.

Malleable-Iron Trade.—No change has to be reported in the state of the malleable-iron trade of the West of Scotland, and now that the holidays have arrived, and the various works are closed, the re-opening will be put off as long as possible unless the horizon becomes clearer. Specifications have been so scarce that work has only been carried on intermittently for some time. Prices are unchanged, and are based on 6*l.* 12s. 6d. per ton for "crown" bars.

Scotch Pig-Iron Trade.—There has been a very poor demand for Scotch pig-iron during the past week, both on home and export account, despite the fact that the present output is much restricted from the normal. The serious crisis which has arisen in the coal trade has hastened the blowing out of furnaces, and since the coal-masters are resisting the limiting by the miners of the coal output of the country, there is the probability of a hard struggle. The success of the miners would have the result of raising the prices of fuel, and if iron-masters find it hard enough to secure business at the present prices, in these days of foreign competition, it is difficult to anticipate what the future prospects of the iron trade may be. The current quotations for makers' (No. 1) iron are as follows:—Clyde, 66s.; Calder, Gartsherrie, Summerlee, and Langloan, 66s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 70s.; Shotts (at Leith), 66s. 6d.; and Carron (at Grangemouth), 67s. Hematite is very quiet and the demand has fallen away considerably.

Iron and Steel Imports.—The registered imports of iron and steel, during the month of June, into the ports of Glasgow, Grangemouth, Greenock, Leith, Dundee, and Aberdeen, were as follows:—

	Ex-Continent. tons	Value. £	Ex-U.S.A. tons	Value. £
Iron bars, angles, &c. ..	3836	24,996	—	—
Steel bars, angles, &c. ..	1058	6,722	117	887
Iron and steel hoops and strips..	831	5,561	1420	11,190
Iron and steel plates ..	2348	15,270	—	—
Totals	8073	52,549	1537	12,077

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—Not for a long period have the South Yorkshire house-coal pits worked so irregularly. The demand from all classes of consumers has shrunk so consistently that there are scarcely sufficient orders to keep the men engaged for more than three days out of the seven. Even with this greatly restricted output stocks are making an appearance. Prices show an average decline of 6d. Steam hards are firmly held at last week's prices. A heavy tonnage is going into consumption in the steel industries. The shipping demand is gradually approaching the magnitude of twelve months ago, though there is still a good deal of leeway to be made up. Gas-coal is a quieter market. During the last week many of the big consumers who have been holding out for reductions on last year's contract rates have agreed to place renewals at the old figures. Coke is weak, and producers are putting out more furnaces. The outlook in this department is regarded with a good deal of uncertainty. Patent oven coke is being taken on contract at 9s. 6d. per ton. The best market is for steel coke, which makes up to 27s. per ton delivered. Best slacks find a ready sale, but in the lower qualities production is considerably in excess of the demand. Quotations:—Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. to 13s.; Derbyshire best brights, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 10s. 3d. to 11s. 3d.; small nuts, 9s. to 10s.; Yorkshire hards, 11s. to 12s.; Derbyshire hards, 10s. to 11s.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.; smalls, 2s. 6d. to 3s. 6d.

Iron and Steel.—Consumers of pig-iron are, for the most part, postponing buying, in the expectation of obtaining cheaper rates, and though for several weeks past quotations have produced only the smallest margin of profit, further slight concessions are being made on orders of any bulk. The excess production of coke has so far enabled makers to keep values exceptionally low, and with prices still declining, there is still prospect of further cheapening in production costs. Makers are looking forward to this cheapening as a means of recompense, and are determined, if possible, to prevent users taking advantage of it. What contracts there are, are mostly short-dated, makers declining to book any length of delivery at existing rates. Foundry iron is the quickest medium. Forge is unsteady, but there is little excess production. Hematite makers are sending big tonnages into the armament works. East Coast products are fractionally lower on the week, but West Coast sorts are firmly held at 73s. to 73s. 6d. Scrap rules at exceptionally low rates, but users are only making purchases where special bargains are to be obtained. The steel output is decidedly smaller on the month. Though unemployment is still very low, the excessive heat that has been experienced has had a restricting effect on all classes of manufacture. Makers, however, find no difficulty in keeping pace with current requirements. But for the heavy contracts recently placed, and upon which work is proceeding, difficulty would be experienced in maintaining constant activity in certain branches. The principal cause of reaction is the marked decline in export business. With important customers like British India, the United States, and Canada, there is something approaching a slump. Small increases are shown in the requirements of Australia and New Zealand. The prosperity in armament work is undiminished. Further big contracts have been booked, including, it is stated, several thousand tons of armour for H.M. battleship Renown, now building at Govan. A fair inquiry is experienced for axles, springs, tyres, and steel tools. Sales of agricultural machinery and implements are satisfactory. Billets are dull.

ALUMINIUM TUBES, SHEETS, WIRES, BAR, STRIP, AND RODS.—The British Aluminium Company, Limited, of 109, Queen Victoria-street, E.C., have issued a wall-sheet giving sections, thicknesses, weights, and areas of their productions, accompanied, in some instances, by comparison of similar weights of brass, copper, and steel. In regard to wire, the current it will carry, and the resistance per 1000 yards and per mile, are stated.

BRITISH RAIL EXPORTS.—The exports of rails from the United Kingdom in June were not so good as in June, 1913; but they were still considerable, coming out at 39,700 tons, as compared with 52,073 tons in June, last year, and 22,743 tons in June, 1912. Construction has slackened somewhat in Argentina, which only imported 18,832 tons of rails to June 30, this year, as compared with 26,451 tons and 22,997 tons. We sent 2881 tons of rails to Russia to June 30, this year, as compared with 25 tons and 36 tons respectively. The colonial demand has been as follows in the first half of the last three years:—

Colonial Group.	1914. tons.	1913. tons.	1912. tons.
British South Africa ..	40,416	33,984	21,267
British India	88,352	73,133	56,747
Australia	74,035	63,873	52,405
New Zealand	13,385	22,850	10,906
Canada	120	297	274

It is encouraging to find that construction is proceeding with some vigour in South Africa, and it may be reasonably expected that the demand for locomotives will improve in that quarter. The course of affairs in India leaves little to be desired; the growth of traffic has decidedly stimulated Indian railway development and improvement. There were apprehensions a few years ago that we should lose our Antipodean rail market, in consequence of the growth of American competition; but this development does not appear to be affecting our exports to Australia for the time being.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Though there has been a little set-back in the demand for iron during the week, the current quotation for Cleveland g.m.b. is in advance of that prevailing seven days ago. Active purchasing is, however, not the rule, buyers being in no way keen to place orders at the prices prevailing. Sellers keep steadily to the quotation of 51s. 6d. as a general rule, but the fact that some makers are very desirous to enter new orders on their rapidly-depleting delivery list is not forgotten by buyers, who are only taking what is needed to cover immediate and pressing wants. Shipments, too, are less buoyant, Connal's stocks having increased to approximately 80,000 tons. There is not likely to be any greatly renewed activity until after the holidays, when briskness in the Continental demand is hoped for. The quotation for Cleveland No. 3 g.m.b. is 51s. 6d. prompt delivery, at which price business is done, whilst warrants are 51s. 4d. cash buyers, with sellers asking 2d. more. No. 1 is 54s.; foundry, No. 4 quality, 51s. 3d.; No. 4 forge, 50s. 6d. to 50s. 9d.; mottled and white, 50s. 3d.—all for prompt delivery. There is a fair inquiry for hematite. East Coast mixed numbers change hands at 59s., with No. 1 sixpence more, either for prompt or forward delivery. Best Rubio ore, 50 per cent. quality, is at 17s., ex-ship Tees. Blast-furnace coke, medium quality, 17s. 6d. delivered at furnaces, but buyers are not keen.

Stocks and Shipments.—The stock of Cleveland pig-iron in the public warrant stores now stands at 79,747 tons—all of which is No. 3 quality. Since the beginning of the month the stock has been increased by 1458 tons. Shipments of pig-iron from the Tees are on a moderate scale. To date this month they average 2595 tons per working day, the total despatches being returned at 33,738 tons, 30,968 tons of which have gone from Middlesbrough and 2770 tons from Skinningrove. To the same date last month the loadings were given at 29,392 tons, or a daily average of 2260 tons, and for the corresponding part of July a year ago the clearances reached 44,762 tons, or an average of 3443 tons per working day.

Manufactured Iron and Steel.—In the manufactured iron and steel industries there is very little new to report. New orders are scarce, and works are only kept busy on contracts made some months ago. Principal market quotations stand:—Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 5s.; iron ship-plates, 6*l.* 15s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron girder plates, 7*l.* 5s.; steel bars (basic), 6*l.* 5s.; steel bars (Siemens), 6*l.* 5s.; steel ship-plates, 6*l.* 5s.; steel ship-angles, 5*l.* 15s.; steel boiler-plates, 7*l.*; steel joists, 6*l.* 12s. 6d.; steel strip, 6*l.* 5s.; steel hoops, 6*l.* 10s.—all less the customary 2½ per cent. discount; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.*; heavy steel rails, 5*l.* 15s. to 5*l.* 17s. 6d.; steel railway sleepers, 7*l.* 5s.—all net at works; galvanised corrugated sheets, No. 24 gauge, in bundles, 11*l.* 5s. f.o.b.—less 4 per cent.

Cleveland Miners' Wages.—To consider the question of wages to be paid to the miners during the ensuing three months, a meeting was held at Middlesbrough this week, between representatives of the Cleveland Ironstone Mine-owners, and the Cleveland Miners' representatives. Mr. A. F. Pease, who presided, said that the mine-owners sought for a reduction in wages of 1.20 per cent. The meeting was adjourned until the 27th, so that the matter could be placed before the miners.

CANADIAN PRECIOUS METALS.—Canada does not produce very much gold, but it is unmistakably rich in silver. In the first three months of this year the output of silver was 6,519,860 oz, valued at 3,549,566 dols. The production of gold was 61,032 oz., valued at 1,202,502 dols.

THE WORLD'S IRON ORE.—The output of iron ore in the principal countries of the world in 1911 was 87,836,000 tons. This total was made up as follows:—United States, 43,877,000 tons; Germany (including the Luxembourg), 29,399,000 tons; France, 16,372,000 tons; United Kingdom, 15,519,000 tons; Spain, 8,633,000 tons; Russia (excluding Finland), 6,882,000 tons; Sweden, 6,055,000 tons; Austria and Hungary, 4,640,000 tons; Canada, 188,000 tons; and Belgium, 148,000 tons. In 1912 the United States produced 55,150,000 tons; Germany, 32,190,000 tons; France, 18,744,000 tons; and the United Kingdom, 13,790,000 tons.

THE MIDLAND COAL-FIELD.—The Yorkshire and East Midland coalfield has exhibited of late great activity and expansion. The division comprises the East and West Ridings of Yorkshire and the counties of Lincoln, Nottingham, and Derby, except that part of Derbyshire which lies south of the Trent. It embraces the whole of the coalfields of Yorkshire, Nottinghamshire, and Derbyshire. The output of coal last year was 73,499,559 tons, showing an increase of 8,069,904 tons as compared with 1912. Of the whole quantity mined in the division, Yorkshire produced 60 per cent., Derbyshire 23½ per cent., and Nottinghamshire 16½ per cent. The proportion of coal produced last year by coal-cutting machines was 7,599,836 tons, as compared with 8,187,301 tons in 1912. Developments are still proceeding in the neighbourhood of Doncaster, and at no fewer than seven new collieries has sinking been started. In Nottinghamshire the hard-coal seam has been reached at the Rufford sinkings, and the Welbeck sinkings are making good progress. Eight miles south of Doncaster, a large venture, financed by German capital, has secured a mineral area of 20,000 acres and has started operations.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has shown little change. Best Admiralties have exhibited strength, but most other descriptions have been the turn easier. The strike of marine engineers has hampered loading operations to a slight extent. The best Admiralty large has been quoted at 20s. 6d. to 22s.; best secondary qualities have made 18s. 6d. to 19s. 6d.; other secondary descriptions have brought 17s. 3d. to 17s. 9d. per ton; best bunker smalls have made 10s. 6d. to 10s. 9d.; and cargo smalls have realised 7s. 6d. to 8s. 3d. per ton. Best household coal has been quoted at 19s. to 20s.; good household qualities at 17s. to 18s.; No. 3 Rhondda large at 17s. 6d. to 17s. 9d.; and smalls at 12s. to 12s. 6d. per ton. No. 2 Rhondda large has made 12s. to 13s.; and No. 2 smalls have brought 8s. to 8s. 6d. per ton. Special foundry coke has realised 25s. to 27s.; good foundry coke, 20s. to 23s.; and furnace coke, 17s. to 19s. per ton. As regards iron ore, Rubio has made 16s. to 16s. 6d. per ton upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

South Wales Coal.—In the South Wales division there were last year 609 mines at work, as compared with 622 in 1912. The total of 609 was made up as follows:—Breconshire, 25; Carmarthenshire, 65; Glamorgan, 392; Monmouthshire, 120; Pembrokeshire, 6; and Radnorshire, 1. The number of persons employed last year was 233,134, as compared with 225,535 in 1912. Of the 233,134 employed in 1913, the number working below ground was 198,123, and the number working above ground, 35,011. The output of coal in the area in 1913 was 56,830,072 tons, valued at 33,744,202*l.* The corresponding production in 1912 was 50,116,264 tons, valued at 27,891,043*l.* Of coal classified as anthracite the output last year was 4,833,159 tons, showing an increase of 480,149 tons. The output last year was 287 tons per person employed below ground, and 244 tons per person employed above and below ground. Of the total output, 242,978 tons were cut by electricity, and 396,741 tons by compressed air, coal-cutting machines being used in forty-one mines.

Minimising Fog Dangers.—The results of experiments conducted on the Canadian Northern Railway liner Royal George with a wireless direction-finder, were made known on a recent arrival of the vessel at Avonmouth. It is claimed for the invention that by its use, in the thickest of weather, and without the aid of compass or sextant, a ship's officers are enabled to determine her position when she is within a radius of 50 miles of a fixed wireless station or one on board a ship whose position is known. Further, should a vessel pick up on the apparatus the distress signals of another ship, she will be able to set her course towards their source.

Welsh Coal Shipments.—The shipments of coal, foreign and coastwise, from the five principal Welsh ports in the first six months of this year compared as follows with the corresponding shipments in the first six months of 1913:—Cardiff—foreign, 9,543,232 tons, as against 9,521,698 tons; coastwise, 1,407,250 tons, as against 1,401,130 tons. Newport—foreign, 2,272,617 tons, as against 2,349,787 tons; coastwise, 355,621 tons, as against 357,671 tons. Swansea—foreign, 1,605,242 tons, as against 1,709,549 tons; coastwise, 179,275 tons, as against 192,678 tons. Port Talbot—foreign, 778,553 tons, as against 981,197 tons; coastwise, 57,684 tons, as against 69,173 tons. Llanelly—foreign, 132,911 tons, as against 110,702 tons; coastwise, 40,843 tons, as against 29,407 tons. The aggregate shipments, foreign and coastwise, for the first half of this year were accordingly 16,373,228 tons, as compared with 16,722,992 tons in the first half of 1913.

Aberavon.—At the last meeting of the water-works committee of the Aberavon Town Council it was reported that the water in the reservoir was 17 ft. below the bye-wash, and that the committee was now procuring 111,000 gallons per day from the Ystradfellte supply of the Neath Rural District Council. The surveyor said the Neath District Council was prepared to supply a maximum of 220,000 gallons per day, and that the cost would be 500*l.* per annum. It was decided to ask the Neath District Council for a maximum supply. The surveyor was also instructed to report on the question of sinking a well on the moors.

An Engineering Appointment.—Mr. Alaric Hope has been appointed chief engineer of the Cardiff Railway, in succession to Mr. H. S. C. Ree, who has retired. Mr. Hope has for many years been chief assistant engineer to the Mersey Docks and Harbour Board. He will take up his new duties early in August. Mr. Hope is forty-two years of age, and he became associated with the Mersey Docks and Harbour Board in 1895.

SHIPPING IN THE SUEZ CANAL.—The increase in the size of vessels using the Suez Canal is an important feature. This tendency has been marked for some years, but the increase in 1913 was unusually large, the average tonnage rising from 3774 tons in 1912 to 3940 tons.

LOCOMOTIVE CONSTRUCTION IN BELGIUM.—The Administration of the Belgian State Railways has let contracts in three lots for sixty-eight locomotives. Fifteen Belgian firms took part in the competition. The Hainaut Metallurgical Works tendered for sixty eight-wheel coupled locomotives at 2732*l.* per engine. The St. Leonard's Company tendered for six engines at 2736*l.* per engine. The highest tender received was that of the Bousau Construction Workshop Company, which offered to supply four locomotives at 2758*l.* per engine. The John Cockerill Company obtained an order for four compound engines with four cylinders and six wheels coup'ed.

INTERNAL-COMBUSTION ENGINES FOR MARINE PURPOSES.

(*For Description, see Page 99.*)

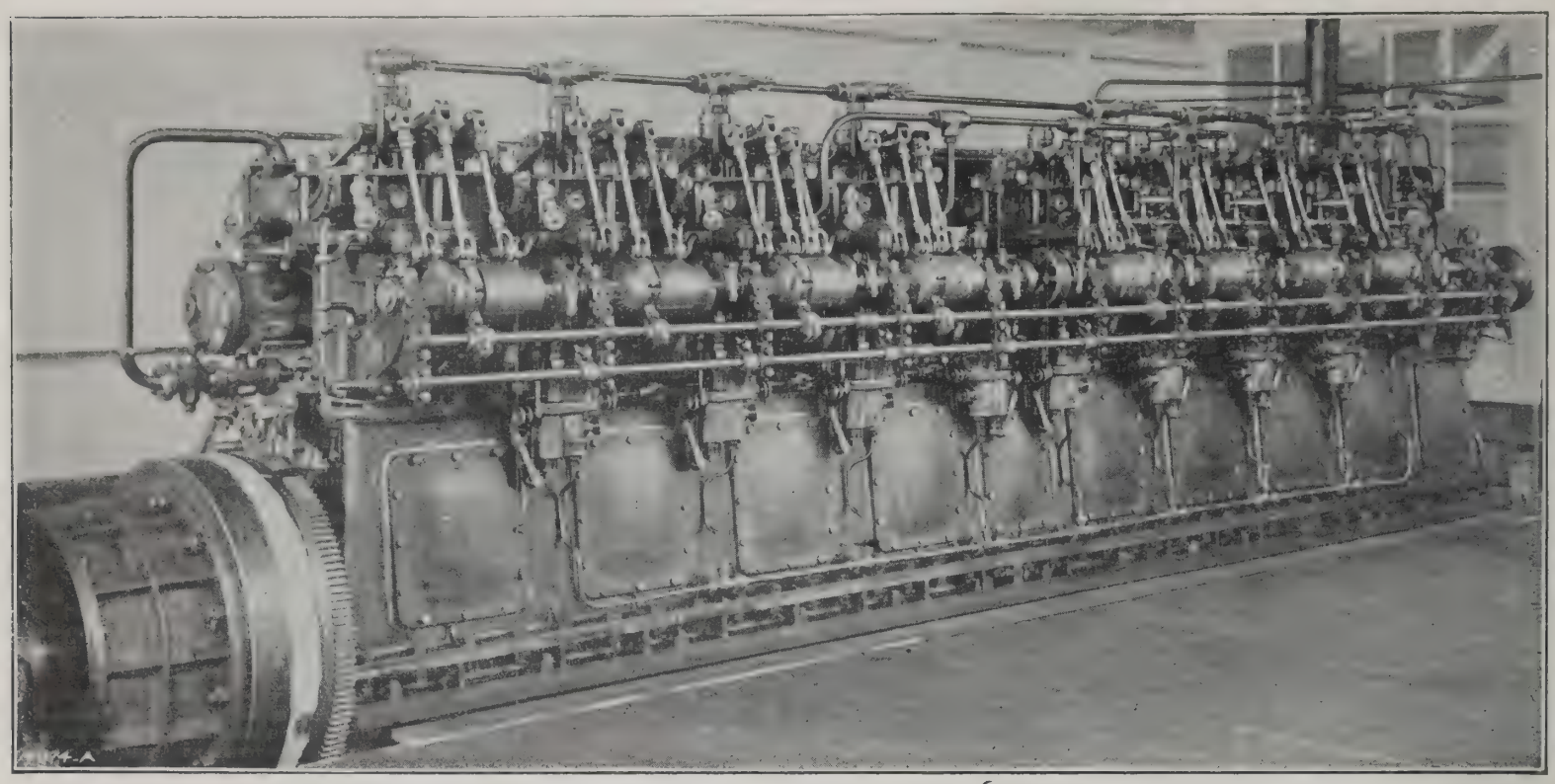


FIG. 1. FOUR-STROKE-CYCLE OIL-ENGINE; 360 BRAKE HORSE-POWER, SUBMARINE TYPE.

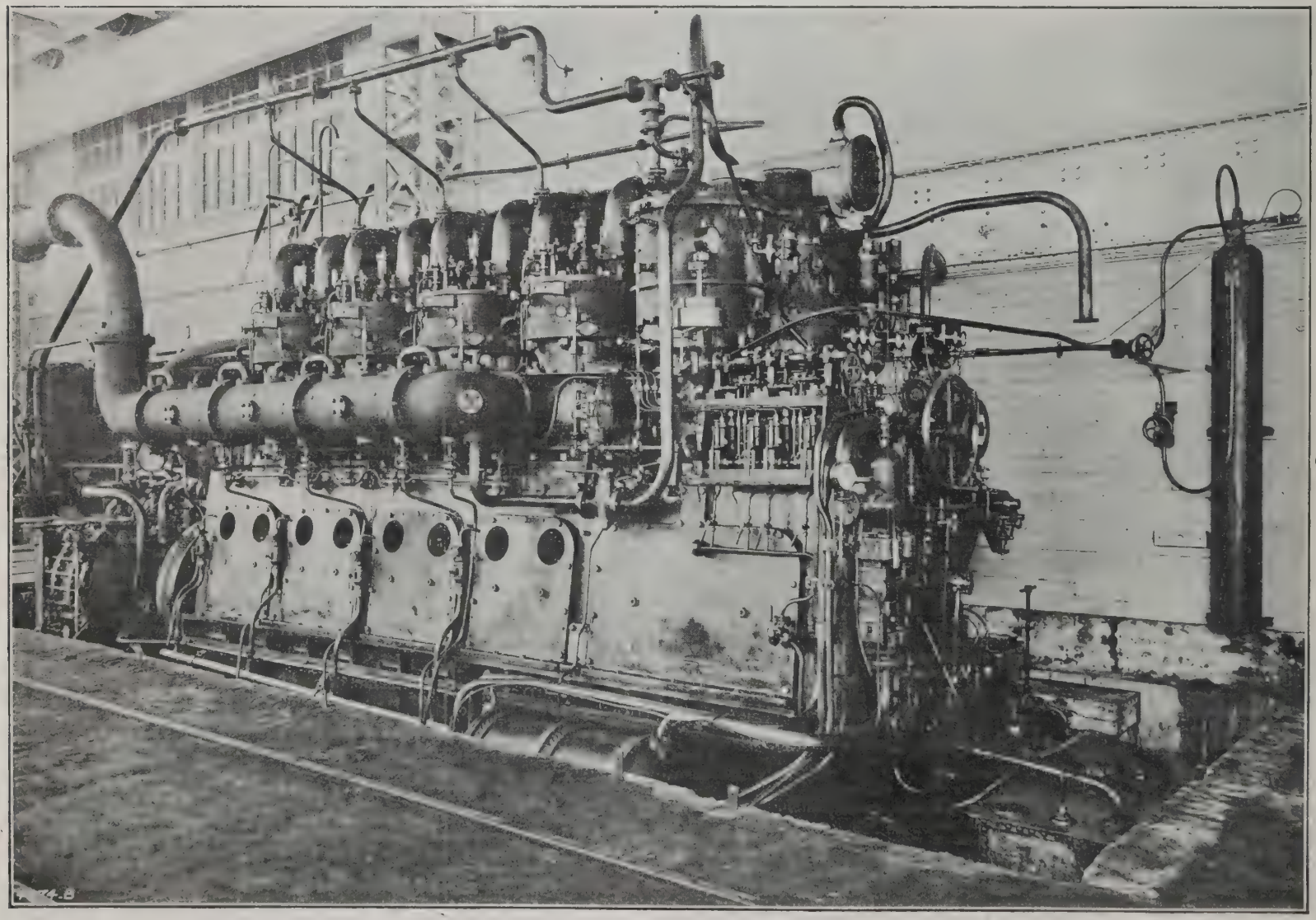


FIG. 2. TWO-STROKE-CYCLE FOUR-CYLINDER STARBOARD ENGINE, 900 HORSE-POWER, FOR THE CARGO-BOAT "FRANCE," 6500 TONS.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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NOTICE OF MEETING.

THE JUNIOR INSTITUTION OF ENGINEERS.—July 20, at 7.45 p.m. Meeting of the North-Western Section at Java Café, 26, Corporation-street, Manchester, Mr. Elam Eaves on "Gassing."

ENGINEERING.

FRIDAY, JULY 17, 1914.

INDUSTRIAL PROFITS AND EXPERIMENTAL RESEARCH.

THERE can be no question about the decrease in the volume of trade in practically every industry. Lloyd's Return shows a diminution of 14 per cent. in the tonnage of the merchant ships in course of construction now as compared with a year ago, and, as there has been a great falling-off recently in the orders placed, the work in hand is in a much more advanced state than was the case at the former date, so that the tonnage, from the standpoint of employment still available, is considerably less than the percentage of the decrease indicates. Moreover, freights are low, and shipowners are indisposed to place orders unless under the most advantageous conditions. Many of the iron works are closing down part of their plant, as they experience great difficulty in keeping their order-books sufficiently full to justify reliance on the future. The Board of Trade Returns tell the same story, for the exports each month show a great decrease when comparison is made with the corresponding months of last year, the decrease for June being 6.9 per cent. In the textile industry, again, there is a prospect of short time being resorted to in order that the plant may be run in full working order, since the closing down of part of the producing machinery involves a diminution in the efficiency of the power plant. The future is therefore, on the face of it, somewhat disheartening, particularly as in no period of decline of activity has there been such keen cutting of prices. This is due in large measure to the fact that foreign countries are able to-day not only to meet a larger proportion of their own requirements, but are themselves entering into markets which hitherto have been regarded as exclusively the field of British enterprise. Indeed, in some cases Continental firms are underbidding British producers even in this country.

Such a condition is not altogether without some advantage, because it carries with it a lesson which ought to be enforced on every available occasion, and that lesson was very happily expressed by Sir William Beardmore on the occasion of the launch of the light armoured cruiser Inconstant some days ago. He stated that "the nation which does not continuously search for improvements must fall behind in the struggle for supremacy." In this matter it is not alone the capitalist who requires to assimilate the teaching of the experience of decadent trade. The workmen, and the leaders of the workmen's unions, must analyse the situation, because on the lessons which can be gathered from it depend in no small measure the encouragement to evolve improvement, as well as to adopt better methods and appliances. Usually, when trade is brisk, when orders arrive in satisfactory volume, and when it is possible to distribute over a wide area of production establishment and other recurring charges, the main idea is to meet demands for delivery—to ensure the maximum turnover in any given time. Volume is then the main idea in securing a reasonable return. But volume itself requires a large body of workers, and, unfortunately, the crude principle of supply and demand dominates the question of the remuneration of labour, and, through this, the cost of production and the amount of profit derivable from a given contract. Although it is admittedly in accordance with the tendencies of uncultured human nature, it is, nevertheless, to be deplored that a certain class of workmen will only put in a sufficient time at work to earn enough for their immediate needs. The trouble which the employers have experienced, not only in meeting contractual dates, but in achieving a satisfactory degree of efficiency from power plant and other producing mechanism, arises from the reduced number of hours which such mechanical appliances are in operation during each week. It follows, therefore, that the employers are not encouraged to improve their mechanical methods, since every improvement made will involve increased capital expenditure, and, therefore, a greater call for return on capital, while the men cannot be relied upon to utilise the plant to its highest producing capacity. At no time is this lesson more important than at present, when every effort must be put forth in order, as Sir William Beardmore pointed out, to obviate Britain falling behind in the struggle for supremacy.

In periods of great industrial activity there is little time and less mental effort available for the development of new ideas and the prosecution of experimental research. It is consequently well, in the interests of applied science, that we should have some relaxation from that intensity of work which falls not only upon the designer, but on the manufacturing managers of our great industrial concerns. The field is wide, and the need great, for effort in such directions. Sir William Beardmore, however, with that directness of attack which is characteristic of him, not only in his manufacturing methods, but in his few public utterances, put his finger on the difficulty in connection with this original research. "Experiments," as he pointed out, "cost much money, and yet it is of vital importance that experimental work should be encouraged, and unless a reasonable profit is made on all work there is less financial surplus to make such experiments, so that, apart altogether from the need to remunerate labour, and to give a return on the capital invested on plant which must be maintained in the highest efficiency at whatever cost, each contract should yield a sum for making progress." On this, indeed, depends our manufacturing supremacy. The question arises whether during the past great boom in trade sufficient profit was made to enable experimental work to be continued during the succeeding relaxation in output. Those firms who have not been making a profit, or who have been foolishly distributing their profits to the last pound, must experience a great disadvantage even immediately, and this must become more intense as the keenness of competition develops during depression in trade.

It is not without interest to glance briefly at the directions in which improvements must be effected, not only in production, but in methods of manufacture. Sir William was able to point with a large degree of satisfaction to the advances signalised in the design of the light armoured cruiser Inconstant, which his firm have just launched; and the First Sea Lord, Prince Louis of Battenberg, who was present at the launch along with his daughter, who christened the ship, pointed to the Beardmore Works as a notable example of continuous progress due to experiment and enterprise. Sir William pointed out, for instance, that the guns with which the vessel is fitted have five times the muzzle energy of those of the same size and weight available twenty years ago, while the improvement in projectiles gives them a still greater penetrative power. The armour, again, although the weight per square foot is only about one quarter, is of greater resisting power than that of twenty years ago. From each ton of machinery it is possible to get four times the horse-power for driving the ship as compared with fifteen years ago. Again, in respect to the structure of the ship and the armour, the improvements made are of still greater moment. The hull itself is of high-tensile steel, and the armour, made of steel of special constituents, and treated afterwards in processes recently evolved, is the result of a great amount of chemical and mechanical experiment made at the Parkhead Works and elsewhere. But for this experimental work in metallurgy, chemistry, and mechanical engineering, such vessels as the Inconstant could not have been built to-day.

One hears a great deal about the price paid for armour, but when one reflects on the enormous expenditure incurred in evolving new compositions and processes of heat and other treatment, the public must feel that the money is well spent. At the present moment the naval officer shows great anxiety regarding the protection of battleships. Mr. T. G. Owens' paper at the Institution of Naval Architects in April last, Sir John Biles's paper at Newcastle last week, and Sir Percy Scott's letters in *The Times*, all reflect this feeling of anxiety. Into the general controversy as to the part to be played relatively by the surface and submerged craft we do not propose again to enter, but there is undoubtedly a great consensus of opinion in favour of the battleship as our mainstay, because, as Lord Charles Beresford has pointed out, the submarine is essentially a weapon of defence, and British naval tactics must be offen-

sive. Consequently the surface vessel, and particularly the battleship, is of vital consequence to our naval supremacy. At the same time the battleship must be protected from the torpedo, the weapon of the submarine-boat. Whether this can be best done by placing armour on the outer surface of the ship below the water-line, or by constructing a series of internal armoured bulkheads, longitudinal and horizontal, as advocated by Mr. Owens, the fact remains that armour of effective resisting power, and yet of light weight, must be evolved, preferably of the "elastic" type. That being so, it is important that the armour-plate makers in this country, who have ever been to the forefront in the evolution of improvements, should be encouraged if our battleships are to be able to resist attack by the submarine-boat's torpedo.

It is, however, not alone in respect to war material that research should be made. In peace productions there is a wide field for advance. We are glad that in respect of metallurgy a new wave of enthusiasm has swept over the country as reflected by the papers at the technical institutions, and it is gratifying to know that even in establishments devoted to the building of tramp-steamers there is a fuller recognition of the importance of laboratory work in connection with iron and steel castings, while in other directions the composition of alloys is now being attacked with some degree of knowledge in chemistry and metallurgy. Indeed, the structure of metals is now accepted as a matter of primary importance. Again, in the field of thermodynamics the effect of superheating is being closely considered, and by experiment and careful observation in service improvements are being effected not only in the superheater itself, but in the condenser, in order to reduce the volume of saline in the feed-water. The system will certainly be more widely applied, its economy being now fully recognised. Another field in which experience is becoming more widely garnered has reference to the application of gear between the high-speed turbine and the slow-running propeller, and here again great advantage must accrue. On the care and capacity of the sea-going engineer, indeed, much more depends than is sometimes realised, and the more the steamship-owner encourages in his own staff observation and careful analysis of results, the greater will be the economy in service and the more valuable the experience utilisable in the design of ships and their machinery. Few engineers, for instance, realise how great is the waste that any steam leakage involves, owing to the steam required for the make-up water. Many other similar instances will occur to the reader in which the leisure which is certain to result from decreased activity in trade may be utilised to introduce improvements and to effect changes in methods of manufacture, so that in the future competition can be met not only by superiority in design, with a view to higher efficiency in service, but by higher economy in the workshop processes. We admit that the "fly in the ointment" is the working man and his organiser; but, even with this depressing disadvantage, the scientist must move forward, and, as far as is possible, carry the working man with him.

CATALONIAN TEXTILE INVENTIONS.

IT is a curious coincidence that just now when the interest of the textile industry—particularly the spinning branch—has been aroused by information relative to a new method of drafting cotton roving emanating from Catalonia, an essay on the Bergadana spinning-machine, one of the earliest types, should be published. The Catalonians have been recognised as extremely progressive in the advancement of the textile industry, and quite a number of important textile inventions have been evolved in the district around Barcelona. The essay* referred to deals with the history, construction, and operation of the Bergadana or Maxerina spinning-machine, which was really an improvement on Hargreaves' spinning-jenny. Hargreaves' machine, invented in 1764, was the first attempt to draft and spin a number of threads at one and the same time. The machine, although manually operated, was semi-automatic in its action, and certainly advanced the production of cotton-yarn very considerably. Essentially it consisted of a framework supporting a large driving-wheel turned by hand, which operated a tin roller, which, in turn, drove a series of upright spindles through bandings passing round the tin roller and the spindle wharves. Running along the top of the framework, in special grooves, was a wheeled carriage, provided with cross-bars placed one above the other and having grooves parallel to the frame sides. The cotton-roving was carried on bobbins placed on creel-pegs about the centre of the framework. This roving was drawn from the bobbins through the parallel grooves, and then practically in a straight horizontal line to the spindles. The grooved cross-bars were operated to trap the roving at certain times and to prevent delivery. The operation of the machine was simple. After the rovings had been drawn

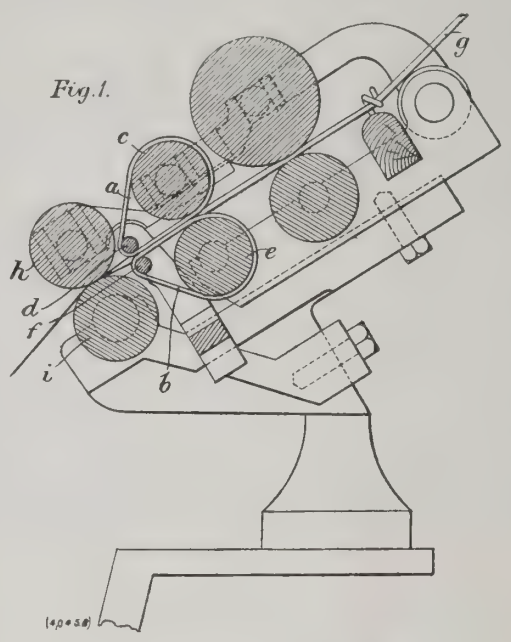


Fig. 1.

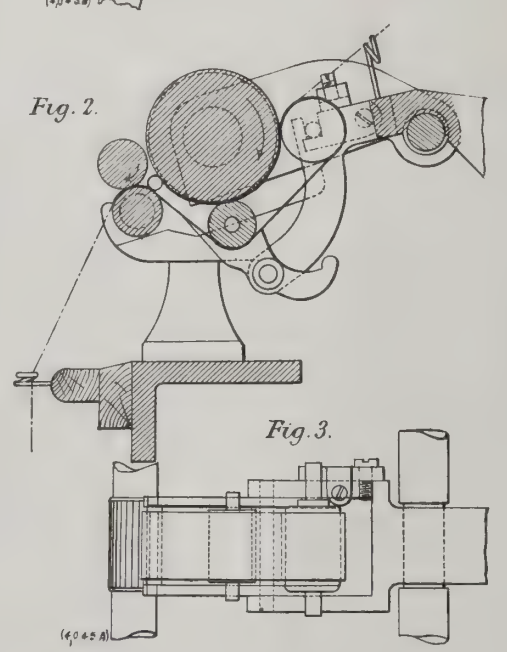


Fig. 2.

Fig. 3.

into position and attached to the spindles, the carriage was moved out by hand away from the spindles in a very similar manner to the way a carriage of a self-acting mule operates to-day. When a certain position was reached the cross-bars were closed, and the roving between the cross-bars and spindles was thus held. The handle and driving-wheel were then turned to rotate the spindles, and at the same time the carriage was moved outwards again, so that a simultaneous draft, or attenuation, and twist were imparted to give the desired fineness.

The Hargreaves frame had only a comparatively small number of spindles, about 40 or 50. The improved Bergadana machine had, however, some 130 spindles, and as the frame could easily be operated by a woman, the production per machine was considerably increased. Moreover, both warp and weft yarns could be produced equally well on the improved machine; but one drawback was that the cops produced could not go direct to the shuttle, but had to undergo a process for rewinding on a special winding-frame. Several variations between the original and improved machines are to be noted. In the latter, the drive of the tin roller was through gearing, whereby one revolution of the driving-wheel secured 315 revolutions of the spindles. The carriage, instead of being drawn out by hand, was dependent on the force of gravity of a single counterweight attached to either side of the carriage, so that even, regular movement was secured. The spindles were also mounted in a much better fashion, and the first attempt at really efficient lubrication was secured by employing a spindle-rail, with slots for the spindles and a strip of iron below, the slots being supplied with olive oil, the surplus dripping on to the iron strip. Two tiers of creel-pegs were necessary to support the roving bobbins. Means were also provided to tighten up the spindle-driving bands, such means being extremely simple, yet at the same time quite efficient. The faller-wire, which was arranged adjacent to the spindle, should not be overlooked. This wire, extending from side to side of the frame, was depressed when drafting and twisting was completed to guide the thread to the part of the spindle on which it had to be wound. In the Bergadana machine the method of operation was much simplified, and certainly reduced the work of the operative; in fact, the whole machine was evidently improved to secure greater production with less labour. Arkwright's spinning-frame, in which rollers and constantly-revolving spindles were used, saw the light in 1769. In this frame the drafting—or reduction of the number of fibres to the cross-section—was accomplished by pairs of rollers running at different rates of speed. The combination of the two methods—namely, the drafting by rollers and by a carriage carrying spindles moving out from the delivery of the material—was made by Samuel Crompton about the year 1779, the machine produced being termed a "mule," because of its hybrid nature. Recently what was stated to be a new method of drafting sliver and rovings in spinning-frames has been introduced in Catalonia. It must be understood that prior to the roving reaching the spinning-machines it passed through three speed-frames, a slubbing, intermediate and roving-frame, the whole object of these machines being to reduce the number of fibres to the cross-section of the material. The inventor of the new system, Don Casablanca, states that he can do away with two of these machines, and obtain a draft of 60 or 80 in the mule or ring-frame, and, at the same time, produce an even and regular yarn. His latest method of accomplishing this is illustrated in Fig. 1. It will be noted that endless bands *a* and *b* are employed, running round rollers *c* and *d* and *e* and *f*. These endless bands travel slowly, and the roving *g* passes between them. The front rollers *h* and *i* travel quickly, and the considerable drafting is occasioned by the creeping action of the fibres set up between the endless bands. The method is simple; but although it is stated to give excellent results, no full-length machine has yet been put to work. Naturally, the very big claims made for the Casablanca invention have evoked criticism, the most searching being that of Mr. Albert Meyer in *L'Avenir Textile*. Mr. Meyer's contention is that in 1903 he invented the system shown in Figs. 2 and 3, in which a single endless band was used. After continuous experiment, the invention was abandoned, chiefly because the cost of upkeep of leather bands was so considerable, 40,000 being required in an average-sized mill. Casablanca would require 80,000, and, moreover, he cannot get at his bands so easily as Meyer, the whole of the bottom rollers, 87, requiring to be taken out to replace one band. Meyer allowed for this by having a swing-piece which carried the rollers supporting the endless band. As the leather bands are the chief essential of the invention, it would appear that the system will be a costly one to maintain, and, moreover, great difficulty has been experienced in keeping the fibres in the centre of the bands.

* *Essay on the Catalan Cotton-Spinning Frame, known as the Bergadana or Maxerina Machine.* By Ramón N. Soler y Vilabella. Barcelona: J. Horta.

THE PORT OF CALCUTTA.

THE issue of the Report of the Calcutta Port Inquiry Commission is an event of no little significance to the trading community which it immediately concerns, while at the same time it is a matter of considerable interest to commercial and professional men generally, and especially to those in shipping circles. The congestion of trade at the premier port of the Indian Empire is bound to have a disturbing effect over a very wide area, apart from the consideration that during the past few

years it has become only too evident that the inability of the Port Authority to cope satisfactorily with an ever-increasing volume of commerce was seriously impeding the growth and development of the port, and undermining its prosperity. The situation has, in fact, become so intolerable and acute that immediate steps to deal with it are imperatively demanded.

Following upon some preliminary discussions with the Bengal Government, a conference of representative non-official gentlemen and railway expert authorities, summoned by the Bengal Chamber of Commerce, in August of last year, strongly advised the appointment of a Committee of Investigation, and the following seven gentlemen were ultimately invited to serve :—Sir Wm. Duke, K.C.I.E. (Chairman), Sir Henry Burt, K.C.I.E, the Hons. A. M. Monteath, J. C. Shorrock, and Raja Reshee Case Law, C.I.E., Mr. Anthony G. Lyster, and Mr. H. I. Howard, C.I.E., with Mr. R N. Reed as secretary. With the exception of Mr. Lyster, the President of the Institution of Civil Engineers, all the members had close association with the port of Calcutta and the Province of Bengal, and were intimately acquainted with local needs and conditions.

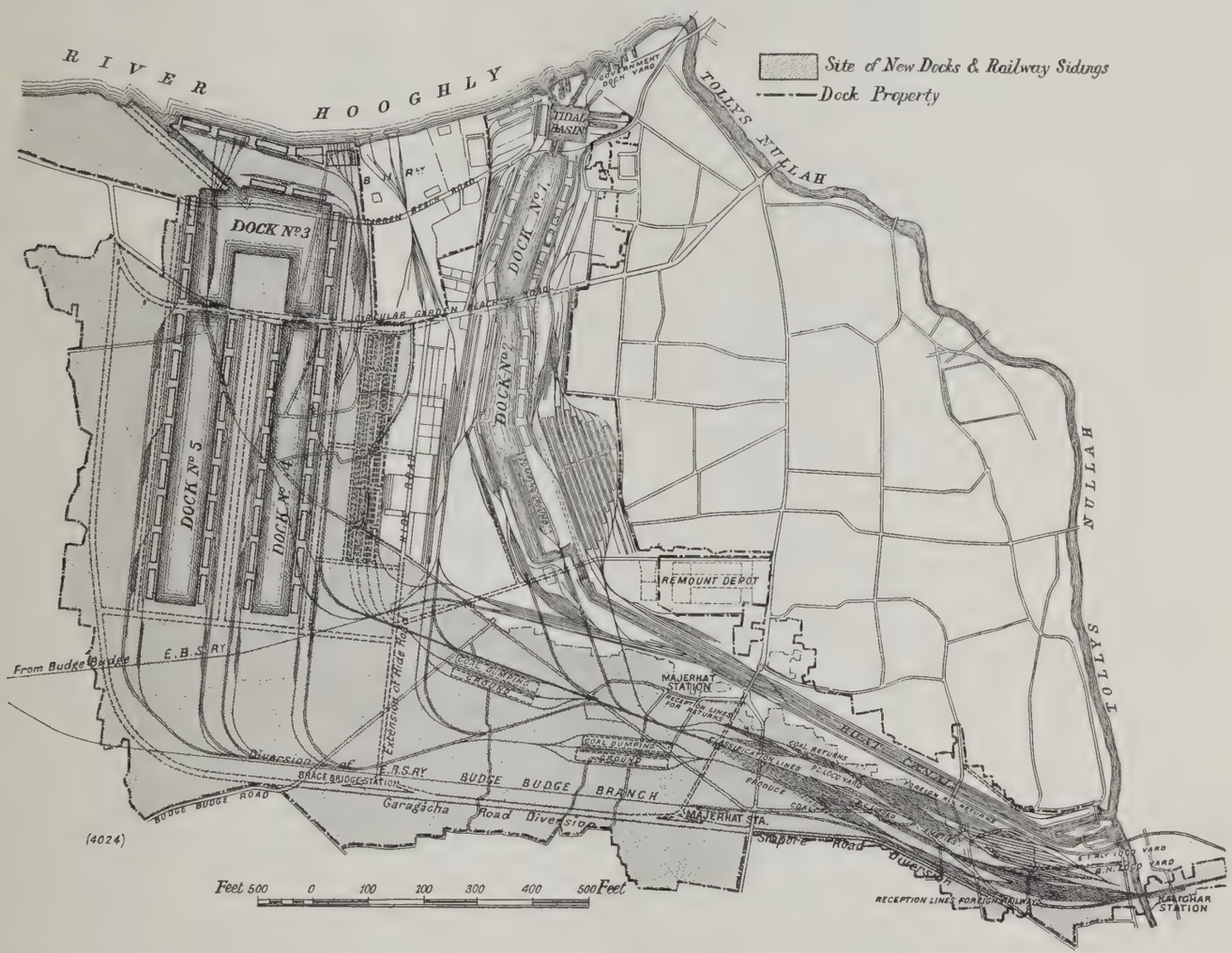
This is not by any means the first occasion in the recent history of the port on which a commission has been appointed to deal with the ever-recurring problem of trade expansion and the extension of shipping facilities. On the contrary, there have been many such committees — they have been an invariable resource in times of perplexity — and the only regrettable experience in connection with them is that they have not always proved an effective remedy for the evils they were called upon to palliate. This has not been so much the fault of the Committees as of the authorities, who, on receiving the Committee's recommendations, have pigeon-holed them as the most convenient form of disposal. As far back as 1846 a Commission recommended the construction of a dock for shipping at Kidderpore, but no action in this direction was taken for forty years, although many Committees sat and debated in the interval. Quite recently there were Committees in 1900-1 and in 1903, whose conclusions were merely of a negative character. A special "inquiry" of 1905 resulted in definite recommendations to the Government, which never materialised ; had they done so, the present investigation would not have been required. It remains to be seen whether the proposals now put forward are destined to meet with any more favourable fate than that of many of their predecessors.

The report is a lengthy one, comprising 75 pages of folio size. It would be impracticable to deal with all the points raised, and some of them are purely commercial and of merely local interest. The Committee covered a good deal of ground in the course of their investigations : organisation, finance, tolls and charges on goods and vessels, railway terminal payments, and the like. Apart from these, however, there is a technical side to the report, dealing with port improvement schemes, and this is the feature which will appeal most strongly to engineers. For reasons of space, if for no other, we must confine our observations to this section.

Sea-going shipping at Calcutta has hitherto been accommodated either at jetties in the River Hooghly or at the Kidderpore Docks. The river jetties consist of eight berths, with an aggregate frontage of 4150 lineal feet, furnished with sheds and warehouses for dealing with the import trade. A ninth berth, with a frontage of 585 lineal feet, is now nearing completion. The Kidderpore Docks, dating from 1892, contain seventeen berths for general produce and ten coaling-berths. There are also thirty-four transit and storage sheds, with a total floor area of over 1,000,000 sq. ft. The jetties have been particularly conspicuous for the degree of congestion prevailing along their frontage, and for the inadequacy of their facilities for the discharge of cargoes. Only four of them can accommodate vessels of 500 ft. length and over, and only three are so constructed as to render it possible to dredge with safety alongside to a depth of 25 ft. below lowest low water. The other five cannot be dredged to a depth greater than 13½ ft. below low water. Moreover, the constant dredging operations which are necessary, seriously interfere with the occupation of the berths by shipping, and they are largely rendered abortive by the slipping forward of silt from the banks within the jetty face.

At the docks the defects are in regard to insufficiency of accommodation and an unsatisfactory entrance arrangement. The quayage of Dock No. 1, which was formerly adequate for twelve vessels, now only suffices for eleven, and sometimes for ten. With the steady growth in the size of vessels (the average length of the ten largest vessels frequenting the port has increased by 100 ft. since 1880) the berthage will become more and more restricted, and the available accommodation correspondingly diminished. The defects of the entrances are even more serious and vital. There are two entrances—one a lock, 60 ft. wide, with a length of 400 ft. between gates, and the other, a simple entrance, 80 ft. wide, with a single pair of gates. Both are inadequate for the needs of modern shipping. The average beam of the ten largest ships using the port is 57 ft. 9½ in., which leaves an insignificant margin of width in the lock, while its length (despite the fact that by an ingenious contrivance of caissons it can be rendered serviceable to a maximum extent of 510 ft.), is quite insufficient for vessels even of moderate size, which are being built at the present day. The 80-ft. entrance lies at right angles to the stream, and can only be utilised at times of slack water, and then merely to a nominal extent, as, except on the few occasions on which the flood tide approaches the level of the water impounded within the dock, there is an excessive loss of water in passing ships in and out. There is at least one case on record where a vessel, too large for the 60-ft. entrance, was seriously delayed at the 80-ft. entrance. The sills of both entrances only give at lowest low water a depth of 19 ft. 6 in., although the docks themselves are suitable for vessels with a draught of 33 ft.

The shortcomings of the docks and jetties were recognised long ago, and the recommendations in



regard to dock extension put forward in 1906 by the then chief engineer to the Calcutta Port Trust (Mr. F. Palmer, C.I.E., subsequently Chief Engineer to the Port of London Authority, and widely known as the author of the "Proposals for the Improvement of the Port of London"), are practically identical with those which now receive the approval of the Commission. The scheme, as will be seen by the plan on page 93, comprises a new dock system on land which has already been acquired in the vicinity of Garden Reach, consisting of a turning basin or main dock, with a minimum dimension of 1000 ft., and two arms or branch docks, running approximately north and south, with widths of 600 ft. and 700 ft. respectively. The depth of the dock is fixed at 35 ft. The entrance is designed to allow continuous docking and undocking of vessels throughout the twenty-four hours. It is proposed that the lock shall have a length of 1200 ft., divisible into two sections of 700 ft. and 500 ft., by which it will be possible to pass either one or two vessels through the lock at a single operation, with a corresponding saving of time and of water. The width proposed is 90 ft.; in proportion to the length this seems somewhat meagre, especially in view of the tendency of naval architects to increase the ratio of beam to length. In Mr. Palmer's scheme the width was given as 100 ft., and this is certainly preferable. Widths of 100 ft. or over have been adopted at London, Liverpool, Newport, Avonmouth, and Bombay, and in the Panama, Kiel, and North Sea Canals. It cannot, therefore, be deemed an excessive allowance for future developments. The Commission's attitude on this point is the more strange, in that they fully recognise the necessity of avoiding the mistake made in the case of the existing entrances, where they expressly state that "expansion to meet the future growth of vessels has been restricted by cramped conditions." The docks are to be equipped with the usual sheds, and railway sidings and connections. No graving docks are shown on the plan accompanying the report, but it is understood that two are contemplated to be provided in the position shown in Mr. Palmer's plan of 1906—*i.e.*, at the end of the tongue between the arms.

The recommendations of the Commission involve an immediate expenditure approximating 3,000,000*l*. The Commission advocate the inception of the new dock, comprising its entrance and five internal berths, together with five riverside berths at Garden Reach, a distributing dépôt at Beliaghata for the delivery of imports from the docks, an enlarged junction yard for the reception and despatch of railway traffic, and the realignment of the Budge-Budge branch of the Eastern Bengal State Railway. The Commission are of opinion that it would be unwise to incur any large outlay in developing the present jetties, and their observations in this respect are confined to suggestions for relieving the congestion by more efficient service and attention to detail, until such time as the additional berths are available. They make several comments also upon the arrangements at the existing docks, more particularly in regard to the coal trade.

The navigable channel has not been overlooked, and there is a reference to the river approaches, the view being expressed :—(*a*) That the prosperity of the port will depend upon its capacity to receive the size and draught of vessels which navigate the Suez Canal, a condition involving a very considerable advance in the measure of improvement in the river approach channel ; (*b*) that it will be unwise to rest satisfied with a more or less empirical system of dredging as the sole means of river improvement ; and (*c*) that expert opinion will be necessary to solve satisfactorily the physical and economical problems which present themselves in connection with the improvement.

Apart from the immediate concerns of shipping and port accommodation, the Commission dealt with several questions of an engineering character, affecting the town and its external communications. They examined, for instance, the proposal to reconstruct the Howrah Bridge, and they endorse the demand for the construction of a new and much wider road bridge over the Hooghly, on the site of this existing bridge. They further recommend that a new railway bridge, providing more direct access to the docks, should be constructed within the next few years.

Such are, in brief, the principal conclusions of the Report. That, at a very early date, steps will have to be taken to improve, on very extended lines, the accommodation and facilities of the quays at the port of Calcutta, if it is to maintain unimpaired its prestige and commercial standing, is a proposition which no longer admits of any controversy, and with the representations of a highly competent body of professional and commercial men before them, the Government can hardly defer taking action. The report is, however, not merely the expression of the personal opinions of the signatories ; it reflects the views entertained by the majority of those interested in the port and its welfare. It devolves, therefore, upon the Port Trust to press the matter forward for immediate decision in order that they may continue to deserve the encomium passed upon them by the Commissioners, who affirm their conviction that the Trust "have developed their property, generally speaking, on sound lines, and with a zealous regard to the best interests of the Port."

DECREASED ACTIVITY IN SHIPBUILDING.

LLOYD'S Returns, just issued, show that, including merchant and war ships, there are in course of construction at the present time 567 vessels, aggregating 2,314,669 tons. This is 8.8 per cent. less than at the same date last year, notwithstanding that there is an increase in the number of warships now being built. It must be noted, moreover, that many of these warships have reached an advanced state of construction, and that, from the pure shipbuilding point of view, little remains to be done, many of them depending altogether on the completion of the guns, armour, and propelling machinery. Indeed, within the next three or four months there will be passed from the private shipbuilding works to the respective navies seven battleships, including the Turkish battleships Osman I. and Reshadieh, the British battle-cruiser Tiger, and the British battleships Benbow, Warspite, Queen Elizabeth, and the Emperor of India. Such a list, apart altogether from small war craft, will make a big difference in the total warship tonnage on hand. Thus, although Lloyd's list shows that 90 war vessels, of 592,545 tons, are building, these do not represent such a volume of work as the tonnage would seem to show. This applies in equal measure to the merchant shipping. Of merchant vessels there are 477, of 1,722,124 tons, in course of construction. When compared with a year ago, this total shows a decrease of 281,000 tons, and, when compared with fifteen months ago, when the total reached the maximum at any period in the history of shipbuilding, there is a decrease of over 331,000 tons. Thus the fall from the highest point is 16 per cent., from the figure of a year ago 14 per cent., and from the total of three months ago about 8.9 per cent. All the vessels are in a more advanced state than was the case three months ago, as, owing to the fewness of orders placed recently, there is less work to do in the shipbuilding yards of the United Kingdom. The figures of work now in progress, with those of a year ago, are given in the accompanying table :—

	July, 1914.		July, 1913.		Increase or Decrease.
	No.	Tons.	No.	Tons.	
					per cent.
Merchant ships ..	477	1,722,124	543	2,003,241	−14
H.M.S. (private yards)	60	306,030	57	273,149	+12
Foreign warships (private yards)	16	152,145	17	129,300	+17.6
	553	2,180,299	617	2,405,690	− 9.4
H.M.S. (dockyards) ..	14	134,370	14	132,190	+ 1.5
	567	2,314,669	631	2,537,880	− 8.8

As regards the condition in the various districts, there is, so far as merchant work is concerned, a decrease all round, excepting only Liverpool, where there is an improvement as compared with a year ago, but a slight falling-off as compared with three months ago. The largest decreases are in those districts where general traders are built. As compared with a year ago, the biggest falling-off is in Sunderland, where the reduction is 27 per cent., the number of vessels on hand now being 45, of 172,103 tons. Greenock comes next, with a reduction of 24 per cent., the number of vessels building being 49, of 229,710 tons. Then comes the Tees, with a falling-off equal to 23 per cent., there being in the yards now 42 vessels, of 82,504 tons. The Tyne on the other hand, has a decrease of only 8.7 per cent., the work there including 66 vessels, of 285,157 tons. At Hartlepool the reduction is only 3.5 per cent., the total vessels building numbering 19, and the tonnage 85,406 tons. Glasgow work, which earlier in the year had a slight rally, seems now to have dropped considerably, as the decrease since March last is equal to about 10 per cent., whereas when compared with a year ago the decrease is only 5.2 per cent. Belfast also seems to be suffering from the general depression, and here the 26 vessels, of 296,350 tons, in course of construction, mark a decrease of 18 per cent.

LITERATURE.

The Naval Annual, 1914. Edited by VISCOUNT HYTHE, D.C.L., A.I.N.A. London: William Clowes and Sons, 31, Haymarket, S.W. [Price 12s. 6d. net.]

THE "Naval Annual" appears this year about a month later than usual, owing to the fact that Lord Hythe has been devoting his time and energies to the furtherance of the federal solution of the great political question of the day. In his preface he states further that the duties of editorship have been in part undertaken by Mr. John Leyland and Captain C. N. Robinson. Lord Hythe has again to be congratulated on the maintenance of what is universally regarded as a standard work on current naval affairs. This is as it should be, because, apart altogether from the splendid traditions of the "Annual" established by Earl Brassey, and now maintained by his son, its publication is almost a necessary corollary of our position amongst the naval Powers of the world.

In the review of the progress of the British Navy, which forms Chapter I., Lord Hythe has had as collaborator Mr. Alexander Richardson, and the record is thoroughly comprehensive. It is again pointed out that two years is too short a period for the completion of the modern battleship, owing principally, as shown, to the resources of the armour-plate manufacturers being overtaxed, notwithstanding that there has been very considerable capital expenditure, not only to improve the processes of production, particularly hardening, but to augment the output. Within a few years the amount of armour required for each ship has increased from about 4500 to over 6000 tons, while the newer processes of treatment, whereby 10 to 15 per cent. has been added to the resistance to penetration by projectiles, involves longer time, more expert knowledge, and greater care. In the past two years one million sterling has been spent by each of two of the large firms, and to-day the annual output of the country is 65,000 tons. No other country in the world can equal this. Chief interest centres in the remarks made in regard to the policy of the Admiralty with reference to the overseas Dominions. The problem is one of great difficulty, because of the desire of the Dominions to have in their own possession, or within their territorial waters, ships sufficient to ensure their local defence; on the other hand, the claims of strategy require that ships should be in a position to attack the enemy if possible before he leaves his port. It must be confessed that there has been a considerable degree of vacillation on the part of the Admiralty ; irrespective of the wisdom of the policy decided upon at the Imperial Conference in London in 1909, there is some excuse for the Colonies insisting on its fulfilment. This policy required Australian, China, and East-Indian units for the Pacific, the idea being that the battle-cruiser New Zealand and a vessel of a similar type, as well as the battle-cruiser Australian, should be at the head of each of these respective units. So far as the two former ships are concerned, the arrangement has not been fulfilled, and there is some justification for the attitude taken up by Australia, who consider that, in addition to the vessels they have built, two cruisers of the "Town" class should be added from the Imperial Navy for Australian defence. As Lord Hythe points out, the whole problem of Imperial defence requires the earnest consideration of the statesmen of the Mother Country and of the overseas Dominions. Larger co-ordination of the efforts made is necessary, and it is to be hoped that the conference which will probably be held in 1915 will enable some agreement to be come to which will satisfy the desires of the Colonies, without interfering with the dominant needs of strategy. Lord Hythe

also makes the remark that "it is not reasonable that Canada should be defended at the expense of people who are being taxed out of their homes."

Mr. John Leyland is again responsible for the chapter reviewing the progress of all foreign navies. In this, as well as in the chapter on armaments by Captain Robinson, much interesting light is thrown on the policy of the various Powers regarding the gun-power of ships. First, as regards the calibre of the main armament, it is shown that several of the Powers have followed the British example by adopting the 15-in. gun; but it was only in the vessels of the 1913-14 programme that Germany adopted a gun of this size in preference to the 12-in. weapon. To-day Britain has ten battleships with 12-in. batteries, all complete; twelve ships with 13.5-in. batteries, of which ten are complete; and ten ships with 15-in. batteries, of which two have been launched. Germany, on the other hand, has four battleships with 11-in. batteries, all complete; thirteen with 12-in. batteries, nine being complete; while only two ships with 15-in. batteries have been laid down, and neither of these has been launched. The situation regarding battle-cruisers is equally illustrative of the progressive policy of our Admiralty. The United States in their battleships have adopted the 14-in. gun, and there is some talk of this year's ships being designed for eight 16-in. weapons. There is no indication of heavier guns than the 13.4-in. in the French Navy. Russia is fitting twelve 14-in. guns. The new ships for Italy are to have eight 15-in. guns, and Austria, like Germany, is adopting a similar armament. The 14-in. gun is being adhered to by the Japanese authorities in their latest ships. Of the secondary Powers, Spain in the new ships will probably fit eight 14-in. guns. Chili is adopting the 14-in. gun; Brazil, like the Argentine authorities, has adhered to the 12-in. gun, while it is probable that in the new Turkish ships the 13.5-in. or 14-in. gun will be adopted. The number of guns being fitted generally varies with the calibre; with the adoption of the 15-in. gun, it is found preferable to mount only eight; with 13.5-in. and 14-in. guns, ten, and in a few cases twelve guns are being mounted, as is the case with the 13.4-in. guns in the latest French ships. On the question of the number of guns in each turret, there seems still to be a difference of opinion; it is somewhat significant, as pointed out by Mr. Leyland, that in the new Italian and the new Austrian ships the triple-turret system is to be abandoned, the twin-turret being reverted to. But the French, in the ships now in progress, have four quadruple gun-turrets; the Americans and Russians are adopting triple gun-turrets. The American design differs in this respect, that, while in all the other ships with multiple-gun turrets, the guns are arranged with their axes at the same height above the water-line, the Americans have adopted the principle, now common with twin-gun turrets, of having the No. 2 and No. 3 turrets at a higher level respectively than the No. 1 and No. 4 turrets, so that they secure an end-on fire, either forward or aft, of six 14-in. guns. There is, however, a growing desire to have all the guns at the same height and to have a flush deck.

In regard to secondary armament, the tendency is to have as many of the guns as possible for bow-on fire, because, as pointed out by Captain Robinson, a 30-knot destroyer attacking a 20-knot battleship, will approach, when they are steaming in opposite directions, at a relative speed of 50 knots. Under such circumstances there is less time for ensuring accuracy, and the deficiency must be made up by rapidity and volume. On the other hand, where a destroyer is chasing a battleship with a view to bringing her torpedoes to bear, the relative speed is only 10 knots, so that the gunners in charge of the torpedo-boat-repelling armament have then longer time to ensure accuracy, and a smaller number of guns suffices. The secondary guns now being fitted are generally of about 6-in. bore. In destroyers the tendency is to fit two or three 4-in. guns, although Germany still has its faith pinned to the 15-pounder.

The Editor contributes, as usual, a very carefully prepared analysis of the comparative strength of the fleets. He points out that the balance of power is well preserved in Europe now, and Britain is holding her own in battleships. In the cruiser class we have a great superiority, but certainly not greater than is needed for the protection of our enormous oversea trade. As regards light cruisers, however, he does not think our position is satisfactory. The armament of the Arethusa and Calliope class—namely, two 6-in. and eight 4-in. guns—although respectable for the displacement, does not, in his view, seem powerful enough for dealing with a merchant-cruiser. Although the "Town" class of cruiser have a speed of three miles per hour less, he thinks their armament of eight 6-in. guns makes them valuable craft, and that more of them should have been built, instead of some of the light-armoured cruisers.

The engineering chapter is again contributed by Mr. Alexander Richardson, and is on the influence on speed of the weights added to ships (aerial, submarine, or surface) due to guns, armour, and other fighting requirements. It is pointed out that an effectively armoured barbette, with a pair of 14-in. guns, gun-mountings, structural supports, and the requisite ammunition, weighs approximately 1100 tons, while a triple-gun turret weighs 1520 tons, and a quadruple-gun turret 1920 tons. Obviously having the contention of Admiral Sir Reginald Custance in mind, the writer considers the effect of the reduction in the weight of broadside armour. If the thickness of the main belt on the latest ships were reduced so that it would resist 6-in. guns only, 1000 tons weight would be saved. The length of the ship could then be reduced by 10 ft. to 12 ft. Saving would also be effected in the structural weight of the hull, owing to the thinner armour carried. The same speed would be realised with 2000 shaft horse-power less, owing to the less displacement. Thus the gross reduction would be 1550 tons approximately. Were the reduction in the weight of armour utilised for increasing the speed, half of the 1000 tons would be available for the heavier machinery and half for the increased length of ship to accommodate the more powerful machinery; the final result would be an increase of $1\frac{1}{2}$ miles per hour to the speed. Another alternative for utilising the 1000 tons saved in armour would be the addition of a twin-gun turret, which could be fitted with very little difference in the size or speed of the ship. Were it desired to increase the number of turrets of the present-day ships from four to five—to increase the number of guns from eight to ten—the speed of the ship, other things being equal, would be reduced by $1\frac{1}{2}$ miles per hour. The same problem is discussed in connection with light cruisers and destroyers, the advantages of geared turbines, superheated steam, and other improvements being considered. As regards submarine-boats, interesting data are given as to the adoption of steam-turbines in substitution for Diesel engines, and the effect on size, power, and speed of fitting 12-pounder, 4-in., or 6-in. guns is reviewed. With four guns of 4-in. calibre, instead of the same number of 12-pounders, the weight of the armament with ammunition would be increased by 12 tons, but the displacement of the ship, in order to get the same speed, would be increased about 100 tons, while the adoption of 6-in. guns, involving, with their ammunition, a net increase of 78 tons, would require a gross addition to the displacement of 200 tons. The difficulty, however, is to get higher speeds in submarine-boats, as this involves a rapid increase in the weight of machinery. Consequently the problem of the future is one largely for the marine engineer. Loads on airships and aeroplanes are considered from the same standpoint.

The subject of wireless telegraphy in the Navy is dealt with by Commander C. F. Loring, R.N., now inspector of wireless telegraphy to the Post Office. The treatment is in part historical. On the Vernon alone there are now about twenty officers whose duties are solely connected with wireless telegraphy, as compared with three or four in 1904, while the number of trained operators in the Fleet in 1912 was over 1100. At the end of 1913 there were 435 warships and 30 stations equipped with wireless telegraphy in the Navy, as compared with 42 and 8 respectively at the end of 1900. In submarine boats communication can be maintained so long as the vessel remains on the surface, but when once totally submerged it appears impossible to establish any connection with the outside world. In airships communication is fairly satisfactory, though the ranges obtainable are not great in comparison with the radius of action of the airships. Signals can be sent from aeroplanes; but owing to the noise of the engine exhaust, the rush of air, and such causes as vibration, it has been impossible to instal apparatus for the satisfactory reception of signals by anyone in an aeroplane or sea-plane. Sound-proof helmets and other devices are being tried, and promise a reasonable degree of success. Wireless telephony has been under regular observation in the Navy since 1909, but, so far, has not attained a degree of reliability which would justify its adoption for fleet work, particularly in view of the success of wireless telegraphy. As regards surface ships, an admiral in European waters can receive instructions from his base, no matter where he is, from one or other of the high-powered wireless telegraph stations. He can inter-communicate directly with his base at ranges of 500 miles or more by making special arrangements, and he is always in direct touch with any of his ships at distances up to 500 miles, according to their size. Commander Loring refers to atmospherics (or X's) as the most serious difficulty experienced in wireless telegraphy. The special difficulty they give rise to is thus explained by him:—"A receiving aerial system can be designed to oscillate to one particular wave-length to the practical exclusion of all others, but an atmospheric is too often a purely local effect, and causes the aerial system to oscillate with its own period; consequently, no alteration of the local receiving tuning arrangements makes any difference—the circuits still oscillate to the local disturbances, and the desired signals of the distant station are blurred." He caused a record to be kept for a year of all such disturbances at one of the coast stations in the Channel, and he groups the disturbances under three heads: "moderate," meaning that the signals were unaffected at normal ranges; "strong," that they were difficult at normal ranges; "violent," that they were impossible at normal ranges. During the year there were 385 hours of violent disturbances, during which wireless communication at normal ranges was absolutely impossible. September was the worst month, 94 cases being recorded. In addition, there were 285 hours during the year when the signalling was difficult at normal ranges, and 222 hours when the disturbances were moderate and the signals unaffected at normal ranges. His experience is that, in the north of Europe, atmospheric disturbances are usually most prevalent in July, August, and September.

There is a very informative chapter on the British and foreign aircraft, the work done by all nations being carefully reviewed. Great Britain, it is pointed out, still holds the lead in seaplanes, although the collection is somewhat heterogeneous. All nations agree that more powerful engines are required in seaplanes, and it may be accepted that machines with engines of 300 or 400 horse-power will be flying in the course of the next few months. Efforts are being made in all countries to reduce the vulnerability of airships by subdividing them into compartments, and by fitting light fabric screens inside, with a view to these being sucked into a hole, if made by a projectile or otherwise, and thereby closing it. It is pointed out that the aeroplane is in a more advanced state of development than the airship, but the possibilities of the latter are now beginning to be realised outside Germany, and all the important nations are taking up the work. The writer of a chapter to which no name is attached thinks that if aircraft could be fitted with water propellers, and be designed so as to be able to alight on the water and to use the propellers when there was a high wind, a great step forward would be made.

There is a very suggestive chapter by a naval officer on naval literature, advocating that capable writers should be encouraged by the Admiralty to prepare theses on various phases of naval warfare, so that students of strategy might have placed at their disposal, from the great mass of history, accurate lessons from the war experience of the past. Mr. John Leyland gives a very interesting description of the German dockyards, all of which he has visited under conditions conducive to the acquisition of a full conception of their equipment. Admiral Sir John Slade has a chapter on the right of capture in maritime war, and Captain Robinson deals with the operation of the Greek and Turkish fleets during the Balkan war. These special chapters, combined with the usual lists of ships (surface, submarine, and aerial), plans of all the latest ships, Captain Robinson's very complete and well-illustrated description of the new developments in armour and ordnance of all kinds, along with a table of ballistics of the guns of all nations and makers, make up

a volume which is, at least, equal to any of the former issues of the "Naval Annual," and higher praise, we think, cannot be given.

THE GERMAN ASSOCIATION OF GAS AND WATER ENGINEERS AT MUNICH.

UNDER the presidency of Dr. Reese, Royal Government Surveyor, of Dortmund, the fifty-fifth annual meeting of the German Association of Gas and Water Engineers was held at Munich, the capital of Bavaria, from July 1 to 4. The number of names registered on the preliminary attendance list was 1334; the final list comprised about 1500 names, of which about three hundred were those of ladies.

With due observance of the usual custom, a social gathering to inaugurate the proceedings took place on Tuesday evening, June 30, when the large hall of the Hackerbräukeller, in the Theresienhöhe, was crowded. The reception was given by the Municipality of Munich, whose welcome was expressed by one of the members of the Town Council, by Herr Pschorr, President of the Munich Gas Exhibition, and by Herr Lempelius, its leading spirit, and Director of the German Commercial Gas Association for popularising the uses of gas. Members of the Committee of the German Association were present in large numbers, and guests from abroad were represented by M. Boutan, President de la Société Technique de l'Industrie du Gaz en France; M. de la Paulle, of Brussels, Belgian Association of Gas Engineers; Mr. George Weinberg, of St. Petersburg, Society of Russian Water and Sanitary Engineers; Dr. A. H. Elliott, American Gas Institute; de Heer J. van Rossum du Chattel, Dutch Association of Gas Engineers; Mr. O. Pihl, President of the Norwegian Association of Gas Engineers; Sig. Marcel de Jongh, Italian Society of Gas and Water Engineers; Mr. John Bond, Mr. W. E Price, and Mr. Walter T. Dunn, President, Honorary Secretary, and Secretary respectively of the Institution of Gas Engineers; and Bailie Thomas Paxton and Mr. W. M. Mason, the respective President and Secretary of the British Commercial Gas Association, representing Great Britain.

On the following morning, punctually at nine o'clock, the members were ready to commence the business of the meeting, held at the capacious Bayerischenhof, Promenadeplatz.

After a very cordial welcome to the delegates from abroad, the President, Dr. Reese opened the Congress by an address. This was followed by a paper by Herr Lempelius on "The Present State of the German Gas Industry, and the Munich Gas Exhibition of 1914." A paper on "Gas and Hygiene" was given by Professor Dr. M. von Gruber (Royal Privy Council, and of the Medical Council of the Municipality of Munich); "The Work of the German Gas Industry for the Good of the Community" was the title of a paper by Mr. E. Körting, of Berlin. The Report on the Question of the International Standardisation of Gas-Threads, by Sir William Lindley, of Frankfort-on-Maine, was down as the last item of the first day's session, but Sir William unfortunately was prevented from attending to read it himself.

The programme of the second session was as follows:—(1) "Prussian Water Board Regulations in Connection with Town Water Supply," by Herr Kreutz, Government Counsel and Life Member of the State Water Board, of Berlin; (2) "The Influence of Forests on Water Supply," by Herr Ernst Henle, of Munich; (3) "Removing Manganese from Water," by Professor Dr. Tillmans, of Frankfort-on-Maine; (4) "Removing Manganese from Artesian Well Water in the Elbe Valley, and the Dresden Plants in connection therewith," by Herr Otto Vollmar, of Dresden; (5) "Biological Results of Rapid Filtration at the Barmer Weir," by Professor Kolwitz, of Berlin; (6) "A Graphic Method of Measuring the Electric Drive of Pumps," by Herr M. Gaze, Chief Engineer of the Allgemeine-Elektrizitäts-Gesellschaft, of Berlin.

The programme, which was considered and discussed at some length at the third session, on Friday, July 3, consisted of:—(1) "Questions Relating to the Prices of Gas;" (2) "Communications on the Subject of Gas Heating," from Dr. Karl Bunte, the Secretary of the Association, who is in charge of its experimental and testing works and laboratory at Carlsruhe, a place doing most excellent and useful work. In view of the important results achieved, we would suggest to the British gas-engineering profession the great desirability of forming a similar institution in London. (3) "Report of work done during the past year by the following Commissions of the Association:—On gas meters, on standard threads, on water-works management, on education and experiments, on gas-works management, on light measurement, and on pipe questions." We hope at a later date to publish abstracts of some of these papers.

The annual report of the Council was presented, and consideration was given to the Simon Schiele donation and to arrangements for next year. The election of President, Council, Committees, and Commissions took place, Dr. Reese, of Dortmund, being elected for the third year in succession as President of the Association.

On Wednesday afternoon, the 1st inst., the Isaria Gas-Meter Works and the Dachauerstrasse Gas Works of the Municipality of Munich were visited by the members. At the latter was shown one of the latest examples of a Munich inclined chamber-oven installation. This system seems to bid fair to rival the well-known vertical-retort processes, and in places where extension of plant is under consideration it will doubtless receive due regard. Low labour costs, facility of operation, cleanliness, and general efficiency are notable characteristics.

The same evening the special incident of the meeting occurred—viz., the formal opening of the German Gas Exhibition. Its royal patron, His Majesty King Ludwig III., was to have performed the ceremony, but owing to the tragic assassination of the Archduke Francis Ferdinand (who was related to him) and his consort the Duchess of Honenberg at Sarajevo, on the previous Saturday, it was carried out by the Prime Minister, His Excellency Dr. Georg Graf von Herthing, who was accompanied by the other Ministers of State, and representatives of the naval and military services.

The members of the Association and all the visitors have nothing but praise to bestow on the President of the Exhibition, and on all those who have been responsible for its organisation and realisation. It is, indeed, excellent in every particular, but the critic from abroad must not forget that the promoters were specially fortunate in having at their disposal existing buildings which are so well adapted to their varied requirements. The buildings, which belong to the Municipality, are situated on the Theresienhöhe, and have indeed been designed and erected solely for exhibition purposes, and there is usually an exhibition in course of installation, or one being held, at all times of the year. Beautifully-laid-out gardens, open free to the public, surround the buildings, and there are cafés, with bands playing, and all the other usual enjoyable accompaniments of a Continental exposition.

The exhibits are divided into the following sections:—(1) Scientific and historical; (2) gas-works management; (3) manufacture of illuminating gas; (4) distribution, measurement, and installation; (5) gas-lighting for houses and streets; (6) capacity of a cubic metre of gas as regards light, heat, and power; (7) gas in the kitchen, the household, and the school; (8) bath and other water-heating; (9) warming of houses; (10) gas for industrial purposes; (11) gas-engines; (12) gas for airships; (13) the treatment and utilisation of by-products; (14) gas (other than coal-gas) as applied to various industries.

The Bavarian Aero Club will hold, in connection with the Exhibition, from August 14 to 17, a balloon display, in which the Royal Bavarian and the German Automobile Clubs will take part, showing auto-wagons, &c., for the conveyance of balloons.

That part of the grounds leading up to the entrance is flanked on either side by a number of tastefully-designed pilons, from the summits of which gas flares away Greek fashion. In the grounds are some good examples of outdoor gas-lighting, on the Graetzin system. Amongst the striking exhibits inside is a very fine and complete model of a gas works, made by Friedrich Schroder, of Munich, which cost about 1000*l*. It is shown in motion, electric motors being employed for driving it. Its destination at the conclusion of the Exhibition is to be the German Museum already referred to. Perhaps no better graphic representation of the weight of nickel placed in the prepayment gas-meters of Berlin during the past ten years could be imagined than that which was erected for the purpose in a prominent position in the Exhibition. It consisted of a magnification of a 10-pfennig piece, about 30 ft. in diameter and exactly 1 metre thick. There are also shown numerous models of gas plants; well-produced pictures and photographs of various works throughout the German Empire; samples of pipes, vertical retorts, and interior lighting most artistically arranged.

Exhibits by British firms seemed to be conspicuous by their absence, although in one case was noticed some of the instruments with which Messrs. Alexander Wright and Co., of Westminster, have won a world-wide reputation—namely, their new gravitometer, calorimeter, &c. The latter apparatus, of course, will now come into great demand as a result of the recent Parliamentary Bills promoted by the Gas Light and Coke Company, the Liverpool Gas Company, and other companies, whereby calorific power is to be taken as the test for gas, superseding the test for candle value.

Another interesting exhibit which claimed attention was that from the Association's testing laboratory and training college at Carlsruhe, for intending gas engineers and chemists, under the direction of Dr. Karl Bunte. This exhibit comprised replicas of the apparatus used in teaching, results of the experiments conducted under the supervision of Dr. Bunte, diagrams, &c. There were numerous other exhibits which might be written upon, but considerations of space prevent our noticing them.

The Association's annual dinner took place at the Bayerischer Hof, on Friday evening, July 3, the President, Dr. Reese, occupying the chair. The total number present was about seventeen hundred, but notwithstanding the immense number of the company the occasion passed off in a most enjoyable manner without the slightest hitch.

On the following day (Saturday) there were four non-technical excursions available. The German Association of Gas and Water Engineers have to deal with large numbers at their meetings and excursions, numbers with which the technical associations of Great Britain are unaccustomed, unless it be the British Association. The writer therefore cannot refrain from closing this report with a note of praise and admiration on account of the excellent way everything was arranged and conducted from beginning to finish. The representatives of Great Britain particularly, about 20 in number, were highly gratified at the warmth of their reception throughout the whole course of the week's proceedings.

INDUSTRIAL NOTES.

WE learn from the *Board of Trade Labour Gazette* that employment in June showed some decline on the previous month, but was still good generally. The pig-iron and iron and steel trades remained almost stationary, but employment in the engineering and shipbuilding trades slightly declined. In the tin-plate trade there was a decrease in the number of mills working. The coal-mining, furnishing, boot and shoe, and glass trades were not so well employed as in May, and there was some falling-off in the textile industries, especially in the case of woollen and lace manufacture. The building trades showed little change.

Compared with the high level of a year ago there was, on the whole, a decline, which was especially noticeable in the pig-iron, iron and steel, engineering, shipbuilding, woollen, and lace trades. There was, however, some improvement in the printing, boot and shoe, and brick trades, and a considerable increase in the number of tin-plate mills working.

Amongst those whose wages were reduced were 141,550 coal, iron, and shale mine workers in Scotland, and 34,250 iron and steel workers in the North of England, the Midlands, South Wales, and Scotland. The principal increase affected 4000 ironmoulders in Lancashire. The net result of all the changes reported was a decrease of 9600*l*. in the weekly wages of 190,000 workpeople.

The dispute in the building trades in London continued throughout the month, and is still in progress. The number of new disputes in June was 118, and the total number of workpeople involved in all disputes in progress was 82,752, as compared with 76,779 in the previous month and 122,623 in June, 1913. The estimated total aggregate duration of all disputes during the month was 1,072,900 working days, as compared with 1,040,900 in May, 1914, and 1,718,200 in June, 1913.

In connection with the strike last week at the Woolwich Arsenal, the Court appointed to inquire into the matter has been formed as follows:—Sir G. Askwith (chairman), Sir Clarendon Hyde, Colonel J. M. Denny (representing the Arsenal authorities), Mr. G. N. Barnes and Mr. J. R. Clynes (representing the employees). The Court commenced its sittings on Monday. The sittings will be in private, and a report will be made to the Secretary of State for War. The men all returned to work on Thursday, the 9th inst.

The Board of Guardians of West Ham last week went on strike as the result of the interference of the Local Government Board auditor with regard to payments for out-relief. The auditor recently requested the Board to meet him to discuss certain payments made, and on the 9th inst. the Board adopted a resolution declining to administer further out-relief unless allowed to do so at their discretion. The Local Government Board pointed out that the auditor was required by law to review the expenditure of the guardians on out-relief.

A "recognition" and anti "non-union" strike has developed at Liverpool, where the Mersey Docks and Harbour Board has refused the demand of the men in the warehouses and engineering departments for a conciliation board and the employment of only union labour. About 3000 men were called out. The bodies supporting the demand for recognition are the Transport Workers' Federation and the Engineering and Shipbuilding Trades' Federation. About 2000 men came out on Monday at Liverpool and Birkenhead. There have been threats of sympathetic strikes in London if the attempt is made to divert Mersey traffic to the Thames. The Board has issued a statement to the effect that it is determined to make every effort to preserve the liberty of labour and equal rights for

all. A large number of the older men have refused to strike. The prospects of loss of pensions and other privileges are acting as deterrents. The employees of the Board on the established list enjoy many advantages, including continuity of employment, superannuation allowance, liberal sick allowance, and, many of them, leave on full pay. At the time of going to press the strike had not assumed the formidable proportions at first promised.

At a meeting on the 9th inst. the men's representatives on the Coal Conciliation Board for the Federated Districts of England and North Wales agreed to submit to the Board a proposal for increasing the basis rate of miners' wages 50 per cent. The present rates are 50 to 65 per cent. above the 1888 basis. The Miners' Federation proposes to terminate existing agreements next year.

An interesting arrangement has been arrived at in connection with questions of demarcation at Messrs. Harland and Wolff's Works, Belfast. We quote from the United Society of Boiler-Makers and Iron and Steel Shipbuilders' report as follows:—The trades concerned shall give evidence before a neutral chairman appointed by the Board of Trade. The firm shall also give evidence, and thereafter the trades concerned, with the neutral chairman, shall endeavour to agree on a decision, *in the absence of the firm's representatives*. If the trades concerned fail to agree, then the neutral chairman shall give a decision.

At the Dowlais Collieries of Messrs. Guest, Keen, and Nettlefolds, Limited, about 4000 men struck work on Monday last as a protest against the employment of about 200 men not belonging to the Miners' Federation. On Wednesday only three men still remained outside, and work had been resumed.

Before the Committee which is inquiring into the Prevention of Railway Accidents, Mr. J. H. Thomas, M.P., on Tuesday last, asserted that many of the accidents were due to "speeding up" and to the payment of bonuses. Among other recommendations, he asked that the Board of Trade should have power to enforce the recommendations of their inspectors. It has often been pointed out that this could not well be done without making the Board of Trade responsible for the safety of the railways.

In an interim report of the Dominions Royal Commission, just issued, it is pointed out with regard to the white labour question in the Transvaal that if two Europeans replaced three natives at their present pay of 3s. 2d. per shift, and the Europeans received 10s., out of fifty-two producing mines twenty-six would cease to make a profit. If the white labourers received 12s. 6d., the rate of pay in Western Australia, where living is cheaper, thirty-five out of these fifty-two mines would cease to pay. It is stated that "it is clear that high remuneration divorced from certainty and other conditions essential to a contented and well-ordered life cannot be a panacea for industrial discontent." The opinion is recorded that the conditions would be better met by the employment of fewer white men, but of a superior class, so that they might be given more responsibility in regard to the native unskilled labour without fear of the power being abused.

We notice that in the Associated Blacksmiths and Iron-Workers' Society's monthly report for June that attention is drawn to a recent compensation case of some interest. A blacksmith employed by Messrs. Petrie and Co., Limited, Rochdale, received an injury in 1913 by which he lost the sight of his right eye. It was stated for the employers that the man's average wages before the accident of 36s. 10d. per week were still being paid, with 18s. 6d. per week compensation. The man had been offered his old or other employment, but had refused, and the firm asked for an order terminating or reducing the compensation. On the part of the man it was contended that he was unable to perform his former work. Four one-eyed blacksmiths were called, two of them having met with their injuries when over thirty years of age, and attested their ability to follow their employment without inconvenience. It was decided that the man was able to follow his former employment, and that the compensation must stop.

The United Pattern-Makers' Association report for June states that at the end of that month 394 members, or 4.5 per cent. of the membership, were on the vacant-books. The number was 65 above that in the previous month. The society has a total membership of 8628, of which 19 were on strike during June. Trade was reported as bad, dull, unquiet, &c., in quite a number of places. A wages movement at Bolton and Bury was settled during the month, the men accepting an offer of 1s. advance on the first pay in July and 1s. six months later, with an agreement for four years. At Keighley work was resumed on July 6 on terms rejected by ballot three weeks previously. The allied trades in the London district, whose five years' agreement expires in August, are preparing a demand for an 8s. per week advance. The movement is supported by the Amalgamated Society of Engineers, Steam-Engine Makers, Electrical Trade Unions, Brass-Finishers, and other societies. The United Pattern-Makers' Association is contemplating joining the movement under certain conditions.

In the quarterly report of the Cleveland Miners' Association, Mr. H. Dack, President of the Association, states that he is opposed to the policy of building up union funds with the idea of financing strikes to improve the workers' position. It had taken Cleveland eleven years after the Durham strike of 1892 to regain the same volume of trade as was being done just before the strike, and even to-day some of those buyers who formerly took Cleveland iron had not been won back.

The July report of the Steam-Engine Makers' Society states that the number of unemployed was only 153 in that month, or 0.9 per cent. of the membership, but compared with 108 in the previous month. There were 346 members on the sick fund, an increase of 70 on the previous month. The branch reports show that in most districts trade continues from fair to good, though in a few cases it is described as not so good, only moderate, or unsteady.

The building trades' dispute underwent some changes in the week. Preparations are being made in the provinces for the national lock-out, meetings being held daily with a view to making the necessary arrangements. The non-associated master builders, who are said to number about 300 firms, excluding jobbing builders, met in conference in London on Tuesday, with the result that a decision was arrived at that unless a settlement were reached in the interim, all firms represented at the meeting would close their works to union labour on August 1. It was also decided to appoint a committee to see whether the basis of membership of the London Master Builders' Association could be broadened, so as to bring in all classes of master builders in the London district. In the event of a national lock-out, about 6000 employers and a quarter of a million men will be affected.

There has of late been a great deal of unrest in Norwegian labour, and the men have more than once resorted to violent measures. The most recent examples of their reckless doings have occurred at the Nydalen Works. On July 8 more than 800 hands, practically the whole staff, left the factory with much shouting and disturbance after breakfast time instead of resuming work, and this they did without notice and in the absence of any dispute as to pay or hours. The female hands appear to have been the most disorderly. The demonstration was principally directed against a Swiss engineer. The trouble was at once reported to the Norwegian Employers' Union.

At the ordinary monthly meeting of the Council of the Leeds Chamber of Commerce, held on Tuesday, the 30th ult., the chairman, Mr. F. J. Kitson, moved the following resolution, with which we fully agree:—"That the Council of the Leeds Chamber of Commerce are of opinion that Consular appointments should, as far as possible, be confined to men of British nationality, who have a knowledge of at least two foreign languages, of which one shall be French, and have had special training in commercial subjects; that all appointments at the ports and other centres of industry should be salaried ones, and should provide, where necessary, for whole-time service, and that the degree of Bachelor of Commerce, conferred at the Leeds University, should be a qualification for a Consular appointment, but should be followed by a course of inspection of works in connection with some of the main industries of the country . . ." He and Mr. Bedford, one of the vice-presidents of the Chamber, he said, had gone very fully into the subject, and were strongly of opinion that Consular appointments should be given to British subjects, and that whenever possible the practice of giving such appointments to foreigners should be avoided. They thought also that these appointments should be made on merit, and not merely because a man happened to possess a title, which was, he believed, sometimes deemed sufficient qualification.

Mr. J. E. Bedford seconded the resolution. He urged that there should be a carefully followed method of selecting men to fill such positions as that of British Consul in foreign countries. In times gone by, he was afraid, these posts had been given to retired soldiers or to superannuated naval officers. Those no doubt were very estimable men, but, from a commercial standpoint, unless they had special knowledge or training for the work, they were scarcely suitable candidates for such positions. Germany and other European nations, who might be said to keep a keen eye on commerce, appeared to regard such appointments from a different point of view, and they took care to appoint only technically and commercially-trained men of the first order. The representative of Great Britain in foreign countries was too frequently the best available local man. In Norway and Sweden, for instance, England's representative was often some enterprising German merchant. The tendency in such a case was to supply the wants of the particular country through German channels. In connection with the University of Leeds there was a Chair of Economics and Commerce, and a diploma in connection therewith had been arranged, providing for the degree of Bachelor of Commerce. The training received at the University was sound, and at least two foreign European languages must be learned, preferably French and Spanish.

The resolution was carried unanimously.

A recent issue of the *Birmingham Daily Post* contains an interesting article on the status of the officers in the German army, from which we take the following paragraph:—". . . How unprofitable is the army as a career was shown by an incident of this year's Estimates debate. The Minister of War asked for a small vote for financing an officers' 'Labour Exchange,' already opened. The exchange was to find work for penniless retired officers. The Minister reported that immediately after the exchange was opened 850 officers applied for employment. Any employment short of manual labour is sought for, and almost any wage is accepted. In 1913 the Minister of War circularised chambers of commerce with the request that they use their influence with business men in order that retired officers might be given employment as clerks, &c. This expedient failed. The organised clerks protested against outside competition backed by the State. A service journal estimates that there are at present 3000 ex-officers practically without means who would accept any honest work; and that 4000 are already employed as clerks, overseers in industrial works, employees in State lotteries, and agents and order-hunters for champagne firms, furniture removers, and undertakers. From experience German citizens understand this state. I have myself had visits from seedy, but unquestionably military gentlemen, with cards bearing the legend *Leutnant ausser Dienst* (Lieutenant in Retirement), who brought invitations to buy or hire things. Often the proposed transactions would have yielded the ex-officer at most a few shillings. . . ."

The report for 1913, recently issued by the Inspector of Mines for the Liverpool and North Wales district (Mr. A. D. Nicholson), states that during the year the coal trade of the district was remarkably good, and regular work and higher prices were the rule. The slate industry continued to be in a very depressed condition, and metalliferous mining could hardly be regarded as being in a flourishing condition. Under the Coal Mines Act there were 218 mines at work, 83 metalliferous mines (some being on a very small scale), while about 386 quarries were worked regularly, but almost all the most important quarries showed a slight reduction in the number of persons employed. The total number of persons employed in and about the mines was 72,540, or an increase of 1483 as compared with the previous year. This constituted a record for the district. With regard to the total output, there was an increase of 959,584 tons, and the total quantity of coal and also of all minerals obtained, it is pointed out, has only been exceeded by the record year of 1907.

There was again an increase in the number of coal-cutting machines and conveyors at work. Machines increased by 33, and the output was 1,522,962 tons, an increase of 262,317 tons on the previous year's output.

The district was free from any large disaster. The total number of accidents reported was 328, causing the loss of 80 lives and injuries to 266 persons, showing a reduction on the figures for the previous year of 13 in the number of deaths and 39 in the number of persons injured.

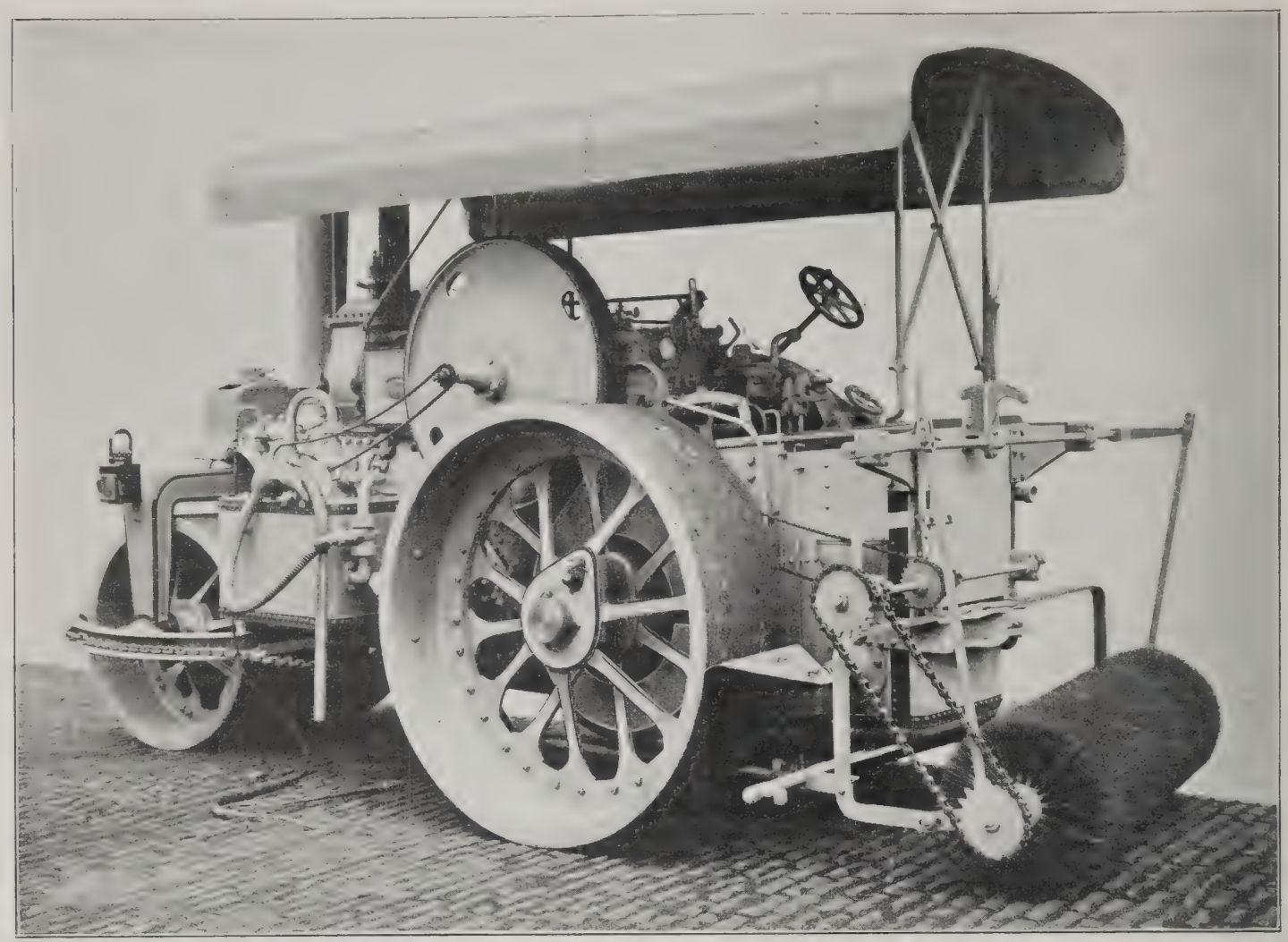
No legal proceedings were instituted during the year against owners, agents, or managers. The total number of prosecutions of workmen by owners amounted to 69, as compared with 25 in the previous year and 75 in 1911.

The Imperial Merchant Service Guild has been officially informed by the Director of the Labour Exchange at Rotterdam that the Municipal Council of that city has established at 4, Kaasmarkt—*i. e.*, in the centre of the shipping district—an institution for the employment of seamen. The institution will enable captains of British and other ships to obtain their crews in a quick and impartial way, thereby doing away with the services of shipping masters and boarding-house keepers, who hitherto obtained a living through placing seamen on board ships. The city of Rotterdam offers assistance to seamen of all nationalities entirely free of expense, looks after their general interests, and pays their advance notes in full without any charge whatsoever.

The new institution will also undertake to have the crews of ships signed on at the Consular office of the

COMBINED ROAD-ROLLER, TAR-SPRAYER, AND SWEEPER.

CONSTRUCTED BY MESSRS. JOHN FOWLER AND CO. (LEEDS), LIMITED, LEEDS.



nationality to which the ships belong, and to have the men taken free of charge on board at the proper time by officials in uniform. Such officials will also be on board up to the time the ship sails, during the day or night, and will be ready to supply substitutes if necessary. A small charge per man is to be made to owners.

Captain J. P. van der Does, an old commander of the Rotterdam Lloyd, is in charge of the institute, and has a staff of officials who have been chosen from amongst members of the nautical profession. At the head of the institution there is a general director and a special advisory committee consisting of shipping officials. One of the members of the committee is Mr. E. G. B. Maxse, Consul-General of Great Britain and Ireland. The consul-generals of other nations, steamship inspectors, and the Government dock-master of the port, Sir S. B. Ortt, and a number of other shipping officials of the port are also members. The institution is provided with a special reading and writing-room for the express use of captains and officers.

COMBINED ROAD-ROLLER, TAR-SPRAYER, AND SWEEPER.

In our issue of July 3 we referred to an exhibit at the Royal Agricultural Society's Show consisting of a combined 10-ton road-roller, tar-sprayer, and sweeper. This was to be seen at the stand of Messrs. John Fowler and Co. (Leeds), Limited, and is illustrated in the engraving above. In addition to embodying all the well-known features of Messrs. Fowler's road-rollers, this machine is fitted with a tank under the boiler barrel, of a capacity of 160 gallons of tar. This tank is furnished with a rotary pump chain-driven off the fly-wheel shaft. The pump is arranged with piping and cocks, so that it can either be used for filling the tank or for circulating the tar for mixing purposes, or for delivering it to six spraying-nozzles arranged on a transverse pipe at the back end of the machine. The tank is fitted with 60 ft. of heating pipe fed with exhaust steam from the cylinders, or live steam. The tar is delivered at the spraying-jets at a pressure of 300 lb. The machine may be used for tarring roads or for grouting new metal, the pressure being high enough to force the tar well into the interstices between the material. The machine will do a length of about 300 yards in five minutes. The engine is a compound, and is fitted for two speeds. The wheels have spring scrapers, and a water-sprayer is also provided. The brush does away with manual labour in sweeping the road. It is lifted clear of the surface previous to tarring.

Metallic Permanent-Way.—Our exports of metallic permanent-way do not appear to be making much progress; they amounted in June to 7828 tons, as compared with 7994 tons in June, 1913, and 10,258 tons in June, 1912, while in the six months ended June 30 they attained an aggregate of 56,141 tons, as compared with 61,955 tons and 56,807 tons respectively. In these latter totals shipments to British India figured for 47,002 tons, 46,037 tons and 43,710 tons respectively.

A Record Blasting for Europe.—On May 30 a blasting of iron ore took place at the iron-ore deposits of the South Varanger Company, Norway, to the works of which reference has been made in these columns on previous occasions. It was a question of blasting surface deposits, and by means of 17,000 kg. of dynamite 180,000 tons of solid ore were dislodged by one single blast. This is a record for Europe, and has, as far as is known, only been surpassed at the Panama Canal. The company is working at six places within the area of the deposits, and the ore is loaded on to railway-wagons by means of steam-shovels, the largest blocks being broken up by small charges. As a result of the blast referred to above some 30,000 tons of ore will be loaded per month until disposed of. The working at the South Varanger deposits and the various installations connected with it are being continually extended and increased. The concentration works are now finished, and will be able to receive and deal with some 150,000 tons of ore per month. During the month of June of the present year the new briquetting works, with a capacity of about 100,000 tons per month, commenced operations. The export has during the last few months—since March—exceeded 50,000 tons per month, and in that month it approached 70,000 tons. The export altogether is increasing at a very rapid rate; for 1912 it was about 250,000 tons, for last year about 450,000 tons, and for the present year it is expected to exceed 600,000 tons. Three steamers—two 11,000-ton ore-boats and one of 7000 tons—are regularly engaged in the Continental export traffic, more especially to Rotterdam, and five steamers, varying in size from 2200 tons to 5000 tons, are regularly engaged in the English trade; in addition, other boats are occasionally employed.

Fast Motor Vedette Boats for Greek Ministry.—Messrs. John I. Thornycroft and Co., Limited, have recently completed, to the order of the Greek Government, two fast motor-launches. The boats are driven by twin Thornycroft motors, with a combined power of 140 brake horse-power, giving a speed of over 15 knots. The over-all dimensions are:—Length, 50 ft.; beam, 8 ft. 3 in.; depth, 4 ft. 9 in. The machinery is situated amidships immediately forward of the wheel-house, with reverse-gear controls carried up through floor. Electric light is fitted throughout the boat, together with a powerful portable searchlight fixed on the roof of the wheel-house. A dynamo is run off one of the engine shafts, with accumulators stowed under the engine-room seats providing the necessary current. A small signal-mast is fitted on the fore-deck. The fuel is carried in two tanks, one under the floor of the wheel-house and the other right aft; together they have a capacity of 140 gallons. The two boats went through their trials with satisfaction to the officials.

The British Corporation for the Survey and Registry of Shipping.—The 1914 Register-Book and Rules of the British Corporation Registry, which has just been issued, gives a good indication of the steady growth of its operations, through the number of vessels which have been added to the Register during the past twelve months, and the additions to the list of owners who have adopted its classification for their vessels. Comparison with the Rules for 1913 shows a continuance of the Society's policy of maintaining the main features unchanged, but adapting details to meet experience. Evidence of this is found in the extension of the Rules for Periodical Surveys, which require an annual inspection of hatchways, casings, ventilators, and other protection to openings in the weather-deck, in addition to the ordinary special surveys, at intervals of four years. The construction rules relating to these parts have also been subjected to thorough revision, and have been considerably extended. These alterations should appeal to shipowners and underwriters as acting more directly towards greater security of life and property at sea. Several other minor modifications and amplifications have been made which are obvious improvements, and altogether the new volume is of great interest and value to the shipping community. The classification rules and tables come into force on August 1, and will supersede all other regulations previously issued by the Committee.

DEVELOPMENT OF INTERNAL-COMBUSTION ENGINES FOR MARINE PURPOSES.*

By M. DROSNE, of Messrs. Schneider and Co., Paris.

MESSRS. SCHNEIDER AND CO. have for some years specialised in the construction of oil-engines working on the Diesel principle. They concentrated their efforts at first on four-stroke-cycle engines specially designed for submarines for the French Navy or for foreign navies, but they very soon found that the two-stroke-cycle type might be of great use for engines of medium and of high power, both as regards reduction in weight and bulk, as well as for improvement in cyclic regularity. They therefore had no hesitation in studying and constructing that type of engine, together with the four-stroke-cycle one. Being, on the other hand, aware of the fact that it was not advisable to start on this new line without precise data on the advantages of the two-stroke cycle, derived from their own experience, they faced the heavy cost of erecting a couple of two-stroke-cycle engines at the works for trial purposes. These were vertical and each with a single cylinder. One had a stroke of 1 m. (3 ft. 3.37 in.), and developed 1200 h.-p. at 150 revolutions per minute. The other had a stroke of 0.46 m. (1 ft. 6.11 in.), and developed 300 horse-power at 400 revolutions per minute. These engines were to give an idea of the difficulties in regulating and running engines of large size or at high speed, so that means could be found to remedy any defects that might arise. The results enabled the constructors to start with confidence on the difficult solution of the problem relating to high-speed two-stroke-cycle light engines for submarines, and placed them in the foremost technical position to solve the problem of the use of large oil-engines for ordinary vessels. The experiments took place over a period of two years.

The two-stroke-cycle engines—like the four-stroke-cycle—are mostly light engines, of relatively high horse-power, built for marine work. On the other hand, the constructors did not lose sight of the development of heavy slow-speed engines (four-stroke cycle or two-stroke cycle) for cargo-boats, or of horizontal double-acting engines of high horse-power for land purposes. Their great experience in the construction of engines for land and sea placed them in such a position that they could safely set to work in executing their new designs, and to-day they are able to deal with all the intricacies of Diesel engines either of the land or marine type, two-stroke cycle or four-stroke cycle, vertical or horizontal, and single or double-acting. These engines have been highly successful, due to the excellence of construction and the materials used, the original design of the mechanism, and the care taken in perfecting them.

The following engines constructed at their works are worthy of note :—

(*a*) Eight engines of 360 horse-power each, four-stroke cycle, with eight cylinders, stroke 0.28 m. (11.02 in.), 400 revolutions per minute, for submarines of the Laubeuf type.

(*b*) Two engines of 700 horse-power each, four-stroke cycle, with four cylinders, stroke 0.48 m. (18.9 in.), 300 revolutions per minute, and two motors of 150 horse-power, four-stroke cycle, with four cylinders, 360 revolutions per minute, representing the main and auxiliary engines of the French submarine Amiral Bourgois.

(*c*) Two engines of 900 horse-power each, two-stroke cycle, with four cylinders, stroke 0.56 m. (22.05 in.), 230 revolutions per minute, for the cargo-boat France, belonging to the Société des Navires Mixtes, of Rouen.

(*d*) Two engines of 2400 horse-power each, two-stroke cycle, with eight cylinders, stroke 0.47 m. (18.51 in.), 350 revolutions per minute, for the French submarine Nereide.

(*e*) Six engines of 650 horse-power each, two-stroke cycle, with six cylinders, stroke 0.36 m. (14.17 in.), 400 revolutions per minute, for a French submarine.

(*f*) Eight engines of 1100 horse-power each, two-stroke cycle, with eight cylinders, stroke 0.37 m. (14.57 in.), 400 revolutions per minute, for submarines of the Laubeuf type.

(*g*) One engine for an electric generating set of 225-250 horse-power, two-stroke cycle, with three cylinders, stroke 0.36 m. (14.17 in.), 300 revolutions per minute.

It must be remarked that the submarines of the Laubeuf type come from Messrs. Schneider and Co.'s

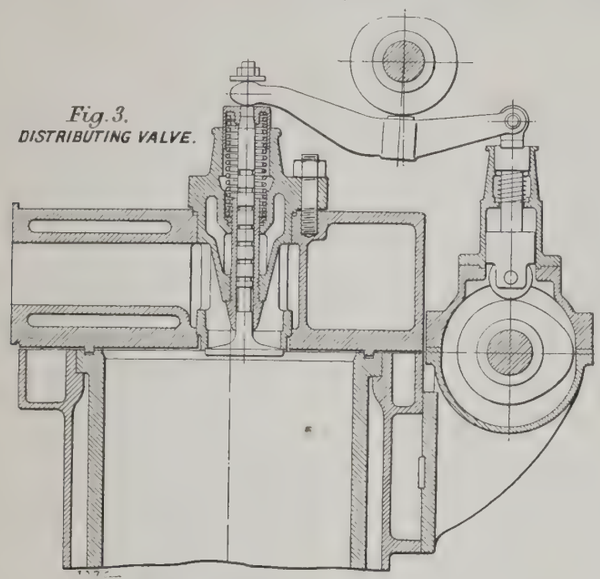


Fig. 3. DISTRIBUTING VALVE.

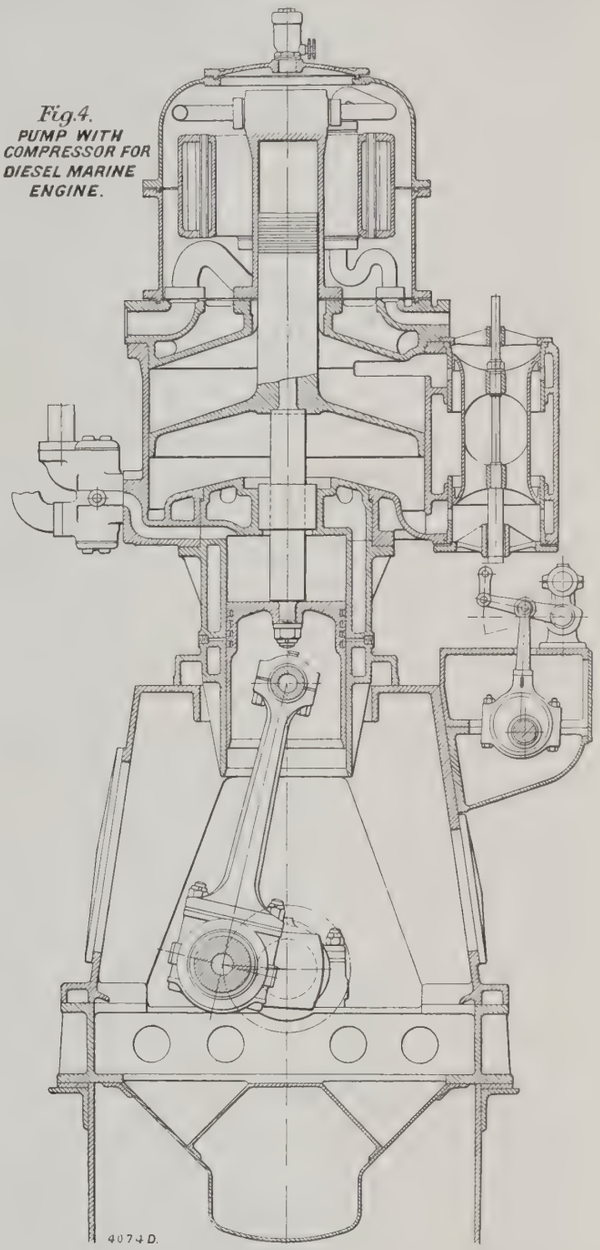


Fig. 4. PUMP WITH COMPRESSOR FOR DIESEL MARINE ENGINE.

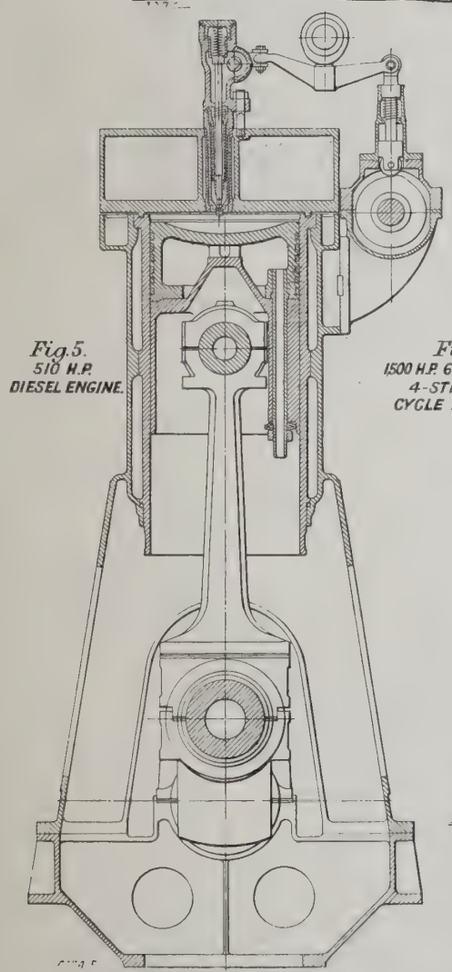


Fig. 5. 510 H.P. DIESEL ENGINE.

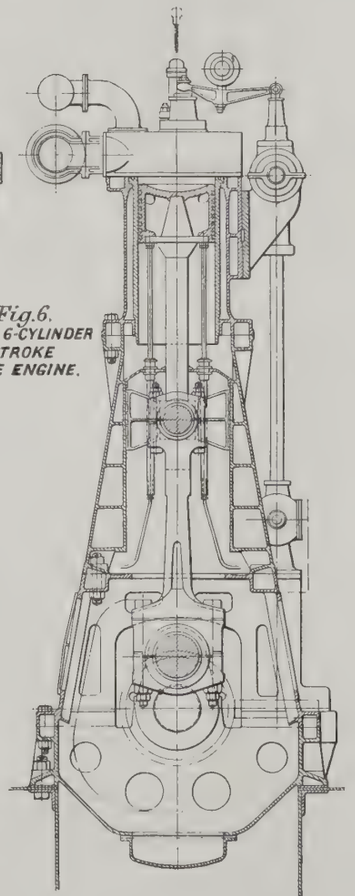


Fig. 6. 1500 H.P. 6-CYLINDER 4-STROKE CYCLE ENGINE.

* Paper read before the Institution of Mechanical Engineers at Paris, July 8, 1914.

naval works. Other engines in course of design or of construction may be mentioned :—

Four engines of 510 horse-power, four-stroke cycle, for submarines; one engine of 1500 horse-power for a cargo-boat; one horizontal tandem engine, double-acting, four-stroke cycle, of 2200-2600 horse-power, for an electric generating station; and two-stroke-cycle engines of 1100 horse-power for submarines.

Description of the Engines.

All the engines for submarines, whether four-stroke cycle or two-stroke cycle, are extra light. They are vertical, single-acting, with trunk pistons. The bed-plates and frames are of cast steel; the cylinders, which are either separate or cast with the frames, are of cast iron or cast steel with cast-iron liners. The cylinder-cover is of cast steel and carries (for four-stroke-cycle engines) the inlet-valve, the exhaust-valve, the injection-valve for fuel, and starting-valve. For two-stroke-cycle engines the air and exhaust-valves are replaced by scavenging-valves.

The crank and cam-shafts are of medium hard steel, which is tempered and annealed, and all the parts subjected to hard wear, such as cams, rollers, valves, pins, compressor-valves, &c., are in special steel. The air inlet and exhaust-pipes (the latter having water-jackets) are of sheet steel. All parts exposed to heat, such as the cylinders, cylinder-covers, exhaust-valve seats and exhaust-pipes, are water-jacketed. For the four-stroke and the two-stroke engines of large size the pistons are cooled by oil circulation. The crank-pins and crank-shaft bearings, the cylinders, and other main working parts have forced lubrication. The air-compressors, and for the two-stroke engines the air-compressors and scavenger-pumps (whether separate or forming part of the engine), are worked directly off the crank-shaft, which in many cases also works the oil-pumps for lubricating and cooling, as well as the pump for the water circulation. All these devices are practically the same for heavy engines, except that for the latter the bed-plates, frames and cylinders are of cast iron, and the pistons are provided with rods and cross-heads in engines of larger size.

Fig. 1, page 90, is a view of a four-stroke-cycle engine with eight cylinders, of 360 horse-power. Fig. 2 shows a two-stroke-cycle engine with four cylinders, of 900 horse-power; but two-stroke-cycle engines of 1100 horse-power with eight cylinders are constructed. Illustrations of one of the two-stroke motors of 900 horse-power on the cargo-boat France will be found on Plate XXIX. in Engineering of October 10, 1913.

Improvements in Working Parts.

Starting and Manœuvring Gear.—This has been applied to all the latest engines with a view to make starting and reversing as easy and as quick as possible. There are two cams for operating each valve on the main cam-shaft, one for ahead and the other for astern running. The rocking levers are, however, also controlled by cams fixed to a manœuvring cam-shaft, and these cams are adjustable, so that in certain positions the rocking-levers are thrown completely out of gear with the main cams. Thus one can see that by making adjustments to the cams on the manœuvring cam-shaft certain valve-levers will be thrown out of gear, whereas others will continue to bear on their main cams, so that according to the distribution required it is possible, when starting, to connect all the cylinders to the compressed-air supply, and then by adjusting the manœuvring cams to cut the air off from one or more of the cylinders and feed one or more with fuel as required. The adjustment to the manœuvring cams is made by revolving the cam-shaft, and one complete revolution of the shaft, worked by hand through a reducing gear, or by a servo-motor, is sufficient to start the engine. In the position corresponding to "stop," all valve-lever rollers are free, so that in order to change from ahead to astern drive all that is needed is to move the manœuvring cam-shaft to the "stop" position, and then to move the main cam-shaft longitudinally so as to place the "astern" cams under the valve-lever rollers, and then start the engine as explained above. This operation, which only takes 10 to 15 seconds, is made by successively rotating two small hand-wheels placed side by side one after the other. A safety device prevents the main cam-shaft moving longitudinally until the other cam-shaft is moved to the "stop" position. The whole arrangement is remarkably safe.

Valves.—The exhaust, air-inlet, and starting-valves (Fig. 3, page 99) are of the ordinary type, except that they are provided with a special device to prevent their falling into the cylinders if their rods break. The fuel-valves are either of the ordinary type—that is, direct-acting straight needles passing through a stuffing-box—or of the Swedish type, balanced and worked by rotation.

Fig. 5 (page 99).—This figure shows the cross-section of a cylinder belonging to a four-stroke-cycle engine, of eight cylinders and 510 horse-power. The fuel-valve casing is fitted at the bottom with a ball pulveriser and a multiple-hole diffuser. The ball pulveriser distributes the fuel in a very uniform manner with the air that is injected, though it offers but little resistance to the passage of that air owing to the balls being round. On the other hand, the multiple-hole diffuser allows the mixture to be sent in the required direction so as to distribute it evenly in the compression chamber, thus preventing it from being injected on to any one part that might get injured.

Fuel-Pumps.—One pump is provided for each cylinder. The plungers are specially constructed so as to render them perfectly tight. Each oil-pump is regulated by varying the amount of lift of its suction-valve, and the special feature of the gear for giving this variation is as follows:—(1) Hand regulation; (2) Regulation from the manœuvring cam-shaft (3) Regulation by over-speed. The hand-regulator, which works on a quadrant, serves to regulate the speed or load on the engine. The regulation from the manœuvring-shaft comes into play when starting ahead or astern, so that the pumps begin to work at the right moment only. Lastly, the speed-limit device acts so as to prevent racing.

Air-Compressors.—The air-compressors, Fig. 10 (Plate XXIX., of October 10, 1913), either independent or combined with the scavenger-pumps in the two-stroke-cycle engines, Fig. 4, page 99, are three-stage compressors and are worked direct off the crank-shaft. Their valves, which are of special steel, extra light and with short lift, are designed so as to give large openings. Their coolers, which are multitubular or of the coiled single-tube type, are fitted with large water-jackets, and ensure the most efficacious cooling.

Scavenging-Pumps. — According to the speed, the scavenging-pumps, which are worked off the crank-shaft, are provided with Hoerbiger valves or cylindrical slide-valves. Fig. 10, Plate XXIX., shows a pump fitted with Hoerbiger valves. Fig. 4 shows a cross-section of a pump with cylindrical slide-valves, and combined with its compressor, of which it forms the low and intermediate-pressure part. The slide-valves are driven by eccentrics fixed on the main cam-shaft. A sliding-sleeve with feather enables the cam-shaft to move longitudinally for ahead or astern drive without affecting these eccentrics.

Oil-Cooled Pistons.—The pistons are in two parts, joined together by long bolts, in which tubes carrying the cooling oil work telescopically (Fig. 8, Plate XXIX, and Fig. 5, page 99). The piston-head carries segments in cast iron or steel which bear lightly against the central part of the body of the piston. The telescopic tubes are provided at the bottom with a swivel joint, leaving them free to move in any direction, and maintaining a proper oil-tightness. The hot oil is returned from the piston to a filter, whence it is pumped by a special pump through a tubular cooler and back into the pistons.

Forced Lubrication. Splash-Guards.—The bearings of the crank-shafts and of the connecting-rods have forced lubrication. This is an excellent arrangement for efficient lubrication, but the splashing of oil by the cranks is undesirable for the following reason :—The oil thrown on to the cylinder-walls is sucked past the piston, which causes waste, and its partial combustion causes a smoky exhaust. These defects are now got rid of by means of special splash-guards. These, Fig. 8, Plate XXIX., are very efficacious.

Fig. 6 shows a section through one of the six cylinders of a 1500-horse-power engine for a cargo-boat, of the four-stroke-cycle type, and of low speed, which is now being designed. The pistons are provided with rods and cross-heads, and they are cooled by water circulation. The frames joining the cylinders to the bed-plate are made in two halves, bolted together and arranged so that one half can be easily removed, to allow the connecting-rod, piston, and cross-head to be taken out. The same arrangements apply to this motor as have been already described above.

THE CHARGING OF TWO-CYCLE INTERNAL-COMBUSTION ENGINES.*

By B. Hopkinson, M. Inst. C.E., F.R.S.

The performance of two-cycle internal-combustion engines is determined very largely by the efficiency or otherwise of the process of charging. In the course of less than one-fourth of a revolution the products of combustion resulting from the previous explosion have to be replaced as far as possible by the fresh charge of air, or of gas and air, which is blown in through the inlet-valves and drives before it through the open exhaust-ports the exhaust gases. Inevitably some mixing occurs, and some of the fresh charge, or of the scavenging air, passes away to the exhaust, and is wasted. On the amount of this waste depends very largely the performance of the engine. Its economy suffers to the extent of the waste of fuel. Its weight and cost are affected by the size of the charging-pumps, which must be big enough to deliver the whole charge of gas and air, including that which is wasted. The imperfection of the charging process is probably in large measure responsible for the fact that the two-cycle engine, in spite of the obvious advantage of double the number of working strokes, has not hitherto competed successfully in small sizes with the four-cycle type, and even in large sizes has achieved only moderate success.

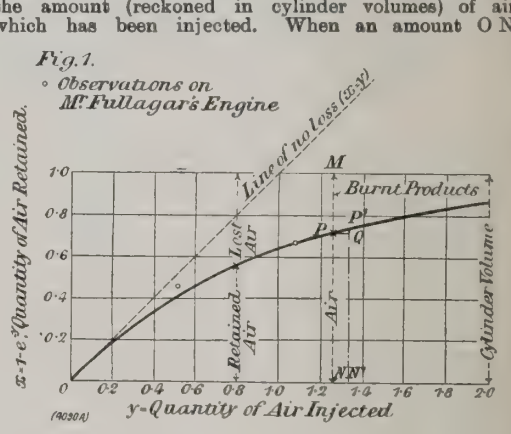
In considering recently the designs of certain two-cycle gas-engines, the author was struck by the almost complete absence of data of general application on which to base, in the case of a new design, a calculation of the size of pumps required to give a certain mean pressure and a prediction of the economy which may be expected. Little or nothing has been published as to the amount of the loss to exhaust which occurs in existing engines, and there is no theory to guide designers in the use of such data as exist on this point or may become available. In the present paper an attempt is made to provide a working theory of this kind, some experimental confirmation is given of it, and methods are suggested for getting more information.

In the course of the charging process, for each unit of volume of air or mixture which enters at the inlet an equal volume of the gas near to the exhaust-ports will be driven out through those ports, which gas will consist partly of burnt products and partly of air which has mixed with the products. It is here assumed that the pressure in the cylinders during the admission period is that of the atmosphere; the effect of the disturbance of this pressure by throttling at the exhaust-ports, and by the inertia of the gases in the exhaust-pipe will be considered later. Denote by z the proportion of air by volume contained in the exhaust gases. This will be the same as the proportion which is contained in the cylinder contents near to the exhaust-ports at any state of the charging. For this purpose z is not the volumetric proportion determined by an ordinary analysis; it is the volume, reckoned at atmospheric pressure and at the temperature of the air as it comes in, contained in a cubic foot of the cylinder volume; the balance $1-z$ consists of burnt products from the previous explosion, whose volume is, for this purpose, reckoned at the temperature of those products before charging began. Obviously z will increase from zero as charging goes on, and will approach, but never reach, the value unity; at first, when very little air has been put in, the exhaust gases contain no air; when a large quantity has been blown through, the exhaust is almost pure air. The total amount of air lost in charging will be equal to the volume delivered (denoted by z) multiplied by the average value of z, and is readily calculable if this quantity is known at every stage. The amount of air retained in the cylinder is equal to y minus the loss; this will be denoted by x.

Two cases admit of very simple treatment. The first is the ideal case of perfect stratification. The air simply drives the burnt gases before it without mixing with them at all, and there is no loss until the amount of air exceeds the cylinder volume. It is quite certain that this condition is never even approached in practice. Probably the first two-cycle engine ever built, that made by Dr. Dugald Clerk in 1880, came nearer to attaining this ideal condition than any which has been made since. Dr. Clerk, who thoroughly appreciated the necessity of getting as much stratification as possible, used a very long conical combustion-chamber. Even so, there must have been a good deal of mixing, and in modern high-compression engines (the compression-ratio in the Clerk engine was 3) such a construction is impossible.

The second case represents much more nearly what actually happens. Suppose that instead of complete stratification there is no stratification at all—suppose the mixing so complete that the cylinder contents are at every instant of uniform composition throughout. Here again it is possible to calculate the proportion lost up to any stage with complete certainty and accuracy. The quantity z now represents not only the proportion of air in the gas which is going into the exhaust at any stage, but also the proportion then present in the cylinder as a whole. It is convenient in these calculations to take as the unit of volume the whole volume of the cylinder, and x the volume of air which has been retained in the cylinder then represents also the proportion of air in the whole cylinder contents, so that in the case now under consideration $z = x$. In Fig. 1 x is plotted against y, the amount (reckoned in cylinder volumes) of air which has been injected. When an amount O N

Fig. 1.



has been injected, the air present in the cylinder P N, the remainder P M being burnt products. The effect of adding the further dose of air N N¹ is to expel at the exhaust the quantity of air $\frac{P N}{M N} \times N N^1$. The balance remains in the cylinder, increasing the quantity of air there by $P^1 Q = \frac{P M}{M N} \times N N^1$. So the curve can be constructed step by step. It is the well-known exponential curve whose slope at any point is equal to the ordinate P M. The relation between x and y (of course, easily obtained mathematically) is $x = 1 - e^{-y}$.

In many engines now in use the mixing is probably fairly complete, and the simple formula just given represents fairly accurately what occurs. Such are short-stroke Diesel engines with valves in the cylinder-cover, and probably also the double-ported engines having the inlet-ports opposite the exhaust-ports and a deflector-plate on the piston. In engines having relatively longer cylinders, such as the Oechelhäuser, there is some stratification of the cylinder contents; but even here the effects of stratification are probably not very great. They are of the nature of a correction, and before discussing this correction along with others, the necessity of which will appear later, it will be convenient to compare the simple formula with results actually obtained from an engine in the course of some recent trials conducted by the author for the Fullagar Engine, Limited, and then to give some illustrations of its application to other papers.

Tests on Mr. Fullagar's Engine.

The engine in question was built to the designs of Mr. H. F. Fullagar. It represents an important de-

* Paper read at the joint meeting of the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, and the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle-on-Tyne, July 8, 1914.

velopment in large-power gas-engines, and has several features of great interest, but, as Mr. Fullagar will be describing it himself, it is only necessary to give here such details as bear on the subject of this paper. It has four vertical cylinders of the Oechelhaüser type, coupled together in pairs, the upper piston of one being coupled by diagonal rods to the lower piston of its neighbour, in the manner invented by Mr. Fullagar. The leading dimensions of each cylinder are given in Fig. 2. The air-ports (there is only one set of admission-ports) communicate with a large receiver, to which air is delivered by an electrically-driven fan. Coal-gas was used in these trials, and was admitted by a piston-valve at the centre of the cylinder. The valve was opened 5 deg. of crank angle before the exhaust-ports closed, and remained open for 36 deg. crank angle. The coal-gas was delivered at high pressure by a reciprocating pump.

The verification of the formula above given required the accurate measurement (1) of the total quantity of air delivered to the engine per minute, and (2) of the proportion of that air retained in the cylinder.

1. *Quantity of Air.*—A diaphragm with a circular hole was inserted in the air-delivery pipe, between the fan and the engine, and the drop of pressure measured by means of a water-gauge. The diameter of the air-pipe was 18 in., that of the hole in the diaphragm 9 in. The current of air through the diaphragm was nearly uniform, the pulsations caused by the engine being nearly damped out by the large air-receiver. The velocity of the air through the hole was calculated according to the usual formula, assuming 0.62 as the coefficient of discharge. The coal-gas was also metered, and the quantity of coal-gas used, together with an analysis of the exhaust gases, gave an independent measure of the amount of air used. The quantity of air delivered to the engine was probably determined correct within 3 per cent.

2. *Proportion of Air Retained.*—For determining this samples were taken of the contents of all four cylinders, and analysed. The average proportion of carbon determined in the samples was compared with the proportion in a sample of the exhaust gas taken simultaneously. The ratio of the two carbon contents is equal to the ratio of the total air delivered to the air retained in the cylinder, $\frac{y}{x}$ in our notation.

For the purpose of collecting the samples of the cylinder contents, a pipe of very small bore was screwed into a hole drilled in the sparking-plug. The other end of the hole was closed with a nipple having a small hole in it. The pipe communicated with the sampling vessel, into which it delivered the gas slowly, a small quantity coming in at each explosion. The result of this procedure is that the sample consists partly of a mixture of unburnt gas and air blown through the pipe during the compression stroke, and partly of burnt gases which come through during the expansion stroke. Usually the proportion of burnt to unburnt was about 2 to 1. As the coal-gas admission-valve is opposite the sampling-hole, both being at the middle of the length of the cylinder, the tendency of the method is to collect samples which are a little too rich in coal-gas. But it is believed that the error so caused is not large. The greater part of the sample comes through while the pistons are near the in-centre, by which time any stratification of the coal-gas will in large measure have disappeared, and will moreover be of less importance because of the compression of the cylinder contents.

Samples were taken from all four cylinders simultaneously, and after absorbing the CO_2 the combustion of the residue was completed over palladium, and the further yield of CO_2 obtained. The total CO_2 gave the proportion of coal-gas to air in the cylinder contents. A simultaneous analysis of the exhaust gases gave the proportion of coal-gas to air delivered to the engines. A check was obtained by estimating the oxygen in the exhaust and in the cylinder contents. The analyses were made for the Fullagar Engine, Limited, by Dr. Mechie and Mr. Hill, of the Wallsend Laboratories. Great care was taken by these gentlemen to eliminate all errors in the estimations, and the author believes that, thanks to their labour, the figures now given are of an order of accuracy rarely attained in a commercial trial.

The following is a summary of the results obtained in two trials, in one of which the volume of air delivered to each cylinder per stroke was about equal to the cylinder volume, in the other about half. In the first case the engine had to be run slow, as the fan would not at the normal speed deliver a sufficient volume of air to give a cylinder-full per revolution:—

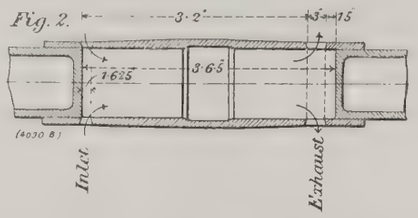
Trial.	Ia.	Ib.	II.
Speed .. .. revolutions per minute	200	200	250
Air per cylinder per revolution (by diaphragm) .. .. cub. ft.	2.70	2.70	1.42
Air per cylinder per revolution (by gas-meter and exhaust analysis) .. cub. ft.	2.86	2.86	1.38
Coal-gas per cylinder per revolution (by meter) .. .. cub ft	0.189	0.182	0.163
Air delivered to engine (exhaust Coal-gas analysis)	15.1	15.7	8.45
Air in cylinder contents (analysis, Coal-gas mean of four cylinders)	9.4	9.45	7.35
Air retained, per cylinder per revolution cub. ft.	1.78	1.72	1.20

The volume of the cylinder when the pistons are at the out-centre is 2.75 cub. ft. When the inlet-ports are just closed it is 2.50 cub. ft. Having regard to the dwell of the pistons near the out-centre, the mean volume during the period of injection will be nearer to the former figure; take it as 2.65 cub. ft. Dividing this volume into the volumes of air given on lines 3 and 7 of the above table we get the value of y and x. They are tabulated in the following table, together with the corresponding values of x calculated from the formula.

—	Ia.	Ib.	II.
y = air delivered per cubic foot of cylinder volume	1.08	1.08	0.52
x = air retained per cubic foot of cylinder volume	0.67	0.65	0.45
Calculated value of $x\,(=1-e^{-y})$	0.66	0.66	0.405
$y-x$ (measured)	0.41	0.43	0.07
$y-x$ (calculated)	0.42	0.42	0.115
Percentage of air lost to exhaust (measured)	38	40	13.5
" " " (calculated)	39	39	22

It will be seen that there is rough agreement between the calculated and measured figures, sufficient at any rate to justify the use of a simple supposition of complete mixing as a first approximation to what occurs. On the other hand, the deviation with the smaller amount of air is too great to be ascribed to errors of observation. The observed loss of air is only about two-thirds of the calculated loss. This shows that there are disturbing factors which must be taken into account as corrections to the simple theory. In trials Ia. and Ib. these connections apparently neutralise each other, producing, as it happens, almost exact agreement. Before dealing with these corrections, it will be convenient to give one or two simple illustrations of the application of the theory to practical cases.

Fig. 2.



(*a*) Diesel engine, stroke equal to bore, or slightly greater; inlet-valves in cylinder cover. This is a case in which the mixing will be nearly complete. Suppose that the volume of the air-pump is $1\frac{1}{4}$ times the total cylinder volume (including clearance space). The volume of air delivered, reckoned at the temperature of delivery, will be approximately that of the pump, the rise of temperature due to the pumping work compensating for the volumetric inefficiency of the pump. Hence $y = 1.25$ and the volume of air retained (P N in Fig. 1) is $x = 1-e^{-1.25} = 0.71$. The volume wasted ($y - x$) is 0.54, or 43 per cent. of the amount pumped. The cylinder contents consist of a mixture of 0.71 air at 40 deg. to 50 deg. Cent. (temperature in air-delivery pipe) and 0.29 of burnt products at perhaps 500 deg. Cent. The scavenging is far from complete, and the charge would be rather hot and the flame temperature correspondingly high, necessitating a low mean pressure in order to avoid over-heating. It may be added that no substantial improvement can be effected in this respect except by the use of excessive quantities of air. For instance, it will be seen from the diagram that to reduce the amount of burnt products left in the cylinder to 15 per cent. the air-pump must be nearly twice as big as the cylinder.

(*b*) Gas-engine, with separate gas and air-pumps, using producer-gas. In such an engine the pumps and admission-valves or ports would be arranged so that as far as possible the air goes in first, the gas following it. Thus in the Oechelhaüser the air-ports open first, and a large part of the air is discharged through them before the gas-ports open. Then the gas comes in, mixing with the remainder of the air. The amount of air coming in with the gas in any case can be calculated roughly beforehand from the size of receivers and the size and position of gas and air-ports; but such calculations are apt to be much upset by the exhaust back-pressure, whose efforts are difficult to allow for, and will vary in different cases according to the length of the exhaust-pipe. For purposes of illustration, we will assume that at full load the volume of air passing the air-ports before the gas-ports open is half the cylinder volume; and that this is followed by quarter cylinder volume of gas and the same quantity of air, and that no air enters after the gas-ports are closed.*

The volume of mixed gas and air is half the cylinder volume. Hence $y = \frac{1}{2}$, and the amount of mixture retained in the cylinder per cubic foot of its volume is $x = 1-e^{-0.5} = 0.394$. The proportion of the pumped gas which is retained and burnt is $\frac{x}{y} = 0.79$, and the balance (21 per cent.) is wasted to exhaust. Assuming the engine to have a compression ratio of 6.5 (ratio of cylinder volumes at out and in-centre), it would give an indicated efficiency on the basis of the gas actually burnt of 0.37 or 0.38, say 0.375. The quantity of gas retained and burnt per cubic foot of stroke volume is $0.79 \times 0.25 \times \frac{6.5}{5.5} = 0.233$ cub. ft. If the gas has a lower calorific value of 140 British thermal units per cubic foot at atmospheric pressure and at the temperature in the receiver, the indicated mean pressure will be $0.375 \times \frac{0.233 \times 140 \times 778}{144} = 66$ lb. per sq in., which is a little above the normal figure for an engine of this type. Allowing a mechanical efficiency of 83 per cent., the practical efficiency (ratio of brake power to the lower heat-value of the whole of the gas pumped) will be $0.83 \times 0.79 \times 0.375 = 0.246$, equivalent to about 10,400 British thermal units per brake-horse-power hour.

In practice two-cycle gas-engines do a little better than this, though at the high mean pressure of 66 lb. per sq. in., it is doubtful whether any of them could be relied on to produce a brake-horse-power hour for much less than 10,000 thermal units. The Oechelhaüser engine with its long cylinder gets the benefit of some stratification. In the Körting the admission valve is timed so that it closes after the exhaust-ports, and some of the charge is thus trapped without any possibility of getting out. On the other hand, in both cases these favourable factors are apt to be neutralised by the exhaust pressure holding up the scavenging air. But broadly speaking, and subject to corrections of this nature, which, on the whole, are small, the simple theory leads to conclusions which are in accord with practical results. It may be noted in this connection that the Fullagar engine, in which there was no waste of gas at all, showed an indicated efficiency of 0.376, and a brake efficiency of 0.30; and the latter figure would reach 0 31 if the mechanical efficiency were raised to the normal figure for these engines by the use of a more economical method of serving the engine with air.

Effects of Stratification.—In the simple theory of the charging process which has been discussed, it is assumed that at every instant during the period of admission the cylinder contents are homogeneous in composition, and that their pressure is that of the atmosphere. In fact, there is in all engines some stratification of the cylinder contents, the portions near the exhaust-ports being poorer in air and richer in burnt products than the average. There is also in all cases some throttling in the exhaust-ports and exhaust-pipe, and inertia effects in the exhaust-pipe, in consequence of which the pressure in the cylinder varies during the admission period. The effects of these two factors will now be considered, beginning with stratification. Suppose that y represents, as before, the volume of air which has been delivered through the inlet-ports at any stage, and x the volume which has been retained in the cylinder, $y - x$ having been wasted through the exhaust-ports. These volumes are reckoned in terms of the total cylinder volume taken as unity, and x is therefore the average proportion of air (by volume) in the cylinder contents. These contents are now, however, not of uniform composition, but near the inlet-ports they are richer in air than the average, and near the exhaust-ports poorer. Thus a cubic inch of air delivered through the inlet now displaces and drives through the exhaust a cubic inch of gas containing a proportion z of air, where z is less than x. The full discussion of the relation between z and x—that is, of the amount of stratification—is beyond the scope of this paper; it will suffice to state here that there are good *à priori* grounds for the supposition that in practical cases it is given by an expression of the form:—

$$z = x\left\{1-\lambda(1-x)\right\}$$

where λ is a constant depending on the engine (proportions of cylinder, size and shape of ports, &c.). It will be seen that this formula satisfies two necessary conditions: the one that at the beginning of injection the exhaust shall contain no air ($z = 0$ when $x = 0$), the other that when a large quantity of air has been blown in, so that the burnt products have been nearly all cleared out, the exhaust shall be practically pure air ($z=1$ when $x=1$).

The constant λ, which is characteristic of the engine as regards stratification, I propose to call the "stratification constant." The greater its value the greater is the amount of stratification; and when $\lambda = 0$ there is no stratification, for then $z=x$; that is, the proportion of air near the exhaust-ports is equal to the average proportion throughout the cylinder.

Once the proportion of air near the exhaust-ports (z) is known in terms of the average composition (x), the relation between the quantity of air retained (also x) and the total quantity injected (y) can be obtained with mathematical certainty. For the relation between z and x given above, it takes the form:—

$$x = \frac{1 - e^{-(1+\lambda)y}}{1 + \lambda e^{-(1+\lambda)y}}$$

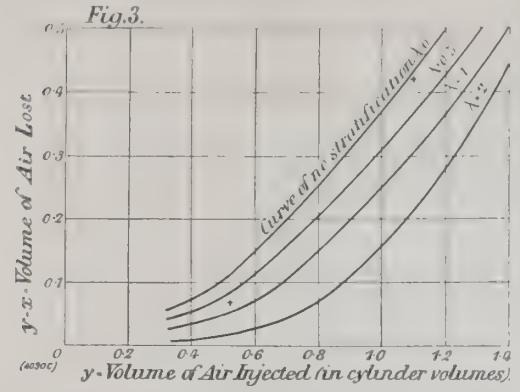
This formula applies to such amounts of stratification as are likely to occur in practice, for which λ will not usually exceed 1. For larger values of λ the expression for z in terms of x obviously ceases to be accurate, since it would take a negative value unless x is nearly equal to 1. The more accurate relation between x and z, to which the simple equation given above is an approximation, leads to a somewhat more complicated formula for x in terms of y, which it is unnecessary to give here, as it is not required in any practical case.

In Fig. 3 are plotted the curves of loss $(y-z)$ calculated from this formula for various values of λ. If this constant is known for the type of engine under consideration, the corresponding curve gives (subject to any correction for the effects of exhaust-back-pressure) the amount of air wasted out of any given quantity injected. It is to be

* With a perfectly free exhaust, this distribution of air and gas is possible in the ordinary design of the Oechelhaüser engine; but the author is of opinion from data in his possession that in ordinary practice the distribution is not so good. Cards taken from the receivers in one case, which is probably typical of many, show that the exhaust pressure had not fallen to atmosphere when the air-ports opened, so that the air was held up, and more of it went in along with the gas than is here assumed.

noted that in most cases λ is not much greater than unity, and a comparatively rough guess at its value, based on experience with similar engines, will give results good enough for practical purposes.

Fig. 3.



The points determined from the tests on Mr. Fullagar's engine are noted on the same sheet, from which it will be seen that the lower point falls between the curves corresponding to $\lambda = 0.5$ and $\lambda = 1$, while the upper, as already indicated, falls near the curve $\lambda = 0$.

Experiments with a Water Model.

The phenomenon of stratification can be studied very conveniently by means of a model of the engine cylinder in which water is used instead of air. The model can be made to scale, of sheet iron, and is provided with an admission-valve at the lower end, which can be opened and closed by hand. Through the valve the cylinder communicates with a large chamber containing water with an air-space above, whose volume is equal to or greater than that of the water. Air is pumped into the chamber until the pressure is 10 or 15 lbs. per sq. in. The exhaust-ports at the upper end of the cylinder are permanently open, and discharge into a channel, whence a shoot leads to a tank. The cylinder is filled up to the edge of the exhaust-ports with brine containing a known proportion of salt; this corresponds to burnt products. In making an experiment the valve is rapidly opened and closed by means of a handle and crank, this operation taking in an ordinary case about 1 second. The water from the chamber (which corresponds to the air in the engine) rushes through the inlet-valve and displaces the brine. Samples of the contents of the cylinder and of the exhaust-tank are then analysed for their contents of salt, and from the analysis the quantity of pure water which has passed out through the exhaust along with the brine can be estimated. The experiment corresponds, in fact, with that already described as having been made on Mr. Fullagar's engine, in which simultaneous analyses were made of the cylinder contents and of the exhaust gases.

The use of water models for ascertaining the behaviour of air is familiar to those who are concerned with aeronautics. The resistance of an airship, for instance, can be ascertained by towing a model in a water-tank. Theory, which has been confirmed by experiments of many different kinds, shows that the motions of the two fluids will be dynamically similar if the velocities and the linear dimensions are so related in the two cases that $\frac{VL}{\nu}$ is the same for both, ν being the viscosity. For air the value of ν is about 13 times as great as it is for water. Hence, if the dimensions of the model and ship are the same, the motions will be similar if the model is towed $\frac{1}{13}$ of the speed of the ship.

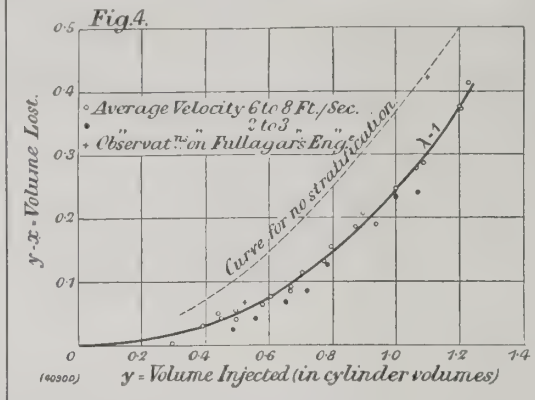
In the case of the engine cylinder the matter is more complicated, because the hot burnt products which the cylinder at first contains have greater viscosity and less density than the air which displaces them. Moreover, owing to the varying back-pressure in the exhaust, changes of density occur in the cylinder contents which can have no counterpart in the water model. But subject to these points there cannot be any question that the law of dynamical similarity will apply equally to this case. That is to say, if producer-gas is injected into a cylinder containing cool air (as happens if there has been a previous scavenging charge) and possessing a completely free exhaust, the loss will be precisely the same as the loss of water in the water model when the same quantity of water is injected at $\frac{1}{13}$ of the velocity. The period of injection of the water will be 13 times as great as that of the gas; thus the whole operation can be done slowly by simple mechanism.

Fig. 4 shows the results of a large number of experiments made on a full-size model of Mr. Fullagar's engine The curve is that corresponding to the formula given above for the case where $\lambda = 1$. It will be observed that within errors of observation the observed points agree with this curve. This is a satisfactory confirmation of the theory on which the formula is based. It will also be noticed that the velocity of injection varies widely in different experiments, but that there is apparently no considerable difference between high and low velocities as regards the loss to exhaust. This fact is of some importance, because it follows from it that similar variations in the viscosity of the fluid would have a like small effect.

On the same diagram are marked the two points showing the loss of air actually occurring in Mr. Fullagar's engine. It will be seen that in both cases the loss in the engine is greater than in the model, though the difference is not very great in the case of the smaller quantity of air. The differences must be due to one or both of the two factors which have been mentioned as not represented on the model; that is, the difference in viscosity and density between the air and the burnt products which it displaces, and the varying pressure in the cylinder. The effect of viscosity is certainly small; that of density may be considerable. But in the author's view it is probable that the important cause of the difference is the varying pressure, which is considered in greater detail in the next section.

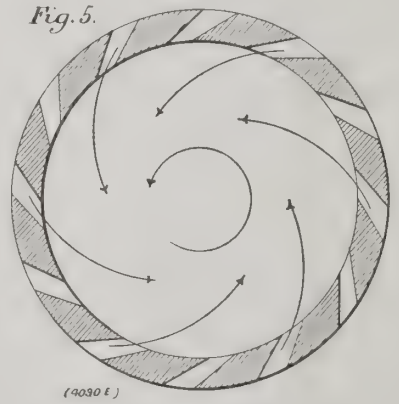
It is obvious that the use of water models cannot be relied on as a means of quantitative investigation until further comparisons have been made between engines and their models, and even then the disturbing factor of exhaust pressure complicates the interpretation of the results. But the author believes that it promises to be a

Fig. 4.



useful way of comparing, with little expense and trouble, the properties of different forms of cylinder and of ports and valves as regards stratification. For instance, it would appear from experiments of this kind which the author has made that a cylinder like the Oechelhaüser, whose length is perhaps three times its diameter, is much better from this point of view than a cylinder of one-third that length, such as a short-stroke engine with admission-valves in the cylinder cover. In the shorter cylinder none of the many devices that the author has tried with the view of directing the motion of the incoming air have availed to produce any stratification. But in the larger cylinder it would appear that such an

Fig. 5.



arrangement as is shown in Fig. 5, whereby a whirling motion is given to the air, has the effect of substantially reducing the loss.

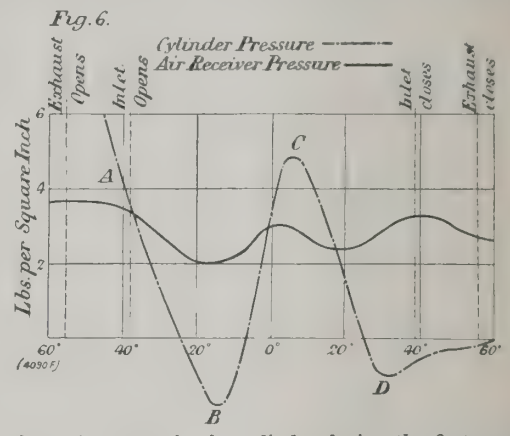
Effect of Varying Pressure in the Cylinder.

Both the simple theory and the discussion of the correction of that theory for stratification rest on the assumption that the pressure in the cylinder is atmospheric during the admission period. As a matter of fact, in any actual case this pressure will vary, the variations being determined partly by the throttling effect of the exhaust-ports, but mainly by the inertia of the column of gas in the exhaust-pipe. The surging of this column of gas causes the pressure in the exhaust-pipe near the engine to rise and fall in a periodic manner, the period depending on the length of the pipe. A full discussion on the amount and nature of these variations of pressure is outside the scope of this paper, and all that will be attempted is a short consideration of their effects, in one or two simple cases, on the charging of a two-cycle engine.

It seems probable that those pressure variations which are likely to occur in practice will cause increased loss to exhaust. For instance, it may happen that the exhaust-pipe pressure is rising when the admission-ports or valves are first opened, with the result that at first the injection of a cubic inch of air will not be accompanied by the discharge of an equal volume of mixed air and burnt products, but a less volume will be discharged. When at a later stage the exhaust-pipe pressure falls to atmosphere or (it may be) below atmosphere, the excess volume which had been held up in the cylinder will be discharged. The proportion of air in the gas which then goes out corresponds to the whole, or nearly the whole, amount which has been injected, and will be greater than it would have been had the exhaust come out as fast as the air went in. To take an extreme case, suppose that half of a cylinder volume of air is put in without anything going out of the exhaust-ports at all. The cylinder contents will then consist of one volume of burnt products more or less thoroughly mixed with half a volume of air, the pressure of the whole being $1\frac{1}{2}$ atmospheres. Now suppose that the exhaust-pipe pressure falls to 1 atmosphere. The accumulated cylinder contente, now well mixed up, will at once escape. The volume of gas passing out will be half the cylinder volume, and it will consist of air and burnt products in the proportion of 1 to 2. Thus the quantity of injected air which is lost will be $\frac{1}{3} \times 0.5$ or 0.17 cylinder volume. Reference to the curve, Fig. 1, will show that if the pressure had been uniform, the quantity lost (in the absence of stratification) would be 0.105. This, of course, is an extreme case, which could not arise in practice, but it shows the tendency of a high exhaust pressure at the beginning of admission to increase the loss of air.

The actual pressure variations in the cylinder of the Fullagar engine at a speed of 250 revolutions per minute are shown in Fig. 6. It will be seen that here the surging in the exhaust-pipe is of such a character as to produce

Fig. 6.



a drop of pressure in the cylinder during the first part of the admission period (A to B). During this period the gas is going out quicker than it comes in, and the exhaust consists mainly of burnt products mixed with a little air. Then at B the pressure begins to rise, and the air accumulates in the cylinder. At C the pressure falls rapidly, and the accumulated cylinder contents, which have had plenty of time to mix, are rapidly discharged, thus reproducing at this stage the conditions described in the last paragraph. Moreover, at C the cylinder pressure is higher than the air pressure, so that some of the cylinder contents (which still contain a large proportion of burnt products) will back into the receiver; some of the contents of the exhaust-pipe must also at this point come back into the cylinder. A quantitative estimate of the effect of the variations on the loss of air could be made by the use of the principles enunciated earlier in this paper, but would be a long and complicated piece of work. It will be sufficient to observe that the general result must be to increase the loss. The holding-up of the air and the backward and forward flow in the middle of the admission period will mix up the air and products of combustion, and will destroy the stratification which would otherwise exist. The author believes this cause to be sufficient to account for the difference between the results obtained with the water model and with the engine.

Though the theory of the charging process which has been suggested in this paper cannot be regarded as completely proved as regards details, the author has ventured to bring it to the notice of those interested in two-cycle engines in the hope of eliciting from them more facts about the loss to exhaust. It is to be regarded as a working hypothesis which may prove useful in the interpretation of data, but which will probably require modification in its details as more facts are accumulated. This remark applies more particularly to the corrections for stratification and for varying exhaust pressure. The simple theory based on the assumption of complete mixing and uniform cylinder pressure is, in the author's opinion, a very fair first approximation, which will give results of sufficient accuracy in most practical cases, and as such he hopes that it may prove of use to designers.

The author wishes to express his gratitude to the Fullagar Engine Company, and to Mr. Fullagar, for permission to make use of the results obtained in the trial of their engine, and for the facilities which they provided in the course of that trial for making measurements, the commercial value of which was not immediately obvious. He is also much indebted to his assistant, Mr. Bird, for his care and zeal in carrying out many experiments and designing apparatus used in connection with this paper.

English Enterprise in Sweden.—Extensive surveying and investigating work is at present going on in Iämtland, Sweden, for account of an English syndicate. The two localities in question are Karberget and Ankarvattnet; the former, close to the Ström valley, contains vast deposits of magnetic ore and copper ore, also cornite. At the Ankarvattnet there is a sulphur ore, containing copper, the vein being about 40 metres broad, and the ore containing about 45 per cent. of sulphur, which means that it is well suited for export. The value of the Ankarvattnet, should the calculations of the experts prove correct, will certainly be very considerable, the more so as a place within the northern frontier, and about 6 miles distant, is about to have railway connection with a Norwegian port.

BALANCING OF INTERNAL-COMBUSTION ENGINES.*

By H. F. FULLAGAR, M.A. (Cantab.), of Newcastle-on-Tyne.
Communicated by WILLIAM HANNING, Member, of Paris.

THE problem of balancing internal-combustion engines is in general much more difficult and complex than the corresponding problem with steam-engines. The adoption in the former case of the single-acting cylinder and trunk-piston generally necessitates wider crank-angles than with steam. If, on the other hand, a larger number of cylinders are employed, vibration arises owing to the increased length and flexibility of crank-case or framing. A further difficulty in comparison with steam practice arises from the sudden and violent increase of pressure when the charge is fired by a spark, which has nothing comparable in the gradual admission of steam pressure to the piston, whilst when the charge is fired by high-compression the compression stroke produces a severe reversal of torque in the crank-shaft and reversal of side-thrust between the piston or crosshead and its guide. But while on the one hand the difficulties of balance are greater in the case of the internal-combustion engine, the need of perfection of balance is also greater, owing to the purpose for which the internal-combustion engine is particularly applicable.

In marine work a very high standard of balance has been set by the steam-turbine; for motor-car and aviation purposes an even higher standard is required, for the following reason:—When an engine with a very light framing is mounted on a light fuselage, the inertia forces, which are relatively very large, unless well balanced amongst themselves, will communicate vibration to the whole machine. Long-distance flying is at present largely a matter of endurance of the pilot, and vibration, apart from its effect upon the engine and fuselage, induces fatigue and saps the nerves of the pilot and observer.

Absolute freedom from vibration involves balance of two kinds—balance of mass and balance of impulse.

Balance of Mass.—Dealing first with the balance of mass: this requires that if the engine be driven by some external source, the inertia forces due to the acceleration of the rotating and reciprocating parts neutralise each other and have no external resultant. Balance of mass is so well understood by members of this Institution that it is necessary only to notice very briefly the degree attained with ordinary constructions of internal combustion engine. Balance of the rotating members, the crank-shaft and cam-shaft, presents, of course, no theoretical difficulty, provided the crank case is sufficiently rigid to resist the reactions set up.

The inertia forces of the reciprocating parts are of two kinds: primary forces, such as would result if the piston had simple harmonic motion, that is, if the connecting-rod was of infinite length; and secondary forces, due to the additional motion resulting from the finite length of the connecting-rod. This secondary motion is almost exactly simple harmonic in character, but has double the frequency. Perfect balance of both primary and secondary forces can together be secured only by placing connecting-rods on opposite sides of the crank-shaft (Figs. 1 and 2). If, as usual, the crank-shaft revolves, the connecting-rods must be attached to opposite cranks; but if the cylinders revolve, both connecting-rods can be attached to a single crank (Fig. 3). All three constructions can, however, have but limited application.

The ordinary motor-car engine with four cylinders operating upon the four-stroke cycle necessarily has its crank in one plane, 180 deg. apart, in order to give reasonable uniformity of impulse. In this case the secondary forces are wholly unbalanced. When the plane of the cranks is horizontal the connecting-rod has moved the piston to below mid-stroke by the amount a, Fig. 4, which, if the length of the connecting-rod be four times the crank radius, amounts to one-sixteenth of the stroke. As this displacement occurs twice per revolution, and affects all four pistons, the secondary forces set up are equivalent to the inertia of a single piston moving the whole stroke, but acting with double the frequency. With a connecting-rod of the length of five cranks, the secondary inertia force is four-fifths of this amount. When two such sets of four cylinders are placed together in the "V"-type engine, the secondary forces of each set are unbalanced, and their resultant is 40 per cent. greater than either, and acts in a horizontal plane, Fig. 5.

The secondary forces of the four-cylinder engine, Fig. 4, result from the fact that the common centre of gravity of the four pistons, instead of being stationary, as would be the case if the connecting-rods were infinitely long, has a small harmonic motion of double frequency. It can therefore be balanced by reciprocating or rotating balance-weights, driven at twice the frequency of the main piston. Mr. Lanchester's ingenious method of doing this is to gear a pair of wheels carrying balance-weights to the main crank-shaft, which drives them at double its speed. As the wheels rotate in opposite directions, the components of the centrifugal forces of the weights always balance themselves in the plane through the axes of the wheels, but have a vertical component which balances the secondary inertia forces. Such a four-cylinder engine, though with its cranks in one plane, will have, as a whole, complete balance of mass, but the method involves calling into play two otherwise useless forces, with some addition to the weight and number of parts.

With four cylinders operating upon the two-stroke cycle, the cranks can, of course, be placed at right angles instead of at 180 deg., and then it is possible to secure complete balance of both primary and secondary forces, with exception of a couple produced by the secondary forces in the plane of the cylinders and crank-shaft, which tends to rock the engine in a fore-and-aft direction. This couple can usually be neglected in practical application. Engines with five and six cylinders in line, with either cycle, can, of course, be perfectly balanced as to the primary, and almost perfectly as to the secondary inertia forces.

To sum up, therefore, the only engine constructions in common use in which balance of mass is completely, or almost completely, secured by the neutralisation amongst themselves of the primary and secondary inertia forces, are the rotating engine, Fig. 3, above, the engine with five and with six cylinders in line, and the four-cylinder two-stroke engine with cranks at right angles. Of course also multiplications of these last three of the "V" or radial-type engine, in which the parts in each axial plane are balanced, are completely balanced as a whole. All these engines will be vibrationless when driven by an external force, provided the crank-case or framing is itself perfectly rigid. In practice it is not always possible, if the engine is very long, to obtain sufficient rigidity. With the light motor-car type, even if the

Fig. 1. ENGINE WITH PERFECT BALANCE OF MASS.

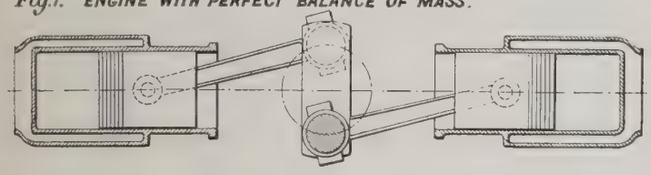


Fig. 2. ARROL JOHNSON ENGINE. MASS AND IMPULSE BALANCED. TORQUE UNBALANCED.

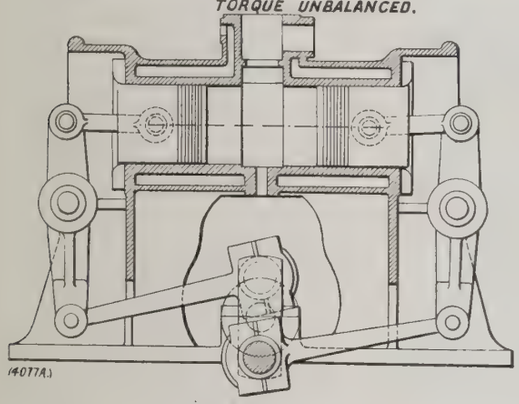


Fig. 3. ROTATIVE ENGINE, HAVING PERFECT BALANCE OF MASS.

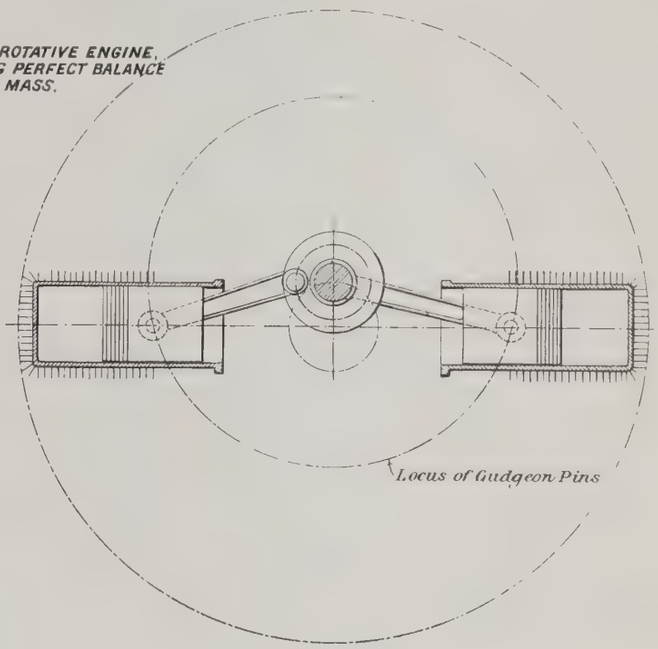


Fig. 4. ORDINARY 4-CYLINDER ENGINE. SECONDARY FORCES ENTIRELY UNBALANCED.

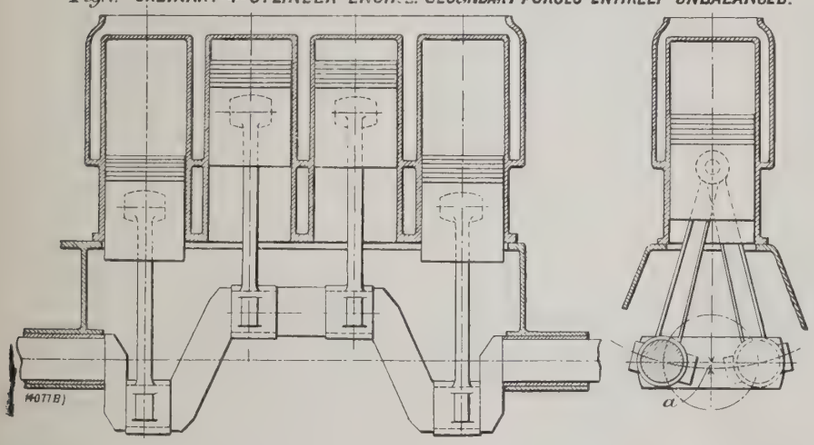
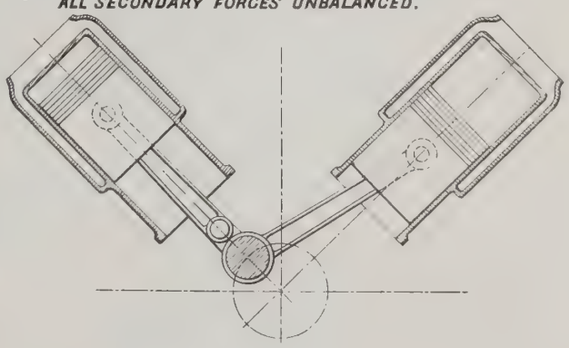


Fig. 5. "V" ENGINE WITH 8 CYLINDERS. ALL SECONDARY FORCES UNBALANCED.



* Paper read before the Institution of Mechanical Engineers at Paris, July 8, 1914.

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Fig. 6. "OECHELHAUSER" ENGINE.
BALANCE OF IMPULSE BUT WITHOUT SECONDARY BALANCE.

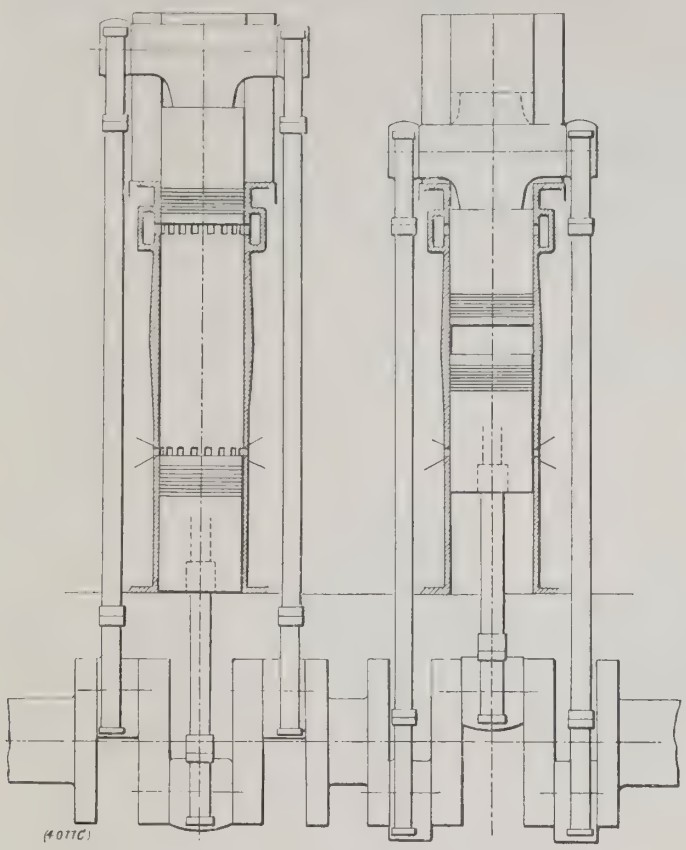


Fig. 7. "JUNKER" ENGINE.
PRIMARY AND SECONDARY BALANCE OF MASS AND BALANCE OF IMPULSE.

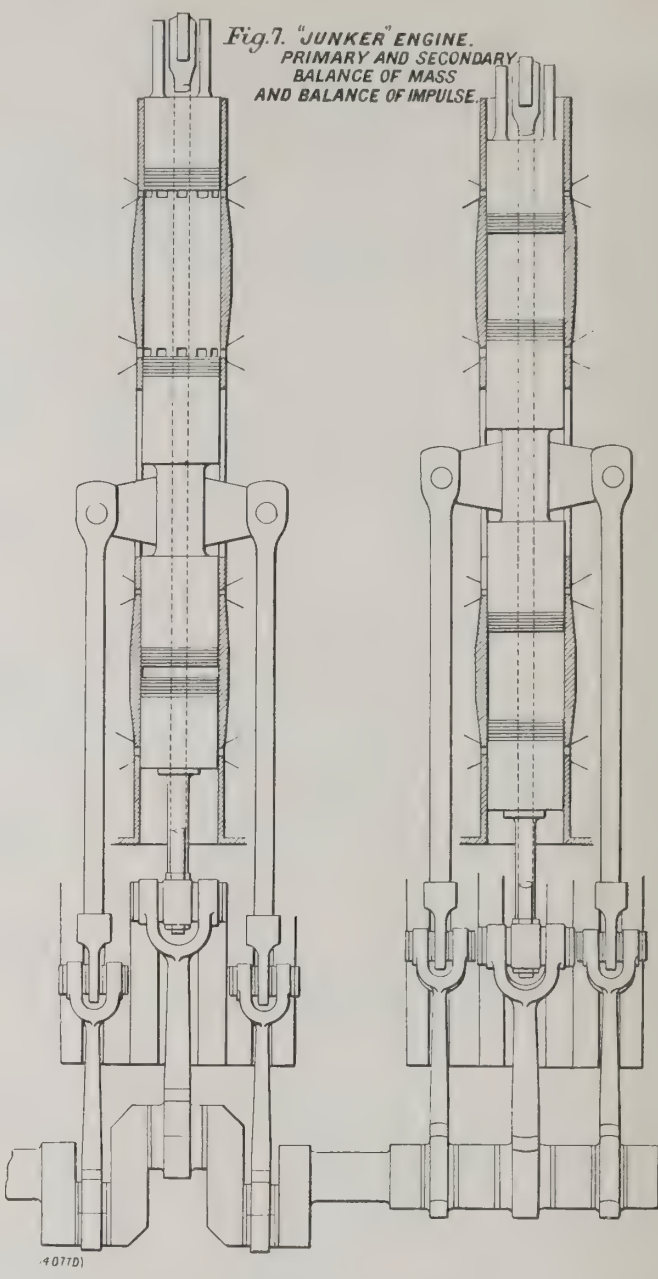


Fig. 11. "LANCHESTER" ENGINE.
MASS AND TORQUE BALANCED, IMPULSE UNBALANCED.

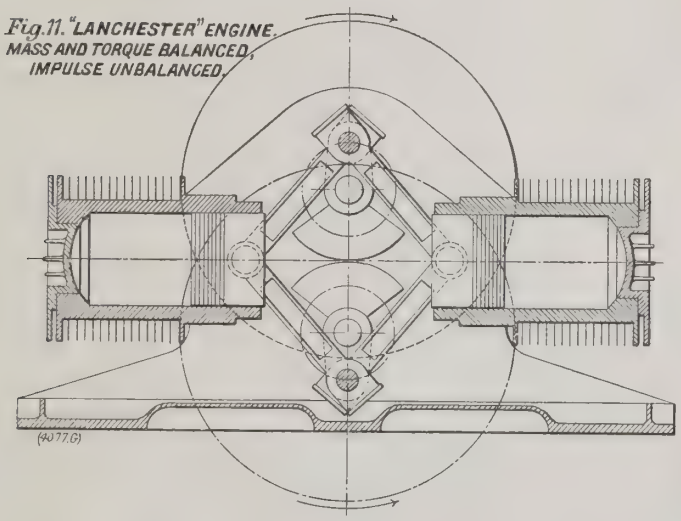
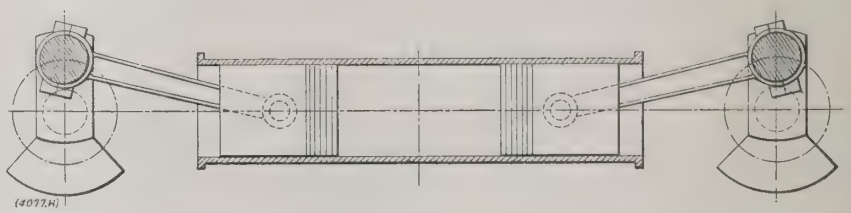


Fig. 12. ENGINE WITH MASS, IMPULSE, TORQUE AND GYROSTATIC ACTION BALANCED.



crank-case be sufficiently rigid, it is difficult when the crank-shaft is long to make it so stiff that the engine will not tend to vibrate relatively to its fly-wheel, whose mass-centre remains almost stationary.

Balance of Impulse.—Balance of mass is, however, insufficient by itself to produce a vibrationless engine, because it takes no account of the violently fluctuating pressures in the cylinders, and the consequent strains in the crank-shaft and engine framing. To secure freedom from vibration, it is necessary so to arrange the cylinders in relation to the crank-shaft that strains in the framing are either eliminated, or so balance each other as to have no tendency to shift the centre of gravity of the engine relatively to its crank-shaft and point of support.

If in Fig. 1 (page 103) the cylinders are arranged in line and fire simultaneously with exactly equal charges, there will be no tendency for the engine to move, except, of course, to rotate round the crank-shaft. The same result is obtained more simply in Fig. 2, which ensures equal pressures on the two pistons. Junkers obtains this equality of impulse, and, at the same time, a valveless two-stroke engine by his well-known arrangement, Fig. 6, but this, unfortunately, is unbalanced as to the secondary mass forces. The three cranks of each cylinder receive simultaneous impulses once only per revolution. The crank-shaft of the two-cylinder engine shown, therefore, receives virtually one impulse for every half-revolution. It will be seen, moreover, that in this, as in all single-acting engines, the pressures on the pistons during the compression and explosion strokes twist the crank-shaft first backwards and then forwards, producing a severe condition of stress, whilst the reaction of the crossheads on their guides also alternate in sign with each stroke.

If, however, a second pair of cylinders, each with a pair of pistons, be arranged tandem on the top of the first two, as shown in Fig. 7, each tandem line is then double-acting, and the cranks of the two sets can consequently be placed at right angles, when balance of impulse will be obtained with primary and secondary mass balance, except only as regards the rocking secondary couple in the principal plane of the engine. The torque transmitted to the crank-shaft, and the reactions of the crossheads on their guides, will then also be in one direction only. This arrangement, however, involves very great height and large number of parts, together with an expensive form of crank-shaft, and the same results are obtained more simply, and without these objections, in the author's arrangement, Fig. 8.

In this two open-ended cylinders, each with a pair of opposed pistons, are placed closely together side by side, and the upper piston of one cylinder is connected to the lower piston of the other by a pair of external oblique tie-rods, as shown, the piston A to the piston D, and the piston C to the piston B. An explosion between A and B drives B down and A up, drawing up D by the oblique rods, and giving two equal and opposite impulses to the two cranks. The pistons A and B, in separating, draw together the pistons C and D, compressing the charge between them. The engine operates upon the two-stroke cycle, the pistons at the ends of their stroke uncovering inlet and exhaust ports, as in the original Oschelhäuser arrangement.

The complete engine has two such pairs of cylinders, and a second pair of cranks at right angles to the first. The explosions in the four cylinders, acting upon the eight pistons, produce eight impulses per revolution, which are transmitted to the shaft in equal pairs. The vertical forces at all times balance each other, and, as in the Junkers engine, are not transmitted through the engine frame.

On referring to Fig. 9 it will be seen that the pistons of each pair are rigidly joined together and form one moving part. The centre of gravity of the pistons A and D is at the point q, and travels up and down on the line pq, whilst the centre of gravity of the other pair of connected pistons C and B is at the point p, and travels up and down on the same line. Thus the primary forces are perfectly balanced, and this is probably the only engine in which the centres of gravity of the balancing masses have exactly the same locus.

Secondary forces result from the fact that the common centre of gravity of all four pistons and their connecting-

THE BALANCING OF INTERNAL-COMBUSTION ENGINES.

Fig. 13. DOUBLE-ACTING VALVELESS ENGINE WITH FOUR IMPULSES PER SHAFT PER REVOLUTION. PERFECT BALANCE OF ALL FIVE KINDS.

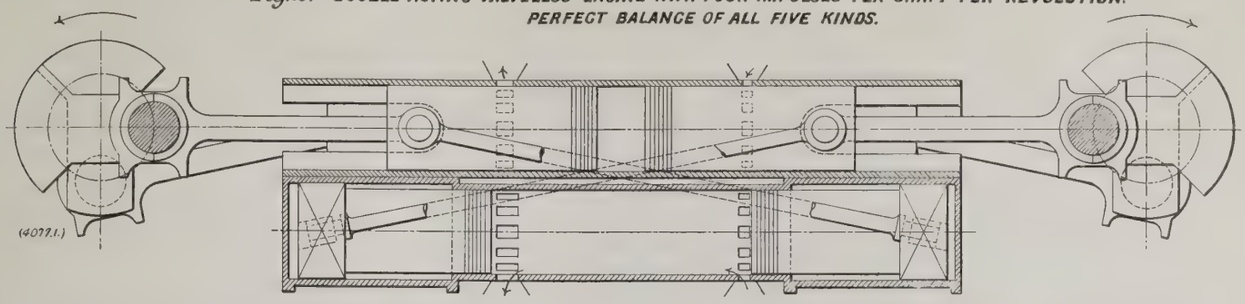


Fig. 8. "FULLAGAR" ENGINE. PRIMARY AND SECONDARY BALANCE OF MASS, AND BALANCE OF IMPULSE, IF MADE WITH 4 CRANKS.

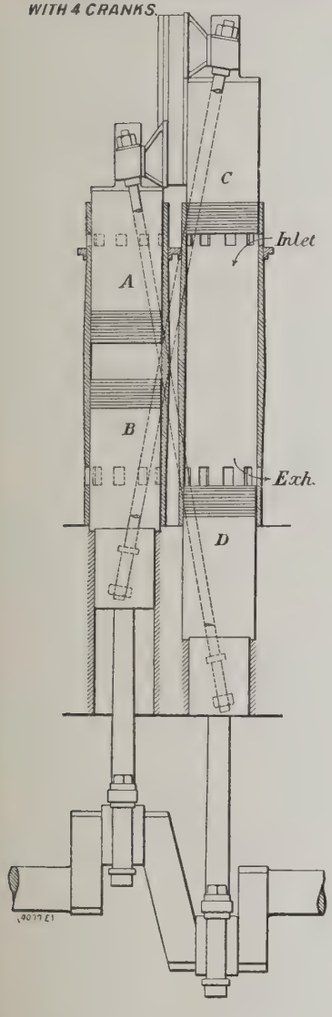


Fig. 9. COMPLETE PRIMARY BALANCE.

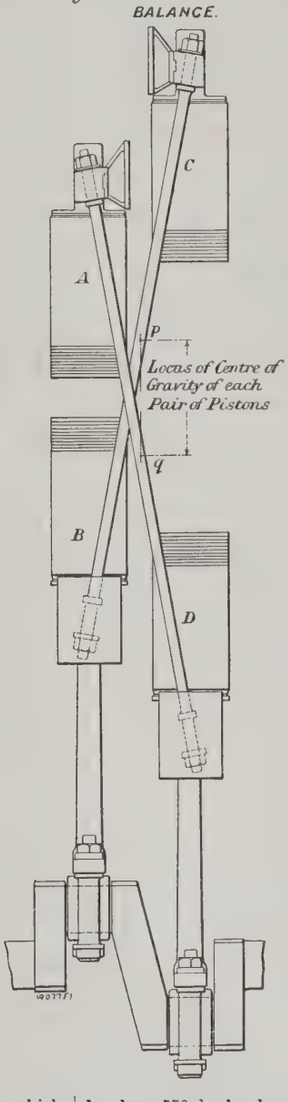
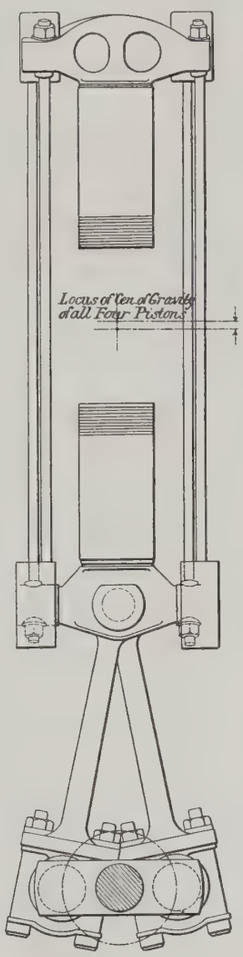


Fig. 10. WANT OF SECONDARY BALANCE WITH TWO CRANKS ONLY



rods oscillates on the line $p q$ with an amplitude which, with a connecting-rod of the length of five cranks, is equal to $\frac{1}{10}$ of the stroke of each piston, Fig. 10. This force is, however, balanced by the corresponding force in the other pair of cylinders which oscillates in the opposite phase, and as the two pairs of cylinders are brought closely together, the secondary couple, which alone remains, is much smaller than in Junker's arrangement. With a six-cylinder engine of this type, even this secondary couple is entirely obliterated.

The Fullagar engine, therefore, obtains perfect or nearly perfect balance of mass, with complete balance of impulse. Excepting the small secondary couple above mentioned, no vertical forces are transmitted to the engine-frame. The only reactions on the frames are the horizontal thrusts of the crossheads on their guides, which are always in one direction, and are the unavoidable equivalent of the useful torque transmitted to the crank-shaft. In respect, therefore, of the combination of balance of mass, balance of impulse, and good turning effort, this engine is probably superior to any other of the reciprocating type hitherto built.

A 500-horse-power engine of this type has been in operation about a year. It has four cylinders of 12-in. (305 mm.) bore, and eight pistons with a common stroke of 18-in. (457 mm.), connected to a four-crank shaft. It develops 550 brake horse-power easily, and its weight, including a fly-wheel of 30 cwt. (1500 kg.), is under 21½ tons (21,000 kg.). The four pairs of connected pistons, weigh approximately 2 tons (2000 kg.), and, at normal speed of 250 revolutions per minute, when the pistons have a mean speed of 750 ft. per minute (3.8 m. per second), there is hardly any perceptible vibration. Even when the speed is increased to 300 revolutions per minute, giving a piston speed of 900 ft. per minute (4.57 m. per second), vibration is still very slight. At first sight it might be supposed that the oblique rods would involve considerable friction, but the angle of the rods is less than the maximum angle of the connecting-rods, and this friction is actually less than would be the case if each of the eight pistons had its own crank and connecting-rods. In the 500-horse-power engine above mentioned the mechanical efficiency, excluding the air and gas-pumps, is over 90 per cent.

The conditions of balance attained with the cross-connected construction of engine above mentioned is all that could be required for almost every application of internal-combustion engine; but there is still one unbalanced reaction of the engine itself—namely, the effort of each successive impulse to rotate the engine backwards round its crank-shaft, and there is also the gyrostatic effect of the fly-wheel or propeller which, in the peculiar case of aeroplane engines, it may be desirable also to eliminate.

To Mr. Lanchester belongs the credit of having produced the only engine extensively used in which, in addition to mass balance, torque balance was secured between the working parts of the engine itself. His well-known engine, which is shown in Fig. 11, was fitted to Lanchester cars about 1896. In this, it is sufficient to note, the primary forces were balanced by the balance-weights on the crank-shafts; the secondary forces of the pistons balance themselves, whilst balance of torque was secured by the oppositely-rotating fly-wheels. Balance of impulse was not obtained.

An engine which secures perfect balance of all forces is shown in Fig. 12. In this two opposed pistons in a single cylinder are connected to two oppositely-moving crank-shafts at opposite ends of the engine. The shafts need, of course, to be kept in phase by a lay-shaft and screw-gears or by a pitch-chain and spur-gears, though the connection has to perform no appreciable work under normal conditions. This arrangement has the further advantage that for aviation purposes two propellers can be driven directly. If of the same area as a single propeller, they will, of course, have a correspondingly less diameter, and for the same revolutions have 41 per cent. greater pitch ratio, a feature which will considerably increase their efficiency. If two such cylinders are placed side by side, and their connecting-rods coupled to opposite cranks, these rods will then balance each other. Such an engine will have absolutely perfect balance of all forces, mass, impulse, torque, and gyrostatic effect. By applying this two-shaft principle to the Fullagar cross-connected cylinder construction shown in Fig. 8 a two-stroke and double-acting engine is produced, in which each crank will receive two impulses per revolution. The engine then consists of two horizontal cylinders with four cross-connected pistons, one piston at either end being connected to separate crank-shafts at either end of the engine.

A still better arrangement for the same purpose is shown in Fig. 13, in which a pair of cylinders with cross-connected pistons is arranged in a plane at right angles to that of the shaft. Two such pairs of cylinders can be arranged side by side, with the cranks at right angles. Small balance-weights will then be needed to balance the connecting-rods, and four impulses will be transmitted to each crank-shaft per revolution. As the cylinders in either case work on the two-stroke cycle, an air-pump of some kind is required, and in Fig. 13 the two cross-heads of each upper cylinder are arranged to act as blowers, a method which has been found satisfactory.

These engines have absolutely perfect balance, and consequently exert no force whatever upon the fuselage on which they are mounted, except that due to their weight and to the useful thrust of the propellers when this is taken by the engine framing. All the metal in the stationary part of the engine is, moreover, usefully employed to support the engine and propellers, whilst its disposition renders it readily attached to and supported by the fuselage. Such an engine would appear to meet the requirements of aviation more completely than any arrangement yet devised, and, quite apart from the advantages of being "two-stroke" and double-acting, is, so far as the writer is aware, the only arrangement hitherto proposed which secures at the same time balance of both primary and secondary mass forces, balance of impulse, balance of torque, and balance of gyrostatic action.

THE PHYSICAL SOCIETY OF LONDON.

AT the meeting of the Physical Society of London, held on June 20, 1914, at the Cavendish Laboratory, Cambridge, Sir J. J. Thomson, O.M., F.R.S., President, in the chair, a paper entitled "*Production of Very Soft Röntgen Radiation by the Impact of Positive and Slow Cathode Rays*" was read by the President.

Röntgen and his pupils had always held that light waves were identical in nature with electrical waves produced by mechanical means; but there was a gap, on which very little work had been done, between the longest infra-red radiation and the shortest electrical wave that could be mechanically produced. He believed the investigation of this gap to be essential to the proper study of the constitution of the atom. The work already done on X rays had demonstrated the existence of two separate rings of electrons in the atom, one within the other. These rings were responsible for the K and L types of radiation respectively. The L radiation was so much softer than the K that if a third ring of electrons existed, the radiation from which was proportionately

softer than that of the L type, this radiation would fall well within the gap already mentioned.

In the first experiment described a special form of discharge-tube was employed. The positive rays passed through a tubular perforation in the cathode and impinged obliquely on a metal target. A photographic plate of the Schumann type was situated at the further end of a branch tube in such a position that no solid obstacle interposed between the target and the plate. When the discharge passed between the electrodes, the photographic plate was affected. The application of an intense transverse electrostatic field between two metal plates situated between the cathode and the target completely stopped the effect, showing that this was not due to stray radiation reflected from the target, since, while charged particles would be swept to one side, radiation would not be affected by the field. Hence the passage of positive particles from the cathode to the target was essential. On the other hand, a strong transverse electrostatic field in the branch-tube had no effect, showing that a radiation was passing between the target and the plate, which was not, therefore, merely affected by positive particles rebounding down the side-tube after impact on the target.

The properties of this radiation were intermediate between ordinary X rays and Schumann waves. They were susceptible to reflection by metal surfaces, and their penetrating power was very small. They were completely stopped by the finest collodion film obtainable.

It was shown that the quality of the radiation did not depend on the energy of the moving particles which gave rise to it, but on the velocity. Hence equally soft rays should be produced by cathode particles if these were travelling as slowly as the positive rays. A discharge-tube was constructed in which the cathode rays, leaving the cathode with the ordinary velocity, could be subjected to a retarding electrostatic field of variable strength before impinging on the target. In this way the velocity of impact could be varied over a large range, and radiations were obtained varying in quality from ordinary hard X rays to the so-called Schumann waves. It was hoped by the study of these radiations to be able to determine not only the number of rings of electrons within the atom, but the number of electrons in each ring.

Discussion.—Sir Oliver Lodge expressed the opinion that the work just described was of far-reaching importance, and he felt confident that the results warranted the anticipation that further work would confirm the explanation foreshadowed by the President. The full meaning of the experiments, and the way in which they enabled us to estimate the number of rings in the atom, was given to some extent in previous papers by the President and others. Eventually we would understand the argument more fully, and in this way the unravelling of the secret of the atom would be materially advanced.

A paper on "*The Homogeneity of Atmospheric Neon*" was read by Mr. F. W. Aston.

Dr. A. Russell proposed a vote of thanks to Sir Joseph and Lady Thomson for their kindness in taking so much trouble to ensure the success of the Society's visit to Cambridge. The vote was carried with enthusiasm.

At the meeting of the Society held on June 26, 1914 at the Imperial College of Science, Dr. A. Russell, Vice-President, in the chair. A paper entitled "*On Atmospheric Refraction and its Bearing on the Transmission of Electromagnetic Waves Round the Earth's Surface,*" was read by Professor J. A. Fleming.

In this paper the author considers the conditions under which true atmospheric refraction would be sufficient to carry a ray of light or electromagnetic radiation sent out horizontally from any point on the earth's surface round the earth parallel to its surface. It is now generally agreed that pure diffraction is insufficient to account for all the phenomena of long-distance wireless telegraphy, but that we have to postulate some action of the atmosphere which tends to curve the radiation round the earth. The theory of ionic refraction has been put forward, which is based on the theoretical conclusion that in ionised air the velocity of long electric waves is increased. We know as a matter of fact that the atmosphere decreases in density as we rise upwards, and this alone produces a decrease of refractive index and an increase in velocity.

The first part of the paper is concerned with the deduction of formulæ expressing this variation of density with heights taking into account as far as possible the known temperature variation with increase of height. It is shown that at a height of 100 km. the terrestrial atmosphere must consist substantially of hydrogen and helium. An expression is then obtained for the radius of curvature at any point of a ray of light sent out horizontally from the earth's surface, and it is shown that this radius at the starting point is given by the formula $\rho = \mu_0 / (98\ A\ q_0^2)$, where μ_0 and q_0 are the refractive index and density at the surface of the earth, and A is the Gladstone and Dale constant for the gas which forms the atmosphere. From known values for various gases it is shown that for air ρ is four times the earth's radius, for hydrogen 136 times, and for krypton equal to the earth's radius. Accordingly, if the terrestrial atmosphere consisted wholly of krypton, a ray sent out horizontally would be refracted round the earth, and in such an atmosphere wireless telegraphy to the Antipodes would be possible. The above formulæ are deduced in three ways. It is also shown that for the same atmospheric density and constant A this circular refraction would result if the earth were twice its present diameter.

The question of atmospheric composition is then considered in the light of what is known about the auroral spectrum. The suggestion is made that perhaps the non-valent gases neon and krypton are manufactured at great atmospheric heights by electric discharges occurring in the rarefied hydrogen atmosphere. Also that by their ease of ionisation they contribute to produce the ionised layer demanded by the theories of Heaviside and Eccles to account for the actual achievements of long-distance wireless telegraphy.

Finally, it is suggested that our earth is perhaps unique in being the only planet on which such long-distance radiotelegraphy is possible.

Discussion: Mr. Duddell considered it was very difficult to follow what was going on in long-distance transmission. One difficulty was that it seemed probable that the heavier gases were absent from the upper atmosphere, yet we had to assume their presence either to get the refraction effect or the Eccles effect.

Dr. C. Chree thought Professor Fleming's paper emphasised the importance of the field common to meteorology and wireless telegraphy. With regard to the relations between temperature, pressure and altitude in the atmosphere, aqueous vapour was an element which meteorologists had to take serious account of; its variability exercised a great influence on the results within 2 km. or 3 km. of the ground. With respect to the constitution of the upper atmosphere, more or less successful attempts had been made of late years to obtain samples by means of apparatus sent up by pilot balloons. On the theoretical side, there were papers more recent than the pioneer one by Sir James Dewar quoted by Dr. Fleming. In particular he would call attention to two papers by Wegener in the *Physikalische Zeitschrift* for 1911. A fundamental point was whether the auroral spectrum did or did not connote a gas different from all hitherto isolated at the earth's surface. Wegener thought it did, and believed the unknown gas thus indicated to be a very light one, which at great heights was even more important than hydrogen. The fact that Professor Störmer's recent photographic determination of auroral heights had in some cases supplied heights well over 300 km. was evidence that an atmosphere of some kind extended to a very great height. The fact emphasised by Dr. Fleming that wireless results by day and night differed markedly, certainly seemed to support strongly his contention that the upper atmosphere played a most important part in the phenomenon. A similar conclusion had been drawn in the case of the ordinary diurnal variation of the elements of terrestrial magnetism, where normally changes were much larger by day than by night, and much larger in summer than winter. It had been found, however, that while the difference between midsummer and midwinter existed in high altitudes, the difference between night and day was there much reduced, even at the equinoxes. Systematic wireless observations in the Arctic or Antarctic might throw a great deal of light upon the whole question.

Professor G. W. O. Howe congratulated Professor Fleming on his interesting and suggestive paper, and pointed out that although the upper atmosphere undoubtedly had a profound effect on the transmission of electro-magnetic waves over long distances, they were still uncertain to what extent long-distance radiotelegraphy would be possible without any assistance from the upper atmosphere. As successive mathematicians attacked the problem, errors were discovered in the previous work, and up to the present the effect of the correction seemed to have been in every case to increase the amount of energy diffracted around the globe.

Professor C. H. Lees mentioned that in the formula $(\mu - 1)/q = A$, the value assumed for μ was for sodium light, whereas the value required was for $\lambda = 500$ metres. Professor Marchant mentioned that in some work recently published it was shown that the difference between the carrying power of signals by night and by day was very much greater in summer than in winter. He asked within what limits of accuracy Gladstone and Dale's law held.

Professor Fleming, in reply, said that Dr. Chree's remarks were of importance, and the questions raised required to be cleared up. In reply to Dr. Lees, he said that for all gases the square root of the dielectric constant for steady voltage practically agreed with the refractive index for sodium light. It would be useful to have the known facts as to the nature of the atmosphere collected for the use of wireless investigators.

A paper on "*Atmospheric Electricity Observations made at Kew Observatory,*" by Mr. Gordon Dobson, was read by Dr. C. Chree.

The paper gives an account of experiments made to determine accuracy of the results obtained with the apparatus designed by Mr. C. T. R. Wilson for measuring the electric conductivity of the air, and the electric current passing from the air to the earth. Observations were made (1) using the standard instrument on a stand according to the usual practice and (2) using an experimental apparatus level with the ground, which was assumed to give correct results. It was found that it was necessary to apply a small correction to the results obtained with the standard apparatus when used in the ordinary way.

A comparison was also made of the electric conductivity of the air as measured by Mr. Wilson's apparatus and that designed by Professor Ebert. The results given by this latter apparatus appear to be too inaccurate to allow any satisfactory conclusions to be drawn.

Discussion.—Professor C. H. Lees said it was important to settle which was the better of the two methods. He thought the large Langevin ions were at the root of the trouble.

Dr. Chree said the large ions considerably affected the charge per unit volume, but he did not think they would affect the value of the earth-air current.

A paper on "*Thermal and Electrical Conductivities of Some of the Rarer Metals and Alloys*" was read by Mr. T. Barratt.

A new method of the "stationary temperature" type is employed for measuring the thermal conductivities of some of the rarer metals, including tantalum, molybdenum, rhodium, iridium, and tungsten, at air temperatures and at 100 deg. Cent.

It is shown that if a rod of metal is of length l, perimeter p, and cross-section q, then its thermal conductivity k is given by

$$k = \frac{H^2}{p q h\ V^2} \coth^2 a l,$$

where H is the heat given per second to one end of the rod, V the excess of temperature of this end over that of the enclosure, h the heat lost per second from 1 sq. cm. of surface when its excess of temperature over that of its surroundings is 1 deg. Cent., and $a = \sqrt{\frac{h\,p}{q\,k}}$.

If l is large, the equation reduces to the very simple form: $k = \sqrt{\frac{H^2}{p q h\ V^2}}$, this latter equation being employed in nearly every case.

Experimental details and the method of working out the results are given, and it is shown that the thermal conductivity of non-metals can also be determined in the same way.

Electrical conductivities of the same specimens have also been measured, and, for purposes of comparison with electronic theories, the values of $k/K\ T$ have been worked out, where k = thermal conductivity, K = electrical conductivity, and T = absolute temperature.

Discussion—Professor C. H. Lees thought the method extremely useful and simple. The accuracy obtained was quite sufficient to allow of verification of the ionic theories on which the author touched. His figures differed sufficiently from the theoretical value to show that the theory was only approximate in its present state.

Dr. Harker asked about the uniformity of temperature in the air space. The apparatus was horizontal, and if the heat supplied to the wire was very great, there were bound to be considerable irregularities of temperature in the chamber.

Mr. Barratt, in reply to Dr. Harker, said there was sometimes a very slow change of temperature of the air in the enclosure, but as the actual experiments, once conditions had become steady, took only a few minutes, the small change in temperature would not matter. Moreover, this change would affect both the hot end of the specimen and the cold one, so that the value of V, which was the object of the measurement, would not be altered. The same remark applied to the temperatures at the top and bottom of the water jacket. So long as the platinum thermometer was kept in the same place the measurement of V was unaffected.

A paper entitled "*Some Investigations on the Arc as a Generator of High-Frequency Oscillations,*" by Mr. F. Mercer, was read by Professor Marchant. This paper contains the results of a series of experiments on the copper-carbon arc when used as a generator of high-frequency oscillations. The copper electrode is water-cooled, and the whole enclosed in a cast-iron cylinder filled with hydrogen under pressure.

Preliminary experiments were carried out to determine the conditions which would give maximum steadiness of burning, and in the ensuing experiments these conditions were adhered to as rigidly as was possible.

The first experiments deal with the effect of varying the arc length, and also the arc current (by changing the resistance in series with the arc), on the magnitude and frequency of the shunt current The deduction is drawn that the effect on frequency arises from a change in the resistance of the arc.

The second experiment refers to the effect on the shunt current of altering the ratio of inductance to capacity. Keeping the latter constant and varying the former, a series of curves are obtained showing that for a given capacity there is a certain value of inductance giving maximum current in the shunt circuit.

Experiments were also made to determine the effect which the pressure of the hydrogen would have on the magnitude of the shunt current. This is dependent on the P.D. used. With small P.D 's the effect is negligible, at 1000 volts it is just appreciable, and at 2000 volts a marked increase is apparent. Beyond this it is impossible to obtain readings with any degree of accuracy, as the oscillations are very unsteady.

Discussion.—Professor Fleming mentioned that Mr. Bairstow had used an arc under pressure as a source of high-frequency oscillations over a year ago. He then described a more satisfactory method recently used by himself and Mr. Coursey. A number of carbons are fixed vertically to a metal plate which is suspended near the bottom of an iron vessel containing heavy oil. The carbons just project above the oil. Over each carbon tip is suspended a copper cylinder, the walls of which go down into the oil, and the thick top of which is perforated. Arcs are struck by lowering the cylinders until they make contact with the carbons, and then raising them with a screw. In this way very steady oscillations are obtained.

Mr. Duddell said that the Society was indebted to Dr. Marchant, who had come from Liverpool purposely to read Mr. Mercer's paper. Many of the observations mentioned in the paper were common knowledge to those who had worked with arcs. He would like, however, to call attention to the peculiar shape of the curves connecting the current in the shunt circuit and the frequency which the author had obtained, and in this connection he would like to ask the author whether the oscillations were of what are known as the first or the second type. If the latter were the case, it might be possible to explain the peaks on the curve, and that their position would probably depend on the relation between

the self-induction in the main circuit and the capacity in the shunt circuit.

Mr. E. H. Rayner asked what was the source of supply, and whether large amounts of inductance and resistance were used between the arc and source of power, as it might be that the character of the curves obtained might be modified if the "ballasting" in this part of the circuit were small. He also asked whether any attempt was made to load up the oscillating circuit with resistance to represent power radiated or otherwise employed. One would expect some modification in the results as compared with a "frictionless" oscillating system.

Professor Marchant, in reply, expressed his interest in Professor Fleming's generator. The author had found that when the power was too great the arc became unstable. He thought Mr. Duddell's explanation was probably correct, as the oscillations were of the second type. It was noticed that with a big capacity the peak was considerably less pronounced. There was a constant inductance in the circuit, and the current was reduced by adding resistance.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

South Africa: H.M. Trade Commissioner for South Africa reports that a member of an engineering firm in South Africa, which already represents several United Kingdom machinery, &c., manufacturers, is now on his way to this country with a view especially to obtaining the agency of manufacturers of railway material. United Kingdom manufacturers of railway material may obtain the name and London address of the gentleman in question on application to the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C., but they should address any further communications regarding the inquiry to H.M. Trade Commissioner for South Africa, P.O. Box 1346, Cape Town. H.M. Trade Commissioner has also forwarded the text of two Bills dealing with irrigation schemes, which have been laid before the Union Parliament. The first Bill proposes to authorise the Governor-General to make, out of public funds, a loan not exceeding 438,000*l.* for irrigation works in the Breede River Valley. The works comprise the construction of a diversion dam across the Breede River, and the construction of a canal crossing several rivers by inverted siphons, as well as all other works necessary to the scheme. The second Bill proposes to authorise the Government to proceed with the Hartebeestport Irrigation Scheme on the Crocodile River, in the Transvaal. A reservoir of 5,100,000,000 cub. ft. capacity is to be formed by the erection of a concrete and masonry dam, 160 ft. high, at Hartebeestport. H.M. Trade Commissioner reports that the East London Municipality, Cape Province, proposes to borrow a sum of over 12,000*l.*, of which amount 7814*l.* is to be utilised for the extension of the tramway system, covering duplication of the existing track and rearrangement of the overhead equipment, and 775*l.* for electric supply extensions, including high-tension feeder, static transformers, and switch-gear. H.M. Trade Commissioner further reports that the Fraserburg Municipality, Cape Province, is proposing to raise a loan of 3000*l.* for the installation of a local water-supply system.

Italy: The *Gazzetta Ufficiale* of July 2 announces that tenders are invited for the construction of the first section of a dyke in the roadstead of Brindisi, which, starting from the sand-bank of Punta Riso, in the Island of S. Andrea, goes towards the Island of Traverso. The total length is about 500 metres, and the estimated cost is put at 4,000,000 lire (about 160,000*l.*). Although this contract will doubtless be awarded to Italian firms, nevertheless the carrying out of the works may involve the purchase of materials outside Italy.

Bulgaria: The *Lieferungs-Anzeiger* (Vienna) of July 5 announces that the management of the Bulgarian State Railways will shortly be inviting tenders for the supply of 25 locomotives and 500 railway carriages, the estimated cost of which is 5,000,000 francs (200,000*l.*).

Norway: H.M. Consul at Christiania reports that, according to the local Press, it is proposed to build a new quay, about 377 yards long, at Arendal harbour at an estimated cost of 40,000*l.* It is also reported that plans are on foot for the construction at Bövaagen, on Karmöen Island, near Haugesund, of a dry dock capable of taking large merchant vessels and the ships of the Norwegian Navy.

Morocco: H.M. Chargé d'Affaires at Tangier reports that tenders are invited by the Moroccan Adjudications Commission for the construction of a section, 12 km. (about 7½ miles) in length, of the road from Rabat to Casablanca. The estimated value of the contract is 181,930 francs (7277*l.*), and a deposit of 3000 francs (120*l.*) is required to qualify any tender. Tenders, accompanied by certificates of competency, will be received by M. le Président de la Commission Générale des Adjudications et des Marchés, Dar-En-Niaba, Tangier, up to 11 a.m., on August 25. The contractor must elect domicile in the neighbourhood of the works. A copy of the *cahier des charges* may be seen, and copies of the form of tender to be used obtained, by contractors in the United Kingdom at the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C. With reference to the notice on page 763 of the *Board of Trade Journal* of March 26 last, relative to a call for tenders by the Moroccan Special Committee of Public Works for the construction of a lighthouse at El Hank, near Casablanca, H.M. Chargé d'Affaires at Tangier reports that the contract has been awarded, at a reduction of 19.2 per cent. on the estimated cost, to a French subject at Casablanca, whose name and address may be obtained by United Kingdom manufacturers of lighthouse material and equipment on application to the Commercial Intelligence Branch, as above. With reference to the notice on pages 121 and 122 of the *Board of Trade Journal* of April 16 last, relative to a call for tenders by the Moroccan Adjudications Commission for the construction of a section of the road from Salé to Kenitra, H.M. Chargé d'Affaires at Tangier reports that the contract has been awarded, at a reduction of 13.3 per cent. on the estimated cost, to an Italian firm at Casablanca, whose name and address may be obtained by United Kingdom exporters of road material on application to the Commercial Intelligence Branch, as above.

Costa Rica: With reference to the notice on page 120 of the *Board of Trade Journal* of January 16, 1913, relative to a call for tenders for a concession for the construction and working of a tramway from Alajuela to Grecia, H.M. Consul at San José reports that no further action has been taken with regard to tenders. The matter has, however, been discussed in Congress, and a Legislative Decree was issued on May 29 modifying the original decree. The principal modifications are that the line is to be extended from Grecia to the towns of Palmares and San Ramon; that the motive power shall be electricity, steam, or any other system of mechanical traction; and that the State will now guarantee interest at 6 per cent. per annum on the capital cost up to a total of 2,000,000 colons (about 191,300*l.*). The executive is authorised to spend the money needed to have the line surveyed, so that fresh tenders may be called for within eight months from the publication of the modifying decree—*i.e.*, before the end of January, 1915.

Portugal: The *Diario do Governo* of June 29 contains a law authorising the expenditure by the Government of a sum not exceeding 348,000 escudos (about 66,000*l.*) on the construction of a railway line from Evora to Ponte de Sor, including the construction of a bridge over the Raia. H.M. Consul at Oporto, in his report on the trade of that district in 1913, which will shortly be issued, states that it is reported that the specifications for the work of carrying out the improvements to Leixoes Harbour (see pages 36 and 37 of the *Board of Trade Journal* of July 3, 1913) are all but completed, and that the invitation for tenders will not long be delayed.

Spain: With reference to the notice on page 278 of the *Board of Trade Journal* of November 6, 1913, relative to the proposed construction of a broad-gauge railway from Saragossa to Caminreal, it now appears from the *Gaceta de Madrid* of July 3 that the Bill presented to the Cortes by the Ministerio de Fomento in this connection has now become law, and that the Government is authorised to announce a competition of plans for the construction of this line.

Italy: H.M. Consul at Milan reports the publication, in the *Sole* (Milan) of June 26, of the names of Italian firms with whom orders have been placed for the supply of rolling-stock required by the Italian State Railways. The contracts are for a total value of 56,302,000 lire (about 2,252,000*l.*), and include the supply of passenger-coaches, luggage-vans, and goods-wagons. The above-mentioned issue of the *Sole* may be consulted by United Kingdom manufacturers of accessories for railway rolling-stock at the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C.

CATALOGUES.

Electricity in Coal-Mines.—We have received from the British Thomson-Houston Company, Limited, of Rugby, a pamphlet bearing the above title and illustrating examples of electric-power installations they have carried out in collieries. The illustrations, which are bright and clear, show examples of turbo-generators, switchboards, electric winding gears, electrically-driven screens, haulage gears, pumps, and other plant for work on the surface or underground. Nearly all the machinery and apparatus illustrated has been designed to comply with the latest Home Office regulations governing the use of electricity in mines. It is pointed out that recent mining legislation has rendered it imperative for those collieries desirous of maintaining their outputs under the new conditions to instal electrical machinery.

Pulley-Blocks and Runways.—Messrs. Herbert Morris, Limited, of Empress Works, Loughborough, have sent us a booklet giving full particulars of "H.M.B." spur-geared pulley-blocks, which they make with lifting capacities ranging from 2½ cwt. to 5 tons. The blocks are also made with geared or ungeared travelling carriages, which run on the bottom flange of an overhead steel joist, the load being moved horizontally either by pulling a chain or by simply pushing the load. Some examples of overhead runways, overhead travelling-cranes, and other lifting and transporting appliances, are illustrated. Another booklet from this firm deals with electric overhead runways and trolley-hoists, illustrating several examples. Full particulars are given of different types, having lifting capacities up to 15 tons; prices are stated in both booklets.

Lifts.—Messrs. R. Waygood and Co., Limited, of Falmouth-road, S.E., have sent us a copy of an eight-page pamphlet illustrating electric, hydraulic, and hand-power lifts for passengers and goods. The firm's patent "Electroil" lifts are also briefly dealt with. These lifts are intended for use where it would not be convenient to instal an ordinary electric lift, and where an hydraulic-power supply is not available. The lifts are operated by a direct-acting hydraulic ram supplied with oil under pressure from a special form of rotary pump driven by an electric motor. The power used is thus proportional to the load lifted, and another obvious advantage is that, since oil is the working fluid, all moving parts are kept thoroughly lubricated. Several of these direct-acting lifts have been installed for the purpose of lifting motor-cars, and a few suspended lifts are also being worked on the same system.

Oil-Engines.—From the Westinghouse Brake Company, Limited, of 82, York-road, King's Cross, N., we have received a copy of the latest edition of their catalogue of Cross patent vertical oil-engines. These engines were illustrated and described in our issue of January 27, 1911, on page 113, so that we need only remind our readers that they are of the four-cycle high-compression type, making use of the heat of compression to ignite the charge as it is sprayed into the combustion-chamber. It should also perhaps be mentioned that the special feature of the engine is that an annular pocket is formed in the cylinder walls near the upper end. This pocket, which is covered by the piston towards the end of the compression stroke, is uncovered early in the working stroke, so that the heated and compressed air in it mingles with the burning charge in the cylinder, and so completes the combustion. It is to this feature that the exceptional cleanliness claimed for the engine is ascribed. The engines are now built in sizes ranging from 7 to 120 horse-power for marine or stationary work, and the catalogue gives full particulars of the engines and also shows them in service for electric lighting, pumping, and other work. The firm's reversing-gear for marine work is also illustrated and described, and drawings and photographs of vessels on which Cross engines have been fitted for propulsion are reproduced.

Machine-Tools and Accessories.—From Messrs. Alfred Herbert, Limited, of Coventry, we have received sectional catalogues dealing, respectively, with combination-turret lathes, capstan lathes, drilling-machines, and small tools and accessories. The turret lathes dealt with are the firm's No. 3 combination type, for bar and chuck-work, fitted with single-pulley headstock, dial feed-motion, patent draw-in chuck, and many other special features, all of which are described in the catalogue. They have 8-in. centres, and can machine bars up to 32 in. long with one chucking. When the draw-in chuck is furnished, bars up to 2⅜ in. in diameter can be dealt with; but without it, bars up to 2¾ in. in diameter can be admitted through the spindle. The catalogue gives full particulars of the lathes, and of standard tool outfits for use with them. The section relating to drilling-machines gives particulars of sensitive drills with from one to four spindles fitted with ball-bearings. These bearings are put together in dust-proof housings, with a supply of grease which lasts almost indefinitely, so that oiling is neither necessary nor desirable. The list also includes bench drills, and radial drills with geared spindles, both types being also fitted with ball-bearings. The capstan-lathe section deals with two sizes having 5¼-in. and 6½-in. centres respectively. The smaller size, which is driven by a stepped-cone pulley, is capable of taking 1½-in. bars without the draw-in chuck, or 1¼-in. bars with the chuck, while the large size, which has a single-pulley headstock, can take 1⅝-in. and 2-in. bars with and without the chuck respectively. Full particulars of standard tool outfits for bar or chuck-work on these lathes will also be found. The one remaining catalogue section deals with Van Dorn portable electric drills, key-seating and oil-grooving tools, "Eternite" case-hardening composition, oil-filters, vices, pipe-wrenches, lathe and drill-chucks, stocks and dies, attachments for drilling-machines, milling-cutters, gauges, expanding mandrels, and many other small tools and accessories for the machine-shop; prices are stated for most of these articles.

Portable Electric and Pneumatic Tools.—From the Chicago Pneumatic Tool Company, Fisher Building, Chicago, Ill., U.S.A., we have received two bulletins dealing with Duntley portable electric tools. One of these bulletins gives particulars of drills and grinding-machines for use with direct current at 600 volts pressure, and therefore especially suitable for tramway and railway-track work, as they can be supplied with current from the trolley-wire or third rail. A portable tool for driving screw spikes, used in railway-track work, is also dealt with in this bulletin. The other bulletin gives full particulars of a special stand by means of which a portable electric drill can be converted into a sensitive bench drill. The stand is made in five sizes, to take standard Duntley drills, with capacities ranging from $\frac{5}{16}$ in. to ½ in. holes in metal. We have also received from this firm a number of publications dealing with pneumatic rock-drills of the percussion type, for mining, quarrying, tunnelling, &c. These include special drills for plug and feather work, stoping-drills, and sinking-drills for large deep holes, as well as drills for ordinary service. In these drills the valve consists of a hollow steel ball, the travel of which is only about ⅛ in. Its movement is thus very rapid, so that the drill delivers a very large number of strokes per minute. A dust-allaying device for use with these drills is also illustrated and described. It consists of an air-jet which draws up water from a bucket near the drill and delivers it in the form of a spray round the mouth of the hole. One other publication still remains to be mentioned. This is a bulletin devoted to rotary drills, operated either by pneumatic or electric power, and intended for use in coal-mines. They are capable of boring a 2-in. hole 6 ft. deep in from one to three minutes, according to the hardness of the coal. All these bulletins, which are well printed and clearly illustrated, give dimensions, prices, and all other necessary particulars of the appliances they relate to. The London address of the company is the Consolidated Pneumatic Tool Company, Limited, 9, Bridge-street, Westminster, S.W.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

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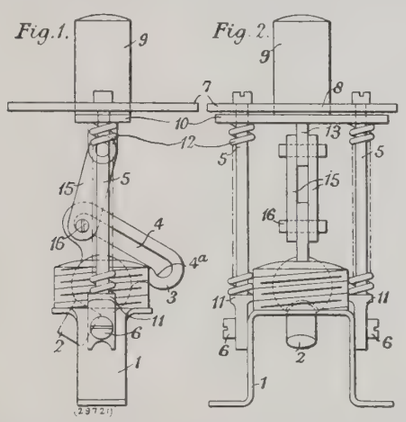
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

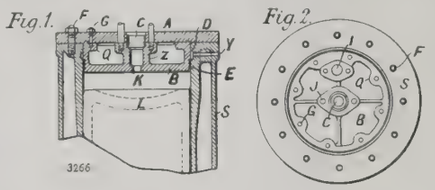
29,721/13. A. P. Lundberg, G. C. Lundberg, P. A. Lundberg, and G. Pegg, London. Electrical Switches. [2 *Figs.*] *December* 24, 1913.—This invention has reference to electrical switches, and has relation to means or arrangements whereby the contact-making and breaking member of the switch may be actuated to or from its "on" or "off" position by the depression of a button, one, or the first depression of the button effecting the firstly-mentioned movement, and another, or the next depression effecting the secondly-mentioned movement. It has already been proposed to actuate switches by the depression of a button through links and a pin and slot connection in such wise that when pressure is applied to the button, such pressure acts directly on the contact-making member, which is caused to move in one direction, the button, links and pin, when the pressure on the button is removed, being caused by a spring to assume positions which, when pressure is again applied to the button will cause the contact-making member to move in an opposite direction. In conjunction with such mechanism it has also been proposed to mount a pair of arms on opposite sides of the switch member, and to connect their free ends, said arms serving as guides for the push-button, and carrying springs which serve to return the push-button to its normal position. The object of this invention is to adapt the push-button actuating mechanism referred to to a tumbler switch of the type in which the actuating or tumbler-lever has a knob or dolly at its free or outer end, and a ball or boss intermediate of its ends, the ball or boss being pivotally mounted in a recess or opening formed in a bridge member or piece, so that the inner end of the lever which end acts upon the contact-making members, is between the two legs of the bridge member. The adaptation consists in dispensing with the knob or dolly on the free end of the actuating-lever, substituting therefor a slotted cross member to form one part of the pin and slot connection before referred to, and mounting the two arms connected at their free ends, which serve as guides for the push-button and carry the springs for returning the push-button to its normal position, at opposite sides of the bridge piece.



1 is the usual bridge member or piece of an electrical tumbler-switch, having levers and members movable as described, in which the actuating-lever 2 is pivotally mounted. In carrying out this invention, the actuating-lever, instead of being provided with a knob or dolly, as is usual, is provided with a cross-member or piece 3, and this cross-member 3 is slotted parallel with its length. The dimensions of the slot 4 at its ends are made slightly greater than the dimensions of the main portion of the slot. 5, 5 are arms mounted at their one ends on the opposite sides of the bridge member 1, and secured thereto by screws 6 or the like. The arms 5, 5 extend upwardly in relation to the bridge member 1, are parallel the one with the other, and at their upper ends are secured to a plate 7, centrally of which is a hole 8. 9 is the press-button. This press-button is mounted in the hole 8 in the plate 7, and is movable in relation thereto. The button 9 is carried by a plate 10, and the plate 10 is mounted on and movable in relation to the arms 5, 5. Between the under face of the plate 10 and a shoulder or abutment 11, formed or provided on each of the arms 5, 5 near the lower ends thereof, is a spring 12. These springs 12 maintain the plate 10 at the upper ends of the arms 5, 5. When pressure is applied to the button 9, the plate 10 is moved in relation to the arms 5, 5 and against the action of the springs 12, 12. The lower end of the button 9 is provided with an extension 13. This extension 13 extends through the plate 10, and below the plate 10 is connected as by a pin with the one ends of a pair of links 15, the other ends of which are connected together by a pin 16 that also engages the slot 4. The lengths of the cross-member 3 and the slot 4 therein are such that when the contact-making and breaking member is in the "on" or "off" position, and the pin 16 is at one or other end of the slot 4, the links 15 are inclined with relation to the arms 5, 5. When the pin 16 is at one or other end of the slot 4, it is in engagement with one of the depressions 4*a*, and such depressions prevent slipping or movement of the pin 16 in relation to the slot 4, while pressure is being applied to the button 9. (*Sealed June* 25, 1914.)

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

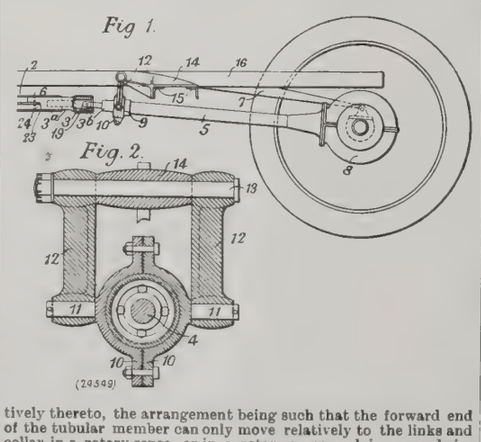
3266/14. Scott's Shipbuilding and Engineering Company, Limited, and J. Richardson, Greenock. Internal-Combustion Engines. [7 *Figs.*] February 7, 1914.—This invention relates to internal-combustion engines—for example, to engines of the Diesel type—working preferably on the two-stroke-cycle, the scavenging system of which is such as to permit of the reduction of the number of valves fitted to the cylinder-head to a minimum. The object of the invention is to provide in such engines an improved form of cylinder-head constructed in two parts—one of which is formed as a plate of sufficient thickness to take the load of the explosion, and the other of which is formed as an inwardly-dished element fitted into the cylinder and serving in conjunction with the plate to carry the valves, the space between the parts forming a cooling-water space. Referring to the drawings: S indicates the cylinder, K the combustion space, and L the main piston of an internal-combustion engine embodying the invention. The piston may contact directly with the inner wall of the cylinder, as shown, or the cylinder S may be fitted with a separate liner. Within the cylinder S is loosely fitted a dished element B, affording, in con-



junction with the substantially flat cylindrical cover-plate A of forged steel secured to the cylinder by studs F, a closed water-cooling space of shallow dimensions. The dished element is preferably fitted with packing-rings E, preferably of copper or bronze, and shaped after the manner of piston-rings to ensure tightness. Any leakage which may pass the rings E, and the wall of the cylinder or liner, is trapped in an annular space D formed in the cylinder wall or in the liner, and is led off by a pipe Y. The dished element B is secured to the plate A by means of studs G, and is formed with an inwardly-projecting flange Q spigoted into the cover-plate A, as shown, or with an outwardly-projecting flange fitting into the cylinder wall or into the liner wall, so that these parts form a rigid unit. The fuel-injection valve C may be carried by a boss Z formed integral with, and, for instance, disposed centrally of, the dished element B. An additional valve I, or valves, may be fitted adjacent to the valve C, as shown in the drawings. (*Accepted April* 15, 1914.)

MOTOR ROAD VEHICLES.

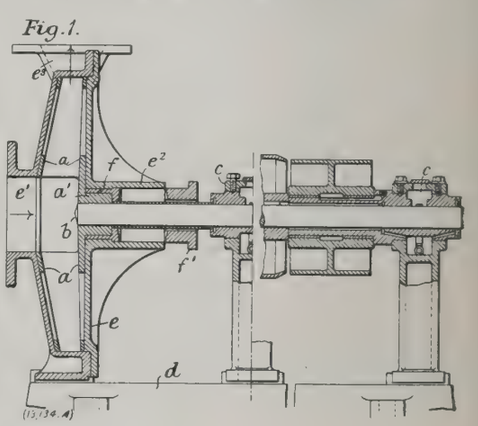
24,549/13. A. M. Arter, E. Arter, and Marshall Arter, Limited, London. Motor-Propelled Road Vehicles. [2 *Figs.*] October 29, 1913.—This invention has relation to motor-propelled road vehicles, and has reference, in particular, but not exclusively, to a motor-propelled road vehicle having a back axle with combined differential and change-speed gearing, such as is described in the Specification of Letters Patent No. 28,327, dated December 16, 1911, and a propelling member or members intermediate the prime mover and the change-speed gearing and differential gearing, such as described in the Specification of Letters Patent No. 2818, dated February 3, 1912. It has been proposed to enclose the propelling member within a tubular member connected at one end with the casing of the differential gearing and/or back axle, and connected at its other end to the chassis by means of a connecting-rod, one point of articulation of which was constituted by a ball-and-socket joint fixed rigidly to a transverse member, while the other point of articulation was constituted by the front end of the tubular member itself ending in a ball-and-socket joint. This construction enables the vertical reactions which are transmitted to the forward end of the tubular member to be resisted, and permits angular and longitudinal movements thereof. Now, in the improvements in accordance with this invention, the tubular member is mounted at its forward end in a collar carried by, and between, the one ends of a pair of links, mounted at their other ends on the vehicle chassis in such wise as to be incapable of lateral movement rela-

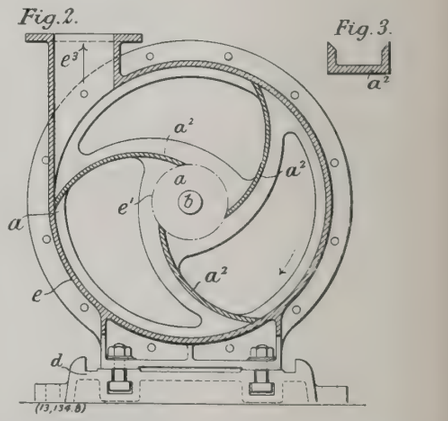


tively thereto, the arrangement being such that the forward end of the tubular member can only move relatively to the links and collar in a rotary sense, or in a rotary sense and in an endwise direction. In carrying out this invention, the drive is transmitted from the engine to the load through the agency of a propelling member 2, as described in Specification No. 2818, of 1912. The propelling member 2 is driven by the engine through a clutch. The one member of the clutch is provided with a boss, on which are shoulders, between which is mounted a collar connected with the clutch-pedal. When the clutch-pedal is actuated the clutch member is moved out of contact with the other clutch member. The two clutch members are normally maintained in engagement by a spring, as well understood. The boss of the first-mentioned clutch member is provided with an extension having a curved face, and is also provided with a slot, in which one end of the propelling member 2 is secured. The other end of the propelling member 2 is mounted and secured in a slot 23 formed in the end of an extension of prolongation 24 of the member 3*a* of the universal joint 3. The propelling member 2 is secured in the slot 23 by a bolt or pin, which serves to aid in the securing of a tube 6. This tube, which may be secured to the extension 24 by other bolts or pins, is of a length to extend the full length of the propelling member 2, and its other end is in contact with the extension of the boss of the firstly-mentioned clutch member, but is not secured thereto in any way. The member 3*a* of the universal joint is slotted, and in the slot work the blocks 19, to which is connected pivotally the other member 3*b* of the universal joint to which the propelling member 4 is connected. The propelling member 2 and the member 3*a* of the universal joint are always maintained in the same line, and when declutching takes place, the propelling member 2 and universal joint member 3*a* move relatively to the universal joint member 3*b*. The universal joint member 3*b* is connected to the one end of the propelling member 4, the other end of which is connected through gearing with the load. In the example, the rearward end of the propelling member 4 carries the small bevel-wheel that gears with the crown wheel and differential gearing of the back axle. The back axle and gearing is, as usual, enclosed within a casing 8, and to this casing is rigidly attached the one end of a tube 5. The propelling member 4 is enclosed within the tube 5. The tube 5 forms the torque member, and its other and forward end, which extends as far forward as the universal joint 3, is carried by links 12. The forward end of the torque member 5 has a sleeve 9 fixed thereto, and this sleeve 9 is embraced at or near its outer end by a two-part collar 10. In the construction illustrated, the collar and sleeve are such that endwise movement of the sleeve in relation to the collar is not possible. The collar 10 has diametrically-arranged bearing-pins 11, and on these pins are mounted the one ends of the links 12. The other ends of the links 12 are mounted on a pin or spindle 13 carried by a bracket 14 mounted on and carried by cross-bearers 15 of the chassis 16. The links 12 can thus only have a to-and-fro motion in the longitudinal plane of the chassis. The lengths of the links 12 and the position of the spindle 13 are so chosen that the propelling member 2 and tube 6 are horizontal, or nearly so, and the torque member 5 and links 12 at right angles, or nearly so, to one another. (*Sealed June* 25, 1914.)

PUMPS.

13,134/13. Bertrams, Limited, Edinburgh, and G. Robertson, Aberdeen. Centrifugal Pumps. [3 *Figs.*] June 6, 1913.—This invention has reference to centrifugal pumps of the kind adapted to allow for the impeller spindle and bearings being removed without disturbing the suction and discharge-pipes, and it consists of an improved construction of this class of pump, specially designed for paper-mill work and for dealing with thick pulp, one of the features of the pump being an impeller adapted to give full-way passages for the liquid to be pumped, and formed with opening in its sides, and having its blades of straight or curved shape in cross-section, and made integral with such sides, those edges of the impeller or blades contacting with the edges being bevelled. In a centrifugal pump, according to this invention, the impeller is adapted to give full way passages for the liquid to be pumped, and is formed with openings in its sides and with blades of straight or curved shape in cross-section, integral with such sides, those edges of the impeller or blades contacting with the casing being bevelled. In carrying out the invention, the impeller *a*, which is provided with a laterally extending boss a^1, is mounted upon the end of a





shaft *b* supported in pedestal bearings *c*, *c* upon a bed-plate *d*. The bed-plate also supports the pump casing *e* having central inlet opening e^1 on one side and an outwardly-extending tubular boss e^2 on its opposite side. Into this latter the boss a^1 of the impeller projects to lie within or against a flanged neck-ring or bush *f* held in position by the packing gland f^1. At the top of the casing is the discharge outlet e^3 which is preferably of rectangular formation on the inside and circular on the outside, the cross-sectional area of the outlet at any point, however, being not less than the area of the inlet opening e^1. The impeller *a*, the sides of which are of open-work formation, as shown in Fig. 2, is formed or provided with curved blades a^2 which extend from the inner periphery or wall of the casing towards the centre, their inner ends or edges terminating at distances from the centre equal to the radius of the inlet opening. The blades or vanes a^2 produce channels or troughs of the section, shown at Fig. 3, the vertical edges being of sharpened formation or bevelled, and thus serving to clean the side of the casing *e* and prevent the pulp jamming between the impeller and casing (*Accepted April* 29, 1914.)

LITERATURE.

The Scientific Determination of the Merits of Automobiles. Reports I. to IX. of the Laboratory for Motor-Cars at the Royal Technical University, Berlin-Charlottenburg. By Dr. A. RIEDLER. London: The General Oil Publishing Company, Limited, 6, Broad-street Place. [Price 21s. net.]

WHILE there has been a great deal of money spent on various trials of motor-cars since the start of the industry, it is certainly a fact that it has produced far less definite scientific information for the expenditure than in the case of any other trade. A large amount has, for instance, been spent in racing, with practically no scientific result at all, for it is impossible in the case of a race to separate the influence of various factors on the result, and one of the most important of them—namely, the skill of the driver, has no bearing whatever on the subject of the merits of the car. The volume now before us is therefore exceedingly welcome, giving, as it does, very definite information as to the performance of several cars. The greater part of the book consists of a description of the testing-plant and a simple statement of the results obtained with it. Certain conclusions are drawn from these results.

The method of testing adopted is to place the car on a test-bed with its wheels resting on rollers situated below the floor, these rollers being connected to dynamos, which can, if desired, be also used as motors. The shaft on which the rollers are mounted also carries two friction brakes. The power at the road-wheels can therefore be measured either by the dynamos or the brakes. Further, arrangements are made for measuring the tractive force of the vehicle under test, the front wheels being carried on a roller-bed, and the tractive force taken at the back axle. This checks the accuracy of the brake measurements. Means are provided for measuring separately the various items of both power and loss, and in all cases these measurements are taken as nearly as possible in actual running conditions. For instance, to get the brake horse-power of the motor separately it is not dismounted from the chassis and placed on a test-bed, but is tested mounted on the chassis, where all parts will be subject to the same vibration effects, as far as these depend on the motor, as will be the case in actual practice. It is considered that this gives more accurate results than mounting the motor on a rigid test-bench, as in the latter case various parts are subject to much less vibration. From these tests a balance-sheet is made of the total available energy in the fuel and how it is expended. These measurements are taken for the various speeds with which the car is provided and at different revolutions of the engines, and curves drawn of the available tractive force. Curves are also drawn of the various items of resistance. From these the speed of the car can be estimated on the flat and also the margin of power available for hill-climbing at any given speed. The only item not actually measured in this is the air-resistance; but this is calculated, and it is stated that the actual speed of the cars tried corresponds so nearly to the calculated speeds as to show that the assumption of air-resistance is sufficiently accurate for practical purposes. On hills, and at moderate speeds, the air-resistance is not a very large proportion of the available power of the car, and therefore will not materially affect the actual performance.

The following cars were tested:—

30-horse-power Renault touring-car.
100-horse-power Benz racing-car.
70-horse-power Adler touring-car.
Mercédès electromobile.
35-horse-power Büssing military transport-wagon.
40-horse-power English Daimler-Knight car.

Tests were also made of a Mercédès-Knight engine, and comparisons are made between the Knight and poppet-valve systems.

As an example of the results obtained we may take the trials of the 30-horse-power Renault, premising that this is a very old type, built in 1905, and therefore does not in any way represent Renault's present practice. A series of curves are given of the available motor power at various speeds, there being a different curve for each of the three gears. Below these are curves each showing the result of deducting one of the various losses—*e.g.*, transmission, the rolling resistance, &c. The lowest of these, therefore, gives the power available for air-resistance and hill-climbing. The point at which this curve crosses one plotted to represent the air-resistance is therefore the speed the car will attain on a flat road, and at any speed below this the margin of power for hill-climbing can be ascertained by measuring the distance between the two curves. The curves cross at 69 km. (43¾ miles) per hour.

At a speed of 60 km. (37½ miles) per hour the balance-sheet of the available energy of the fuel is as follows:—

	Per Cent.
Cooling water	35.8
Exhaust gases and radiation	35.6
Exhaust piping	1.0
Silencer	1.2
Friction of motor	5.6
Driving-gear	2.9
Back tyres	3.7
Front tyres	1.1
Friction and air resistance of front wheels	0.6
Air resistance of car	7.1

The balance is available for gradients or acceleration. At the same speed the percentages of losses of the available power of the engine without silencer are as follows:—

	Per Cent.
Exhaust-piping	4 5
Silencer	5.2
Transmission gear	12.7
Friction and air-resistance of front wheels	2.6
Front tyres	4.8
Back tyres	16.2
Air-resistance of car	31.0

The balance of 23 per cent. of the power of the engine is available for gradients and acceleration.

This car had a motor with four cylinders, 100 mm. by 140 mm. (4 in. by 5½ in.), having valves 36 mm. diameter by 6½ mm. lift ($1\frac{7}{16}$ in. by ¼ in.). The compression ratio (total volume ÷ compression space) was 4.02. Three speeds were provided of a ratio, engine to back wheels, of 10.8, 5.83, and 3.14, the latter being direct. The tyres were 875 mm. by 105 mm., the external diameters of the wheels, as actually measured, averaging about 895 mm.

As a contrast to this, we may take the 70-horse-power Adler, which has cylinders the same diameter as the Renault, but 150 mm. ($5\frac{7}{8}$ in.) stroke. The valves are, however, much larger—namely, 56 mm. (2¼ in.), with a lift of 9 mm. (⅜ in.), and the compression ratio is 4.76. The top speed has a ratio of 2.895, and the back wheels have tyres nominally 820 mm. by 120 mm., but which actually measured about 816 mm. diameter.

Curves of performance similar to those of the Renault car are given, and show that a speed of 114 km. (71 miles) an hour should be obtained on the flat. The balance-sheet of the effective power of the motor is as follows:—

	Per Cent.
Transmission losses	16 0
Friction and air-resistance of front wheels	4.7
Front tyres	4.6
Back tyres	26.7
Air-resistance of car	48.0

In comparing these results with those of the Renault, it is to be observed that the speed is nearly twice as great, and that the effective power is taken for the motor with silencer, whereas in the case of the Renault the loss of power from silencing is included in the losses. It is stated, however, that the exhaust was only "slightly silenced," so the power might have been materially reduced by a really effective silencer. The weight of this car, with a four-seater racing body, including tools and 9 gallons of petrol, was 21 cwt.; and with three passengers 25½ cwt.

Want of space forbids our giving further extracts from the details of the tests, which cover the greater part of 300 pages, all of which are of interest, and therefore we are compelled to be content with a few general observations.

The two motors compared above represent two different types—namely, the one with comparatively small valves and built for quietness, and the one with large valves built for power. The Adler, of course, gives over twice the power of the Renault, the powers being almost exactly proportionate to the area at the lip of the valves. A great part of this increase in power is, however, solely due to the fact that the Adler engine will run at much higher revolutions. The cars are, however, geared to much about the same speed at the same revolutions, and therefore this extra engine speed of the Adler is only useful at very high road speeds. Thus, at 50 km. an hour (32 miles), which is much more like the usual travelling speed of the ordinary motorist than the racing speeds mentioned, the Adler engine is running at about 1000 revolutions, the Renault at 950. Under these circumstances the Adler will give about 42 horse-power, and the Renault 22 horse-power. Part of the difference is, no doubt, due to the better silencing of the Renault, and part to the lower revolutions and shorter stroke; but it seems evident that the larger valves have a distinct effect even at such low revolutions. Whether the rise in power is worth the disadvantages of the large valves is, of course, a matter of opinion. The Renault being of an old pattern, it is, however, reasonable to expect that a more modern type would give considerably greater power without undue noise.

Of the general conclusions drawn, one of the most interesting points is the loss of power in the transmission and the road-wheels. Various estimates of the loss in transmission have been made, some of them higher, some lower, than that shown; but it has not been generally thought that the loss in rolling resistance of the back wheels was very great. The actual losses between the engine and the rims of the back wheels at 60 km. (37 miles) per hour were: English Daimler and Benz, 11 per cent. of the brake horse-power of the motor; Renault, 12.7 per cent.; Adler, 12.8 per cent. At 16 km. (10 miles) the Bussing lorry had a loss of 18 per cent. It is noticeable that the loss of power in the gearing rose with the engine speed, the loss being 16 and 16½ per cent. in the Adler and Benz respectively at full motor speed of something over 2000 revolutions.

It is curious that although the top speed is direct in all four cars tested, the loss by gearing does not seem to materially increase on the lower speeds. It would have been expected that the loss would have been much greater on the lower speeds, as there are two extra pairs of gear-wheels for the power to pass through. In the Bussing lorry the drive on all speeds is through spur-gear, bevel-gear, and chains, the requisite reduction not being obtainable on one drive, and this accounts for the greater loss than in the cars. It appears likely that the loss through the fluid friction of the oil in the gear-box is considerable, and the fact that many of the wheels are revolving more slowly on the lower speeds may be the reason for the relatively small loss in them. This points to the advantage of using thin oil in the gear-box.

Another point of interest is the great loss through the rolling resistance of the back tyres. It will be seen that in both the Renault and Adler the loss through rolling resistance of the wheels is greater than that through friction in transmission; and, further, that although the front and back wheels carry nearly the same weight, the loss is far greater in the back wheels than in the front. The same effect is observed in the Bussing lorry, and is shown to be due to the internal friction of the tyre under the deformation produced by the driving stress. Diagrams are given showing the loss when running light and when transmitting the engine power, and it is shown that on the lower speeds, when the driving stress gets very high, the rolling resistance, when transmitting the power, may be ten times that of the wheels running light. This very well explains the greatly increased wear of driving tyres as compared with those carrying load only.

Whether the conditions of rolling on a drum accurately reproduce rolling on a flat road is not stated, but there appears no reason why any difference should affect the relative resistances of the front and back wheels. This difference therefore raises a point which should bear further investigation.

A rather interesting point is the actual weight of some of the cars tried. As mentioned, the 70-horse-power Adler only weighed 21 cwt. with a four-seated body. The racing 100-horse-power Benz, having four cylinders 115 mm. by 175 mm. (4½ in. by $6\frac{7}{8}$ in.), weighed 26½ cwt. with tools and 9 gallons of petrol. On the other hand, the Renault weighed 31 cwt., and the Daimler, with cylinders 101.6 mm. by 129 mm. (4 in. by 5 in.), weighed 28 cwt., of which the chassis weighed 22 cwt. It is well known that the ordinary modern four-seater car, with cylinders, say, 90 mm. by 120 mm. (3½ in. by 4¾ in.), generally weighs well over 24 cwt. While it is doubtless impossible to get the weight as low as in a racing-car and have a comfortable body, it appears that there should be considerable margin for reduction.

At the end of the book a summary is given of the conclusions come to as a result of the trials. A great deal is said about the advantages of high-

speed motors and the possibility of reducing weights by the adoption of high speeds. The author does not appear to have grasped the fact that the greater part of the weight of a motor does not consist in the cylinder barrels, but in the crank-shaft, crank-case, valves, valve-pockets, &c., and that above a certain speed these have to be made very much heavier than in the moderate-speed engine. Curiously, he quotes the Benz as a proof of his contention that weight can be reduced by excessive engine speed, whereas the fact is that the Benz aero-engine, which is obviously made as light as the builders can make it consistent with its not breaking down, runs at a very moderate speed. He states that the advent of the high-speed engine was delayed by the motor-cycle type having failed, but that at present the high-speed engine is becoming universal for car work. If this is the case, however, it is only so as regards Germany, whose contribution to the motor-cars of the world has not been a very large proportion. The facts are that the early French motor-cycle engines had all the essentials of the modern high-speed engine, and performed exceedingly well, in fact, all high-speed engines are, more or less, copies of them. The extreme high-speed car-engine has, however, only been adopted, even in Europe, where an arbitrary system of rating has favoured it. All the larger and more expensive European cars are fitted with such gear ratios that the engines are run at very moderate revolutions at ordinary touring road speeds, while the American cars of all kinds have moderate-speed engines, and the sale of these is extending rapidly all over the world.

An interesting point is that in the trial of the motor-lorry a trailer was also tested, and it was found that its rolling resistance was far greater than that of the lorry. It is suggested that there is room for a good deal of improvement in trailers. A considerable amount of space is devoted to a consideration of the requirements of the lorry, and how they can be met, all of which is of very great interest.

Mention is made in this connection of the advantages of the worm-drive as a means of simplifying the transmission gear. In the Bussing lorry three successive reductions were made to get the desired gear ratio. With a worm-drive, this could be done in one. The author, however, appears not to be well acquainted with modern worm-drives. Thus he states that the loss in the worm is great, and also that it is irreversible. In actual test, however, the efficiency of the transmission gear of the English Daimler with worm-drive is given as varying from a minimum of 84 per cent. on the lowest speed to a maximum of 90 per cent. on the top. That is to say its efficiency is given as being as high as that of the other gears tested. With regard to the question of reversibility, this depends solely on the angle of the worm, and all worm-drives for vehicles are made of such an angle that the wheel will drive the worm perfectly well. The worm is spoken of as if it were a quite untried device for commercial work, but it has been used for this purpose in England for six years or more.

While there are naturally points open to criticism in a book dealing with such a large range, there is no doubt as to its great value. The contents bear witness to an enormous amount of work, and when we state that it consists of over 330 pages, with 227 illustrations, and is, as a whole, very concisely written, it will be seen that it is impossible here to deal with even a small fraction of it, and it should certainly be studied by all those in the least interested in scientific motor construction.

Compressed-Air Practice. By FRANK RICHARDS. New York: McGraw-Hill Book Company, Inc. [Price 12s. 6d. net.]

THE ever-increasing spheres of usefulness of compressed-air appliances, and the large compressed-air and high-pressure gas schemes which have been rendered practicable by the increased efficiency, capacity, and reliability of the modern compressor, of both reciprocating and centrifugal or turbine types, render the volume under review of considerable interest.

The author first makes a few observations as to the functions of air in Nature, and then deals with definitions and general information—*e.g.*, conversion tables of weight, temperature and pressure, and tables of weight and volume of air at different altitudes. The causes of loss of energy between compression and expansion are explained by reference to adiabatic and isothermal curves. Tables and graphic charts are given for the various computations involved in compressed-air calculations. He then proceeds to deal with the uses of the indicator, and explains the proper interpretation of indicator diagrams and their bearing on the proportioning of the cylinders of two and three-stage compressors. The illustrations include cards indicated on old machines, and their faults are enlarged upon.

Continuing, the various devices for compressor regulation are explained, and their relative advantages discussed, special attention being given to "clearance controllers." The author then mentions how the big contracting companies who excavated the underground subways in New York were amply repaid by the adoption of every refinement on the steam and air sides of their compressor plants, and that, notwithstanding the fact that these machines which proved so efficient were available for the work of excavating further tunnels shortly afterwards, the electrically-driven compressor was adopted on the score of cheapness, as by this time the large electric supply companies of New York were in a position to offer cheap power.

The turbo-compressor, though at present looked upon as essentially a large-capacity machine, may in the future also compete with the small unit of the reciprocating type. A short chapter is given to a description of the turbo-compressor and a few general considerations of its design and construction. The next chapter is devoted to describing the Taylor compressor and the Humphrey pump; special reference being made to the Taylor compressor of 40,000 cub. ft. per minute capacity at Ragged Chutes, on the Montreal River, which supplies compressed air to the mines at Cobalt. Owing to the solution of a greater percentage of the oxygen than that of the nitrogen of the air while compressed in contact with the water, it is found difficult to burn candles in the mines supplied—the compressed air was proved by analysis to contain only 17.7 per cent. of oxygen, as against the 21 per cent. in normal pure air. The Humphrey pump is described, and its possibilities when applied to air compression instead of water-raising discussed.

A table giving the power required for the compression of air at constant temperature and without cooling is computed, and the various sources of loss are considered; and also tables and charts which afford a means of determining the consumption of steam per 100 cub. ft. of air compressed, on a basis of certain assumed steam consumptions per indicated horse-power hour on the steam side, are given.

A short chapter follows on "Power from Compressed Air," and then the function of air-receivers is considered, the author favouring a combination of after-cooler and water-extractor in one, with sufficient capacity (volumetric) to act also as the receiver; he also speaks for an increase in the size of receivers above that usually found in present-day practice, and describes the unique receivers of the plant for supplying air for the driving of all the hoists of the Anaconda Copper-Mining Company at Butte, Mont., in which the total capacity of the receiver vessels is utilised, and an almost absolutely constant pressure maintained, by the connection to the bottom of these vessels of a huge water-pipe connected up with a dam on an adjacent hill.

Continuing, transmission is dealt with, tables and formulæ being given for pipe-resistance for air under different pressures, and the advantages and limitations of re-heating are enlarged upon. Combustion of oil in receivers and pipe-lines take place at comparatively low temperatures, on account of the high pressure, and combustion of oil is shown to have started at 275 deg. when under a pressure of 65 atmospheres in the case of a receiver fitted with a recording thermometer. The author advocates the careful use of cylinder oil and the frequent cleaning out of receivers and other parts in proximity to the compressor, with a view to reducing the frequency of such occurrences.

Compression of gas for distribution is advocated in a chapter of considerable length, wherein is also made out a plausible case for the abolition of the gas-holder by boosting up the pressure in the mains and fitting reducers at points of consumption. The St. Louis and other high-pressure gas systems, and the natural gas transmission, 123 miles in length, to Cincinnati, are cited as proof of the success of high-pressure gas transmission and distribution. The gas in the latter case is drawn from 100 gas-wells supplied over some 300,000 acres.

The next two chapters are given to air drills in general, and to the "electric-air" drill, the performances of the latter during the construction of the great Kensico dam for the new water supply to New York City being quoted as an example of the high efficiency of this type of machine. Several more or less well-known compressed-air appliances are described, and data and calculations are given for the proportioning of the well-known "air lift" for water. Caissons, diving-bells, and allied applications of compressed air find a place, together with such apparatus as the air blast in its application to foundation sinking (which is carefully described), the sand blast, pneumatic painting, and the "cement gun." This last is interestingly described and explained.

A chapter on liquid air concludes the volume with diagrams and descriptions of the Linde and Claude oxygen plants and explanations of their processes.

To the practical engineer who, though thoroughly conversant with his own branch of the profession, has not had much experience of compressed air, this volume should prove of great value.

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THE ALEXANDRA DOCK EXTENSION AT NEWPORT.

(*Continued from page* 37.)

HAVING dealt in our last article with the construction and general features of the dock extension and the new lock, we now propose to say something of the gates and their operating machinery, the fender-chain gear, and other mechanical appliances fitted in connection with the lock. The gates, which were constructed by Sir William Arrol and Co., Limited, of Glasgow, are of iron and steel, with greenheart heel-posts, meeting-posts, and sills. A characteristic example is illustrated in Figs. 47 to 53, on Plate XVI. The middle and outer gates are 49 ft. high by about 56 ft. wide. The inner gates are the same width, but 10 ft. less in height. Figs. 47 to 53 show one of the deeper gates. In general construction the gates may be said to consist of a series of girders or decks, of form in plan as shown in Figs. 52 and 53, and varying from 2 ft. 6 in. to 3 ft. 6½ in. apart vertically. The girders are placed closer together near the bottom of the gate, except that the bottom pair are 2 ft. 9½ in. apart. The distribution of the various girders is shown in Fig. 50.

At the vertical edges of the gate there are two box-frames built up of plates and angles, and carrying respectively the heel-post and meeting-post. These frames are shown in cross-section in Figs. 52 and 53, while one of them, in process of being lifted into position for the erection of a gate, is shown in Fig. 71, on page 112. As will be seen from this latter figure, the frame has a series of horizontal webs. These join up with the ends of the decks when the main girders are riveted in place. The method of building up and the construction of the gates will probably be better understood from Fig. 72, on page 112, in conjunction with Figs. 74 and 75, on page 113, than from any description. The two end frames and the bottom pair of girders were first erected, and the various girders, from the bottom upwards, then placed in position and riveted up. As will be seen from Figs. 74 and 75, the girders and the inner strakes of skin-plating were first erected, and the spaces between alternate pairs of girders afforded convenient access to the interior of the gates during erection. These spaces were closed by the outer strakes of skin-plating, which were fixed as the riveting of the skin-plating proceeded.

The webs of the girders, which form the decks of the gate, are in the majority of cases of lattice construction in the two centre panels, as shown in Fig. 53. Decks G, R, and V, however, are of plating throughout, as shown in Fig. 52. These decks divide the interior of the gate into water-tight compartments. Details of the method of joining the box-girders to the end frames will be followed from Figs. 49, 52, and 53. The vertical and horizontal plates of the two members form butt-joints, double cover-plates being placed on the webs, and outside cover-plates on the verticals. Inside cover-angles are used in each corner. The skin-plates, which form the intermediate strakes, form lap-joints with the verticals of the end frames. Caulking-strips are used over the cover-plate joints. The intermediate strake-plates lying over the vertical outer plates of the box-girders can be caulked completely round their edges. The appearance of the curved outer surface of the gates with the plating complete is shown in Fig. 77, on page 113. The other sides of the gates, which carry wood fenders, are shown in Fig. 73, on page 112. In connection with these fenders it should be noted that any blows which they may sustain from a passing ship, when the gate is standing open and lying in the recess in the lock wall, will be transmitted by the main framework of the gate direct to the vertical timber fenders upon the wall of the gate recess, against which the gate rests when fully open.

A series of manholes are provided through the various decks and vertical partitions, giving access for repairs and painting. Trunks fitted with ladders lead to the two water-tight compartments from the upper deck. The manholes in water-tight decks are fitted with water-tight covers. The upper portions of the trunks can be seen in Fig. 75, on page 113. Each gate is surmounted by a platform forming the footway, which is clearly shown in Figs. 68 and 69, on Plate XVI., and need not be described in detail. The flooring is of oak planking 4 in. thick. The platform under construction is also shown in Fig. 77, to which we have just referred. The trunks project from the upper deck to just below it, and square covers are provided in the flooring. Each gate is fitted with an ejector, operated from the high-pressure hydraulic mains, for the purpose of removing leakage and condensation water from the interior of the water-tight compartments. As stated at the beginning of this description, both iron and steel have been employed in the construction of the gates. All rolled sections are of steel, as are the braced decks and the vertical web-plates. The water-tight decks and all skin-plates are of iron.

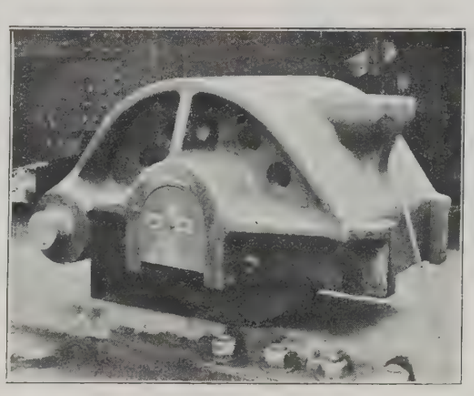

FIG. 70.

The supports for the gates are illustrated in Figs. 54 to 67, on Plate XVI. Figs. 54 to 60 show the upper bearing-bracket and its details. Fig. 54 is a plan of the complete bearing, while Figs. 55 to 57 are various sections. Fig. 59 is a plan of the anchor casting only, with the upper bearing-plate removed. The anchor-casting is secured to the well by two 5½-in. tie-bolts, which, as will be seen, are bent down, so that they distribute the pull over a large mass of concrete. Each tie-bolt carries two cast-iron washers, which lock it in position on the concrete formation. The distance between the two washers is about 18 ft. This length is much shortened in Fig. 56, in order to bring the figure within the limits of the page. The outer washer lies in a pit, furnished with a cover-plate, so that it may be got at from the quay. The type of washer used is illustrated in Fig. 61; it is 3 ft. in diameter. It will be noted that the tie-bolt shown in Fig. 56 carries a third washer at its outer end. This is a temporary fitting only, and was used for putting an initial stress on to the tie-bolts during setting up. This was achieved by using hydraulic jacks between the washers and the concrete wall. The temporary washer is illustrated in Fig. 60. As shown in Fig. 56, the tie-bolts are secured to the anchor-casting by means of cotters.

The upper pivot of the gate, which is shown in Fig. 56, is 2 ft. in diameter, works in a strap which runs right through the anchor-casting, and is secured by double nuts at the ends. The arrangement is clearly shown in Fig. 55. Above this strap-bearing for the gate-pivot there is a pin-bearing, 11 in. in diameter, which serves for the "crocodile" lever by which the pull or push from the operating engine is transferred to the gate. This lever is shown in Fig. 69, but is best seen in Fig. 75, on page 113, and Fig. 76, on the same page. The lever is free from the gate. At its inner end it has the independent bearing to which we have just referred. At its outer end it works between two vertical brackets fitted to the gate immediately over one of the vertical bulkheads, but is not secured to them. The arrangement is well shown in Fig. 75. The connecting-rod from the gate-engine is connected to the "crocodile" lever at a point about a quarter way along its length. The seats for its bearing-pin can be seen in Fig. 75. The object of the arrangement is to obtain a reasonably short stroke for the gate-engine, and at the same time to apply the force for moving the gate on the vertical line through the centre of pressure, and so minimise cross stresses as much as possible. It will be clear that as the "crocodile" lever is swung in or out by the gate-engine the gate will follow, owing to the brackets between which the outer end of the lever works.

Returning now to the gate supports, shown in Figs. 54 to 67, on Plate XVI., little more need be said of the upper anchor, as the purpose of the 11-in. pin-bearing will now be clear. It should be pointed out, however, that this bearing is carried in a cover-plate, which sits in a machined groove in the anchor-casting. The complete bearing can be removed without interfering with the anchor-casting, and the removal of the anchor-strap will then allow the gate to be removed for repairs if necessary. The lower gate-bearing does not need much comment. It consists of a hollow cast-steel socket with a forged steel bearing-plate, which works upon a cast-steel pivot secured by lewis-bolts to a granite bed-stone in the floor of the gate-chamber. The outer end of the gate is supported by a roller, which is illustrated in Figs. 63 and 64, on Plate XVI., and in Fig. 70, annexed. The arrangement consists of a cast-iron carriage with a pivot-pin at one end. The pin projects from each end of the carriage and fits into two round-ended notches cut in the plates which form the sides of the roller-box. These plates are, of course, part of the gate construction. The projecting pivot-pin can be clearly seen in Fig. 70. The carriage carries a cast-steel roller, 3 ft. in diameter at the centre, working in gun-metal bearings. The weight of the gate is transferred to the roller through the pivot-pin and through a spear-rod 6½ in. in diameter, which bears in a bracket cast on the top of the roller-carriage. The spear is clearly shown at the left-hand side of Fig. 64, and can be seen in section in Fig. 65. The spear runs up the front of the gate through guides which can be seen in Fig. 49, and in the general view given in Fig. 77, on page 113. At the top the spear terminates in a square rod which works between longer guides, which again can be seen in Figs. 49 and 77, and are detailed in Figs 62 and 63. Slots in the square rod and the guides and cotters serve to transfer the weight of the gate to the spear, from which it is transferred to the roller-carriage. The arrangement serves as an adjustment for wear of the roller-bearings. Such wear lowers the level of the outer end of the gate a little, and tends to put extra strain on the pivots, and affects the water-tightness. By driving in the cotters at the top of the spear the gate is lifted a little, and the wear allowed for. Details of the track on which the roller works are given in Figs. 66 to 68. The rail is of cast iron, and the foundation fish-plates are of cast steel. The track is held down by lewis-bolts.

Turning now to the gate-operating machinery, attention may be directed to the general plan of the lock given in Fig. 4, on Plate X., in connection with the first article of this series. It will be there seen that for each gate there is a long trench in the quay lying at a slope to the side of the lock and towards the

THE ALEXANDRA DOCK EXTENSION AT NEWPORT.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C. E., WESTMINSTER, ENGINEERS.

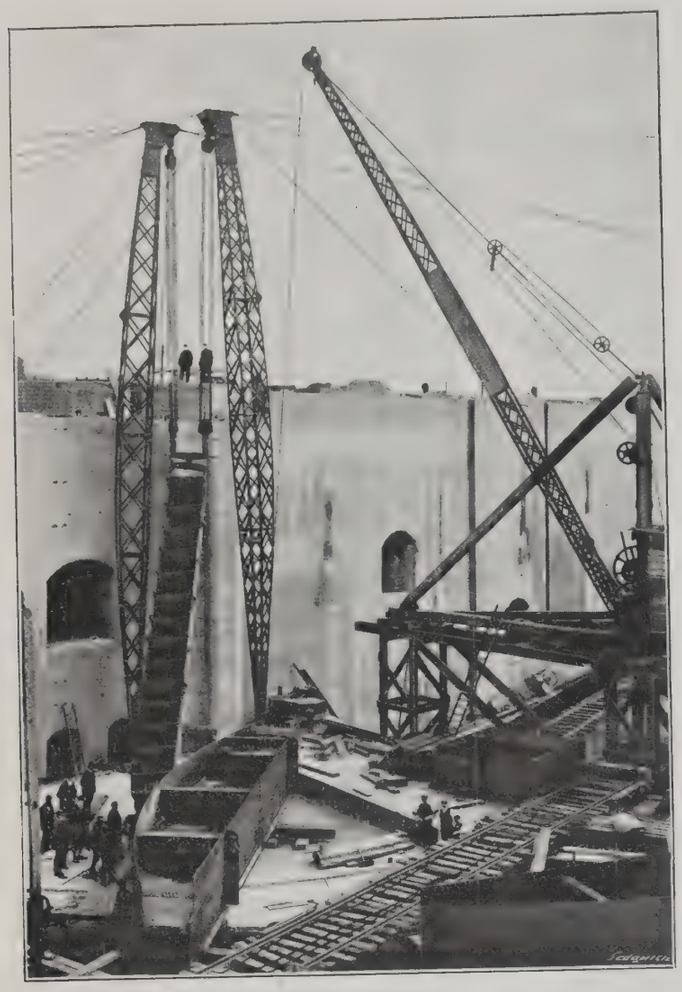

FIG. 71. ERECTION OF LOCK-GATES.

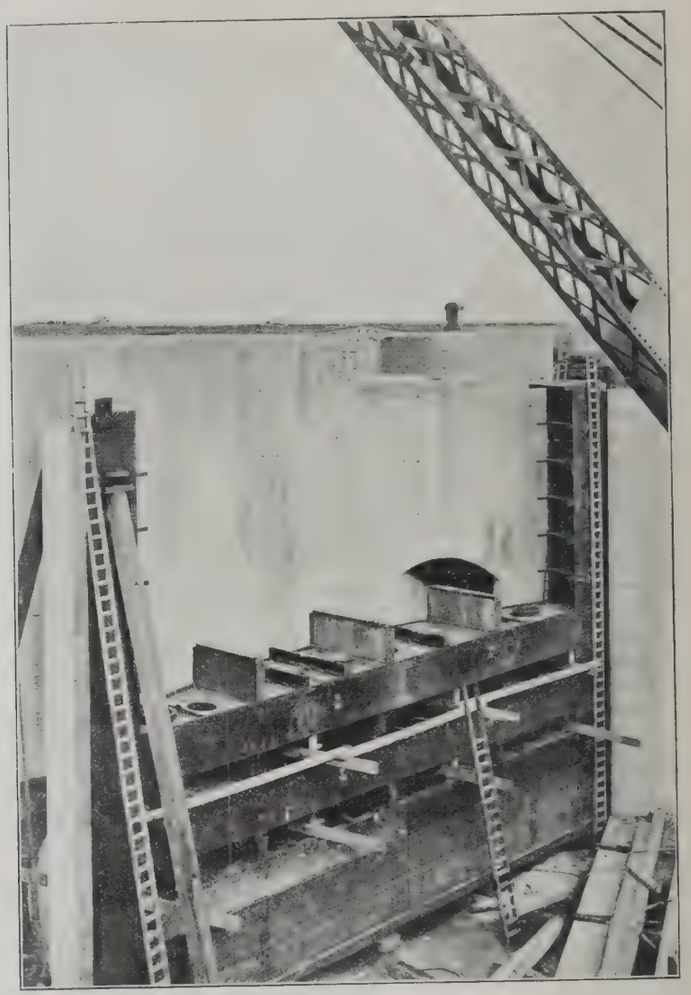

FIG. 72. ERECTION OF LOCK-GATES.

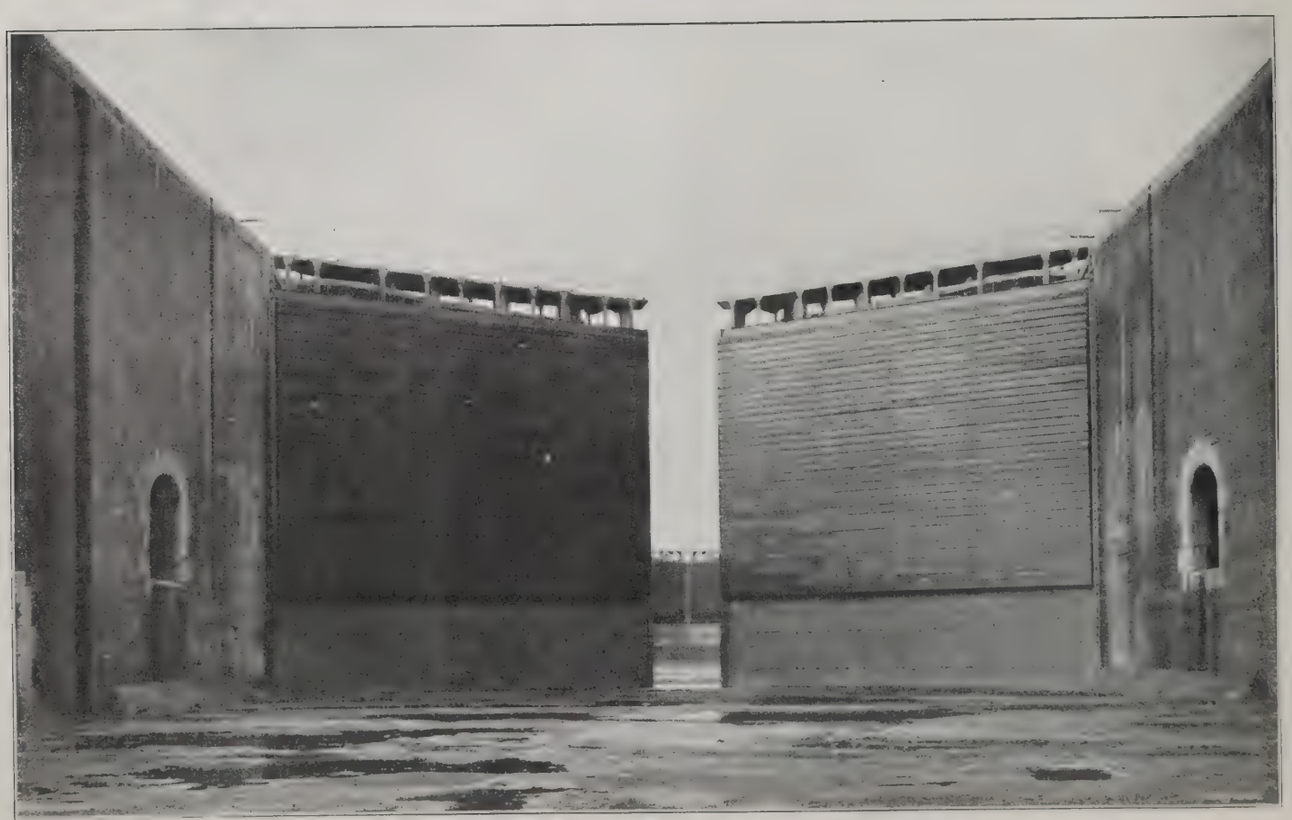

FIG. 73. VIEW IN LOCK SHOWING INNER SIDE OF GATES.

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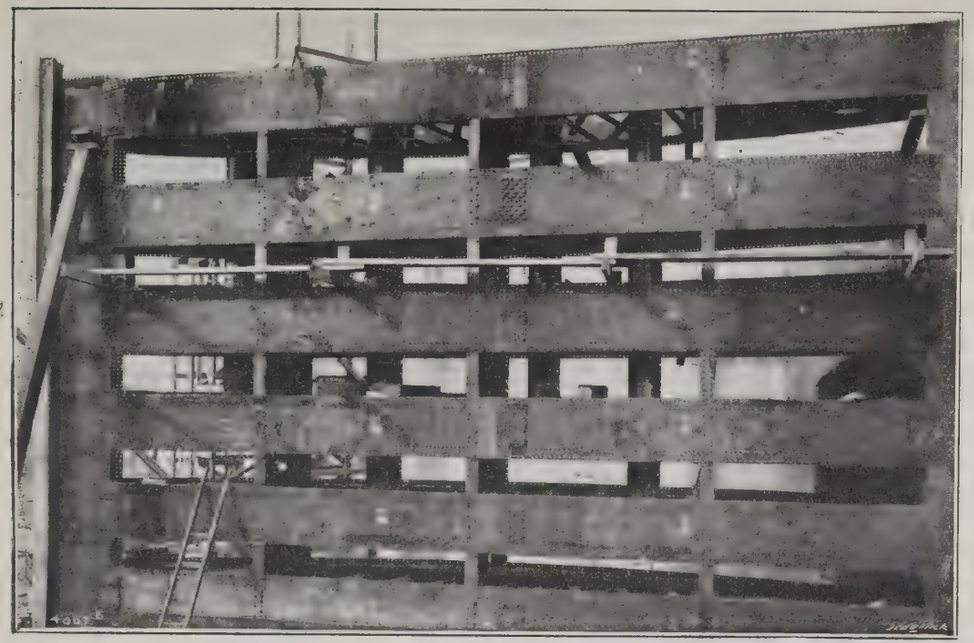

FIG. 74. LOCK-GATES DURING ERECTION.

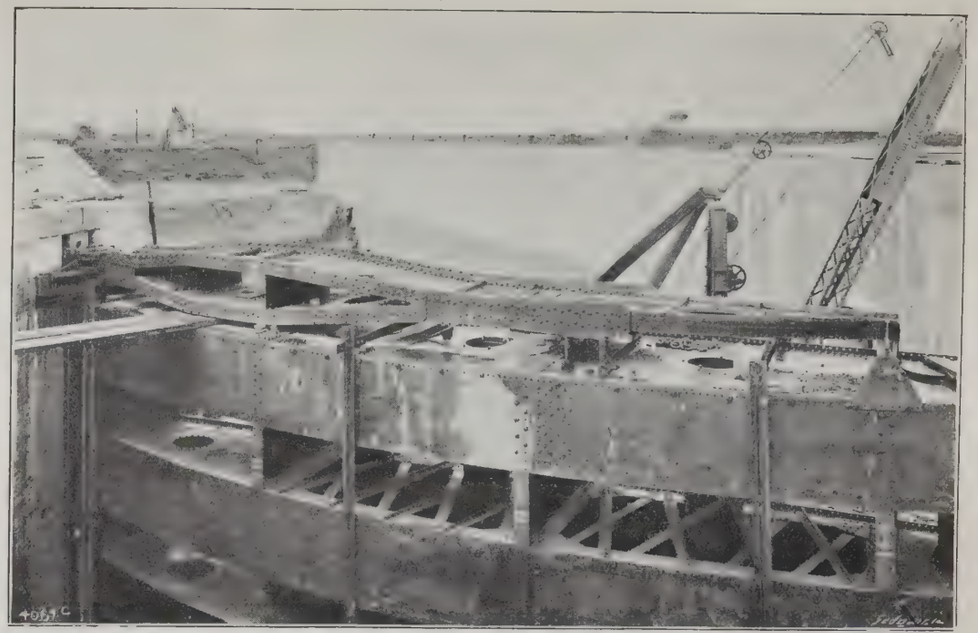

FIG. 75. LOCK-GATES DURING ERECTION.

FIG. 76. FOOTWAY OVER LOCK-GATES IN COURSE OF ERECTION.

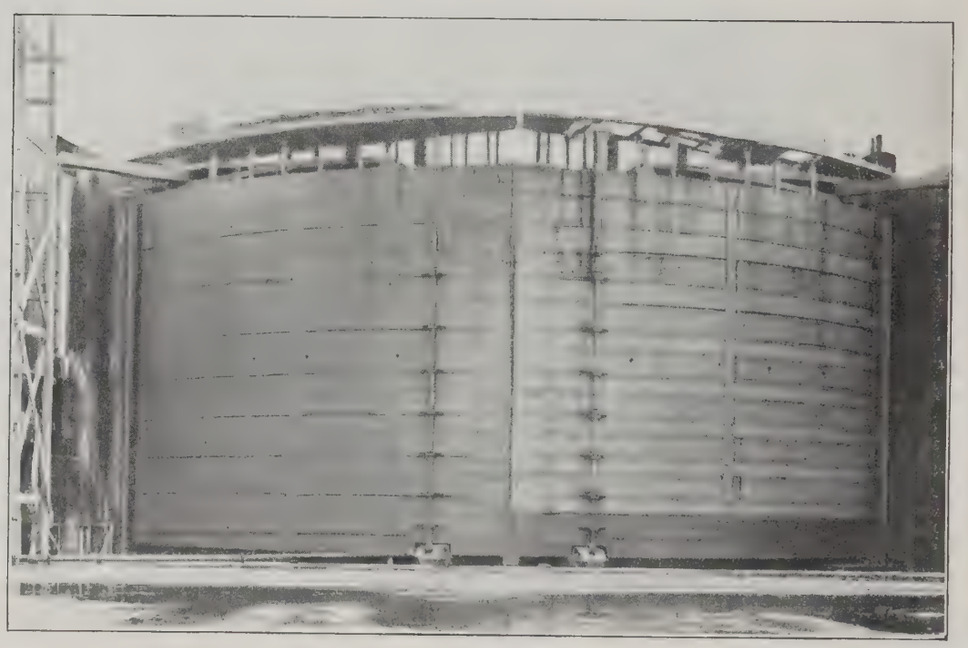

FIG. 77. VIEW OF OUTER SIDE OF LOCK-GATES.

THE ALEXANDRA DOCK EXTENSION AT NEWPORT: HYDRAULIC OPENING GEAR FOR LOCK-GATES.

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Fig. 78.

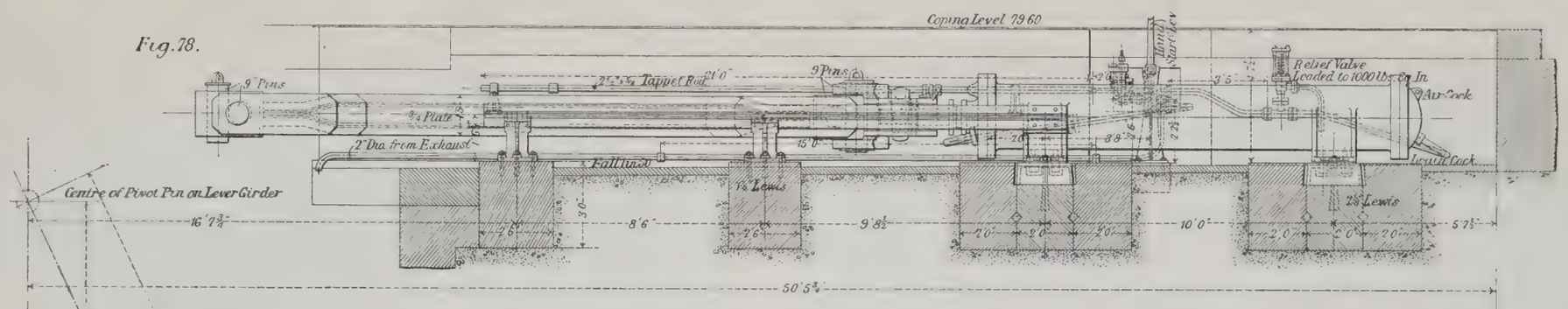


Fig. 79.

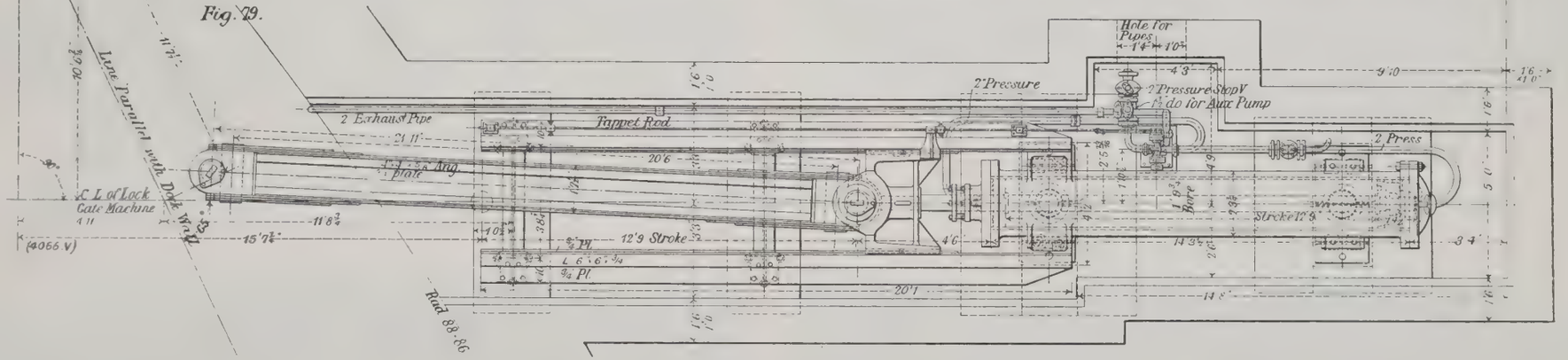


Fig. 80.

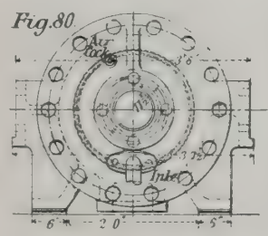


Fig. 81. SECTIONAL PLAN

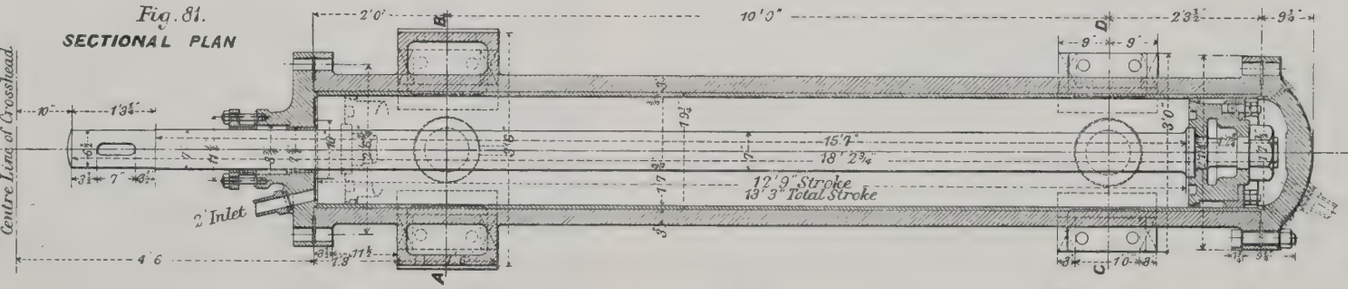


Fig. 82.

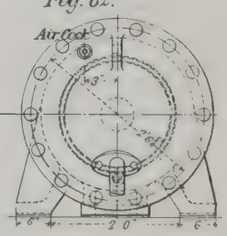


Fig. 83. PLAN OF FOUNDATION GIRDERS.

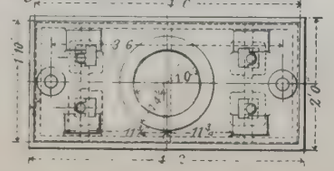


Fig. 84.

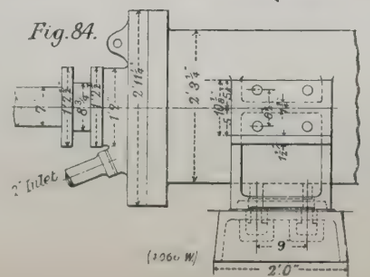
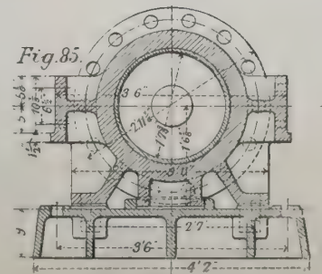
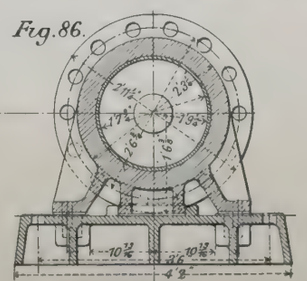


Fig. 85.



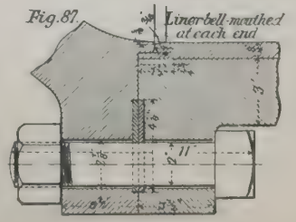
SECTION THROUGH A.B

Fig. 86.



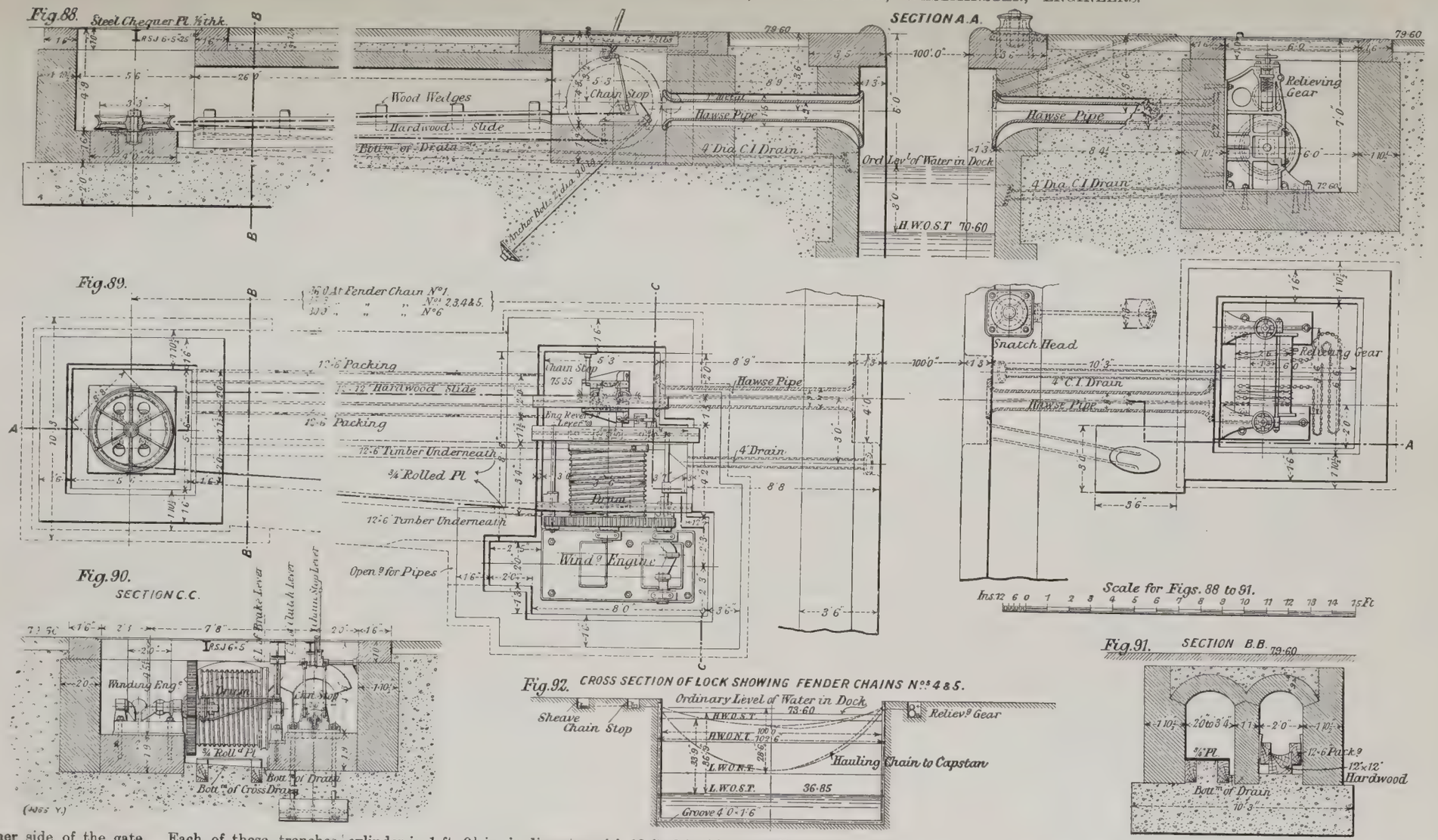
SECTION THROUGH C.D

Fig. 87.



THE ALEXANDRA DOCK EXTENSION AT NEWPORT; CHAIN-FENDER GEAR.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C. E., WESTMINSTER, ENGINEERS.



inner side of the gate. Each of these trenches contains an operating engine, which consists of a single hydraulic cylinder with piston, piston-rod, and crosshead, and a connecting-rod, which is directly connected to the "crocodile" lever already dealt with. The movement of the piston from one end of the cylinder to the other opens or closes the gate. It will be clear that the engines are very simple and straightforward affairs. They were supplied by Messrs. Glenfield and Kennedy, Limited, of Kilmarnock, and one of them is illustrated in Figs. 78 and 79, on page 114. Details are given in Figs. 80 to 87, on the same page. The cylinder is 1 ft. 9¼ in. in diameter with 12 ft. 9 in. stroke, and works with pressure water at 750 lb. per sq. in. As will be seen, the crosshead-guides are bolted to the cylinder, and the whole arrangement rests on four brackets, which are secured to granite blocks set in the concrete. The cylinder is fitted with a ¾-in. gun-metal liner. The connecting-rod, which is built up of angles and plates, has two 9-in. pivots at right angles to each other at each end. This not only provides for the natural inclination of the connecting-rod in a horizontal plane, but also allows for slight errors of alignment in a vertical plane, which might arise in setting up, or from settling of the gate with wear of its bearings. The engine is controlled by a slide-valve, which reverses the direction of water through it.

Our next series of figures—those on the present page—shows the fender-chain gear. Two such gears are fitted—one on the dock side of the inner gates, and the other on the river side of the outer gates. In the construction of the dock, however, grooves have been made on the other sides of these two gates and on both sides of the middle gates, so that a more complete fender-chain installation may be fitted in the future if desired. The general lines of the two gears fitted will be easily followed from the figures annexed. Fig. 88 is a plan of the whole gear, showing the two sides of the lock; Fig. 89 is a cross-section of the same thing. Figs. 90 and 91 are detail sections; while Fig. 92 is a small-scale cross-section of the lock, illustrating the principle of the appliance. To briefly describe the arrangement, it may be said to consist of a heavy chain, which normally lies in a groove at the sides and bottom of the lock, so that it does not interfere with the fairway. The ends of the chain are fixed to a winch and relieving gear, which are situated on opposite quays. When a ship is approaching the gates, the chain is

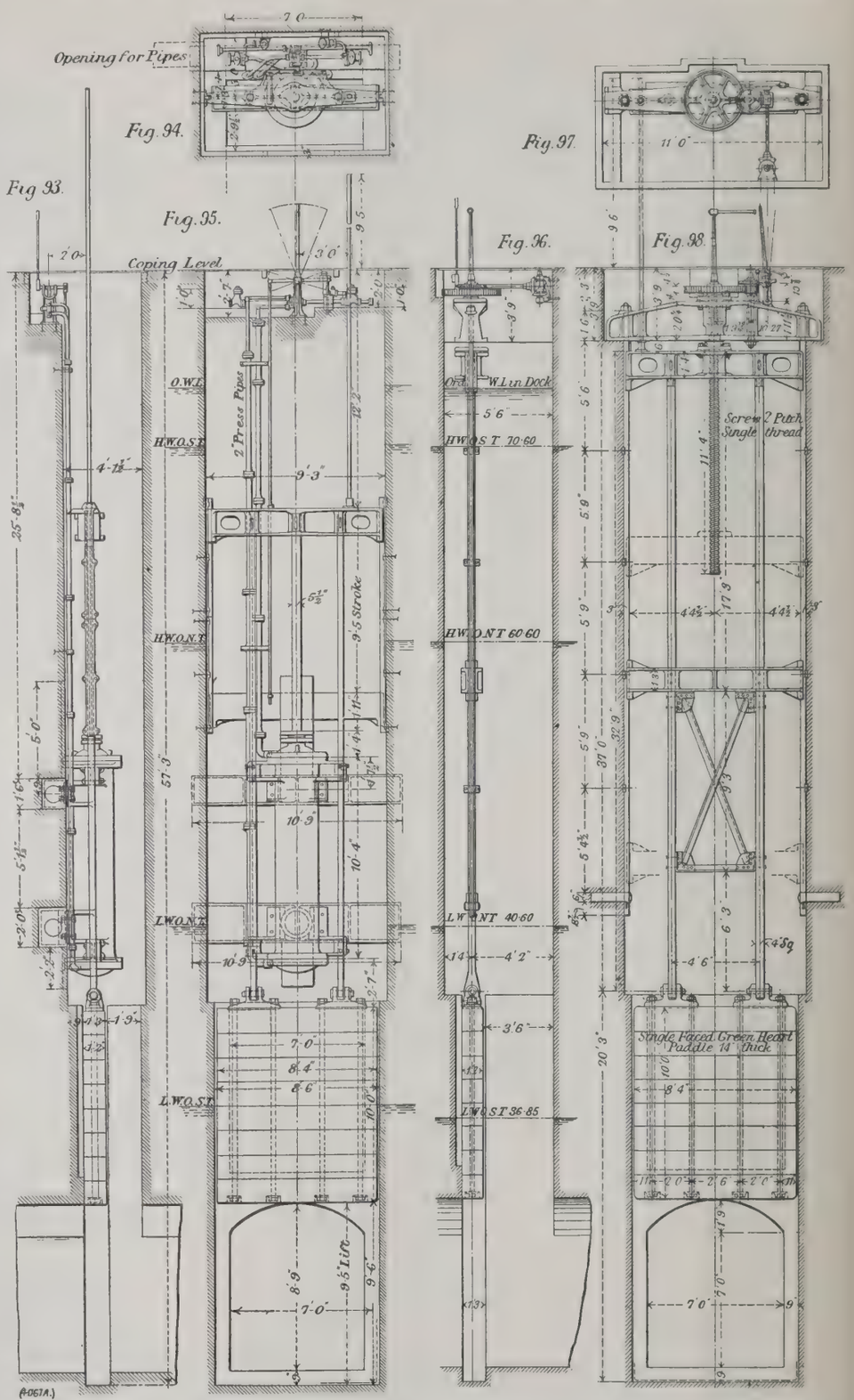
hauled in by the winch at one end (the other end being fixed) until it is stretched more or less taut across the top of the lock, as shown in the upper position in Fig. 92. If now the ship gets out of hand and charges the gates, it strikes the chain and is checked, so that the chain takes the blow instead of the gates. In order that the chain may not be broken by the sudden shock and to take the way off the ship gradually, the relieving gear, to which we have already referred, allows the chain to slip at a predetermined tension, which is maintained during the whole period of slipping, so that the ship is slowly stopped.

The gear by which these operations are carried out is shown in the figure. The winch has a grooved drum, 3 ft. 6 in. in diameter, driven through single gearing from an hydraulic engine having two pairs of facing cylinders, with rams $5\frac{1}{2}$ in. in diameter by 9 in. stroke. A hand-brake is fitted, and an automatic cut-off gear, which stops the engine when the chain is fully hauled in. The chain is led to the winch round a sheave, which can be seen at the left-hand side of Figs. 88 and 89. From the sheave it passes through a tunnel on the quay, and finally out to the lock by a hawse-pipe. The tunnel connecting the winch and the sheave is of taper form in plan, to allow of the horizontal movement of the chain as it is wound in and travels along the length of the drum. This tunnel has a $\frac{3}{4}$-in. steel plate for a flooring, on which the chain lies. The chain between the sheave and the hawse-pipe lies in a wooden guide. The two arrangements are shown in the section given in Fig. 91. The duty of the winch is to haul in the chain from its normal position at the bottom of the lock until it is stretched across the top. The winch is not designed to take the shock of a ship striking the chain, and, accordingly, when the chain has been hauled in, a chain-stop is brought into use which locks it in position. This stop can be seen in Figs. 88 and 89. It is fixed at the entrance to the hawse-pipe and consists of a fixed cast-iron block, anchored to the concrete formation, as shown in Fig. 89, and carrying a movable cast-steel block in a slot on its upper side. This movable block is operated by a hand-lever gear from quay-level. When the chain is being hauled in, the block is in its upper position and the chain passes freely. When, however, the chain is completely lifted, the block is moved down. This locks the chain, and any movement that the chain then makes owing to a ship striking it must be at the expense of the relieving-gear on the other quay.

The relieving-gear can be seen at the right-hand sides of Figs. 88 and 89. It consists of a pair of drums, mounted one above the other in square bearings carried by side frames in such a manner that neither drum can rotate. The upper drum is 1 ft. 3 in. in diameter, and the lower 2 ft. 6 in. The bearings of the lower drum are fixed in position, but those of the upper slide in guides in the side frames. A pressure is maintained between the two drums by adjustable spiral springs mounted above the upper one. The upper drum is parallel throughout its length, but the lower has flanges at each end. The chain enters by a hawse-pipe and makes several turns round the lower drum, as shown in Fig. 88. Leaving the drum, the chain is coiled in the pit behind the relieving-gear, and then makes a few additional turns round the lower drum. Its end is fixed to a staple in the floor of the pit. This arrangement as described normally does not move, but in the event of a ship striking the chain when it is taut, the relieving-gear slips and the chain is payed out by the lower drum under the tension induced by the pressure of the top drum and the friction of the first series of coils round the lower drum. When the whole of the slack has been paid out, the friction of the additional turns round the lower drum is brought into play, and this, together with the anchorage of the free end of the chain in the floor of the pit, ensures that the full strength of the chain is finally brought into use. There is one further point in connection with this gear which should be mentioned. When the chain has been hauled taut by the winch into the position indicated in Fig. 92, and is then released by reversing the winch to return to its original position in the groove, it will tend to pile up at the bottom of the lock on the winch side instead of distributing itself properly throughout the groove. To prevent this, a light chain is attached to it near its middle point, as shown in Fig. 92. This chain is hauled in by a capstan on the quay, and drags

NEWPORT DOCKS; EXAMPLES OF SLUICES.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C. E., WESTMINSTER.



the chain towards the relieving-gear side of the lock, so that it settles down properly in the grooves. The main chain has stud-links made up of $1\frac{5}{8}$-in. material. The gear was supplied by Messrs. Glenfield and Kennedy, Limited, of Kilmarnock.

The final feature with which we propose to deal in this article is the sluices, characteristic examples of which are illustrated in Figs. 93 to 98, annexed. These figures show an hydraulic sluice and a hand-power sluice. Hand-sluices are fixed in all cases as stand-byes to the hydraulic sluices, except in the case of the sluices for the culverts leading to the future graving-dock. Hand-sluices only are fitted at the far end of the discharge-culverts leading from the power-station to the dock, and form stand-byes to the hydraulic sluices which are fixed upon the delivery-pipe of each pump in the power-station. There are in all thirty-four sluices. Eight of these serve for the control of the supply to or from the power-station pumps, in addition to the two hand-sluices, already mentioned, at the far end of the discharge culverts. The remaining twenty-four serve the double levelling culverts, which connect the pens of the lock and the lock with the dock and river. The positions of most of them can be seen from the plan of the lock given in Fig. 4, on Plate X., in our issue of July 10. The sluices, which are all of the same general character, were supplied by

Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, of Newcastle-upon-Tyne. The two types are illustrated in Figs. 93 to 98, on page 116. In both cases the paddles are of greenheart, 14 in. thick. The hand-sluices are operated by a worm and spur-gear which drives a main lifting-screw, working in a nut in the top crosshead. This crosshead and the lower work on guides keyed to the sides of the pit. An indicating-rod carried by the top cross-head projects above quay-level and shows the position of the sluice. The hydraulic sluices are operated by a direct-acting ram which is connected to a single crosshead. The details of both arrangements will be clear from the figures.

(To be continued.)

SETTING OUT WORK.

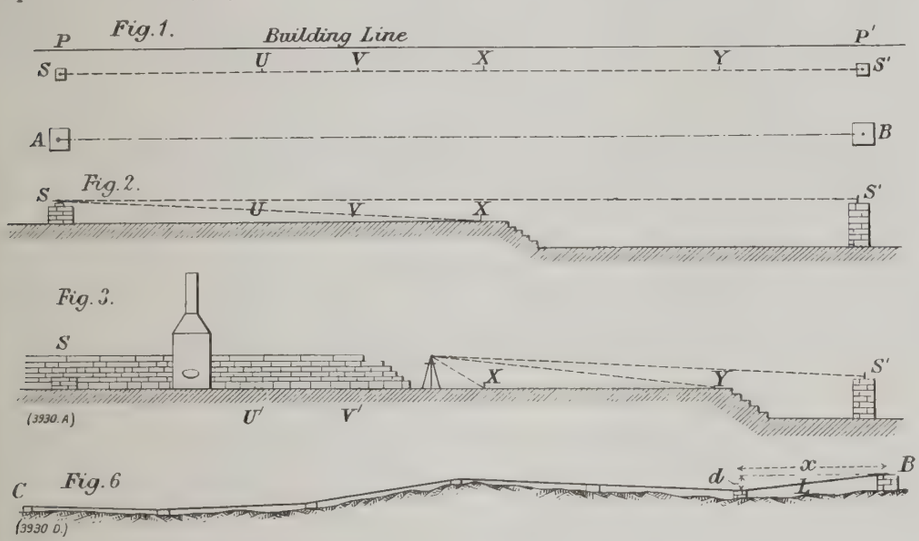
By R. H. LEE PENNELL, Assoc. M. Inst. C.E.

THE following articles are intended to form a guide to young engineers when they first come on to works after leaving college. Men just leaving college are probably fairly well grounded in surveying and the use of the ordinary surveying instruments; but the setting out of work differs considerably from surveying. In the latter operation the positions of existing objects have to be fixed in such a way as to enable them to be plotted on a plan, but in the former case objects have to be located on the ground in certain required positions derived from a plan. Setting out work is therefore an operation which is the reverse to surveying. The present articles are based on a short series of lectures given by the author, in Cairo, to the students of the Egyptian Government School of Engineering.

To Set Out a Straight Line.—The setting out of a truly straight line is a difficult thing to do; it has been said that anyone can set out a curve, but it takes an engineer to set out a straight line. The difficulty is that it is usually impossible to see the whole length at one setting of the theodolite, owing to gangs of workmen, stacks of material, cranes, &c, being on the line of sight. The theodolite therefore has to be set up more than once in order to complete the line it is desired to mark out.

Suppose the line to be set out is for the parapet wall and coping-stones of a long, straight breakwater. In Fig. 1 suppose P P′ is the building-line required. If you set out this line, your points will very likely get destroyed or obliterated with mortar as the masonry is built; also, if there is any bull-face on the stones, the points will be very awkward to build to after the first course is laid. It is therefore much better to set out your line as a parallel line to the building-line, and from 1 ft. to 2 ft. from it. At this distance it is easy for the masons to obtain their building-line with their 2-ft. rules from the points set out by the engineer.

In the figure, therefore, let S S′ be the line it is proposed to set out, within 2 ft. of the building-line, and let A B be the axis-line of the whole work. (This need not necessarily be the centre line; in the case of a dam with under-sluices it would preferably be on the line of the sluice-gates, but in any case all major work should be set out either directly or indirectly, the former for preference, from this line.)



At the theodolite stations A and B, mark off roughly the distances A S and B S′. Build temporary theodolite stations at S and S′, then very carefully set out and mark the points S and S′ on the pillars built.

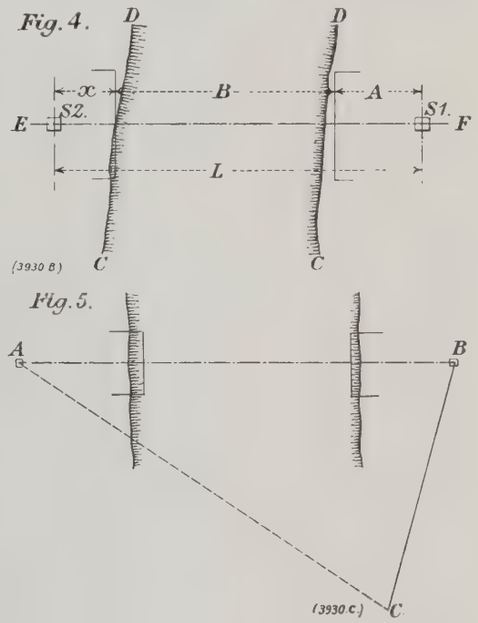
It should be quite easy to see from S to S′ direct. But when the line of sight is depressed, so as to mark the points on the line S, S′, obstructions will often be found in the way. Setting the theodolite up at S, therefore, and sighting on to S′, set out as much of the line as can be seen. Assume the first length is set out as far as X (Figs. 1, 2 and 3). It is now wanted to set out the length X Y. Since S′ should stand high, it will be visible from X (it is important that either S or S′ shall be seen from X, as it is very risky to continue the line relying only on the last points set out).

The obvious way to set out X Y would appear to be to set up on X, sight on to S′, and then put in Y. If you do this, you will almost certainly get a kink in your line at X; you may reverse and swing the theodolite, and take every possible precaution, and yet get a kink at X. Therefore do not set up on X, but some little way back from X, sufficiently far to have X in focus. There will be no point to set up on, but by ranging in the last two points V X, you must get as close as you can. Then sight on to S′ and down on to X; you will not strike X. Unclamp centre-plate and move the instrument over, and try again until, after sighting on S′, you strike X exactly.

When your cross-hairs cut both points X and S′ you are absolutely certain that your line of sight is on the line you require, and you can set out your points with confidence, even should the theodolite be slightly out of adjustment.

To Set Out the Abutments of a Bridge Across a River.—This in most cases entails triangulation, but whenever it is possible to measure directly, always do so. When direct measurement is possible, the procedure may be as follows:—In Fig. 4, C D and C D represent the banks of a river, and are, say, 150 ft. apart. E F represents the centre line of the approach roads of the bridge. It is required to set out the abutments. Select any two points S^1 and S^2 on the centre line E F, keeping these points well back from the top of the bank, and build these points in, in masonry, so as to avoid any fear of them being moved. The points must be kept well back from the banks of the river, as otherwise pile-driving, for example, might affect them by the tremor caused to the surrounding ground and so slightly move them out of position, or railroads for cranes or materials might unavoidably foul them. Then with a light steel measuring-wire measure the distance between these points as follows:—

One man holds one end of the wire 1 ft. back from the base point. A second man kneels over the base point to see that the 1-ft. mark on the wire exactly coincides with the point. (This is much easier than getting the point and the edge of the handle to coincide.) On the other bank an ordinary spring-balance is attached to the wire, and on this a man pulls hard, the wire passing over the base point. Over the low masonry pillar carrying this point the engineer stands with a pencil. (It is assumed that only even feet are marked on the wire.) The engineer watches the man over the base point on the far bank, and when the latter signals "right," the engineer shouts to his man to read the spring-balance, and he himself, with his pencil, marks the position on the pillar of the nearest foot-talley on the wire. He then reads this talley, and the men slack off. The operation should be repeated at least once, the man with the spring-balance this time pulling until he reads the same tension as before on the balance, the engineer marking the pillar as before.



This operation all finished, the engineer measures the distance between the mean of his pencil-marks and the base point. This is obviously either an addition or a subtraction to the measurement by wire. A correction for the sag of the wire has then to be made by measuring a similar length on level ground with a standard tape. The tape should be laid along the ground for a few minutes with a thermometer near it, so as to correct for the temperature of the tape. The steel wire is then stretched over the measured length at the same tension as before, and the length noted; of course, the wire must not touch the ground.

Since the whole length of wire is thus checked, any light steel wire will suit the purpose in the original measurement (if a proper measuring wire is not available), a spot of black paint and a scratch mark at the ends marking the measuring points. The only difficulty in the whole of this operation is the checking of the wire for sag, which will require two plumb-bobs and plenty of men to pull long and steadily. The easiest way is to stretch the wire first and mark the length very carefully on two wooden pegs, or otherwise, and then to measure the length between the two points thus obtained, as described above.

The distance between the two pillars having been obtained, and the position of one abutment settled upon, the position of the other abutment is fixed by measuring back from the pillar. In Fig. 4, $x = L - (A + B)$.

Remember that when setting out, in order to start excavation, it is no use bothering about a few inches one way or the other, and that accurate setting out is not required until the foundations go in. In the case of a bridge, the foundations and lower courses of the abutments will probably be below water level. Setting out such work will be considered later.

If the river is too wide to measure directly across, it is necessary to triangulate it and calculate the length. Two pillars are built as before, and a base line B C measured (see Figs. 5 and 6). The measurement of base lines is fully treated in most text-books on surveying, and a few notes only will therefore be given here.

Do not try to set out the base B C at right angles to the axis. It is much easier to read an angle than to set an angle out correctly. In any case, read all the angles of every triangle and each angle at least three times, and read continuously. Do not attempt to set the instrument back to zero each time.

When measuring the base line, use special base-measuring instruments, if possible; should these

not be available, the following notes may be found useful :—

Level off small irregularities in the ground from B to C (Fig. 6). Set bricks at from 15-ft. to 20 ft. intervals along B C and work them well down on to an even bed. The bricks should be set to line with the theodolite.

Take the level of each brick.

See that the tape when measuring touches the top of each brick ; note where each brick occurs, but measure continuously ; if any full tape length overshoots a brick, book the length to the brick, and start off the brick again.

Keep the tension on the tape constant with a spring-balance.

Have a very good man at the zero end of the tape.

Unskilled helpers may be used to hold the tape down on to the intermediate bricks by pressing on to it with one finger only. If your tape sags between the bricks, more bricks must be put in. Having measured your total length B C, correct same for horizontal distance. In the first length of exaggerated figure (see Fig. 6) :—

d = difference in level of two consecutive bricks.
l = measured length.
x = required length.

$$x^2 = l^2 - d^2.$$

Having obtained the total horizontal distance, next correct for temperature of tape.

(total distance) × (coefficient expansion) × (temperature on ground—standard temperature) = correction.

Theoretically the temperature correction should be applied separately to each length between bricks, but the error involved as worked above is negligible. The standard temperature will probably be freezing-point. The tape will therefore be too long.

This brings us to an important point. Is this correction an addition to or a subtraction from the length ?

This depends upon whether you have fixed the point C. and are measuring between B and C to obtain the distance, or whether you have settled to put C in at a certain distance from B on the line B C. The former measurement is practically a survey measurement. The latter measurement is a "setting out" measurement. In the first case, if you have fixed the point C, and are measuring between B and C to find the distance between them, you must add your correction for your tape being too long. In the second case, if you wish to set out C at any fixed distance from B, you must subtract your correction for the tape being too long. Taking an example :—For simplicity, suppose the length from B to C, in the first case, happened to measure 600 ft. by the tape. The thermometer on the ground registered 82 deg. Fahr. The tape was an ordinary steel tape with coefficient of expansion of 0.00000661, and standardised at freezing-point; the correction will be

$$600 \text{ ft.} \times 50 \text{ deg.} \times 0.00000661 = 2\tfrac{3}{8} \text{ in.}$$

The distance between B and C will really be, therefore,

$$600 \text{ ft. } 2\tfrac{3}{8} \text{ in.}$$

But in the second case, if you wish to mark the station C at exactly 600 ft. from B, and the same conditions as above prevail, you must put the point C in at 599 ft. $9\frac{5}{8}$ in., according to your tape markings. Having measured the base-line, measure the three angles of the triangle as already described. The length of the axis-line between the two pillars can now be calculated, and the abutment lines set out as before.

(*To be continued.*)

THE PANAMA-PACIFIC EXHIBITION.—From September 20 to 25, 1915. there will be an important congress of engineers at San Francisco, Cal., U.S.A., in connection with the Panama-Pacific Exhibition. This congress will be presided over by Colonel G. W. Goethals, and representatives of a large number of countries are expected to be present. The leading American technical institutions are co-operating to make it a success. Undoubtedly one of the most interesting features of the congress will be the presentation of papers dealing with the Panama Canal itself. The contributions on this subject will be presented under twenty-two heads, among which are to be a general report by Colonel Goethals, and an account of the dry excavation, dredging, terminal works, design of locks, &c.; construction of same, the gates, dams, geology of the Zone, &c. These reports, all given under the supervision of Colonel Goethals, will be drawn up by the heads of departments in charge of the particular work described. They will constitute the only procurable official technical record of the construction of the canal.

INDUSTRIAL NOTES.

A MEETING of members of the Federation of Master Cotton-Spinners' Associations (American Section) was held on the 17th inst. at the Coal Exchange, Manchester, with a view to consider a recommendation from the General Committee of the Federation that between July and the end of September next production should be curtailed to the extent of stopping 166½ hours. Firms representing 70 per cent. of the American section attended the meeting.

Sir Charles W. Macara, President of the Federation, opened the discussion, and stated that the object of the meeting was to grapple with a state of things which, unless resolutely dealt with, would land them into difficulties greater than they could possibly imagine. As they looked round the manufacturing districts they saw that looms were stopping in every direction, and if spindles were to continue running in the conditions which now prevailed they would soon be in a state of absolute chaos. He maintained that organised effort, with the burden spread over the whole trade, was infinitely better than any individual effort could be, and would effect the purpose they had in view—*i.e.*, the restoring of the trade to a stable basis, sooner than any industrial effort possibly could.

Referring to the position of the cotton trade in other countries, a statement received from the Secretary of the International Federation of Cotton-Spinners was read. In this it was stated that the cables received showed that in several of the countries the lead set by England in former years as regards short time had been followed. If Lancashire on this occasion adopted the proposed curtailment, it would undoubtedly stimulate other countries to adopt and extend the short-time movement.

Sir Charles therefore moved :—"That this meeting of members of the American Section of the Federation strongly approves of the recommendation of the General Committee that spinners of American cotton should stop their mills for 166⅔ hours, exclusive of holidays, between July 7 and the end of September, and that a circular be issued to ascertain if firms owning the necessary percentage of spindles (80 per cent.) are willing to curtail production, in accordance with the recommendation."

The resolution was seconded by Mr. J. B. Tattersall, Vice-President of the Federation, who appealed for a united effort. It was passed, with one dissentient.

A circular was then sent to all federated firms, appealing to them to support the resolution by filling in their voting paper in the affirmative.

The German textile industry also appears to be in a difficult situation, since a general lock-out of men and women employed in the Lusatian textile mills was declared on Saturday last, the 18th inst. At Kottbus about 5000 to 6000 employed in 50 factories, and at Forst 10,000 to 12,000 hands employed in 120 factories, were locked out. A number of discharged hands belong to the towns of Sprenberg, Guben, Luckenwalde, Sommerfeld, and Finsterwalde.

We are informed that Messrs. Lever Brothers, Port Sunlight, have increased the wages of several grades of their employees. Wages of labourers have been raised from 26s. to 28s. per week ; process labourers will now earn a minimum of 30s. ; the wages of girls over twenty-one years of age, and counting at least three years' service, have been raised from 14s. to 16s. per week ; the wages of youths have also been increased.

In our last issue, on page 96 *ante*, we referred briefly to the difficulty which had arisen with the men employed by the Mersey Docks and Harbour Board. On Friday last, the 17th inst., the Strike Committee issued the following statement :—

In our various letters to the Dock Board up to June 4 we merely asked for recognition of the Union by the formation of a joint or conciliation board, equally representative of the Board and the workers, feeling confident that if that had been granted we would have avoided the present trouble.

The reply of the Board was a direct refusal to meet or discuss the question with them. We then placed the Board's reply before their employees at mass meetings held on June 28 and July 5.

At these meetings the members assembled, and after discussing the Board's refusals, unanimously passed resolutions demanding recognition of port rates and conditions, and at the same time, in view of what might take place in case of a further refusal from the Board, they decided that the whole of the workers under the Board should, in their own interests, become members of some union, and that those members who were at the time in arrears to their respective unions, should make themselves full-benefit members, in order to secure full support during the strike.

The result of the mass meetings was forwarded to the Board in a letter on July 6, as follows :—

Gentlemen,—It is the earnest wish of the Engineering and Shipbuilding Federation and the Transport Workers' Federation to prevent a disruption on the Dock Board estate. Since our last letter the whole of the men employed by your Board have been consulted, and the following resolution unanimously passed :—

That this meeting of Dock Board employees endorses the policy as laid down by the union members employed by the Board :—

1. That a joint board be appointed for the settlement of all disputes.

2. That the port standard rate of wages shall obtain.

3. Agrees that all men employed by the Board shall of necessity belong to their respective unions, and in the light of eventualities be clear on the books of the same.

They further pledge themselves that if, in the judgment of their leaders, drastic action is necessary, they will support such action by all means in their power.

In view of this we are again instructed to request you to receive representatives of the above Federations to discuss the position as early as possible.

(Signed) T. GRIFFITHS,
JAMES STEPHENSON,
Joint Secretaries.

"This," the statement adds, "was in order to warn them of the impending trouble, and apparently our efforts to save the present situation have been wrongly used by the Board to complicate the issue. We therefore reiterate that we have not at any time asked or intended to imply, either directly or indirectly, that the Board should be responsible for anything beyond the fact that the men employed by them should be paid wages in accordance with the established rule of the port."

Later news received from Liverpool at first tended to show that matters were improving. The Strike Committee had held numerous sittings, and had been in constant communication with the Dock Board with a view to settle the dispute. At the time of going to press we learn that the Committee met again on Tuesday to await a communication from the Dock Board. This was received, but it did not prove satisfactory to the men.

On Saturday, the 18th inst., the Joint Committee of the Engineers' Societies distributed among the members on Tyneside a communication pointing out that the wages of sea-going engineers were less to-day than those paid to men holding similar positions 30 or 40 years ago. Recent experiences had proved to them the futility of individual effort, and the only means whereby important concessions could be secured was by the power of combination.

On the same day there were about 60 steamers, including 20 colliers, held up in the Tyne ; these ships were unable to get to sea owing to the engineers having handed in their notices. Six colliers having completed their cargoes before the 24 hours' notices expired, left the river. Some of the men decided to leave the boats as they arrived in London, and others, who reside on Tyneside, were to return with the vessels and terminate their engagements on their arrival. The seamen are lending support to the engineers, and decline to work with "blacklegs."

The Marine Engineers' Association, South Shields, have stated that the owners would be unable to secure engineers on the Continent even if the vessels were towed there, as the British engineers had an alliance with the foreign engineers, who were loyal trade unionists.

All shore fitters engaged in ship-repairing work on the Tyne ceased work last week, with the exception of those employed on oil-tank steamers and on foreign-owned vessels. The number of men affected is approximately 2000, in addition to about 300 marine engineers. The number of vessels held up in the Tyne is increasing, and it is expected that the dispute will extend to other British ports.

The following remarks are taken from the last issue of the *Moniteur Industriel* :—One of the French Chambers of Commerce recently adopted a resolution in view of the excessive number of social laws passed by Government. In this the Chamber asserted their desire to see improvements made in labour conditions, but express the view that the number of social laws increases every year, and by restricting production or by placing fresh burdens upon it, increase the cost of output and the cost of living. The resolution proceeds to "ask Parliament to show more prudence in future with regard to the adoption of fresh social laws, and not to put in force any new regulation concerning labour if a similar regulation be not adopted simultaneously by the other industrial nations." The so-called social laws, adds our contemporary, increase the price of all necessary articles and react upon those they were destined to assist. When the power of production of an industry is weakened legislatively, and when the taxes with which that industry is encumbered are raised, the cost of living is increased and no real benefit is derived from the measure. No

measure has yet succeeded in France in checking the exodus of labour from the land to the towns; there is an excess of urban workers, and in order that they all may live, the power of production of each has to be reduced, the wages remaining at the same standard. Such methods are ruinous to the nation.

Since we reported, on page 43 *ante*, that the Financial Committee of the French Senate had rejected the proposal for the Saturday half-holiday for State employees, Parliament has taken up the matter afresh, and, according to our contemporary already mentioned, the Senate has voted the reduction of working hours per week to forty-nine—*i.e.*, five days at nine hours and four hours on Saturdays—for State employees. The private firms throughout the country, it is believed, will have to adopt the same measure.

The dispute in the London building trades remains unsettled. A large number of the men involved held a meeting in Trafalgar-square, London, last Sunday, the 19th inst., and announced their intention of carrying on the dispute until the employers deleted the entire clause relating to disability. A minimum for the various grades was also demanded. The speakers further announced that the disability clause had undermined trade union liberty of action with regard to the non-unionist element, and although the struggle had been in progress for six months they had no intention of coming to a settlement until the point was satisfactorily dealt with.

The Home Secretary has issued the draft of an Order which he proposes to make under Section 116 of the Factory and Workshop Act, 1901. The effect is to require particulars of work and rates of wage to be given to all persons paid by the piece who are employed in factories and workshops in which the manufacture of articles of metal (not being machinery) is carried on, or who are employed in that class of work as outworkers. The Order will consolidate and supersede the existing Orders relating to the making of pens (July 12, 1900), the making of locks, latches, and keys (July 14, 1902), the making of chains, anchors, and cart gear (July 14, 1902), the making of iron safes (April 29, 1911), and the making of files (December 23, 1911). It is drawn so as to apply to the same classes of work (other than the manufacture of machinery) as are covered by the definition of "metal works" in paragraph (13) of the sixth schedule to the Act, with the inclusion, however, of workshops as well as of factories. It will not apply to any of the other works (*e.g.*, blast-furnaces, copper mills, iron mills, or foundries) defined in the other paragraphs of that schedule; nor will it apply to any work to which the Order of September 23, 1907, relating to the mixing, casting, or manufacture of brass or articles of brass, and the electro-depositing of brass, applies.

The Chief Registrar of Friendly Societies has issued his Report on Trade Unions for the year ending December 31, 1912. From this we find that during the year 1912 thirty-nine unions were added to, and thirty-six were removed from, the register; of these latter, twenty-three furnished notices of dissolution, eight were amalgamated with other unions, and in five cases the certificate of registry was cancelled at the request of the unions. There accordingly remained on the register on December 31, 1912, 683 unions, of which 576 were registered in England and Wales, thirty-one in Scotland, and seventy-six in Ireland. The 683 unions in question had a membership of 2,597,772. In 1903 the unions numbered 742, with a membership of 1,575,375; these figures show a decrease of fifty-nine unions, and an increase of over one million in membership. Among the unions showing the largest increase in membership during the year 1912 we may mention the National Amalgamated Union of Shop Assistants, Warehousemen, and Clerks, with an increase of 42,694; the Amalgamated Society of Engineers, 22,529; the Amalgamated Society of Railway Servants, 15,486; and the Amalgamated Society of Carpenters and Joiners, 12,600. On the other hand, three unions showed a decrease in membership, as follows:—The London Carmen's Trade Union, a decrease of 18,405; the Dock, Wharf, Riverside, and General Workers' Union, 14,771; and the Lancashire and Cheshire Miners' Federation, 9326. Taking the unions having the largest membership in the year under review (1912), we find the Amalgamated Society of Engineers with 143,998 members; the Durham Miners' Association with 136,966; the Amalgamated Society of Railway Servants of England, Ireland, Scotland, and Wales, with 132,002; the South Wales Miners' Federation with 114,208; the Yorkshire Miners' Association with 99,632; and the National Union of Gas-Workers and General Labourers with 82,135. The total income of the unions in 1912 was 3,845,841*l.*, 90.4 per cent. of which was contributed by the members, 4 per cent. by other trade unions, the remainder, 5.6 per cent., being interest on invested funds and contributions from other sources. The average contribution per week received from each member was 6 5d. The total funds of the unions on December 31, 1912, was 5,617,927*l.*, showing a decrease of 708,785*l.* during the year; this decrease in funds was due to the coal strike, and applied mostly to the funds of the mining group of unions. Taking the six unions at the top of the list, we find that on December 31, 1912, the Amalgamated Society of Engineers had total funds to the amount of 786,320*l.*; the Amalgamated Association of Operative Cotton-Spinners, 500,724*l.*; the Amalgamated Society of Railway Servants, 379,025*l.*; the Derbyshire Miners' Association, 244,022*l.*; the United Society of Boiler-Makers, 227,145*l.*; and the Associated Society of Locomotive Engineers, 169,712*l.*

NOTES FROM THE UNITED STATES.

PHILADELPHIA, July 8.

A RETROSPECT of the past six months reveals a very irregular course in iron and steel so far as demand went. Prices sagged irregularly; output varied from 75 to 50 per cent. of capacity. The lower tariff did not materially affect conditions. None of the anticipations came true. Export trade, especially in rails and pipes, shows improvement. A further growth of the export trade is clearly seen. June orders for cars foot up about 25,000, which call for 275,000 tons of steel, and the roads need much more rolling-stock. The total of rail export orders for June reached 75,000 tons, besides a few small unreported orders. Much railroad construction is contemplated in most of the countries taking these rails. A supplemental pipe order of 10-in. pipes is under consideration for Persia. It is definitely known that there would be considerably more business done if manufacturers were willing to sacrifice future possible profits, and take third and fourth quarter orders at current quotations. Experts in the steel trade see highly encouraging conditions in the near future, all based on the very patent fact that production is not much more than half normal production, and that demand has been repressed to the utmost limits. Everywhere the talk in the steel-using industries is over the uncertain trade conditions. This uncertainty is largely imaginary. The daily rush of small structural steel orders is rather surprising, in view of unsettled conditions generally. Much steel is wanted for small bridge work. All of the shipyards are crowded, and most of them, according to to-day's summary, have upwards of a year's work.

PERSONAL.—Messrs. S. H. Morden and Co., Limited, state that their address is now Morden House, Dartmouth-street, Westminster, S.W., close to St. James's Park Station, Underground Railways.—Messrs. Morris and Lister (London), Limited, have now taken over the sole representation for London and the South of England for Messrs. Miokelwright, Limited, of Alperton, in place of Mr. Raymond Smith, the late representative. All inquiries, &c., should now be sent to Messrs. Morris and Lister (London), Limited, 3 and 4, Palace Chambers, Bridge-street, Westminster, S.W.

THE SEVENTH INTERNATIONAL AERONAUTICAL CONGRESS.—The seventh International Aeronautical Congress will be held between September 27 and October 1, at the Lyons Exhibition. The Congress, which will be presided over by Lieut.-Col. P. Renard, will be held under the auspices of the Aéro Club du Rhône et du Sud-Est, and of the Municipality of Lyons. Many contributions of importance have been promised, from, among others, the following authorities:—MM. R. Soreau (France); Commandant Mathieu (Belgium); A. Sée (France); Adhemar de la Hault (Belgium); Capt. Costanzi (Italy); M. Joukowsky (Russia); General de Wendrich (Russia); M. Rinine (Russia); Ch. Maurain (France), &c. Further particulars may be obtained from the Aéro Club du Rhône et du Sud-Est, 4, Quai de la Pêcherie, Lyons, or of the Commission Permanente Internationale d'Aéronautique, 19, Rue Blanche, Paris.

THE LATE MR. HENRY JOHNSON.—We regret to have to record the death, on the 16th inst., of Mr. Henry Johnson, formerly of the Indian Public Works Department. Mr. Johnson was born in 1837, and from 1853 to 1858 was articled to Mr. J. Hodgson Jones, M. Inst. C.E., Westminster, during which time he was engaged on water, gas, and drainage works. He then went out to India as assistant engineer under Messrs. Brassey, Wythes and Co., on the construction of the Eastern Bengal Railway, having charge of 10 miles of line, including Barrackpore Station. In 1862-63 he was engaged in a survey of Zemindaries for Messrs. P. Watson and Co., Bengal, and then joined the Oudh and Rohilkund Railway, and, under Mr. J. E. Wilson, chief engineer, was first employed on survey, and then as assistant engineer on the line between Lucknow and Cawnpore. In 1866 he obtained an appointment in the Public Works Department, and after being in charge of road and barrack construction was transferred to the Indian State Railways. He had executive charge on the north side of the construction of the Chenal Bridge with the workshops required for its erection. Mr. Johnson was a member of the Institution of Civil Engineers, but retired from that body some years ago.

THE LATE MR. ROBERT COCKBURN.

MANY engineers have learnt, with much regret, of the death of Mr. Robert Cockburn, who, like his father, had long been closely identified with the design and manufacture of steam-valves and other accessories for marine engines. Mr. Cockburn had not for some time attended so actively to the work, owing to illness, but he was able to enjoy life up to the end. His death, sudden and unexpected, occurred at his residence at Blackdales, Largs, on Friday, the 10th inst. He was the son of Mr. David Cockburn, who instituted the well-known Cockburn valve works which are now situated at Cardonald, Glasgow. It was at his father's works that the late Mr. Robert Cockburn served his apprenticeship. He continued in employment in the same works, and in 1889 the business was transferred to him. Ten years later a private limited-liability company was formed, and Mr. Robert Cockburn shortly thereafter was appointed sole managing director, a position he held until his death. Under his management the business has been from time to time enlarged considerably; it was started with a mere handful of men, and now there are over 300 workers, the establishment covering 3½ acres. Mr. Robert Cockburn was buried in Millport, one of the Clyde watering places, in which he had for many years taken a part in public affairs, rendering useful service as a town councillor, and, for a term, as provost or chief magistrate. Mr. Cockburn was also a member of the Bute County Council, and a Justice of the Peace for that county. He is survived by a widow and one son and daughter, the son, Mr. David Cockburn, being assistant managing director of the company.

TORPEDO-BOAT-DESTROYER FLOTILLA LEADERS.—The two flotilla leaders recently provisionally ordered of Messrs. Cammell Laird and Co. and Messrs. W. Denny and Brothers are to be named Kempenfelt and Nimrod respectively.

THE COPPER MARKET.—In their report dated the 16th inst., Messrs. James Lewis and Son state that Standard copper advanced from 61*l.* for cash on the 1st inst. to 62*l.* 10s. on the 7th. The receipt of the American refiners' statistics, giving the home consumption for the month of June as only 20,637 tons, with an increase in the stocks of 9719 tons, induced large realisations, and values fell rapidly until 61*l.* was again accepted on the 14th. On the 16th inst. the closing quotations were 61*l.* 2s. 6d. cash and 61*l.* 11s. 3d. three months prompt. In the early part of the fortnight, American electrolytic copper was freely sold by leading producers at 10s. below the price of Standard, considerable quantities being taken by American consumers at 13⅛ cents per pound, and by European manufacturers at 63*l.* 10s. per ton c.i.f.; 13⅝ cents and 64*l.* being subsequently paid. With the fall in Standard, present values were 13⅝ cents and 63*l.* 5s. per ton. The total increase in American and European stocks during June was 10,995 tons. Production was steadily increasing, while consumption in Europe was not likely to continue on the same scale as that of the past half-year, Supplies to Europe had increased this year as compared with last, 33,351 tons, or over 14½ per cent. European consumption had apparently increased 33,220 tons, or 18½ per cent. Exports showed a falling off of 8195 tons, 2700 tons of which was due to reduced shipments to the United States, and 1828 tons to diminished shipments of sulphate. European stocks had increased 5296 tons, against a decrease last year of 2366 tons. American stocks had increased this year 6550 tons, against a decrease of 23,436 tons, the production being 11,583 tons larger.

THE JUNIOR INSTITUTION OF ENGINEERS.—A party of members of the Junior Institution of Engineers paid a visit last Saturday afternoon, the 18th inst., to the Tunnel Cement Works, Purfleet. The party were shown round the chalk quarry, and the mills in which the chalk and clay are washed and ground to the thick slurry from which the cement clinker is made; they witnessed the burning of the clinker in two rotary kilns, each 210 ft. long. They also saw the mills for grinding coal-dust, and how the firing of this dust takes place in the kiln; the cement-mill in which the cement clinker is ground; the cement stores, where the cement is packed by means of patent dustless vacuum packers exilors; and the power-station, with water-tube boilers and turbo-generators. With regard to the power-house, the 1200-kw. turbo-alternator is of the A.E.G. impulse type, and a favourable steam consumption of 13.8 lb. per kilowatt hour on full load, with a cooling-water supply of five gallons per pound of steam, has been obtained. An interesting feature is the way in which the motors have been assembled in special motor-rooms, so that they are, in a large measure, protected from the dust inseparable from cement manufacture. It has by this means been found practicable to use open-type motors. A certain amount of dust is, of course, inevitable, and the motors have, therefore, been provided with special insulation and dust-proof bearings, with heavy cast inspection covers. The switch-gear is of a most substantial type throughout, all motors being provided with oil-immersed controller-type starters, with self-contained resistances. The smaller motors are fitted with air circuit-breakers in dust-proof cast-iron cases, and the larger machines with sheet-iron switch-pillars containing oil-switches.

200-TON CUTTING-OUT AND FORMING PRESS.

A NEW form of double-crank press recently brought out by Messrs. Taylor and Challen, Limited, of Derwent Works, Constitution Hill, Birmingham, is illustrated on the present and opposite pages. The press is intended for cutting out and forming fairly long sheet-metal articles, such as window frames, troughing, &c. It is built up of two side frames, connected at the bottom by a heavy casting forming the bed, and at the top by two joists, placed with their webs vertical. The slide carrying the press tools works between adjustable guides on the side frames, and derives a reciprocating motion from a crank-shaft above it. These details are well shown in the various figures. The lower ends of the two connecting-rods, which drive the slide, are pivoted to the upper ends of adjusting-studs, which are carried through the upper part of the slide and through worm-wheels which have a threaded central hole. The worm-wheels are driven by two worms which are fixed on a common shaft, and are in turn driven by a further worm-gear from a hand-wheel. The hand-wheel and shaft, with the two main worms, can be clearly seen at the front of the slide in Fig. 1, while the details of the whole arrangement are shown in Figs. 3, 4, and 7. Rotation of the hand-wheel operates the two main worm-wheels, and so raises or lowers the slide on the adjusting-studs, which are prevented from turning during this operation, as they are provided with guides at their upper ends, as is shown in Fig. 3. The arrangement gives a total adjustment of 4 in. in the position of the slide.

The slide is balanced by a box of counter-weights placed on top of the machine. This box is provided with two guides, which can be seen projecting above it in Fig. 1, in which it is shown in its lower position. The guides are also shown in Figs. 2 to 6. The counter-weight box is lifted by four vertical rods, two at each side, as is best shown in Figs. 1 and 4. They work in guides, and are connected at their lower ends to a flat horizontal bar. As will be seen from Figs. 3 and 4, the slide is connected to this bar by two wire ropes, which pass over pulleys carried on the upper part of the framing. It will be clear from the figures that as the slide falls the counterweight rises, and *vice versâ*. This balancing arrangement takes all back-lash out of the slide, so that it does not drop when cutting through a plate. This considerably prolongs the life of the cutting edges of the tools. The balancing is also of advantage in connection with the adjustment of the slide, as it allows it to be moved either up or down with equal ease.

The crank-shaft is driven by a cut spur gearing, of which the spur wheel can be seen at the left-hand side of Fig. 1. The pinion is fixed on the driving-shaft, which runs along the back of the machine, and carries the driving-pulley at the other end. A fly-wheel is fixed to the pinion-shaft at the right-hand side of the machine. It is provided with holes in the rim for barring when setting up. The whole of the driving-gear is well shown in Figs. 2 to 7. The driving-shaft runs at 160 revolutions per minute, the gearing ratio is 6 to 1, and the press makes about 26 strokes a minute. As will be seen from several of the figures, the machine is provided with fast-and-loose pulleys and a belt-shifting hand-lever. This gear is only used when the machine is first started, or when it has to be stopped for some time.

For the intermittent starting and stopping, which is necessary for the removal of a formed piece of work and the insertion of a new blank when the press is working, a gear altogether independent from the belt-shifting gear is provided. This is controlled by two hand-levers, both of which have to be operated, so that there is no possibility of the workman starting the press when one of his hands is in such a position that it may be crushed by the down-coming slide. The starting-gear operates a clutch situated in the boss of the large spur-wheel. This clutch consists, in essence, of a spring-controlled key sliding in a slot formed in the shaft which carries the spur-wheel. The position of the key is controlled by a sliding cam-plate, which embraces the shaft, and, in turn, the position of the cam-plate is controlled by one of the hand-levers through the intermediation of a push-and-pull rod. The cam-plate and push-and-pull rod can be seen at *a* and *b*, in Figs. 4 and 6. When the press is stopped for the insertion of a new blank, the crank-shaft will be standing with its cranks on the top centre, but the driving-shaft and spur-wheel will be running. The spring-controlled key will under these circumstances lie entirely inside the slot in the shaft. The moving of the cam-plate by the hand-levers, however, frees the key, so that it flies outward, under the action of a spring behind it, and engages with a notch in a hard-steel bush in the spur-wheel. As a result, the spur-wheel drives the crank-shaft and the press starts. When it has made a single stroke, the key will again slide out of gear, and the press will come to rest with its cranks on the top centre ready for the next stroke. Normally the press is stopped by the workman releasing the hand-levers after the blow has been given; but even if he holds the levers over, the press is still stopped by a knock-out gear, which is described below.

The double hand-lever mechanism is best shown in Figs. 4 and 5. The starting-lever proper is that which is operated by the workman's right hand, and which can be seen standing out from the right-hand end of the press at *c* in Fig. 4. This lever operates the push-and-pull rod, which works the clutch, through a bell-crank lever, shown at *d*, in Fig. 4. The lever is attached to the bell-crank lever by a link *e*. The vertical arm of the bell-crank lever engages an arm which projects from a boss *f* secured to the push-and-pull rod, as is best shown in Fig. 4. The operation of the arrangement will be clear. When the hand-lever is pressed down, it rotates the bell-crank lever, and—subject to the control of the second hand-lever described below—pulls the push-and-pull rod *d* longitudinally, so operating the clutch and starting the press. When a single stroke has been made, the hand-lever is released and falls back to its first position under the action of the weight shown in Figs. 4 and 5. At the same time the cam-plate of the clutch slides back, so that the clutch-key comes out of gear and the press stops with its cranks on the top centre, as before explained.

The second hand-lever, which has to be operated by the workman's left hand to start the press, is shown at *g*, in Figs. 4 and 5. As will be seen, it is pivoted to the frame near its top end, and at that end is formed into a ring which engages with the end of a horizontal rod *h*. The rod, which is arranged so that it can slide horizontally, carries the bell-crank lever *d* at its other end. The position of the rod is controlled by a spring, and matters are so arranged that when it is in its natural position the bell-crank lever lies in a different plane from the projecting arm on the boss *f*. As a consequence, if under these circumstances the hand-lever *c* is depressed, the upper arm of the bell-crank lever misses the projecting arm on the boss *f*, and the starting-clutch is not operated. To start the press it is necessary that the workman should first bring the bell-crank lever *d* into the correct position by operating the lever *g*. Still holding this lever with his left hand, he has then to operate the hand-lever *c* with his right hand. As a consequence, both his hands are occupied, and it is impossible for one of them to be left in a dangerous position on the table of the press.

There is yet another feature in this starting-gear to which attention should be directed. As has already been referred to, the movement of the press is confined to a series of individual strokes, the action being necessary for the cutting out and forming for which it is intended. Normally, as before explained, the workman releases the hand-levers after the moving slide has made a blow. If, however, he fails to do this, the press is still stopped by the action of a striking-peg which is carried by the brake-disc *k*. This brake-disc is mounted on, and rotates with, the crank-shaft. When the press has made a stroke and the slide is just completing its upward movement, the striking-peg occupies such a position that if the starting levers are still being held in the starting position, the peg strikes a second projecting arm on the boss *f*. This boss is free to rotate, and, as a consequence, as the striking-peg comes in contact with it the boss is moved round, and the first projecting arm comes out of engagement with the bell-crank lever *d*. As a result the push-and-pull rod *b* is released, the clutch *a* comes out of gear, and the press stops. It cannot be started again until the workman has brought the two hand-levers back to the "off" position and re-engaged the bell-crank lever with the first arm of the boss *f*. The brake-disc *k*, in addition to carrying the striking-peg, acts as a continuous brake and prevents the press running away. It ensures that it shall always instantly stop with the cranks on the top centre when the clutch *a* comes out of gear.

The driving-pulley of the press is 38 in. in diameter and has a 6-in. face. The mean power required is about 10 horse-power; but for individual motor drive a 20-horse-power motor is recommended.

CUTTING-OUT AND FORMING PRESS.

CONSTRUCTED BY MESSRS. TAYLOR AND CHALLEN, LIMITED, BIRMINGHAM.

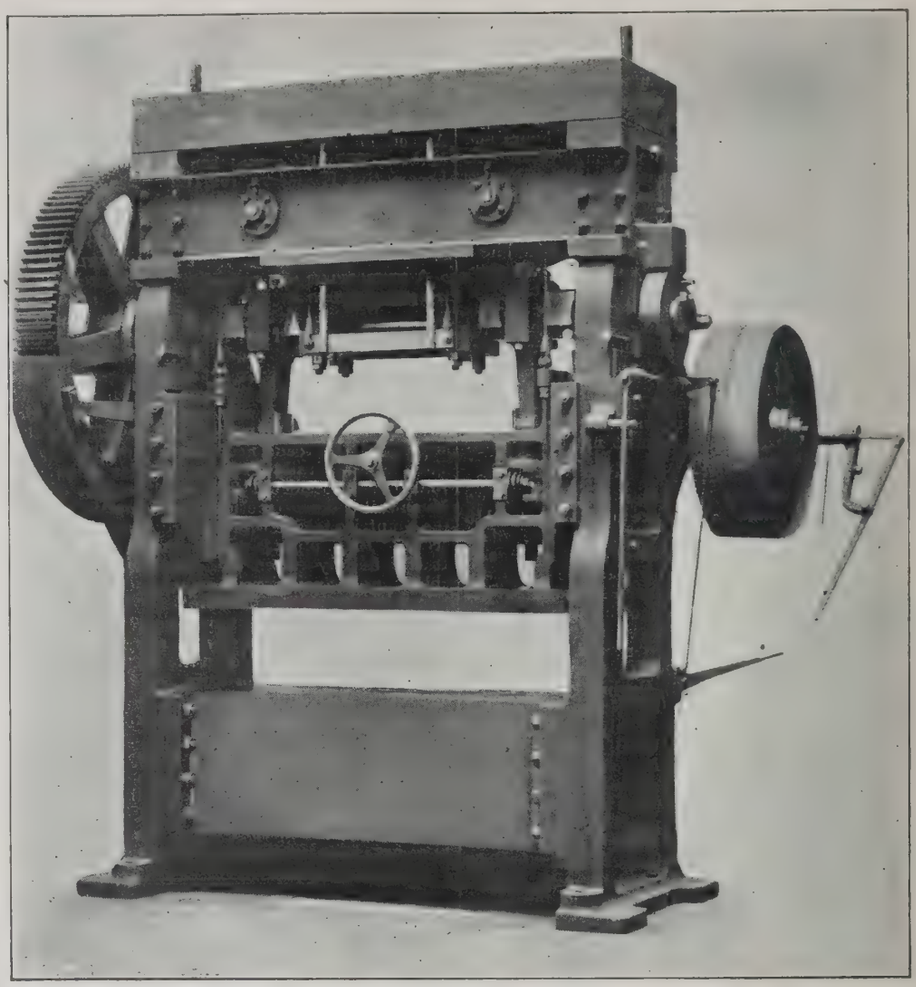


FIG. 1. GENERAL VIEW OF PRESS.

200-TON CUTTING-OUT AND FORMING PRESS.

CONSTRUCTED BY MESSRS. TAYLOR AND CHALLEN, LIMITED, ENGINEERS, BIRMINGHAM.

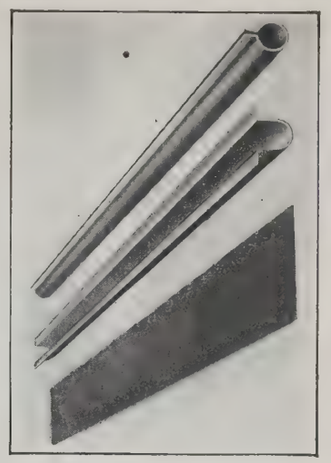


FIG. 9. EXAMPLE OF WORK DONE BY PRESS.

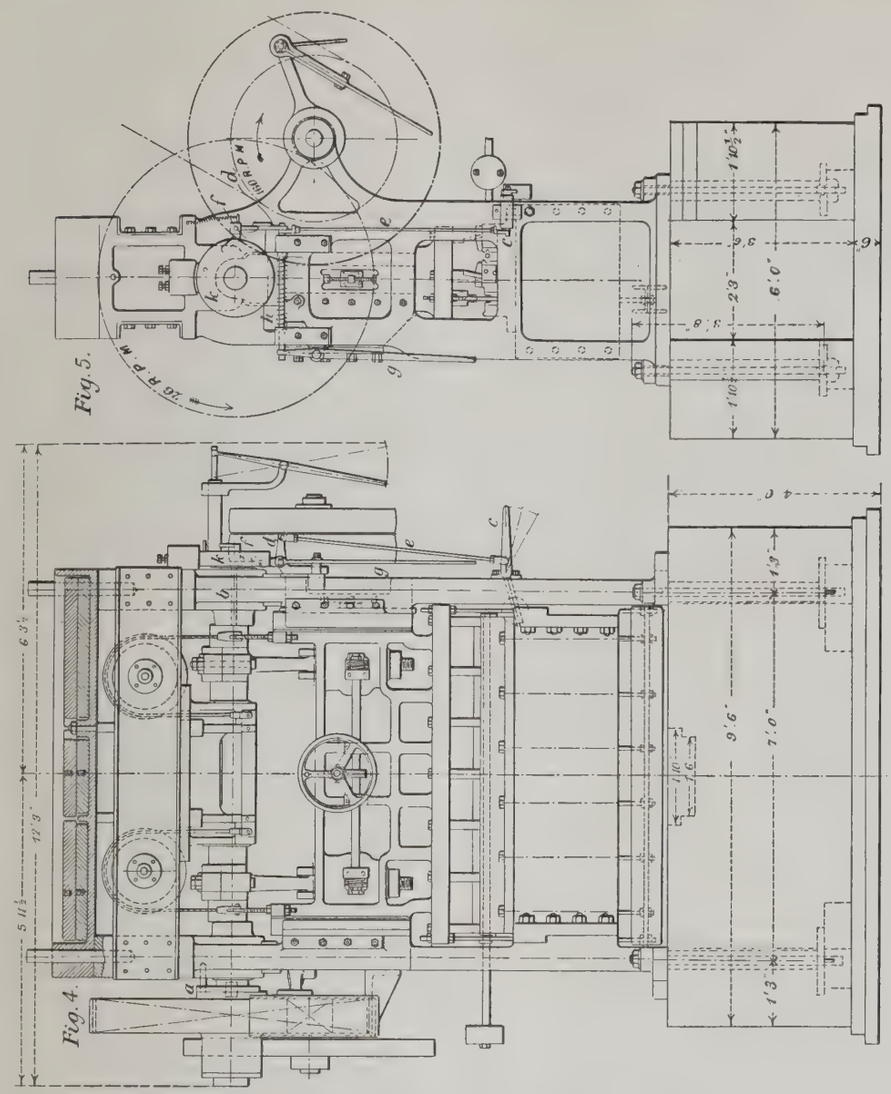


Fig. 5.

Fig. 4.

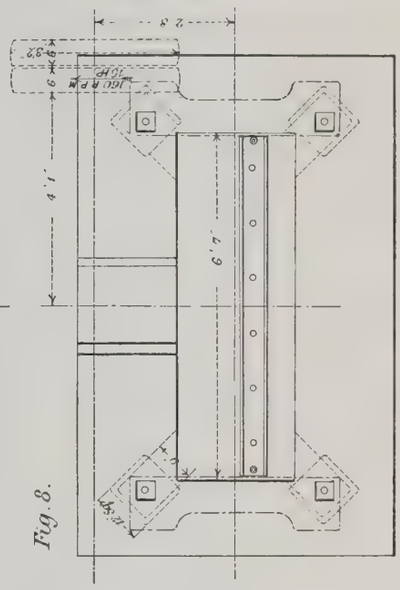


Fig. 8.

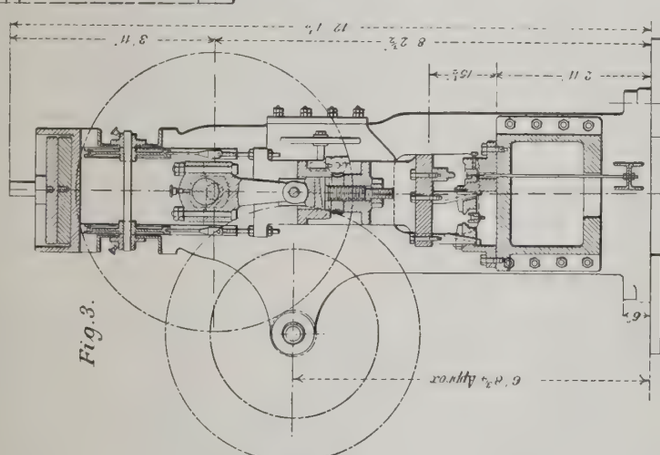


Fig. 3.

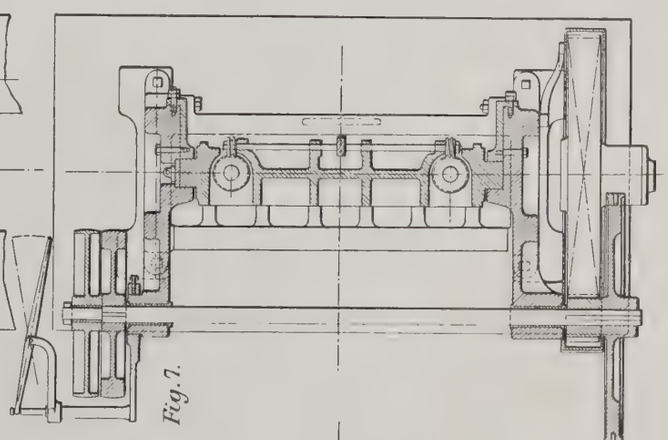


Fig. 7.

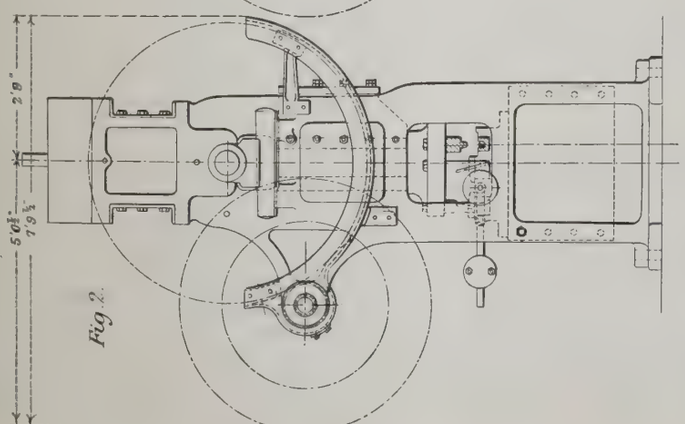


Fig. 2.

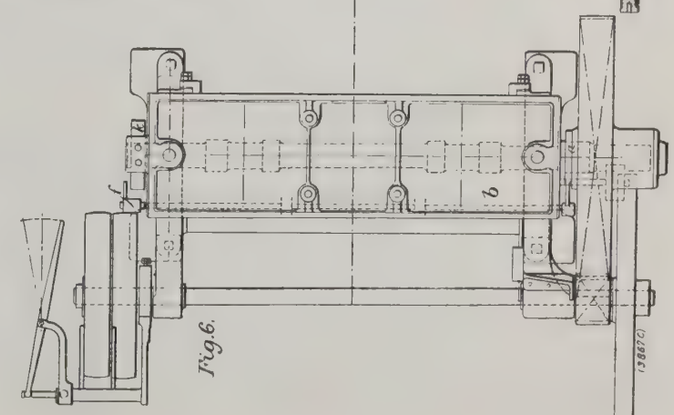


Fig. 6.

The stroke of the slide is 4 in., and the maximum vertical height between the bed and slide 15½ in. The bed is 6 ft. 6 in. wide between the side frames, and there are openings 18 in. wide in the frames to allow of work being passed endwise through the machine. The press is capable of exerting a pressure of 200 tons, and has a total weight of 18½ tons. It has a total height of 12 ft. 2 in., and occupies a floor space of 12 ft. 3 in. by 7 ft. 10 in.

The patent flanged tubes, shown in three stages of formation in Fig. 9, illustrates the class of work the machine is well fitted for. The piece of tube formed is 6 ft. long, so that it can easily be dealt with on the bed. It is formed in two operations, the two sets of tools being set up side by side in the machine. The strip is fed in from the front, and is formed in the first dies to the ∪ shape shown in Fig. 9. It is then passed on to the second set of dies, and the 1½-in. tube is completed. It is then removed endwise through the hole in the side frame of the machine. The material of the tube is 16 S.W.G. The dies that are used in forming it are shown in position on the machine in Figs. 2 to 5. The dies for the first process, in which the ∪ shape is formed, are well shown to the right in Fig. 3. The form and purpose of the male and female dies themselves will be obvious from the figure, and require no comment. Attention may, however, be directed to the ejector arrangement, by which the formed ∪ shape is expelled from the lower die. This consists of a series of six ejector-studs, which are operated by six vertical rods attached to a girder carried below the table. The girder is attached to the machine-slide by two long studs, and moves up and down with it. The arrangement is clearly shown in Figs. 3 and 4. The finishing dies are shown to the left in Fig. 3 and in some of the other figures. The tube is closed round a rod which lies over the lower die and below the upper die. The rod is not shown in Fig. 3, but is indicated in Fig. 5. It is secured at the left-hand end of the machine to a balanced lever, as shown in Fig. 2, and is also balanced longitudinally by a weight fixed to the projecting end, as shown in Fig. 4. These arrangements allow the rod to be swung upwards out of the way when the partially-formed blank is being moved from the first set of dies to the second. When the tube is completed it is removed endwise through the frame of the press, as before explained.

FERRO-CONCRETE ARCHED BRIDGE OVER THE GUMTI RIVER AT LUCKNOW, INDIA.

AN interesting example of the use of ferro-concrete in bridge construction is afforded by the new bridge over the River Gumti at Lucknow, which was recently opened by His Excellency the Viceroy, This structure, illustrated on page 124, replaces the Newabi Bridge at the Machli Bawan, which was built in 1780 by Asafud-dowlah, Nawab Wazir of Oudh.

The old bridge was constructed of nickunk in lime, and consisted of twelve small spans, with a centre span of 50 ft. Some ten years ago the piers showed signs of settlement, and the arch of the centre span cracked badly; as all attempts to deal with the settlement of the piers were ineffectual, it was decided to demolish it, and it was removed in 1907. The old bridge crossed the river at a considerable angle, and as it was considered useless to attempt to deal with and use any of the original piers, a site for the new bridge was selected some 100 yards up-stream, where the diverted roadway crosses the river at right angles, and provides a direct approach to the newly-completed King George's Medical College and Hospital.

The preliminary design for the new structure was prepared by Major Crookshank, R.E., and included five spans of 75 ft., the piers being 84 ft. from centre to centre. The preliminary estimate for this bridge in brickwork in lime amounted to 155,300 rupees (10,353*l.*). The detailed estimate was prepared in the chief engineer's office, and owing to slight alterations in the design was slightly increased to 158,000 rupees (10,533*l.*), and work on the foundations was commenced in 1910

Each pier is founded on three circular cylinders, which are carried down to the hard kunkar-clay layer at a depth of about 33 ft. below the river bed. The foundations for the abutments consist of three pairs of octagonal cylinders, also carried down to the kunkar-clay level.

The pier foundations are 14 ft. in width, and the piers and abutments are carried up to 15 ft. above the foundations. The level of the springing of the arches is at ordinary flood level, which is, however, 10 ft. below the level recorded during the extraordinary flood of 1904—the highest ever recorded at Lucknow.

At the breaking of the monsoon in 1912 the foundations had been completed and all the piers and abutments brought up to springing level. It was then decided to redesign the superstructure and to replace the heavy brick arches by reinforced-concrete ribs. The alteration in design was entrusted to Mr. A. C. Verrieres, C.I.E., and a revised estimate for 280,850 rupees (18,723*l.*) was sanctioned by the Government. The original elevation was adhered to, but the weight on the piers was considerably reduced by the substitution of seven concrete ribs in each span in place of the solid masonry arches.

The construction of the ribs will be understood from a reference to the engravings on page 124. Each rib is 2 ft. thick and 2 ft. 6 in. deep at the crown, and 6 ft. 6 in. on the springing face. Each rib is reinforced with eight 1¼-in. square steel bars, four at the upper and four at the lower edge, connected by stirrup-bars of ½-in. round steel. The proportions of the concrete were 1 part of Portland cement to 2 parts of red sand from the Jumna Valley, and 4 parts of crushed stone.

The centering for the two spans on the north side was formed of solid sand, as the river-bed was dry on that side during the period of construction. The sand being formed to the rise of the arch, a single layer of brick in mud was laid on the sand to the actual radius of the under side of the ribs. The channel of the river had formed under the second arch from the south end of the bridge, and for the centering of this span rows of salwood piles were driven, and a superstructure erected on these, formed of braced and framed struts, with a floor of sleepers to receive the ribs. The centering for the remaining two spans on each side of the channel was formed by filling the space between the piers with earth and sand up to springing level. Upon these earth-beds pillars were constructed in rough brick and mud to carry the wooden shuttering of the ribs.

The construction of the ribs proceeded simultaneously in all the spans during the hot weather of 1913, and the last rib was completed on July 28.

The main ribs are tied together by vertical cross-girders of ferro concrete, 9 in. thick, and varying in depth from 2 ft. 6 in. to 5 ft. These are reinforced by ½-in. steel rods. There are eight cross-girders in each span, and they are placed immediately beneath the spandrels.

The whole of the superstructure above the arches is of brickwork in lime, with red sandstone facings. The decking for the roadway is carried on jack-arches springing from steel joists resting on the spandrel pillars. The roadway is 22 ft. in width, with a 6-ft. footpath on each side.

It will be seen from the perspective view (Fig. 1) that a considerable amount of ornamental work has been added to the superstructure. This has been done in order that the design of the bridge may harmonise with the adjacent buildings of the Medical College and Hospital.

Mirzapur stone has been used to a considerable extent in the construction of the kiosks, minarets, and balustrading of the bridge, while ornamental iron brackets on each kiosk have been fitted with 100-candle-power electric lamps, supplied with current from the power-house at the Medical College.

The total cost of the bridge was 282,548 rupees (18,836*l.*), which only slightly exceeds the revised estimate for the work. In comparing the cost of the bridge having ferro-concrete ribs with the first estimate, which contemplated the adoption of brick arches, it must be borne in mind that in the Gangetic Plain the cost of brickwork is exceptionally low, owing to the cheapness of labour and the general availability of brick earth and native kunkar lime (ordinary straight brickwork costs usually 7 to 8 rupees (10s.) per cubic yard); while the cost of ferro-concrete is correspondingly high, owing to the scarcity of timber for centering and the high cost of Portland cement of good quality, which averages 5*l.* 5s. per ton imported and delivered at a distance from the coast.

The steel rods used in the construction of the Lucknow bridge were manufactured in India by the Tata Iron and Steel Company.

The whole of the work of design and construction of the bridge was carried out by the Indian Public Works Department, the officers employed on the reinforced-concrete superstructure being Mr. E. J. Powell, superintending engineer, and Captain J. A. Graeme, R.E., executive engineer, Medical College Division, under Mr. W. Gunnell Wood, chief engineer to the Government Roads and Rivers Branch.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—This Association has issued the programme of the visit of members to l'Association Française pour l'Avancement des Sciences. A congress is to be held at Havre from Monday, July 27, to Sunday, August 2, 1914. The programme includes addresses by M. Jules Siegfried, Député, Président du Comité Local; M. Armand Gautier, Membre de l'Institut, Président de l'Association Française; Sir William Ramsay, K.C.B., F.R.S., Membre Etranger de l'Institut et de l'Academie de Médecine, Past President and Representative of the British Association; M. Perrot, Professeur à l'Ecole de Pharmacie de Paris, Secrétaire; and M. Perquel, Trésorier de l'Association Française. Various conferences and visits to places of interest have been arranged. Full particulars can be obtained from Mr. O. J. R. Howarth, Assistant Secretary of the British Association, Burlington House, London, W.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was dead idle, and no transactions were recorded. Cleveland warrants were quoted by sellers at 51s. 6d. cash and 51s. 8d. one and three months. The afternoon session was also idle, and Cleveland warrants were easier, with sellers quoting 51s. 4½d. cash, 51s. 6½d. one month, and 51s. 7d. three months. On Friday morning the market was steady, but once again there was little doing, as buyers were absent. The holiday feeling prevailed, and no dealing took place, and closing sellers quoted Cleveland warrants at 51s. 4½d. cash, 51s. 6½d. one month, and 51s. 7½d. three months. The market was closed in the afternoon for the annual Fair holidays, and remained so until Tuesday morning. When business was resumed the market was nominally steady, but idleness again prevailed. Sellers of Cleveland warrants quoted 51s. 5d. cash, 51s. 7d. one month, and 51s. 7½d. three months. In the afternoon business was again at a standstill, and quotations for Cleveland warrants were the turn weaker, with sellers naming 51s. 4½d. cash, 51s. 6d. one month, and 51s. 7d. three months. The market opened to-day (Wednesday) with a fairly steady tone, and one lot of Cleveland warrants changed hands at 51s. 4½d. cash, and closing sellers quoted 51s. 5d. cash, 51s. 6½d. one month, and 51s. 7d. three months. The afternoon session was a blank as regards business, but the tone remained steady, and sellers of Cleveland warrants quoted 51s. 5d. cash, 51s. 6½d. one month, and 51s. 7d. three months.

Sulphate of Ammonia.—No change of any kind has taken place in the sulphate of ammonia market during the past week, and prices are steady, the current quotations being 11*l.* per ton, Glasgow, and 11*l.* 2s. 6d. per ton, Leith, both for prompt lots.

Scotch Steel Trade.—The Scotch steel trade is quite idle at present, owing to the holidays, the weather for which has really been splendid, over the West of Scotland, at any rate. Not only does silence reign supreme in the works, but the selling departments are also very quiet, as little is being done in the way of booking new business. Inquiries are scarce, and contracts on offer are being largely snapped up by the agents for foreign manufacturers, at prices which local makers cannot look at. The holiday notices in some of the establishments intimate that work will be resumed on Monday next, but a restart then is rather doubtful owing to the unsettled state of the coal industry, and from the prevailing conditions it looks as if Monday week would be the more general date. The export trade is dull, and those lots which are being secured here are mainly for consumers who have a special preference for the Scotch article; even at the best the tonnage is not heavy. Prices are steady. The half-year has been a poor one, and the prospects for the second part of the year are far from bright.

Malleable-Iron Trade.—Since the various malleable-iron works closed for the holidays there has been very little inquiry, and also very little fixing up of new business. The foreign competition has told heavily on the local makers, and the past half-year's work will not show up too well.

Scotch Pig-Iron Trade.—Although there are actually no very visible signs of improvement in the Scotch pig-iron trade, some hold that the outlook is not so clouded as the majority make it appear. The threatened fight in the coal industry gives little cheer, and, despite that, prices have certainly an easier tendency when anything decent presents itself. The following are the market quotations for makers' (No. 1) iron:—Clyde, 66s.; Calder, Gartsherrie, Summerlee, and Langloan, 66s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 70s.; Shotts (at Leith), 66s. 6d.; and Carron (at Grangemouth), 67s.

TRADE.—The Wolseley Tool and Motor-Car Company, Limited, announce that the name of the company has been changed to Wolseley Motors, Limited.

THE "BULLETIN OF THE IMPERIAL INSTITUTE."—The current quarterly issue of the "Bulletin of the Imperial Institute" (No. 2 of 1914) contains, among the reports of recent investigations by the scientific and technical staff, the results of examination of samples of soils from Nyasaland, of penguin guano from the Falkland Islands, and of flax from the East Africa Protectorate, where, it is thought, there is every prospect of the cultivation of this fibre becoming established in Nyanza Province. Other reports relate to cocoa from Nigeria, copals from British West Africa, essential oils from various countries, and cohune nuts from British Honduras. A special article by Mr. W. Small, M.A., B.Sc., Botanist of the Department of Agriculture, Uganda, deals with coffee cultivation in Uganda. It appears that coffee is now the staple crop of European planters in Uganda. The area is being extended, and a large increase in the exports of coffee may be looked for in the next few years. An article on "The Utilisation of Fish and Marine Animals as Sources of Oil and Manure" (Part I., Oils), discusses the composition and uses of fish oils, their sources and preparation, and also describes the present position of the whaling industry. Fur farming in Canada and the tin resources of Malaya and India are dealt with. It is interesting to note that considerably more than half of the world's supply of tin is produced within the British Empire; the output in 1911, the latest year for which final figures are obtainable, was: British Empire, 60,497 tons; foreign countries, 54,051 tons.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The hard-steam market is showing a stronger tendency. Shipments are on a substantially larger scale, and a heavy tonnage is going into consumption in the armament works and in the general engineering trades. The only sign of weakness is in the demand from the lighter trades, where quietude reigns following a period of pressure. Collieries occupy a strong position, though forward business is not being arranged with the freedom that might be expected, seeing that small concessions are being offered on last year's contract rates. A moderate trade is passing in house coal. Though greatly restricted, the output is quite sufficient to meet a slow demand from the South Yorkshire district and from the South. Prices are still on the easy side. A fair tonnage of gas fuels has been despatched, chiefly on works contract account. Slacks are steadier. Weakness in the Lancashire demand is not so conspicuous. Coke sags. The extent of over-production is still great. Quotations:—Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. to 13s.; Derbyshire best brights, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 10s. 3d. to 11s. 3d.; small nuts, 9s. to 10s.; Yorkshire hards, 11s. to 12s.; Derbyshire hards, 10s. to 11s.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.; smalls, 2s. 6d. to 3s. 6d.

Iron and Steel.—A period of marked stagnation in the raw material market has been followed by brisk buying of spot lots and some little inquiry on contract account. A few contracts have been arranged, but they are at exceptionally low figures, and only cover a brief period of delivery. In view of the low state of stocks, makers are hopeful of a revival in prices at any moment, and with this in view they are not disposed to accept long-dated contracts at rates which are only barely remunerative. That consumers are not at all perturbed by what the immediate future will bring forth is shown by the way in which they are allowing substantial contracts which will involve many months work to go uncovered. Foundry iron is by far the brightest medium. Reaction in forge qualities has continued for so long that a slight improvement is hardly noticeable. A fair tonnage of hematite is being delivered at the big steel-making and engineering works. For special qualities the demand is good. Bar iron does not make much headway. The South Yorkshire Makers' Association has decided to retain the basis quotation of 7*l.* 5s. A big quantity of foreign material is going into local consumption for the manufacture of cheap finished goods, for which purpose makers declare that the price of locally-produced semi-finished material renders its use prohibitive. Though seriously affected by the heat, the steel output does not fall far short of the average for this time of the year. But for a diminution in export requirements there would be little difference from the position which obtained in the recent "boom" period. Not only with the United States, but with Japan, British India, and Canada are exports seriously down. Comparing the net returns for the quarter just ended with the gross figures for the corresponding period in 1913, the total decline in exports from Sheffield to the United States was 57,512*l.* The chief cause of this decline was the shrinkage in steel exports, which fell from 166,788*l.* to 126,225*l.*, a decrease of over 40,000*l.* Declines were also shown in shears and edge and other tools. The heavy engineering trades are well employed and have a hopeful outlook. Railway steel is being made for South America and for Australia. Several big contracts on home railway and tramway account are in hand, including points and crossings for Doncaster and a heavy tonnage of axle forgings for London. Firms engaged in the production of munitions of war are as busy as ever. It is stated that Messrs. Vickers, Limited, have secured an order for the supply to a foreign Power of 300 garrison artillery guns of 6-in. calibre. Activity in the lighter trades is not so pronounced. Makers of agricultural tools are experiencing a fair season. Business in alloys and steel billets is quiet.

CONTRACTS.—We are informed that the Sirius Autogenous Works Company, Stratford, London, E., have secured the order from the Schmidt's Superheating Company, Limited, for a complete oxy-acetylene welding plant for their new works at Trafford Park, Manchester. The plant is of the same capacity as that recently supplied by the Sirius Company to the British Westinghouse Electrical and Manufacturing Company, Limited, Manchester. These plants will be the two largest automatic acetylene generators in this country.—Messrs. Stothert and Pitt, Limited, Bath, have just received an order from the Hull Joint Dock Committee for twelve electric cranes, and also a further order for four cranes for a new wharf on the Medway. All these cranes are fitted with their new "Toplis" patent horizontal luffing gear.

BRITISH COAL EXPORTS.—The exports of coal from the United Kingdom in the first half of this year—the expression "coal" including coke and patent fuel—amounted to 36,146,907 tons, and when to this is added coal shipped for the use of steamers engaged in foreign trade, the aggregate for six months becomes 46,329,064 tons. Coal has accordingly been leaving our shores this year at the rate of 92,658,128 tons per annum. The corresponding movement in the corresponding period of 1913 was at the rate of 94,270,348 tons per annum, and in the corresponding period of 1912 at the rate of 70,445,222 tons per annum. The principal exports to June 30, this year, were:—Russia, 2,009,789 tons; Sweden, 1,800,093 tons; Norway, 1,247,501 tons; Denmark, 1,389,551 tons; Germany, 4,202,651 tons; France, 6,818,125 tons; Spain, 1,756,681 tons; Italy, 4,533,077 tons; Egypt, 1,636,842 tons; and the Argentine Republic, 1,825,940 tons.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The slight improvement manifested in the inquiry for pig-iron during the week has steadied quotations. Though the orders have not been for large quantities, they have served to lend hopefulness to the sellers' outlook, notwithstanding that the present output of iron is not being absorbed by current requirements. The quotations for Cleveland warrants are 51s. 3½d. cash buyers, and 51s. 4½d. to 51s. 5d. sellers. No. 3 g.m.b. realises 51s. 6d. per ton; No. 1 is 53s 6d.; foundry No. 4 is 51s. 3d.; and forge No. 4 is 50s. 9d. per ton. There is not a great deal doing in hematite, which is maintained at 59s. per ton. For Rubio ore, 50 per cent. quality, 17s. is the prevailing quotation. Blast-furnace coke is 17s. 6d., medium quality, delivered at Tees-side furnaces.

Iron Trade Statistics.—The quarterly returns of the Middlesbrough Chamber of Commerce, issued this week, show that at June 30 last there were within the port of Middlesbrough 50 blast-furnaces in operation, out of 77 built, as compared with 60 in blast and 77 built for the second quarter of a year ago. During the past three months the production of pig-iron in Middlesbrough was 595,000 tons, 355,000 tons of which was Cleveland iron, and 240,000 tons hematite, spiegel, basic, and other special irons. For the previous quarter the output was 630,000 tons, of which 330,000 tons was Cleveland, and 300,000 tons hematite, &c.; for the second quarter of a year ago the make was 715,000 tons, 415,000 tons being Cleveland, and 300,000 tons hematite, &c. The total output of pig-iron for the half-year amounted to 1,225,000 tons, of which 685,000 tons were Cleveland, and 540,000 tons hematite, &c. Shipments of pig-iron from the port of Middlesbrough during the first six months totalled 546,940 tons, against 527,826 tons in the same period last year. The imports of foreign ore into Middlesbrough during the quarter reached 490,768 tons, as compared with 519,045 tons during the previous quarter and 608,749 tons during the second quarter of 1913. The total for the half-year was 1,009,813 tons, as compared with a total of 1,195,983 tons for the first half of 1913. The total value of goods other than coal and coke exported to foreign and Colonial destinations from Middlesbrough during the quarter was 2,730,720*l.*, a decrease of 645,241*l.* on the previous quarter.

Stocks and Shipments.—The stock of Cleveland pig-iron in the public warrant stores now stands at 81,426 tons, all of which is No. 3 quality. Since the beginning of the month the stock has been increased by 3137 tons. Shipments of pig-iron from the Tees are on only a moderate scale. To date this month they average 2182 tons per working day, the total despatches being returned at 41,475 tons, 37,092 tons of which have gone from Middlesbrough, and 4383 tons from Skinningrove. To the same date last month the loadings were given at 49,988 tons, or a daily average of 2737 tons, and for the corresponding part of July, a year ago, the clearances reached 61,028 tons, or an average of 3212 tons per working day.

Manufactured Iron and Steel.—More encouraging accounts are given of the different branches of manufactured iron and steel trades. Specifications are coming in better. Inquiries for joists and constructional work are heavier, and prices for export are hardening. An order for 2000 tons of rails has been booked by the North-Eastern Steel Company for Southampton, at 6*l.* 18s. per ton, a German tender for 6*l.* 12s. being rejected. It is expected that orders for 58,000 tons of rails will be placed in this district shortly. Principal market quotations stand:—Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 5s.; iron ship-plates, 6*l.* 15s.; iron ship-angles, 7*l.*; iron ship-rivets, 7*l.* 5s.; iron girder plates, 7*l.* 5s.; steel bars (basic), 6*l.* 5s.; steel bars (Siemens), 6*l.* 5s.; steel ship-plates, 6*l.*; steel ship-angles, 5*l.* 15s.; steel boiler-plates, 7*l.*; steel joists, 6*l.* 12s. 6d.; steel strip, 6*l.* 5s.; steel hoops, 6*l.* 10s.—all less the customary 2½ per cent. discount; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.*; heavy steel rails, 5*l.* 15s. to 5*l.* 17s. 6d.; steel railway sleepers, 7*l.*—all net at works; galvanised corrugated sheets, No. 24 gauge, in bundles, 11*l.* f.o.b.—less 4 per cent.

MESSRS. HENRY HOLLINGDRAKE AND SON, LIMITED, STOCKPORT.—On Saturday, the 18th inst., this firm of ironfounders, brassfounders, engineers, and general mill furnishers celebrated its centenary. It came into existence just one hundred years ago, and has grown from a small foundry into a most modern concern, thoroughly well equipped for a number of different branches of manufacture.

AMERICAN RAILROADS.—The railroads of the United States, with annual traffic revenues exceeding 100,000 dols., comprised 242,657 miles of line last year, as compared with 238,220 miles in 1912. The traffic receipts in 1913 were 3,125,135,000 dols., as compared with 2,826,958,000 dols. in 1912. The working expenses in 1913 were 2,169,968,000 dols., as compared with 1,959,094,000 dols. in 1912. The number of passengers carried last year was 1,033,679,000, as compared with 994,372,000 in 1912. The quantity of freight carried was 2,058,035,000 tons, as compared with 1,818,795,000 tons. The number of locomotives owned was 63,375, as compared with 61,276; and the number of cars was 2,445,508, as compared with 2,368,942. The aggregate number of persons employed upon the lines last year was 1,815,239, as compared with 1,799,931. The average rate of dividend last year upon outstanding stocks was 4.28 per cent.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Admiralty steam coal has been firm and scarce. Good secondary qualities have shown a tendency to harden for forward loading, but they have shown no improvement for prompt shipments. House coal has exhibited scarcely any change, and the same may be said of coke, patent fuel, and iron ore. The best Admiralty large has made 20s. 6d. to 22s.; best secondary descriptions have brought 18s. 6d. to 19s. 6d.; other secondary qualities, 17s. 3d. to 17s. 9d.; best bunker smalls, 20s. 3d. to 20s. 6d.; and cargo smalls, 7s. 6d. to 8s. 3d. per ton. The best household coal has been quoted at 19s. to 20s.; good households have made 17s. to 18s.; No. 3 Rhondda large has brought 17s. 6d. to 17s. 9d.; and smalls have been quoted at 12s. to 12s. 6d. per ton. No. 2 Rhondda large has realised 12s. to 13s.; and No. 2 smalls, 8s. to 8s. 6d. per ton. Special foundry coke has made 25s. to 29s.; good foundry coke, 20s. to 23s.; and furnace coke, 17s. to 19s. per ton. As regards iron ore, Rubio has been quoted at 16s. to 16s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

More Welsh Coal.—Mr. A. W. Brown (at one time a working collier in the Forest of Dean) has struck a good workable seam in the Tranchard vein in the Crossways Iron Mine Gale. The seam is 2 ft. 2 in. in thickness.

Foreign Coal Contracts.—The Greek Government has placed orders for 35,000 tons of best Admiralty large, 30,000 tons through a London firm, and 5000 tons through a Cardiff house—deliveries to be made during the next two months. Tenders for 20,000 tons of bituminous smalls required for the Belgian State Railways have ranged between 11s. 3d. and 13s. 2d. per ton, according to the place of delivery. The tenders sent in amounted to 165,000 tons.

Gloucester Wagon Company.—The directors of the Gloucester Railway Carriage and Wagon Company, Limited, report that the profit on the past year's trading, after making provision for depreciation, was 80,133*l.* The disposable balance, after deducting an interim dividend paid in February, amounted to 69,995*l.* The directors propose to transfer 10,000*l.* to the reserve fund, which will then amount to 160,000*l.*, and they recommend a dividend for the past half-year at the rate of 10 per cent. per annum, making 10 per cent. for the year. A balance of 41,601*l.* is carried forward. The company now repairs and maintains 26,631 wagons.

THE MEUSE.—Works are contemplated for improving navigation on the Meuse. It is proposed to construct additional sluices, at an estimated cost of 160,000*l.* Four tenders for the works have been received; the lowest is that of Hottat and Sons, of Brussels (134,680*l.*).

HULL.—A scheme prepared by the Hull city engineer for a floating landing-stage at Corporation Pier, Hull, was submitted to Mr. A. C. Hurtzig, who has forwarded a report unfavourable to the project. A sub-committee had passed a resolution instructing the town clerk to forward Mr. Hurtzig's report to the general manager of the Great Central Railway, and to inquire whether he would be prepared, with the Great Central Company's engineer, to meet representatives of the Hull City Council in London at an early date to discuss a scheme for providing improved accommodation at the pier. The property committee of the Hull City Council has authorised the Hull city engineer to prepare a rough sketch showing how such improved accommodation could be provided.

GERMAN PIG-IRON PRODUCTION.—The production of pig in Germany and the Luxembourg in June amounted to 1,531,313 tons, as compared with 1,609,748 tons in June, 1913. The total of 1,531,313 tons was made up as follows:—Casting pig, 248,608 tons; Bessemer pig, 30,699 tons; Thomas pig, 1,021,623 tons; spiegel and steel pig, 192,753 tons; and puddling pig, 37,630 tons. The monthly production to June 30 this year compared as follows with the corresponding production in the corresponding period of 1913:—

Month.	1914. Tons	1913. Tons
January	1,566,505	1,611,345
February	1,445,511	1,493,877
March	1,602,896	1,629,463
April	1,534,429	1,588,701
May	1,607,211	1,643,069
June	1,531,313	1,609,748

The aggregate output to June 30, this year, was accordingly about 9,288,000 tons, as compared with 9,576,203 tons.

STEEL CAR PATENTS.—We are informed that a patent case of some importance has recently been decided in the United States, in the Court of Appeals of the District of Columbia. The patent in question was one filed in 1906 by Mr. W. R. McKeen, relating to the construction of steel box-cars. The first two box-cars built on the system involved were turned out from the Union Pacific shops in Omaha, 1906 and 1907. Since that date the patent has been contested before the Examiners-in-Chief, Commissioner of Patents, and the Court of Appeals, District of Columbia. The decisions settle the validity of the patent, which was therefore issued on June 19 last. The patent is for all-steel box-car construction. Such cars are rapidly coming into use in the United States, and are proving suitable to the requirements of modern traffic conditions. It may be pointed out, for instance, that while the wooden box-car is a constant source of annoyance in grain traffic, owing to leakage through parts damaged by severe service, the steel box-car will carry grain with practically no loss.

FERRO-CONCRETE ARCHED BRIDGE OVER THE GUMTI RIVER AT LUCKNOW.

MAJOR CROOKSHANK, R.E., AND MR. A. C. VERRIERES, C.I.E., ENGINEERS.

(*For Description, see Page* 122.)

FIG. 1.

Fig. 2.

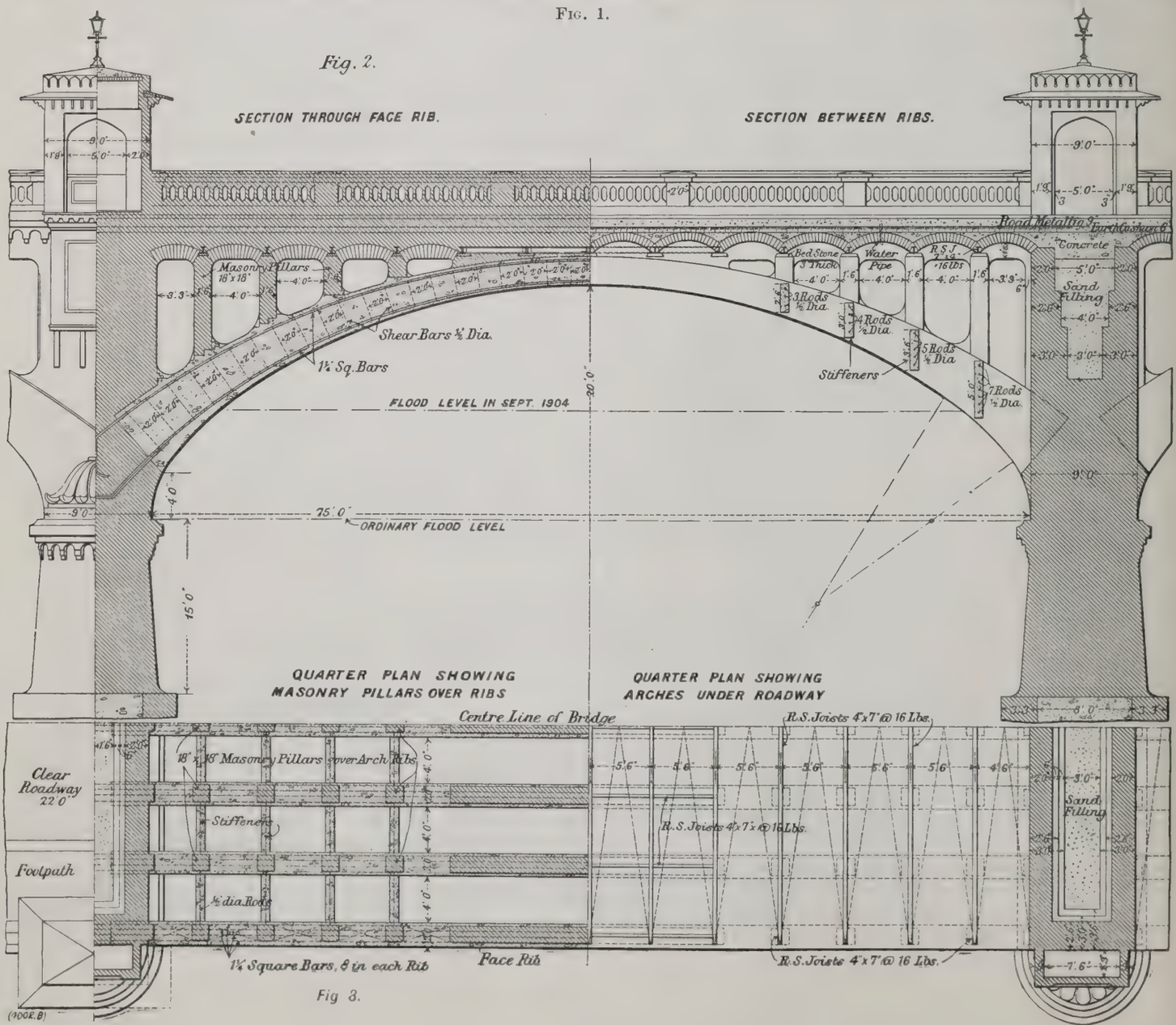


Fig 3.

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With a Two-Page Plate of the ALEXANDRA DOCK EXTENSION AT NEWPORT; DETAILS OF LOCK-GATES.

NOTICE.

Immediately following the Index to our last volume, which is published with the current issue, will be found a Classified Directory of Current Advertisements in ENGINEERING, together with a List of the Telegraphic Addresses of the Advertisers and Key. This Directory and List with Telephone Numbers and Telegraph Codes in use, together with Glossaries for the use of Foreign Buyers, is also published in compact book form for handy reference, and may be had gratuitously on application to the Publisher. This Directory is sent at regular intervals to the principal purchasers of machinery throughout the world.

ENGINEERING.

FRIDAY, JULY 24, 1914.

EFFECTS OF SHORTER WORKING HOURS.

IN no recent labour dispute has the influence of trade-union methods on national industry been so clearly illustrated as in that which threatens a complete stoppage of work by all miners in Scotland, if not throughout the United Kingdom. There is practically no justification for the attitude of the Scottish miners, whether consideration is given to its effect upon the men themselves, upon trade unions generally, or upon national interests. Miners' wages have, in many cases, for a long time been determined on a sliding scale with reference to the prevailing prices of coal, and the present wage in Scotland, which is 7s. per day, is 75 per cent. above the rates of pay in 1888. Decreased activity in practically every industry has involved, or threatens to involve, a lessened demand for coal, with the result that prices are diminishing, and there is great probability that the rates of pay will decrease. The miners of Scotland therefore took the extreme step of arranging that instead of working for 5 or 5½ days a week, as at present, they—or at least a large proportion of them—would adopt a four-day week, with the avowed object of so restricting the production of coal as to bring about an increase in the average selling price. In fulfilment of this policy it was proposed that Monday next should be an idle day; but the owners decided that if the men abstained from work on Monday, all the miners in Scotland would be locked out. The men asked the Miners' Federation of Great Britain, in such event, to declare a national strike, and this request was considered at a special conference at Southport last Tuesday and Wednesday. The Federation, however—although their president also occupies a similar position in the Scottish Federation—did not seem disposed either to agree to a general strike or formally to support the miners of Scotland in their demands. On the other hand, the Scottish Federation have decided, obviously as a result of this week's meeting in Southport, to abandon the four days per week programme. Should wages be reduced by the Conciliation Board under 7s. per day, the Scottish miners are authorised to strike immediately, and a ballot is to be taken of the whole country on the question of a national stoppage in support of the men in the North. It seems improbable that such a stoppage will be agreed to, and, in any case, the Scottish miners have no definite guarantee of immediate assistance.

This brief statement of the case might pass without further comment, because it carries with it condemnation of the policy of the workers of the North. It is, however, so characteristic an example of the general trend of trade-union reasoning that some further reference may be made to it, in the hope that light may be thrown upon the untenable attitude now assumed much too frequently. We have said that the policy is ruinous for the workers concerned. The chairman of the Scottish Federation contends that if the wage falls below 7s. per day it would be "nearly impossible for miners to live decently." The best commentary on this is that the average time worked per week at present is five days, giving 35s. per week, whereas the full time would be six days, rendering possible a weekly wage of 42s. At the present time the men must be living decently on a wage considerably less than 7s. per day, otherwise they would work the full week. Moreover, the proposed restriction of the days of labour to four per week would have brought the average remuneration down to 28s. This, too, would have given the workers three days per week of leisure, and idleness in such circumstances involves more expenditure to "kill time."

We have at all opportune times contended for liberal remuneration for labour, but this in itself, in the national interest, requires high industrial efficiency. Leaving aside for the moment the question whether short time or the artificial restriction of output in any country can be efficacious in maintaining a higher average price for a product such as coal, it must be recognised that the amount of wage which can be paid to workers is in a large measure dependent upon the efficiency of the plant. The cost of production, and therefore the profitable selling price of a commodity, is dependent upon three factors. The first, in point of importance, is the efficiency of the mechanism placed in the hands of the worker; the second is the continuity with which the workers use this plant, and, consequently, the volume of the product per unit of time and of labour cost; and the third is the success of the management, not only in the working of the mine, but in the disposal of the products in keenly-contested markets. If 10,000*l.* be paid over by the workers, the capitalist, the community, or even by Syndicalists, for the installation of mechanical appliances to assist manual labour in the process of production, a return on this money must be found, and the greater the volume of output per unit of time the easier will it be to afford a high wage for the worker, in addition to an adequate return upon the money invested. If, on the other hand, 10,000*l.* worth of machinery is utilised for four days per week instead of six days per week, with a consequent diminution of the tonnage, say of coal produced from a mine, 33 per cent. greater charge must be made against each ton of coal to provide on-cost charges and the same return on the 10,000*l.*, in addition to the satisfactory wage. Herein lies the crux of the question of economy in production. Shortening of hours must increase the cost of production, and consequently cannot conceivably, in a competitive market, gain for the workers a higher rate of wage. This argument applies to all workers in every factory. Instead of the wages varying with the selling price, according to the present application of the sliding scale, we should prefer to see them vary with the amount of time worked by each operative. The man who works six days per week is, other things being equal, more efficient than he who works only four or five days per week, because he enables a higher output to be obtained from the mechanical appliances at his disposal and enables the incidental permanent charges to be spread over a wider field. If the arrangement were not too complicated, we should like to see the sixth day of a man's weekly work paid at a higher rate than the fifth day.

Memory is short, and the workers of one generation never accept the experience of their predecessors. It is an axiom that experience which is not directly expensive is seldom fully appreciated. In 1894 the Scottish miners struck work and appealed to their co-workers in England for assistance in the belief that if their object were attained those of the south would profit. The southerners profited because they continued at work producing coal which found its way to Scotland. At the same time they refused to make a formal strike allowance. The voluntary contributions worked out at a trifle over 1s. per man per week to those concerned in the Scottish strike Mr. R. Chisholm Robertson, a past-president of the Scottish Miners' Federation, brings back to memory at the present juncture this salient lesson; he points out that the movement in Scotland now has been forced a long way along the road of disaster without any definite arrangement with the Miners' Federation of Great Britain to ensure co-operation or a definite scheme of help. Indeed, he goes further, and predicts that history will repeat itself. He says that, "as in 1894, the miners of England and Wales will continue to work, take full advantage of the markets of the Scottish coal suppliers, give voluntary doles—not full lock-out allowances—the Scottish general public will be put to inconvenience and loss, and in suffering and disaster the Scottish miners will be given another cruel lesson of the value of disregarding the teaching of dire experience." Similar language might be used in practically every strike. Mr. Chisholm Robertson himself enforces the point. "If the Scottish miners had a monopoly of the home and foreign markets, they could, by restriction of output, raise prices to a high level—to a level determined by the necessity of general producers and consumers. To the extent that they have not a monopoly of supplying coal, the restriction must be abortive and, both imme-

diately and in the future, be hurtful to their interests." As it is, ships are deserting the Clyde ports in anticipation of the lock-out or strike, and are taking their supplies from the English and Welsh, and even the German, ports, for foreign markets. At the present time no country, not even Britain, can be said to have a monopoly in any branch of manufacture or production, and thus, when work is stopped, those seeking supplies necessarily look to other countries, whose workers profit by the cessation of production, partial or otherwise, in this country. Commercial relationship thus established under emergency conditions has the habit of becoming permanent, and consequently each strike closes many doors for the reception of the work of the producers on strike.

Not only the men, but unions thus suffer seriously. In the report of the Chief Registrar of Trade Unions for 1912, which has been issued this week, it is shown that the miners' strike of that year cost the miners' union over one million sterling, while other unions, in paying unemployment benefit, lost very heavily. The unions in the transportation group, for instance, paid out 125,000*l.*, or more than ten times as much as in the previous year; two of the railwaymen's unions, 100,000*l.*; and the engineering unions, 40,000*l.*, due entirely to this one strike. And yet it is doubtful if any advantage accrued even to the miners' union.

Even greater and more widespread effects always result to the nation from shorter hours. An effective example is that of the colliers, because coal is one of those products which is universally utilised, and any change in the price affects every citizen. The ostensible object of the Scottish coal-miners' action was to increase the selling price. If they had achieved their purpose, the loss would have fallen upon every citizen, either in his work or in his home. The loss, too, would have been immensely greater in its aggregate effect than any gain which the miner might have secured; because not only would the coal-winner have been paid an inflated wage, since he would have worked shorter time, but additional loss would have been involved owing to the mechanical appliances at the mine being idle over a considerably longer period per week. The user has to pay, as the maintenance of the selling price in Scotland at an artificial level would have minimised the influence of competition; coal imported from England or Germany would only have been sold at about, or slightly less than, the price demanded by the home producer. Again, as the increased charge for coal at every factory would have involved higher cost for steam power, the effect would have been to enhance the cost of production of all manufactures. In turn, this would have consequently added a handicap to Scotch producers in the competitive markets of the world, and would have resulted in less demand for labour in other industries. These are truisms well understood by all who take time for reflection, but the trade unionist of to-day is too prone to neglect the national interests, and therefore every opportunity should be utilised for enforcing these economic truisms.

FUEL-BRIQUETTING INVESTIGATIONS.

THE manufacture of fuel-briquettes is now well established as a commercial process on the Continent of Europe, and, so far as the demand permits, in Great Britain. But in the United States, in spite of the vast fields of lignite, or brown coal, which are available, the industry cannot be said to have attained a proper foothold. Up to 1912, in fact, there were only twenty-four American plants in operation. For this reason the Government arranged an exhaustive series of experiments on the briquetting of Americal fuels, and a mass of useful information has been collected. The results, which are given in great detail, are published in Bulletin No. 58 of the U.S.A. Bureau of Mines, and cover a period of eight years' work, from July, 1904, till July, 1912.

Briquettes are made by compressing the finely-ground material into solid blocks, under a sufficiently high pressure. The blocks, if made from lignite suitably treated, are then cohesive, withstand handling, and keep their shape in the fire. But with anthracite, bituminous, and sub-bituminous coals, and even with certain lignites, cohesive blocks cannot be made without the use of a suitable binding material to keep the particles together. More binding material is required with anthracite than with bituminous coals, but peat, like lignite, can be briquetted by pressure alone. The binder which has been most commonly in use up to now is pitch; but, unfortunately, briquettes made with this material are very smoky in burning. Hence many of the United States experiments have been devoted to discovering suitable substitutes. In this respect the chief difficulty which has been encountered is that smokeless binders are generally not waterproof, and can be made so only at a more or less prohibitive cost. As shown by the experiments, however, the difficulty is not an insurmountable one.

The use of briquettes, so far as anthracite and bituminous coals are concerned, lies in the utilisation of the fine or small coal. Although some fine coals coke when burning, most of them remain in their natural state, with the result that the dust clogs the draught, or falls through the bars with the ashes. Well-made briquettes, on the other hand, retain their form in the fire, and allow of a good air circulation being established. It follows that, where the difference in price between lump and fine coal is sufficient, they can be manufactured and sold at a profit. Other advantages which briquettes possess over ordinary coal are that they burn to a fine ash without clinker; the stoker's work is easier; the evaporative power, owing to the higher calorific value of the binder and the loss of moisture, is increased; more resistance is offered to the weather; and the risk of spontaneous combustion is eliminated.

In the case of lignite, which requires no binder, and in its natural state contains a high percentage of moisture, the advantage of briquetting requires no demonstration. A series of tests reported in the United States bulletin shows that, where the moisture content of the samples varied from 33 per cent. to 42 per cent., from 24 per cent. to 32 per cent. was removed in briquetting, and the heating value of the fuel was increased by from 36.5 per cent. to 52.4 per cent.

These experiments are of the highest importance to Americans, but, in view of the smallness of our lignite supplies, do not possess the same interest for us. The principal European lignite fields are located in Germany and Austria-Hungary. In this country, where chiefly bituminous and anthracite coals are produced, it is with the working up of the "smalls" of these coals that we are concerned. Our output is smaller in proportion than that of other European countries, for the reason that briquettes have not been adopted to any great extent in our locomotives and steamships.

The plant required for making briquettes from anthracite or sub-bituminous coals includes a coal-elevator, pitch-cracker, pitch-elevator, measurer, mixer, disintegrator, compo-elevator, vertical heater, briquetting-machine, and briquette-conveyor. The coal is fed into the elevator direct from the wagons, and the pitch, after going through the cracker, falls into the boot of the pitch-elevator. Both are then discharged into the mixer and measurer, which consists of two screw-conveyors—a large one for the coal, and a smaller one for the pitch. The pitch falls from the smaller conveyor on to the coal in the larger conveyor below, and so becomes mixed with it. The compo is then elevated and discharged into the vertical heater, which forms commonly a part of the briquetting-machine itself. In the heater the mixture is heated up, either by a steam-jacket or by the injection of live steam, preferably superheated, and is at the same time more intimately mixed by revolving beaters. The semi-plastic material is finally fed into the moulds of the briquetting-machine, which are arranged on either a vertical or horizontal table, and a system of levers press it from both sides into rectangular blocks, under a pressure of about 2 tons per square inch. Facilities are provided for filling and discharging the moulds, for giving a rotatory feed to the table, and for varying the pressure. For the smaller eggette or ovoid briquettes, which are now in many cases replacing those of rectangular shape, a different type of machine is used, and the moulds are formed in the peripheries of rollers, which press on tangential feed-slides. In the case of lignite and peat briquetting, the material is forced through a tapered tube in a continuous stream, and is cut off by a wire cutter into cylindrical briquettes of the required length. Portable plants for railway use have also been designed, and a typical example was described in ENGINEERING for April 3, 1914.

The English plant, by Messrs. William Johnson and Sons (Leeds), Limited, used in the American experiments, was substantially as above described, except that it was modified in several respects to meet the needs of the experimenters. The principal alteration made was in the measurement of the coal and binder. To ensure absolute accuracy, this was effected by the use of separate scales, instead of by differential conveyors. In the first American plant, by the Renfrow Briquet Machine Company, St. Louis, horizontal heating cylinders were used, fitted with worm-conveyors, instead of beaters. Otherwise the arrangement closely resembled that of the Johnson plant. But in the case of the second American machine, by the American Compressed Fuel Company, Chicago, a different design was adopted. After being measured, the coal was dumped into a steam-jacketed mixer, where the pitch, which had previously been melted and measured, was mixed with it. The mixture was then fed into a roller-press, and formed into briquettes of the eggette type.

For lignite, a German plant by the Maschinenfabrik Buckau Actien-Gesellschaft, of Magdeburg, was used. The lignite, before entering the tube-press, which created a pressure of 14,000 lb. to 28,000 lb. per square inch, was treated in a set of crushing rolls, a rotary drier, sieve, auxiliary crushing-rolls, and cooling-plates with scrapers. The equipment also comprised a small hydraulic hand-press for making preliminary experiments.

The experiments were divided into three periods. From 1904 to 1907 the work was carried on at St. Louis, and the Johnson, American Compressed Fuel Company, and Renfrow machines were used. From 1907 to 1910 at Norfolk, the Johnson and Renfrow (improved) plants were employed, together with a German Schlickeysen peat-machine. And at Pittsburg, from 1910 onwards, the experiments were confined to the German lignite plant and to the small hand-press, although the English machine has been placed on its foundation.

The physical tests to which the briquettes were subjected were called the "drop" and the "tumbler," the absorption, density, weathering and compression tests. In the first, the briquettes were dropped on the floor, and the pieces, which were held by a screen with 1 in. square holes, were dropped again. This procedure was repeated five times, and the weight of the pieces, which, after the fifth drop, would not pass through the screen, was determined. In the tumbler test a weighed quantity of the briquettes (about 50 lb.) was rotated for two minutes at 28 revolutions per minute in a sheet-steel cylinder. The parts which were held by a 1-in. screen and a 10-mesh sieve were then weighed. The absorptive qualities of the briquette were tested by weighing, and the rate of absorption each day, and the time required for the absorption to become complete, or for the briquette to disintegrate, were determined. The density was taken by means of a Nicholson hydrometer, and the weather-resisting qualities were assessed by observations extending sometimes for as long as 286 days. For measuring the crushing strength a 200,000 lb. Olsen testing-machine was employed, although it is stated that the amount of handling which the briquettes will stand is given more accurately by the tumbler and drop tests.

The chemical tests included analyses and moisture tests, and extraction tests, using carbon bisulphide as a reagent, were made to determine the percentage of bitumen in the raw and the briquetted fuel. To determine the evaporative and burning qualities, the briquettes were burned under a stationary boiler. Special tests were also made on locomotives and on a torpedo-boat, and in domestic furnaces and foundry cupolas. The locomotive tests show that the evaporative efficiency of briquetted as compared with raw fuel is greater; that firing is easier; and that both the clinker and smoke produced are less. On the torpedo-boat it was found that there was no gain in smoke production, or in efficiency, but that the work of the stokers was lightened, and the boiler capacity increased. The domestic furnace tests proved that, for the low temperatures common in house-heating boilers, pitch is an unsuitable binder, as it volatilised and escaped unburned, or became deposited as tar. It also gave rise to too much smoke.

In the experiments the question of what binder can be used has naturally been investigated in great detail. The coal-tar pitch binders at present employed give briquettes which are water-proof, do not crumble during transport, leave little ash, and can be manufactured at a reasonable cost. Other

binders, notably cereals and "sulphite pitch" (selpech) have an advantage over pitch, inasmuch as they are smokeless in burning, but they are unfortunately not water-proof, so that the briquettes crumble after exposure to the weather. Such briquettes can easily be rendered water-proof, but the cost has hitherto been considered prohibitive. The American experimenters, however, state that their investigations on this head show that the discovery of a cheap water-proofing process is not an impossible achievement. And the patentee of Middleton's starch binder declares that he has already solved the problem, using 2 per cent. of cereal and ½ per cent. of tar, against, in the ordinary process, 8 per cent. of pitch. The cost of manufacture, he claims, is cheaper than in the pitch process so long as the price of pitch is above 42s. 6d. per ton. He states that the fuel, after exposure to the weather for several weeks, shows practically no deterioration.

In addition to detailed experiments with various kinds and percentages of pitch, the bulletin reports the testing of a large number of other binders. These include creosote, asphalt, petroleum (both of paraffin and asphalt bases), lime, clay, wax tailings, and sludge; various wood products, such as resin, tars, wood pulps, and sulphite liquor; various sugar-factory residues, such as beet pulp, lime cake, and the different molasses; starches, slaughter-house refuse, and petroleum products.

In the tests of pitches it was found that the pitch obtained from the distillation of petroleum gas-tar gave the best results, although other pitches distilled from by-product coke-oven tar, illuminating-gas tar, and producer-gas tar proved quite satisfactory. Water-gas pitch, another binder tested, has an advantage over ordinary coal-tar pitch in that the proportion of free carbon present is only 10 per cent., as against as much as 30 to 40 per cent. with the ordinary material. The free carbon is useless as a binder, and acts merely as a diluent of the bituminous matter. In all pitches it is important to select a material that is not too hard. The actual hardness required varies with the time of year and the climate; but, generally speaking, it was found that pitch which becomes brittle when dropped into water at 55 deg. Fahr. is of the correct texture. The harder pitches have been robbed of the creosote and lighter oils during distillation, so that pitches from which these oils have been distilled off should be avoided. It is also better for briquetting purposes that the pitch should be prepared in this way rather than by distilling all the oil, and then reducing the pitch with the naphthaline and creosote oils, as is sometimes done. As an example of the disadvantage of using the harder pitches, it may be said that in one experiment with a pitch of this kind, 13 to 18 per cent. was found necessary to make good briquettes, while, when a pitch with the proper amount of light oils was tried, 6 to 9 per cent. proved sufficient. Other experiments show that from 7½ to 14 per cent. of volatile oils is the correct proportion to give the proper binding qualities, and that from 6 to 9 per cent. of pitch of this kind will make good briquettes from most bituminous and anthracite coals. To mix with a non-coking coal 10 to 20 per cent. of a coking coal is better than increasing the percentage of pitch.

Of the other binders tried it was found that clay, lime, cement, magnesium oxide, plaster-of-paris, acid sludge, sugar-factory residues, slaughter-house refuse, and wood products are all unsatisfactory, although some of the last-named give good results in combination with other binders, and seem for that reason to deserve further investigation. Wax-tailings give fair results, but are not considered altogether satisfactory, while crude petroleum, although answering well, is deemed unsuitable for working on a commercial scale. Resin, used in conjunction with pitch or petroleum, and a percentage of lime to prevent smoking, makes a good binder; but here, again, the cost makes commercial application impossible. Asphalts are also rather too expensive in most places, and give only fair briquettes, but asphaltic tar was found useful as a water-proofing material in briquettes made with starch.

In fact, the only really good binders besides pitch were found to be starch or flour, and sulphite pitch. None of these is water-proof, but a careful study was made of water-proofing processes, and, as stated above, it is believed that a successful and inexpensive process can be discovered. When using corn starch only 2 to 4 per cent. is required with ordinary coals. The briquettes made with this binder were found to be smokeless. They held their shape well in the fire until completely consumed, and, although the heat value of the binder is small, it leaves no ash. Messrs. Yeadon, Son and Co., of Leeds, are, we understand, constructing a plant for Russia to briquette lignite, with a binder made of finely-ground meal and mazut, and a small proportion of pitch.

Sulphite pitch, also known as cell pitch, is made from the waste liquors which are produced in the sulphite process of manufacturing paper pulp from wood. Until recently these liquors had no commercial value, and their proper disposal was a serious matter, since, if discharged into rivers, they polluted the water and killed such fish as were contained in it. In making the pitch, the liquor is concentrated to a syrup in a sextuple-effect evaporator, and solidified into pitch as a thin film on two rotating steam-heated drums. With some coals, less than half the quantity of cell pitch is required as compared with ordinary pitch; but with others, in the American experiments, the percentage necessary was the same for each material. German experiments, on the other hand, incline to the smaller value. Briquettes made with this binder are smokeless and odourless, and the price of the material, if there are cellulose mills at hand, is low. In the Pollacsek process, used by the Hungarian Government for its collieries, sulphite liquor is employed, and from 3 to 5 per cent. is found to give good briquettes. The briquettes made with sulphite pitch can be rendered water-proof by drying at a temperature of 300 deg. Cent., or by the addition of certain chemicals, the nature of which at present is not divulged. With the latter process, the cost of water-proofing is estimated at 1s. 6d. per ton of briquettes. It is thought at present that the sulphite process will be more useful for anthracite than for bituminous coals, but that it also will be widely employed in preference to pitch in briquetting ores for smelting.

The cost of manufacturing briquettes in England, exclusive of materials, is estimated at about 1s. 6d. per ton of briquettes, and, using 8 per cent. of pitch, the cost of the binder will be about 3s. per ton of briquettes. The cost of the binder, using 2 per cent. of cereal and ½ per cent. of tar, will be about the same, on Middleton's process, when the cereal costs 7*l.* 10s. per ton. In Germany the cost of making lignite briquettes, including all materials, works out at 7s. 6d. per ton, the lignite being taken at ½d. per bushel.

There is evidently a large field for the development of this industry, and the briquetting of ores for smelting, which has not been investigated in the American experiments, is likely to be even more important than the briquetting of coals. Not only iron, but copper, nickel, and other ores can be made into briquettes with advantage.

THE TURKISH NAVAL CONSTRUCTION WORKS.

In December last the Ottoman Government granted a concession to the two great naval construction firms, Messrs. Vickers, Limited, and Sir W. G. Armstrong, Whitworth and Co., Limited, for the re-organisation and complete control of the docks and arsenals at Constantinople, to fit them immediately for the repair and refit of naval and mercantile ships, and, as soon as possible, for the building of all types of vessels. All the preliminary work has been completed, practical operations have commenced, and it is therefore possible to give some idea of the scope of the work. The new company have taken over the dry docks at Constantinople, with the existing workshops there, and the arsenal at the Golden Horn. At the former, which has a very extensive water frontage, there are three graving-docks, one of them 513 ft. long and 62 ft. wide, with a depth of water on the sill of 29 ft., while the corresponding dimensions of another are 400 ft., 72 ft., and 35 ft. It will be obvious that these were not sufficiently large to take the present-day battleship, and the concessionaires have lost no time in ordering a floating dock, which is to have a lifting capacity of 33,000 tons. This will be moored at a new establishment on virgin soil on the southern shore of the Gulf of Ismid, some 50 miles from Constantinople. Here large workshops are to be erected to undertake repair work on the ships while in dock. It is contemplated that the iron-workers' shed, for instance, will be 250 ft. by 150 ft., the engineers' shop 250 ft. by 100 ft., and the woodworkers' shop 150 ft. by 100 ft.; but in all cases these buildings will be so arranged that they can be extended, while provision is made for shipbuilding berths. A wharf for the importation of material is being constructed. A new town is arising, and it is worth noting that the rent is to be from a sixth to an eighth of the wages paid. Indeed Ismid promises ultimately to be a very important naval base, the anchorage being specially satisfactory.

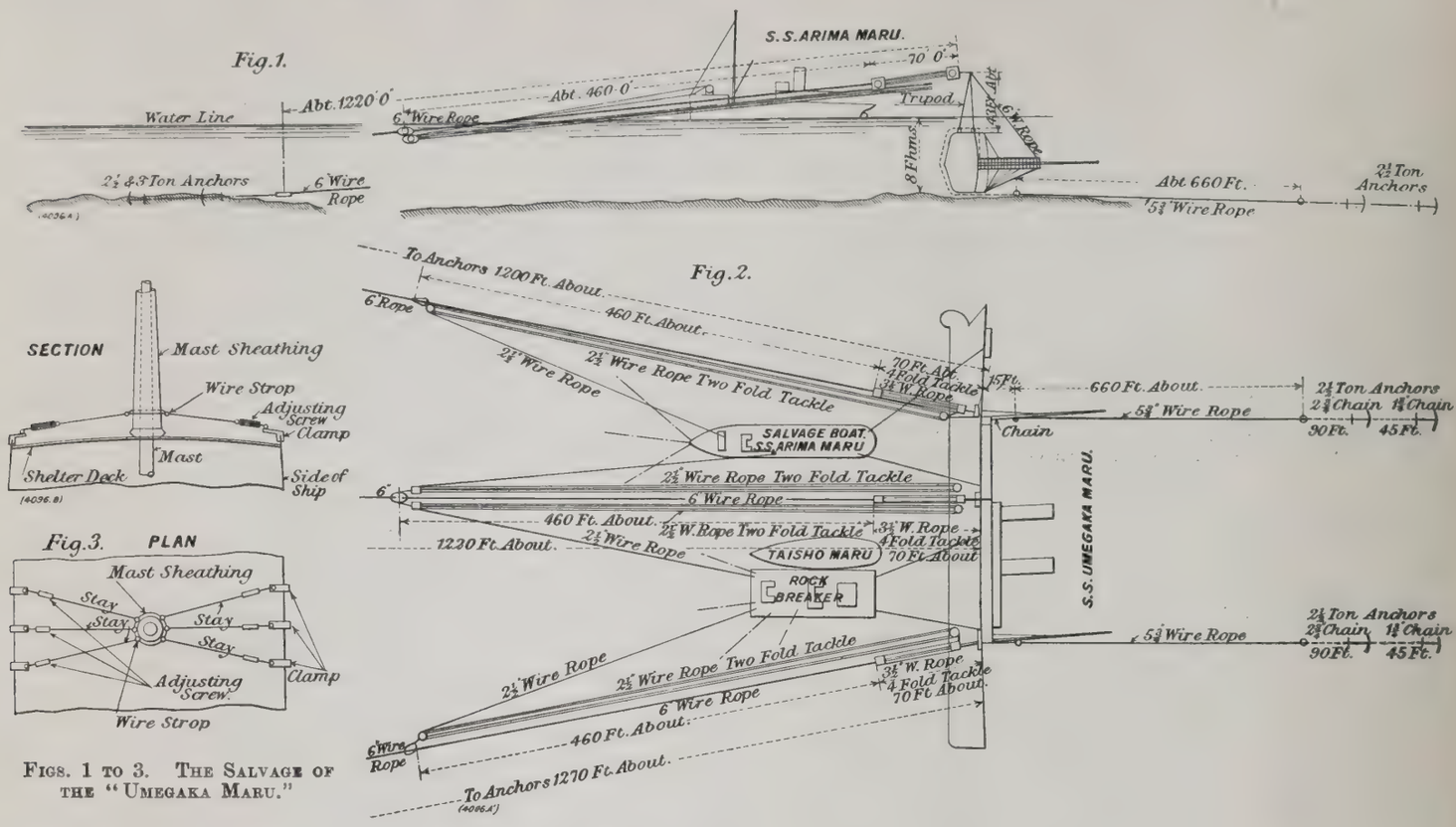
Repair work is in progress already at the existing works, the graving-docks being adequate for the great majority of merchant vessels frequenting Constantinople and trading through the Bosphorus, and as no adequate repairing facilities exist in this region of the Mediterranean, the advent of the Armstrong and Vickers firms is welcomed by the mercantile marine interests. The buildings, both at the docks and arsenal, are substantial masonry structures, but the roofs require extensive repair. The machinery equipment is moderately good, but not powerful or efficient enough to deal with the overhaul of modern turbine and gun-mounting machinery. There is, therefore, in progress a rearrangement of the departments and a large amount of new machinery is being ordered. All such machinery is to be exempt from customs duties. There are three building-berths at the works, but the declivity is too great, so that they will be reconstructed and lengthened.

The intention as regards new construction is to hasten slowly: destroyers will first be undertaken, then scouts, and probably in two years or so second-class cruisers, followed by battleships of all classes. Similarly, the Ottoman Government, while eager to organise a *personnel* of Turkish officers, have placed few restrictions on the English companies, being content to repose full confidence in them. Thus the majority on the Board of Directors will always be British, for the first five years the chairman will be English, for the second ten years Turkish, and thereafter an English and Turkish director will preside for one year alternately. Two Commissioners are to represent the Ottoman Government, but they have no vote; their's is a watching brief, for it will be understood that all work done for the Ottoman Government is to be paid for on the time and material principle, plus establishment charges and a fixed profit of reasonable amount from the point of view of both parties. Of course, as many native workers as possible will be employed, but there are no stipulated limits, as is often the case under analogous contracts. The staff is almost entirely British. Apprentices are to be trained and evening classes instituted, and at the end of ten years 50 per cent. of the entire staff are to be Ottoman subjects. The hours worked are to be nine and a-half per day, and the wages of Ottoman workmen range from 2s. 2d. per day for labourers to 4s. 6d. for platers and blacksmiths, the great majority getting about 3s. 8d. per day. The concession is for a period of thirty years, and during that period no other works, company, or private party, whether Ottoman or foreign, will be granted any concession or authorisation for the working of docks or naval or military construction works in Turkey. The important outstanding feature is the will of the Ottoman Government to encourage British enterprise, to ensure a fuller influence for Britain in the Near East, and closer association with British shipping and industry.

JAPANESE INSTITUTION OF NAVAL ARCHITECTS.

On June 6 and 7 last the Japanese Institution of Naval Architects held a meeting at Tokyo under the presidency of Vice-Admiral M. Kondo, one of its Vice-Presidents. On this occasion, in addition to papers being read, visits were made to some works of interest in Tokyo and to the Taisho Exhibition, now being held there. There was also a social gathering at the close of the meetings. The principal papers read were as follow:—"The Salvage of the Umegaka Maru," by Mr. M. Haramiishi, Engineer to the Mitsu Bishi Dockyard and Engineering Works, Kobe; "A Self-Recording Strain-Meter," by Professor S. Terano, and Assistant Professor T. Yamamoto, both of the Tokyo Imperial University; "Ramsbottom's Packing-Rings," by Mr. Kenji Nakagawa, Engineer to the Mercantile Marine Bureau, Department of Communications;

"Standardisation of Experimental Data of Engine Fuels," by Engineer-Captain Miyagawa, I.J.N.; and "Safety at Sea," by Professor F. P. Purvis, Tokyo Imperial University. The last of the papers just mentioned we print in full on page 140 of the present issue; of three others we now propose to give summaries.



FIGS. 1 TO 3. THE SALVAGE OF THE "UMEGAKA MARU."

THE SALVAGE OF THE "UMEGAKA MARU."

This ship belonged to the Japanese Volunteer Fleet, and was sunk in September, 1912, in the Straits of Moji. The paper acknowledges the assistance rendered in the raising of the ship by Mr. A. P. Macfarlan, special officer of the Salvage Association, London, and describes the work of salvage as carried out by the author's company. The ship lay on her port side on hard sand, in 6 to 9 fathoms at mean tide, the starboard side forward being just awash at ebb tide. The strength of current in these straits is given on the chart as 2½ knots, but is probably more. Salvage work was commenced in November, 1912.

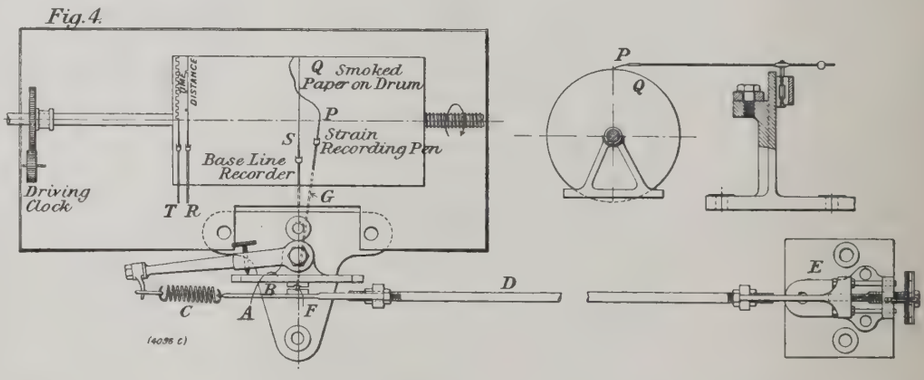
In order to get the ship on a level keel the rooms between the shelter-deck and boat-deck were first made water-tight in seven sections, and buoyancy obtained at this part of the ship by pumping them clear of water. Three tripods, each 40 ft. high, were next erected on the starboard side of the hull and were suitably stayed by guys, the arrangement of these being shown by Figs. 1, 2, and 3, annexed. To the tops of the tripods tackles were connected capable of exerting a pull of 50 tons at the top of each tripod, the tackles being attached to three 6-in. wire cables, which were led off a considerable distance and connected to three groups of anchors suitably disposed. The centre group consisted of two 3-ton and two 2½-ton anchors, while the outer groups each consisted of two 3-ton and one 2½-ton anchors.

The falls from the tackles were led to the salvage steamer Arima Maru, and to a large rock-breaker, which were equipped with the necessary hauling plant, and these vessels again were connected to the Umegaka Maru. The positions occupied by the Arima Maru and the rock-breaker, together with the arrangement of the moorings and the tackle generally, are clearly shown by the plan, Fig. 2.

To assist the righting forces thus applied two 200-ton hydraulic jacks were placed between the ground and the port sheer-strake, and, in addition, weight in the form of sand-bags was applied to the starboard side. After due adjustments, the first operation was successfully carried out, and the ship brought to a level keel on March 19, 1913.

The tripods, platform, and other parts not required were then removed, and a cofferdam, 242 ft. in length, was constructed and made water-tight. Precautions were taken to prevent the bow from rising prematurely. The pumps, &c., were adjusted until they consisted of the following:—Ten centrifugals, 8 in. to 12 in.; two specials, 18 in.; two pulsometers, 10 in. Using these appliances the final operations were commenced on May 15, 1913.

By judiciously drawing from the different connections through the various pumps and pulsometers the ship was brought bodily to the surface on a practically level keel. There was a danger at one time of the current taking charge; the anchors holding the stern dragged, and the ship swung from her position, but was checked before any damage was done. As the amount of water aboard was reduced, a list of 12 deg. to port was experienced. The cofferdam and other temporary structures were then removed, the list thereby lessened, and the pumping continued until, on May 18, the maximum draught was brought to 24 ft.; the ship was then towed to a safe mooring in Moji Harbour, and, after small repairs, was finally towed by easy stages to Kobe.



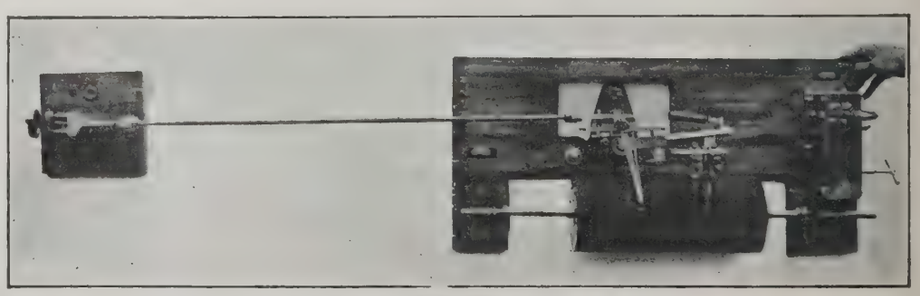


FIG. 5.

FIGS. 4 AND 5. A SELF-RECORDING STRAIN-METER.

A SELF-RECORDING STRAIN-METER.

The instrument described in the paper by Professor S. Terano and Assistant Professor T. Yamamoto is an outcome of Mr. Stromeyer's well-known arrangement made self-recording, and applicable to launching observations in the first

instance, but also ultimately to the recording of stresses at sea. The authors hold that while Mr. Stromeyer's idea was an indicator almost weightless and inertialess, they had found that at the time of the launch of a ship changes of strain were so slow and gradual that practically no shocks have to be provided for; they are therefore justified in making the indicator a little heavier and stiffer. A general diagram showing the arrangement of the instrument is given in Fig. 4, and a photographic view in Fig. 5, page 128. From these views it will be seen that there are two sliding blocks A and B; A is fixed to the stand of the instrument, and through it to the ship's structure, and B is held against A by a small spiral spring C set in balance with the long tube D; the other end of D is connected to the micrometer E, which is also attached to the ship's structure. Small triangular grooves are cut in the faces of A and B, and a knife-edged hard-steel pin F is inserted between them; an aluminium needle G, attached to the pin F, and carrying a light pen P at its end, registers on the drum Q, covered with smoked paper, the relative movement of the blocks. Another pen S, fixed to the stand, traces a base line. The

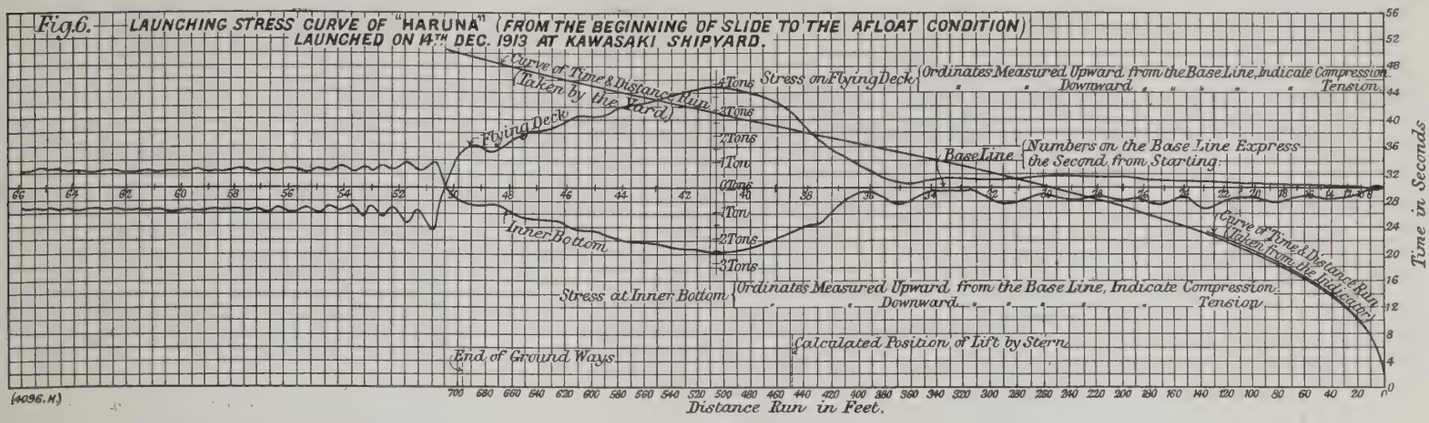


Fig.6. LAUNCHING STRESS CURVE OF "HARUNA" (FROM THE BEGINNING OF SLIDE TO THE AFLOAT CONDITION) LAUNCHED ON 14TH DEC. 1913 AT KAWASAKI SHIPYARD.
Curve of Time & Distance Run (Taken by the Yard)
Stress on Flying Deck
Ordinates Measured Upward from the Base Line, Indicate Compression. Downward, Tension.
Flying Deck
Base Line
Numbers on the Base Line Express the Second from Starting.
Inner Bottom
Curve of Time & Distance Run (Taken from the Indicator)
Stress at Inner Bottom
Ordinates Measured Upward from the Base Line, Indicate Compression. Downward, Tension.
End of Ground Ways
Calculated Position of Lift by Stern
Time in Seconds
Distance Run in Feet.
(4096.H.)

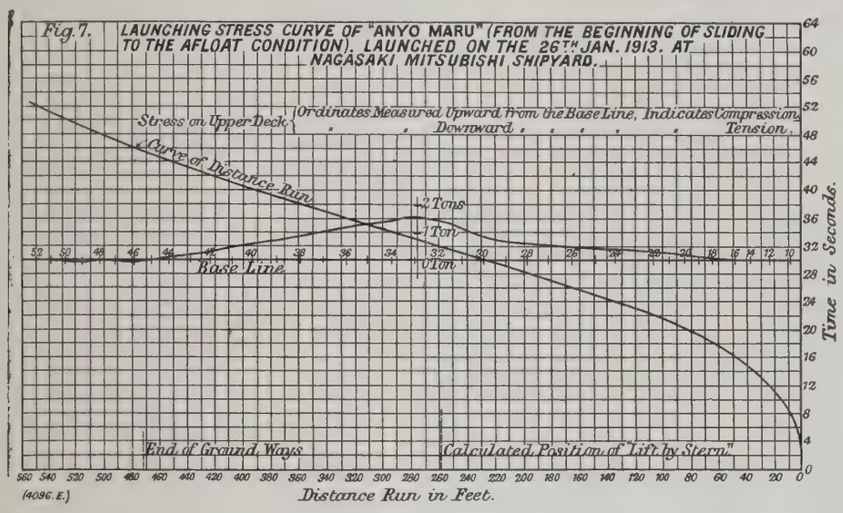


Fig.7. LAUNCHING STRESS CURVE OF "ANYO MARU" (FROM THE BEGINNING OF SLIDING TO THE AFLOAT CONDITION). LAUNCHED ON THE 26TH JAN. 1913. AT NAGASAKI MITSUBISHI SHIPYARD.
Stress on Upper Deck
Ordinates Measured Upward from the Base Line, Indicates Compression. Downward, Tension.
Curve of Distance Run
Base Line
End of Ground Ways
Calculated Position of Lift by Stern
Time in Seconds.
Distance Run in Feet.
(4096.E.)

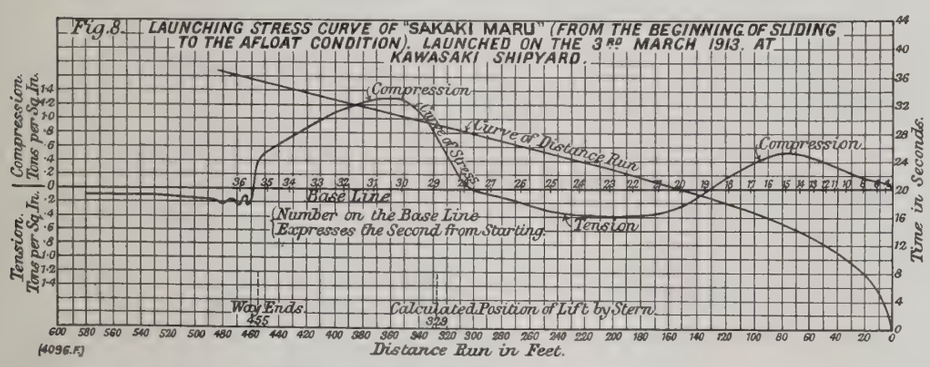


Fig.8. LAUNCHING STRESS CURVE OF "SAKAKI MARU" (FROM THE BEGINNING OF SLIDING TO THE AFLOAT CONDITION). LAUNCHED ON THE 3RD MARCH 1913. AT KAWASAKI SHIPYARD.
Compression
Curve of Stress
Curve of Distance Run
Compression
Base Line
Number on the Base Line Expresses the Second from Starting.
Tension
Way Ends
Calculated Position of Lift by Stern
Compression. Tons per Sq. In.
Tension. Tons per Sq. In.
Time in Seconds.
Distance Run in Feet.
(4096.F.)

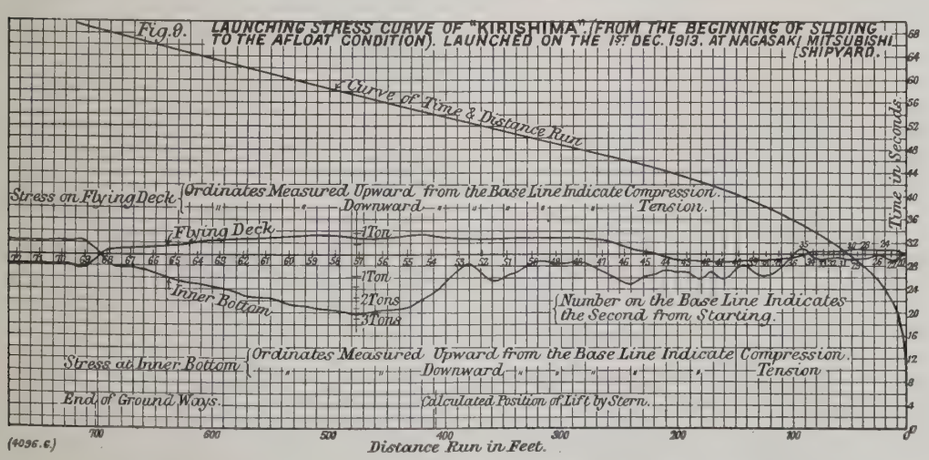
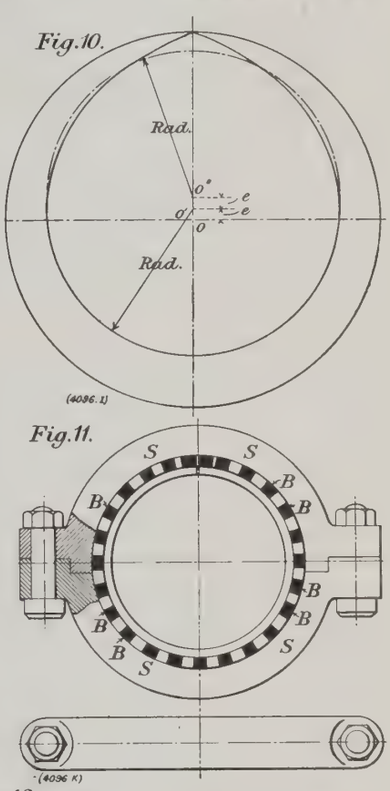
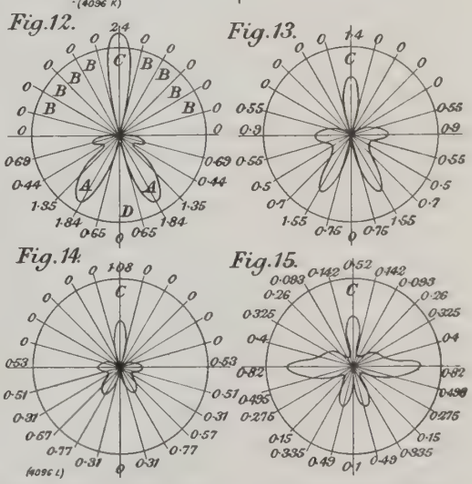


Fig.9. LAUNCHING STRESS CURVE OF "KIRISHIMA" (FROM THE BEGINNING OF SLIDING TO THE AFLOAT CONDITION). LAUNCHED ON THE 1ST DEC. 1913. AT NAGASAKI MITSUBISHI SHIPYARD.
Curve of Time & Distance Run
Stress on Flying Deck
Ordinates Measured Upward from the Base Line Indicate Compression. Downward, Tension.
Flying Deck
Inner Bottom
Number on the Base Line Indicates the Second from Starting.
Stress at Inner Bottom
Ordinates Measured Upward from the Base Line Indicate Compression. Downward, Tension.
End of Ground Ways.
Calculated Position of Lift by Stern.
Time in Seconds.
Distance Run in Feet.
(4096.G.)

FIGS. 6 TO 9. DIAGRAMS OF LAUNCHING STRESSES FROM SELF-RECORDING STRAIN-METER.





FIGS. 10 TO 15. EXPERIMENTS ON RAMSBOTTOM PISTON-RINGS.

relative movements of A and B (due, for instance, to strain in the ship's structure between F and E) are thus magnified and recorded; the micrometer E allows a scale to be made for accurate calibration. For use in connection with launching observations, two more pens, T and R, give time and the distance run by ship.

Three of these instruments have now been made. They have been used at the launch of the Anyo Maru, Sakaki Maru, H.J.M.S. Kirishima, and H.J.M S. Haruna, with results shown in Figs. 6 to 9, page 110. In the Anyo Maru (460 ft. by 60 ft. by 32 ft. 6 in.) the instrument was placed on the upper deck, with length F E = 5 ft. A maximum compressive stress of 1.57 tons per sq. in. (taking E = 13,400 tons) was recorded at a position a little after that of lift at stern, by calculation (Fig. 7). A Stromeyer's indicator alongside showed 1.47 tons per sq. in. In the Sakaki Maru, of the Volunteer Fleet (358 ft. by 46 ft. by 26 ft.), the instrument was placed on the bridge-house; the record (Fig. 8) shows 0.5 ton per sq. in. compression at 70 ft. run, 0.4 ton tension at 200 ft., and maximum compression 1.3 tons at a position 30 ft. after lift at stern, as calculated. In the cruiser Kirishima (27,500 tons) two instruments were used, one placed on the flying-deck, the other on the tank top. Some peculiarities in the record of the latter seem due to local strains, and some failure to give a proper record affects the maximum reading of the former; but maximum compression of the latter is well shown (2.75 tons), and the sudden change from tension to compression, and *vice versâ*, just as the ship left the ways is recorded as simultaneous (Fig. 9). Her sister-ship Haruna gives a more satisfactory result, with maximum tension 3.8 tons. The vertical vibrations (about 60 per minute), occurring immediately after the ship left the ways, are well represented by the variations in the recorded strains (Fig. 6).

Ramsbottom Packing-Rings.

In this paper the author describes experimental investigations into the distribution of pressure round the ring; (α) when the inner circle is concentric with the outer; (β) when it is eccentric; and (1) when the rings are turned once only; (2) when they are tightened after the first turning with a strong belt and returned. In addition he suggests a modified design of ring, with the inner surface formed of two half-circles differing slightly in their eccentricity from one another, as well as from the outer surface. Fig. 10, page 129, shows this design (upper part the chain line) in comparison with Unwin's theoretical curve.* Mr. Nakagawa's experiments were made as follow:—His apparatus consisted of two cast-iron straps S S, Fig. 11, having inside diameter 6½ in., turned to a true circle; another ring, having 6½ in. outside and 6 in. inside diameter, was cut into a number of separate pieces or blocks B B B. The Ramsbottom ring to be experimented on was inserted inside the blocks B B B and the strap S S screwed up, the condition thus approximating to a ring inside a cylinder 6 in. in diameter. The force needed to move each of the blocks B B B was then ascertained by a simple mechanism (lever and weight); as no lubricant was used, this frictional force was taken as a measure of the pressure exerted at the several blocks. The Ramsbottom rings upon which Mr. Nakagawa experimented had all a depth of ¼ in., and a mean thickness of $\frac{3}{16}$ in.; excess of outside diameter of ring over cylinder diameter, ⅛ in. Several diagrams are given, and of these, four only are reproduced on page 129, viz.:—Fig. 12—Ring with inner and outer circle concentric, once turned; Fig. 13—Circles $\frac{1}{32}$ in. eccentric, once turned; Fig. 14—Circles concentric, double turned; Fig. 15—Ring with two half inner circles, one $\frac{3}{64}$ in., the other $\frac{3}{32}$ in. eccentric from the outer.

The radii vectors of the curves drawn on these diagrams represent the pressures in the various cases. Uniformity of pressure is obviously the ideal condition to be aimed at; zero values at one part of the circumference mean enhanced values at others, and the author points out that in Fig. 15 there is no zero value.

THE REACTION OF A STEAM-JET.

When a jet of steam issuing from a nozzle is delivered in a fully-expanded condition, there is no difficulty whatever in deducing the reaction of the jet from theoretical principles. In such case, the final velocity of flow and the weight delivered per second can both be easily calculated, and the reaction is then given by the expression:—

$$R = \frac{w\,v}{g}$$

where R denotes the reaction in pounds per square inch, v the final velocity of the steam in feet per second, w the weight delivered in pounds per second, and g the acceleration of gravity.

In fact, if x be the ratio of the initial pressure to the final, P the initial absolute pressure in pounds per square inch, and γ the index in the usual equation for the adiabatic expansion of steam —viz., $P\,V^{\gamma} = \text{constant}$, we have—

$$R = \frac{2\gamma}{\gamma - 1} \cdot P\left(\left(\frac{1}{x} \right)^{\frac{1}{\gamma}} - \frac{1}{x} \right) a,$$

which if γ be taken at $\frac{10}{9}$ reduces to

$$R = 20\,P\left(\left(\frac{1}{x} \right)^{\frac{9}{10}} - \frac{1}{x} \right) a \quad . \quad . \quad . \quad (1)$$

where a denotes the area of the jet in square inches.

So long as x does not exceed a certain limiting value (approximately 1.73 in the case of steam) this equation gives accurately the theoretical reaction of the jet, the actual figure found in practice being, of course, always a little less owing to the loss of velocity which results from nozzle friction. It has, however, long been known that if the value of x exceeds the limit stated the steam, as delivered from a convergent nozzle, may be very far from fully expanded, and the calculation of the reaction to be expected in such case then becomes somewhat more complicated, but, as we shall show, can nevertheless be deduced fairly simply. The matter is of some importance, since in not a few nozzle experiments, of which data have been published, the steam has completed its expansion after it has cleared the nozzle. The velocity of efflux cannot then be deduced directly from the observed reaction, which, in fact, gives the final velocity of the fluid, and not its velocity at the plane of discharge. Obviously, the expansion which occurs after the jet has cleared the nozzle will take place in all directions, and contribute much less to the axial velocity of the jet than the amount properly due.

The losses thus occurring do not seem fairly attributable to the nozzle, but rather to the misuse of it in improper conditions. Some few experimenters have attempted to correct their results accordingly, but in such cases as have come under our notice have done so incorrectly. Confining our attention to the case of a convergent nozzle, the reaction theoretically due in the case where the final pressure of the steam is less than 0.58 P is given by the relation:—

$$R = \overline{R} + (0.58\,P - p)\,a,$$

where $\overline{R}$ denotes the value of R when p (the external pressure) is equal to 0.58 P.

Taking γ as $\frac{10}{9}$ this "critical" reaction has the value:—

$$\overline{R} = 0.65\,P\,a.$$

So that—

$$R = (1.23\,P - p)\,a \quad . \quad . \quad . \quad (2)$$

Suppose, for example, that P be 200 lb. absolute and p be 14.7 lb. absolute, whilst $a = 1$ sq. in. Then the reaction from a jet flowing under this pressure-difference from a convergent nozzle would by equation (2) be 232.7 lb. On the other hand, were the jet fully expanded on delivery, as it might be in a frictionless divergent nozzle, the reaction would be 272 lb.

The rule given as equation (2) can be proved by the following considerations. Let there be a cylindrical nozzle-box of cross-section A, having formed in its front cover a converging nozzle of which the outlet has the area a. Let P be the pressure inside the box, and p the external pressure. At the outset let p be equal to P, and afterwards gradually reduced. As the external pressure is diminished, "news" of the change in the external status is transmitted back along the jet to the interior of the box, where the conditions adjust themselves accordingly. At the outset each reduction in the external pressure is followed by an increase in the velocity of efflux, which finally attains the velocity of sound when the external pressure is 0.58 of the internal. The speed with which "news" of a change in the external conditions is transmitted back along the jet is, however, also the speed of sound; hence once the velocity of efflux attains this limit the steam in the interior of the box can never get to "know" of any further diminution in the external conditions, and any such further diminution can therefore in no way affect the condition of things inside the nozzle-box.

Now the back thrust on this nozzle-box arises in part from the internal pressure and in part from the external. On the back cover there is a pressure equal to P A. On the front cover the area exposed to pressure is A − a; but over this area the pressure is not uniform, since it is disturbed by the flow of the fluid to the nozzle, part of the pressure which in the static condition would come on this cover being, in fact, balanced by the curvature of the stream-lines. Hence the average pressure on the area A − a is not P, but some smaller pressure $\overline{P}$. Thus the contribution to the total reaction made by the internal pressures is $P\,A - \overline{P}\,(A - a)$.

At the same time the external pressure contributes the amount $-\,p\,a$, where p denotes this external pressure.

The total reaction is therefore given by the relation—

$$R = P\,A - \overline{P}\,(A - a) - p\,a \quad . \quad . \quad (3)$$

an equation which must hold universally.

So long as p is more than 0.58 P, each change in p is followed by a change in $\overline{P}$; but after this critical value is attained $\overline{P}$ remains unaltered, however much more the external pressure may be diminished, and the contribution to the total reaction made by the internal pressures becomes constant; but, as equation (3) shows, the reaction will continue to increase in virtue of the term $p\,a$.

We can, therefore, when the critical value is exceeded, write the reaction in the form—

$$R = \overline{R} - p\,a,$$

where $\overline{R}$ is the value given by (4) when $p = 0.58$ P. Putting $\overline{R} = 0.65\,P\,a$ we get equation (2).

NOTES.

Sweden's Waterways.

The Swedish Waterfalls Board has proposed to the Government the appointment of a special committee for the purpose of investigating several important issues in connection with the country's internal waterways. This, in the first instance, refers to the eastern section of the canal and lake route which connects the east and the west coast, going right through Sweden. The western portion of this waterway, the Vänern-Kattegat, has long ago passed the survey and project stage, the extension of the Trollhätta Canal is approaching its completion, and in the year 1916 Lake Vänern will be accessible for vessels of 4 metres draught. It seems at present possible that an improved connection between the two lakes Vänern and Vöttern might be preferable to an extended waterway between the latter lake and the Baltic. Then there is the canal connection between Lake Hjälmaren and Lake Mölaren, a link in the so-called great Svea Canal, which has been under consideration for a lengthy period. The Waterfalls Board therefore advocates a thorough investigation of the main issues connected with extensions of Swedish canals, technical and otherwise. This plan was brought before the Riksdag in the year 1900, but it was then urged that the works on the western section ought first to be pushed on with, so as not to bring about complications between the different departments. The Waterfalls Board now recommends the appointment of a special committee, with the right to obtain information from various authorities and to call in experts.

Railway Returns for the United Kingdom.

Returns have been published during the week with regard to the working of the railways of the United Kingdom in 1913. These figures are only of a preliminary nature. More complete and accurate data will be, as usual, forthcoming with the annual report still in course of preparation. In addition, this year, there is the fact that several of the items are compiled, owing to the changes required by the Act of 1911, on bases different from those hitherto in use, so that these figures of themselves can only be of restricted value. In view of these facts we shall defer commenting on the working of the railways in 1913 until the publication of the com-

* See "Elements of Machine Design," 1902 Edition, Part II., pages 250 and 251.

plete returns, as has been our custom in the past. In the meantime we give the chief of the preliminary figures now issued. The total capital of the railways is 1,543,331,000*l*, of which 199½ millions are nominal additions. The mileage is now 23,718, the total track mileage, including sidings, being 55,438 miles. The number of passengers carried last year amounted to 1,228,316,000, exclusive of season-ticket holders, of whom there were 595,000, calculated on an annual basis. The goods handled amounted to 371,571,000 tons, of which 226,528,000 were coal, coke or patent fuel, and over 72 millions of the remainder other mineral traffic. The total engine mileage represented 627,779,000 miles, of which 435,346,000 miles were performed in actual train-working, the balance being in shunting, assisting and light mileage. The total receipts amounted to 139,253,000*l*., of which 124,750,000*l*. were derived from actual railway working, the balance being from steamers, canals, harbours, hotels, &c. The total expenditure amounted to 87,242,000*l*., leaving a net income of 52,011,000*l*. Of the total expenditure, 78,803,000*l*. went on railway working proper. It is to be noticed that while the receipts from steamboats amounted to 2,579,000*l*., expenditure in this direction amounted to 2,434,000*l*. The receipts from canals amounted to 1.1 millions, while expenditure amounted to 0.75 million. On docks, harbours, &c., the expenditure was 2,458,000*l*., against receipts of 3,734,000*l*., and on hotels, refreshment-rooms, &c., the expenditure was 2,639,000*l*., compared with receipts of 3,195,000*l*.

ALMANACK.—Messrs. W. T. Glover and Co., Limited, have sent us a copy of their almanack for the ensuing twelve months. Messrs. Glover's almanack runs from July 1 to June 30. It is almost too well-known to need description, though for the sake of those still unacquainted with it we may say that it is of the pull-off variety, with a slip presenting each day some information, either pictorially or by other means, of interest to the engineer.

THE LATE MR. HORACE JOHN MANNERING.—Mr. H. J. Mannering, M. Inst. C.E., who was born on June 24, 1844, died on the 9th inst. at Purley, Surrey. Mr. Mannering was connected with the London, Brighton, and South Coast Railway, having been articled for five years to Mr. F. D. Banister, formerly chief engineer to that company. At the close of this period he was appointed an assistant in the company's office, and in August, 1872, was promoted to the position of chief assistant engineer. He was in responsible charge of many of the construction works on the railway, and personally supervised the construction of the Cliftonville spur-line, the Chichester and Midhurst Railway, and the Battersea, Streatham, and Victoria widenings. Mr. Mannering was admitted to the Institution of Civil Engineers as an associate member in 1876, and was transferred to the class of member in 1897.

THE ALTIOR PROCESS OF DIE-CASTING.—The National Alloys, Limited, Ilford, London, E., have recently brought out an improved process of die-casting for aluminium alloys, which possesses several interesting features. The process is for use with aluminium alloys of a specific gravity of 2.85. The alloy recommended is Ivanium, which has a tensile strength of 12 tons, and 6 per cent. elongation on 2 in. This alloy is guaranteed not to disintegrate, and it is not affected by sea-water, &c. The casting-machine has a gas-heated melting-pot lined with refractory material and provided with a cover. Extending from the cover to within a short distance of the bottom of the pot is a tube of refractory material connecting with a neck-piece fixed above the cover and surrounded by a burner. Above this neck-piece is fixed a plate, to which the bottom half of the die is fastened. The plate, which is hinged and can be thrown back by a worm and spur-gear, also carries the standards and cross-frame for a large vertical quick-pitch screw, to which the upper part of the die is fastened. Between the lower die-plate and the neck is a slot, in which works a sprue-cutting bar. The action is as follows:—After fixing the dies the sprue-cutting bar of hardened steel is pushed over, so that communication between the inside of the pot and the die is prevented. An inert gas is then admitted to the pot above the metal, and a high pressure maintained inside the pot. When the metal is melted and the sprue-cutter pulled over so as to bring a hole in it fair with the hole communicating with the die, metal is forced out of the pot up the tube and neck into the die. The cutter-bar is then pushed over, cutting off the connection, and the upper half of the die raised by the quick-pitch screw. The casting is removed automatically, and the die is returned to its original position. The piece of alloy is punched out of the cutter-bar, and on pulling the bar over again a fresh supply of metal is forced into the die. It is claimed for the machine that the metal is kept hot right up to the time of entering the die, while the dies themselves, being mounted on the pot, are also always kept at a suitable temperature. The whole cover with the die-frame may be swung back, if necessary, by bevel and worm gears. The pot is provided with plungers for mixing the metal and with a filling-hole, while it is surrounded by a casing of refractory material.

THE GERMAN ASSOCIATION OF GAS AND WATER ENGINEERS AT MUNICH.

IN continuation of our report (see page 96 *ante*) of the fifty-fifth annual meeting of the German Association of Gas and Water Engineers, held at Munich from the 1st to 4th inst., we now give summaries of the communications which were presented at the meeting.

THE GERMAN GAS INDUSTRY.

After the annual report of the Committee had been dealt with, Herr Lempelius presented his paper on "The Position of the German Gas Industry and the Munich Gas Exhibition, 1914." Giving a reply to the question as to the advisability of holding such an exhibition, he stated that the results of the work of the promoters had conclusively shown that they were correct in the view that the undertaking would prove successful. The comprehensive collection of exhibits demonstrated the vigour and resource of the German gas industry. After the manufacture of gas came its application to the purposes of lighting, cooking, heating, and many industries. As showing the scientific progress which had been achieved, the author pointed out that with the first retorts fifty men were required for manufacturing 30,000 cubic metres; now, by the employment of vertical-chamber ovens, the number was reduced to five. The improvement in the conditions of living resulting from the intelligent use of gas was very marked; the elimination of smoke and soot were inestimable boons to the community.

GAS AND HYGIENE.

The next paper was by Geheimer Medizinalrat Professor Dr. Max von Gruber, who had taken for his subject "Gas and Hygiene." The adverse criticism on the use of gas as an illuminant in dwelling-houses had necessitated the carrying out of experiments having for their object the investigation of the question as to the influence which gas exerted on the atmosphere of dwelling-rooms. With the assistance of the German Association of Gas and Water Engineers, a number of tests had been conducted at the Munich Hygiene Institution, under the direction of Dept.-Ing. Dr. E. Schilling, Dr. R. Ries, and Dr. Schumann. Most of the determinations were made between March, 1912, and October, 1913, by Dr. Ilzhoefer. They would be published in the *Archiv für Hygiene*. Dr. Ahlborn was responsible for the bacteriological experiments. To obviate the possibility of any change of weather affecting the experiments, the investigations on gas and electric lighting were made simultaneously in two different rooms of the same size (57 cub. m.), under precisely similar conditions. The roof and the walls were perforated with a number of small tubes, so that pressures could be registered.

The gas-lamps were provided with "multiplex" lighters actuated from the laboratory. The mixing of the air was ensured by the use of electrically-driven fans. Air could be taken from sixteen places at three different heights in each room; at the same places temperatures could be measured by means of a resistance thermometer situated in the laboratory. It was not necessary to go inside the experimental room during the course of an experiment, as all the records could be taken from the outside.

Summarising the results of the experiments, it was stated that they went to show that a great number of the evil features hitherto attributed to gas were disproved, and others were shown to be exceedingly small and unimportant. No trace of sulphurous acid could be found, nor any trace of carbon monoxide, even after burning 10 cub. m. of gas in 67 hours.

Experiments were conducted simultaneously with gas and electric lighting under conditions which were unfavourable to the former. They showed that the greatest difference in temperature was 1.6 deg. Cent., and the largest difference in increase of moisture was 10 per cent. In general the difference in temperature between the two rooms was less than 1 deg. Cent., and that of the moisture less than 5 per cent. The ventilation of the unheated, unlighted, or electrically-lighted untenanted room was, on the average, not quite one-third of the room content—*i.e.*, 18 cub. m. per hour. By gas lighting it was two-thirds—*i.e.*, 38.4 cub. m. per hour. The ventilation of the unpapered room was about 17 per cent. more than the papered one.

In the discussion on this paper, Geheimrat Bunte, of Karlsruhe, animadverted on the unimportance of the substances which till now had been regarded as dangerous adjuncts to gas-lighting. The experiments of Professor Gruber showed that gas lighting could undoubtedly fill all the requirements of hygiene. Direktor Göhring, of Stuttgart, drew the conclusion that gas lighting did not contaminate the living-room, but that it improved the conditions of habitation; while Direktor Schonburg, of Gelsenkirchen, expressed the belief that ventilation with gas lighting could be much improved by the introduction of special ventilation chimneys. These had already been introduced at Berlin and Potsdam.

Professor Gruber, at the close of the discussion, warned his audience against overheating the dwelling-room, and maintained that there was no relation between gas-lighting and the forming of mould, &c., as had only recently been again stated.

THE AIMS OF THE GERMAN GAS INDUSTRY.

"The Aims of the German Gas Industry" was the title of the next paper, its author being the well-known and able Chief Direktor Ernest Körting, of Berlin. He referred in complimentary terms to the three sister organisations of the Association—namely, the Central Office for Gas Publicity, the German Commercial Gas Association, and the Training and Research Institute at Karlsruhe. As to the latter, the author was most appreciative in his remarks, and alluded to the great debt the gas industry in Germany owes to Bunte.

One of the chief works of the Institute was the immense number of coal determinations it carried out. As every year millions of money were spent on coal, it was obviously of the first importance that knowledge of its composition should be exact. Dr. Bunte and his assistants had taught them to convert the analysis into a matter of shillings and pence, and experience had shown that cheap coal was often the dearest in the end.

THE HISTORY OF THE LARGE GAS-ENGINE.

Sir William Lindley, being detained at Baku, where he is engaged on his large water-works scheme, the report on the standardisation of screw-threads was not presented. In its place a paper on "The History of the Large Gas-Engine" was given by General-Direktor Dr.-Ing. von Oechelhäuser, in which was summarised his twenty years' work. When the electrical power-station at Dessau was erected in 1886, he tried to meet the new competition by the use of gas-motors for the provision of power. The largest then were only of 60 horse-power, and they naturally could not compete with the larger electrical units. By means of an experimental engine he sought new principles on which to base the large gas-engine by increasing the limits of inflammability of gas and air mixtures. This was obtained by means of a method of gas-injection which he called "dynamic firing," in contradistinction to the method of firing the static gas. For this he employed electrical firing instead of the usual flame, and so was able to use poor mixtures with high compression. This was combined with the two-stroke Benz motor, which seemed to offer the greatest probability of producing a large-power engine with the smallest cylinder dimensions. For this purpose, in conjunction with Hugo Junkers, he founded in 1890 the experimental station for gas-motors of Oechelhäuser and Junkers in Dessau. The remodelling of the Benz engine did not produce the desired result, and it was therefore decided in 1892 to break away from the then known gas-engines, and produce those of 100 horse-power double-cylinder two-stroke cycle.

The compression and explosion pressures were increased to the then unknown extent of 16 and 68 atmospheres respectively. The cylinder cross-section was only about 1½ times larger than that of the four-stroke engines of that time, the gas consumption being lower. In 1893 the manufacture of these engines was taken over by the Berlin Maschinenbau-Gesellschaft in Dessau, and 190 effective horse-power was obtained per cylinder. In 1896 the author, inspired by the suggestions of Ludwig and Löwe, again applied himself to the production of the large gas-engine by burning blast-furnace gases (which up to that time had been used uneconomically to heat boilers) direct in the gas-engine. The first experiments in June, 1896, were so promising that an order for three engines of 600 horse-power was obtained by the Berlin Anhaltische Maschinebau Aktiengesellschaft, in Dessau, and these were erected in Hörde on May 12, 1908, under the direction of Professor Wagener. An indication of their technical and commercial importance was given in the figures of Civil-Ingenieur Fritz W. Luhrmann, of Osnabruck, according to whom 3 marks were saved on every ton of raw iron, representing a possible saving in Germany in 1898 of 21,000,000 marks, and in 1913 of 58,000,000 marks (say 29,000,000*l*.).

The Union Electric Company and Messrs. Siemens and Halske helped to introduce the new gas-engine into Germany and abroad. The firm of Borsig and the Aschersleben Engineering Company also took part, together with the British firm of Beardmore and Co., of Glasgow, with a total introduction of about 85,000 horse-power. The largest engine, of about 1800 horse-power (in one cylinder), built by Borsig in 1904, was erected at the works in Glasgow, where it is now giving good results. The limit of power of a gas-engine has probably not been reached with 1800 horse-power per cylinder; nevertheless, with the advent of the steam-turbine the further construction of these engines had been given up.

GAS CHARGES.

Herr Direktor Johrum's paper on "Gas Charges," which followed, contained some interesting and useful information on the cost of manufacture and expenses

of an increased propaganda. The common method of dividing the annual total cost of production by the yearly output was, he held, only satisfactory if sufficiently specialised, and, in the fixing of the prices of gas used for special purposes, it failed completely.

GAS HEATING.

Dr. Karl Bunte, of Karlsruhe, then gave his paper on "Gas Heating," in which he specified the principles on which gas-ovens should be judged. The efficiency, which, in modern construction of stoves, is 85 to 95 per cent., was not now of such importance as the fulfilment of strict hygiene and practical requirements.

The cleanliness of gas, its ease of application, and absence of smell and soot, had ensured its place in the kitchen and in water-heating. In London, at the present time, about 1½ million gas-ovens were in use, the increase in one year being 10,000. Doctors and hygienists were greatly interested in their use as an important factor in the purification of the London atmosphere.

In Germany, where heating by the old-fashioned stoves was still largely practised, the substitution of a good gas-heating appliance was very important. The newest forms of these were shown in the Munich Gas Exhibition. From the point of view of national economy it was probably better in the darkest and coldest part of the year to convey heat in the form of coke to central ovens, instead of increasing the price of gas by conveying it in gaseous form in such large quantities for a short time. For heating purposes during change of weather, and for rooms not frequently used, gas had, however, great advantages, owing to the ease of putting it into use. A combination of central heating with gas heating had been instituted for the changeable part of the year, to help central heating in its weakest point. Gas heating, therefore, after surmounting commercial, technical, and hygienic difficulties, was now in the happy position of having friends on all sides who were interested in its development.

"WHAT IS HARDNESS?"

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of last week Mr. Albert F. Shore contributes some notes on the value of hardness tests, and more particularly an unbiassed account of the principles governing the measurement of hardness by his own apparatus, the scleroscope.

I have been interested in this instrument for many years, and during that time have frequently had occasion to compare the results of the scleroscope test with those of other standard tests for hardness.

1. What Mr. Shore states regarding the principle of the instrument is in accordance with the view expressed by me in a paper communicated to the Institution of Civil Engineers*—namely, that the scleroscope measures the coefficient of restitution between the material to be tested and the hammer, when the conditions are such that permanent deformation is produced. If the coefficient of restitution is represented by e, then

$$\frac{\text{The height of rebound}}{\text{The height of fall}} = e^2.$$

2. The coefficient of restitution falls below unity (or, in other words, the rebound is less than the fall), because—

(a) Energy is dissipated by the rapid rise and fall of stress.

(b) Energy is absorbed in the permanent deformation of the metal.

In the scleroscope the second of these factors is intentionally made predominant, but if the elastic limit of the material tested is very great, the relative effect of (b) is reduced, and a greater proportion of the total effect is produced by (a).

Take, as an example, the behaviour of plate-glass (though this is not quoted to disparage the instrument, as Mr. Shore suggests). The rebound given by the magnifier hammer agrees with that calculated from the coefficient of restitution, and no mark is produced on the glass at the point of impact; with the universal hammer the stress is greater, and the glass is almost invariably shattered. With the magnifier hammer the above factor (b) is entirely eliminated.

Any treatment which raises the elastic limit of a metal or alloy alters the relative importance of these two factors in determining the rebound; the loss of energy due to the second cause is not only actually less, but is smaller relatively to the total loss. This probably has some influence in determining the fact that the scleroscope shows a relatively greater increase in hardness by such treatment than most other standard methods.

3. Under the conditions of the test, the greater the resistance to permanent deformation, the greater the coefficient of restitution; hence this property may be used as a measure of hardness.

The physical constant involved in the scleroscope, however, is not e for the material tested only, but e between the material and the hammer; and the latter is greater or less than the former according as the material is softer or harder than the hammer. Hence the scleroscope might be expected to give results a little too high for soft material and relatively a little too low for hard. But the exact relation is not so simple; it depends also on the elastic constants of these substances, and I have, I think, shown, in the paper referred to, that where the scleroscope gives results for relative hardness agreeing with the sclerometer and Brinell methods, there is a simple relation between the "hardness number" and the elastic constants.

(i.) This relation appears to hold for metals in the cast or annealed state.

(ii.) It does not hold for wood, rubber, glass, and other material for which the scleroscope was not designed.

(iii.) It does not hold good after the material has undergone any treatment which affects the hardness without greatly affecting the modulus of elasticity. For example, the quenching of steel or of aluminium-bronze, or the cold-working of metals and alloys, has a marked influence on the hardness, and very little on Young's modulus; and, as a matter of fact, increase of hardness so produced, measured by the scleroscope, is found to be relatively greater than if measured by Brinell's method.

The above remarks are merely intended to amplify what Mr. Shore has said, and to point out a few peculiarities which the principle of the scleroscope involves.

I may say again that nothing could be further from my intention than to disparage the instrument, which appears to be admirably suited to a variety of practical and scientific purposes.

Yours truly,

R. H. GREAVES.

University College, Cardiff, July 22, 1914.

* Proceedings of the Institution of Civil Engineers, vol. clxxxi., 1910 (iii.), pages 478 to 489.

THE REPUBLICS OF CENTRAL AND SOUTH AMERICA.

TO THE EDITOR OF ENGINEERING.

SIR,—In your impression of April 17 appears a long and, in general, appreciative review of my book, "The Republics of Central and South America" (Dent and Sons), which, however, contains some extremely erroneous statements and conclusions, to which, perhaps, you will permit me to reply.

Your reviewer says: "A leader of thought, as Mr. Enock is, should encourage a firmer grasp of commercial principles." But, unfortunately, your reviewer imposes upon me opinions to which my book certainly does not give utterance. He thinks that I suggest an antagonism to foreign capital investment in Latin America, and that I propose that the inhabitants thereof "should be allowed to work out a Socialistic Utopia;" and that dividends should not go out of the country. These remarks show that your reviewer cannot have read the book with sufficient care, or that he (in common with so many more) is too ready to apply that "blessed word" "Socialism" to any arguments dealing with the organisation of national resources in the interests of the people of a country.

I do not speak against the operation of foreign capital in Latin America. As an engineer and economist I am fully alive to the necessity of employing such, and I have pointed out the benefits performed thereby, and the opportunities for further development.

What I have inveighed against is the debased economic condition of the labouring classes of these lands—a condition due almost entirely to their oppression and exploitation by the native land-owing and plutocratic classes. Let us take the example of Mexico, which, like Peru and some others, I know very well. What are the conditions? Out of a population of 16 millions (more or less), 85 per cent. are unable to read or write—are simply peons (practically slaves), live in mud huts, insufficiently fed and clothed, have no vote, carry on no occupation profitable to themselves, own no land, and have no stake in their country.

Here, Sir, you have, indirectly, the reason of the present terrible condition of that country: the ruination of part of that excellent brown (or red) race of America, by which alone the American tropics can be developed.

In varying degree the above economic condition covers nearly all the Central and South American Republics except Argentine and Brazil, and even there the Indians are grievously exploited. (Brazil is, perhaps, the best exception.)

Now what part does foreign capital play in this extraordinary social system, under which the people are, in some instances, worse off than they were under their native Aztec and Inca, and other indigenous rulers, 400 years ago? It has conferred great benefits on the various countries under survey, in the building of railways and other public works. But these benefits filter down in very small degree, and in many cases not at all, to the labouring and illiterate classes.

It may be replied that it is no concern of foreign enterprise to consider the sociological condition of the people. But it will be found in the future that this element does gravely concern the foreign investor, and (putting all other motives on one side) his possession, concession, and dividends will be jeopardised if he neglects it.

I cannot trespass on your space, Sir, by going further into the matter here, but whatever I have said in my book is in the nature of friendly advice. Foreign companies operating in Mexico and Central and South America (Great Britain alone has 1000 millions sterling invested therein) would do well to study the well-being of their native employees. It would pay them to send out "sociologists" on their staffs, to insist on fair pay, sanitary housing, and sufficient food. The neglect of these matters, and any form of exploitation, will inevitably lead, sooner or later, to the repudiation of concessions by the growing democracies of Latin America.

The foreigner in these countries is generally welcomed and respected, but this is not always the case, and it is to be recollected that some serious abuses have been committed in the name of foreigners.

In conclusion, perhaps I may be permitted to advance a plea for the study of what, in my address to the Royal Society of Arts recently (which was supported by Lord Milner, in the chair), I ventured to term a "new science" of "human geography;" dealing with the more reasonable adaptation of mankind to its economic environment in all lands.

Yours truly,

C. R. ENOCK, C.E., F.R.G.S.

Valley Croft, Northwood, Middlesex,
June 29, 1914.

[The foregoing letter was forwarded to the writer of the review, and his reply is appended.—ED. E.]

TO THE EDITOR OF ENGINEERING.

SIR,—If I make any comment upon Mr. Enock's letter, it can only be with the view of emphasising more strongly the extracts to which Mr. Enock objects. I have correctly conveyed the impression he left on my mind, and if I have misunderstood the author, it is not from any of the reasons he suggests. I understand the whole of his chapter on "Sociology and Future" to be directed against capitalistic methods, and to constitute an attack on the manner in which concessions have been granted and used. To come to particulars, we are told (page 507), "A growing democracy may protest that it had no hand in these bargains and proclaim that it cannot abide by them; that the increment from its docks, railways, plantations, mines, and public works must belong to the community, and not go to form dividends for foreign shareholders." Couched in however guarded language, we have here a veiled approval of repudiation of existing obligations, and a tolerance of the subversion of the principles that should guide commercial transactions. To people "who have not the stolidity of the British or the European," whose temperament is more mercurial and whose education and moral training are backward, it is more than unwise to suggest "that from protest to confiscation might be a relatively facile step." The author may be justified in encouraging cottage industries and in condemning the existence of industrial centres. Such an opinion is not an axiom, it is open to discussion, and, similarly, one might admit as a general principle "that the systematic and scientific organisation of the national resources should be in the interests of the people collectively" (page 516) is sound, and yet not agree as to the manner in which the principle should be applied in practice. When we read of the growth of an anarchistic element in the city of Buenos Aires, when strikes are frequent at the docks on the Pacific Coast, when the nitrate workers of Chili are using the same menacing machinery, we can only regret that a writer of Mr. Enock's ability and influence should in any way appear to encourage lawlessness and discontent by the use of language which may be regarded as inflammatory.

Yours truly,

THE WRITER OF THE REVIEW.

LARGE SUCTION-DREDGERS.

TO THE EDITOR OF ENGINEERING.

SIR,—In your issue of the 19th ult. we notice an article headed "The Simons Suction-Dredgers."

On page 852 reference is made to the suction-dredgers used at Liverpool by the Mersey Docks and Harbour Board, including the Brancker and the G. B. Crow, made in 1895 and 1897 respectively by Messrs. Simons, and to other vessels of later date, the largest being of 10,000 tons hopper capacity.

Of these, the suction-dredger Coronation was built in 1903, and has a pumping capacity of 4200 tons of sand per hour, and the plant consists of two centrifugal dredging pumping-engine sets built by us, and arranged one on either side of the vessel. The other dredger, built in 1903, the Leviathan, has 10,000 tons hopper capacity, and the plant consists of four triple-expansion centrifugal dredging pumping-engine sets, which were also built by us.

Yours faithfully,

GWYNNES LIMITED,
W. W. WILKES, Secretary.

Hammersmith Iron Works, London, W.,
July 15, 1914.

[We publish Messrs. Gwynnes' letter, but we may point out that the dredgers Brancker, G. B. Crow, Coronation, and Leviathan were not built by Messrs. W. Simons and Co., with whose practice we dealt in our article referred to. We erroneously attributed to Messrs. Simons the order for the Brancker and G. B. Crow. The complete record of the evolution of sand-pump dredgers for the Mersey Dock and Harbour Board was given in an article, describing and illustrating fully the Coronation, in ENGINEERING, vol. lxxix., pages 301, 464, 570 and 671. —ED. E.]

NORMANBY IRON WORKS COMPANY, LIMITED.—The annual report of the Normanby Iron Works Company, Limited, to be presented at the general meeting at Middlesbrough on July 29, shows a total of 8541*l.* 18s. 2d. for disposal. The dividend for the year on the ordinary shares is 6 per cent.

UNITED STATES STEEL CORPORATION.—The unexecuted orders on the books of the United States Steel Corporation's subsidiaries at the close of June amounted to 4,032,857 tons, showing an increase of 34,697 tons, as compared with the corresponding aggregate at the close of May. The improvement in the tonnage was anticipated, the placing of new orders having shown some activity. The total of 4,032,857 tons compares with a corresponding aggregate of 4,282,108 tons at the close of December, 1913; 5,807,317 tons at the close of June, 1913; and 7,932,164 tons at the close of December, 1912.

MOTOR-LORRIES.

*Improvements in Motor-Lorries: Self-Loading; also Driving and Steering through All Wheels.**

By M. BRILLIÉ (of Messrs. Schneider and Co., Paris).

HEAVY lorries are coming more and more into use, and the following is a description of an arrangement which has been introduced recently in France with a view to simplifying and saving time in the operations of loading and unloading.

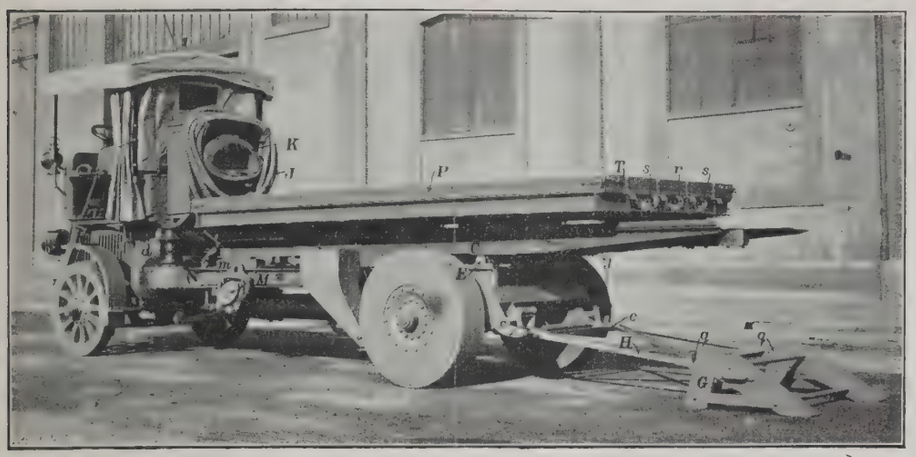


FIG. 1.

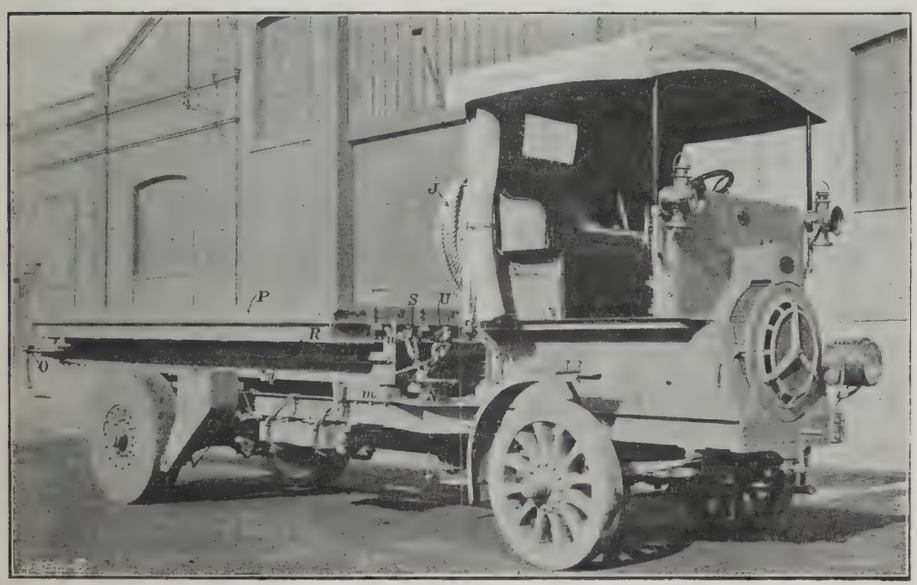


FIG. 2.

Fig. 3. LOADING

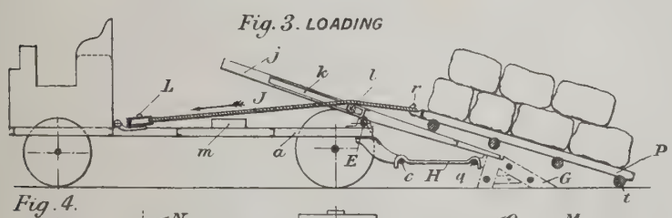
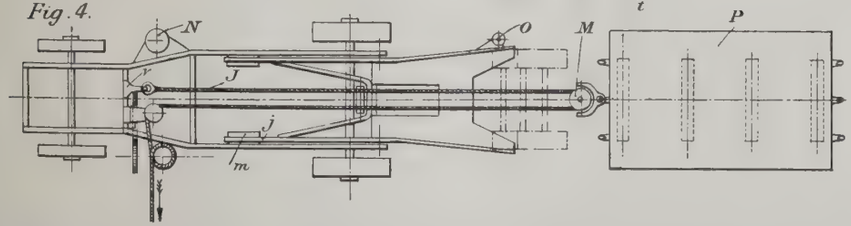


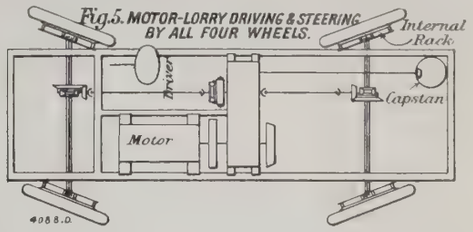
Fig. 4.



SELF-LOADING MOTOR-LORRY.

This vehicle is designed to transport loads which have, in the first place, been placed upon the trolleys P, Fig. 1, above. These are hauled up on to the chassis by means of a capstan worked by the motor itself. By this method the lorry need not be detained for a long time at the loading and unloading places. Say one of the trolleys is being loaded at a point *a*, and another is being unloaded at a point *b*; the lorry departing from *b* leaves an empty trolley at *a* and takes a loaded one to *b*, returning again with an empty one. The operations of loading and unloading are performed by means of an open tilting-truck C, which is pivoted at the back of the chassis, and which serves as an inclined plane. The particulars of the different parts of the lorry and its accessories are as follow:—The chassis, except in a few particulars, is similar to that of the Paris motor-omnibuses. It differs from the latter in that the front seat is made to carry three persons; the bonnet sides have to be lifted so as to free the inside flaps, and the frame plates are cut short behind the back axle so as to allow the truck C to tilt. The framework *c* serves to connect the lorry with the trestle G, which forms a part of the loading arrangement. The capstan is placed on the left of the chassis; it carries a steel drum *d*, worked by a couple of bevel-wheels driven by a chain, the driving-pinion of which is mounted loose on the front end of the change-gear lay-shaft. A dog-clutch worked by a lever throws the pinion in gear and runs the capstan. A safety ratchet prevents running back when the clutch is disengaged, or if the chain breaks. The tightness of the chain is adjusted by a stretcher, which is reached by removing the cover-plate. To lubricate the capstan the top cover must be removed, and oil supplied through the two holes in the drum *d*.

Fig. 5. MOTOR-LORRY DRIVING & STEERING BY ALL FOUR WHEELS.



Tilting-Truck.—This consists of side members *j* (Fig. 2) firmly braced in the centre at E, and also at the back, about which the whole tilting-frame rocks. In front these side members are not connected, but are strengthened by stays. In running order they bear on brackets *m* fixed to the longitudinal frame of the vehicle. In the crutch of the fork formed by the stays rollers are arranged for guiding the ropes when the truck is tilted.

Trestle.—In order to facilitate the operations of loading and unloading, the back of the truck, when tilted, rests on a trestle G, the position of which, with reference to the vehicle, is secured by the metal framework which hooks on to the back of the longitudinal frames of the chassis at *c* and *q*. This trestle forms an extension to the inclined way produced by tilting the truck. At each loading or unloading dépôt a trestle and frame must be provided, so as to save carrying them on the vehicle at every journey.

Loading.—The vehicle must be backed approximately centrally to the trolley P, and the trestle fixed in its proper position by means of the frame H. The rope J is then hooked on, and the truck C tilted till its back end rests on the trestle G. If the trolley P is empty or only lightly loaded (up to 2 tons, for instance), the rope J is arranged with a single purchase-block. One end of the rope is made fast to the central hook *r* of the tilting-truck, and passes thence over the roller in the crutch of the fork of the tilting-truck, over a hinged snatch-block arranged centrally on the chassis at the same height as the capstan, and then takes several turns round the drum *d*. Two or three turns are sufficient for the empty trolley, and four turns for a load of 2 tons. Above 2 or 3 tons the cable is given a double purchase by the use of pulley-block M, Fig. 4, on this page. The free end of the rope is made fast to the front of the chassis, and the pulley-block hooked to the central hook *r* of the truck, and four turns of the rope are taken round the capstan barrel. The motor having been started, the capstan is engaged in gear by means of the lever to the left below the seat. A slight pull on the free end of the rope ensures the hauling into place of the loaded trolley. Two men are necessary for the operations of loading and unloading, the one who is seated in the driver's seat being under the orders of the other; it is necessary that the driver should be ready to stop the operation by slowing the engine or de-clutching in the event of the strands marrying on the capstan-drum; this can only occur if the barrel is allowed to become rusty and the rope is caked with mud. When the truck tilts, one or two turns of rope can be taken off the barrel, and the operation completed with two turns only.

Unloading.—1. *Quick Unloading.*—The trestle G should be set up, and the frame H hooked on. Then the men push or lever back the trolley P from the cleats along the flange R (Fig. 2) until the truck C tilts over, when the trolley P rolls off and stops after rolling a short distance on the ground. To start the trolley backwards, the capstan and the wire rope K may be used, the rope being hooked at *s* (Fig. 1) and the cables pass round the pulleys O and N, and then twice round the drum of the capstan.

2. *Slow Unloading.*—To effect this, the men must hook the cable at *r* and lever the trolley back, keeping the cable taut; this may be done by taking two turns round the capstan drum and slacking out the free end, the capstan being, of course, locked.

3. *Unloading in Bulk.*—The loose cross-bar T at the back of the trolley should be removed; the trestle G is not required. The chain U to the right, at the front of the truck (Fig. 2), must be hooked on to the front hook *s*, on the right of the trolley. When this is done, the men tilt the truck over. The back of the truck then bears on the ground while the trolley P is retained on the truck C by the chain U, and the load falls out in bulk on to the ground. If necessary, the vehicle is drawn forward clear of the load.

MOTOR-LORRY DRIVING AND STEERING BY ALL FOUR WHEELS.

A general arrangement and plan of this motor-lorry is shown in Fig. 5. The box containing the motor and the machinery is situated between the two axles, and the driver's seat is arranged above this. The motor is on the left side of the chassis. The gear is contained in a steel box, which serves to brace the frame-plates together. The main shaft is hollow, to allow the driving-shaft of the motor to pass through and to carry the clutch-gear behind the gear-box. The gear-box is fitted with four speeds forward and a reverse at each speed; it also contains a clutch for working the capstan. Two Cardan joints connect the gear-box with the two differential gears of the front and back axles respectively. The road-wheels are

* Paper read before the Institution of Mechanical Engineers, at Paris, July 8, 1914.

driven by means of internal racks, which are fixed to them, through pinions carried in bearings resting in the stub-axle forgings. The pinions are driven by Cardan joints arranged coaxially with the steering-axes of the stub-axles, so that they can follow the wheels with the steering movement of the stub-axles. The front and back axles are identical in design, as also are the road-wheels, which are interchangeable. A compensating lever connects the front ends of the two front springs to enable the vehicle to travel over uneven ground. The car carries a platform at the back and one at the front, both of which are fitted with sides and ends. This permits of the platforms being so loaded that the load on the wheels is equalised. The principal particulars are:—

Main Characteristics.

Length	19 ft. 0.4 in.
Width over all	6 ,, 10.2 ,,
Wheel-base	11 ,, 1.9 ,,
Gauge	5 ,, 8.8 ,,
Diameter of wheels	3 ,, 3.37 ,,
Double pneumatic tyres	120 mm.
Outside diameter of turning circle	42 ft. 7 in.
Horse-power of motor at 1000 revolutions per minute...	40 h p.
Bore of cylinder	4.91 in.
Stroke	5.51 ,,
Weight empty	5 4 tons
Weight in running order	7.4 ,,

The following table shows the working conditions. The speeds correspond to 1000 revolutions of the motor per minute; this rate can be increased to 1200 revolutions.

Distribution of Load.

Front wheels	3.5 tons
Back wheels	3.9 tons

Load on Driving-Wheels.

At half total weight	3.69 tons
At one-third total weight	2.46 tons

Gear Ratios and Speeds.

Diameter of driving-wheels	3 ft. 3.37 in.
Bevel-gear ratio	13/46 teeth
Reduction at the road-wheels	15/62 teeth

—	First.	Second.	Third.	Fourth.
Speed in miles per hour (1000 revolutions)	1.8	3.5	5.9	10.6
Ratio of speeds	1	1.97	3.3	6
Calculated efficiency	80	80	80	80
Tractive effort in tons ..	2 9	1.5	0.90	0.49

Performance of the Car when Running on Good Roads and Bad Roads.

Roads.		Load Carried, 1.9 Ton.			Load Carried, 1.9 Ton. Load Hauled, 14.6 Ton		
Hard.	Soft.						
Coefficient of Traction.		Total Load, 7.3 Tons.			Total Load, 16.5 Tons.		
44.09 Lb. per Ton.	88.18 Lb. per Ton.	Tractive Effort.	Gear.	Speed. Miles Per Hour.	Tractive Effort.	Gear.	Speed. Miles Per Hour.
gradient per cent.	gradient per cent.	tons			tons		
Level	—	0.15	4th	12.43	0.45	4th	10.56
2	Level	0.3	4th	12.43	0.9	3rd	5.9
4	2	0.45	4th	12.43	1.35	2nd	4.04
6	4	0.6	3rd	7.15	1.8	1st	2.18
8	6	0.75	3rd	7.15	2.25	1st	2.18
10	8	0.9	3rd	6.21	2.7	1st	2.18
12	10	1.05	2nd	4.04	Capstan		
14	12	1.2	2nd	4.04	,,		
16	14	1.35	2nd	4.04	,,		
18	16	1.5	2nd	4.04	,,		
20	18	1.65	1st	2.18	,,		
25	23	1.99	1st	2.18	,,		
30	28	2.4	1st	2.18	,,		

Petrol Consumption.

	Miles per Gallon.
Empty	(about) 7.24
Loaded (1.9 tons)	(,,) 5.76
With carried load of 1.9 tons and towed load of 14.6 tons	(about) 1.89

These figures are for a well-maintained and well-driven car running on roads in fair condition.

Approximate Weight.

	Tons.
Lorry empty (in running order)	5.4
Maximum load	1.9
Total	7.3

The capstan can work at four different speeds according to the notch occupied by the gear-change lever. These correspond to rope speeds of 11.8, 23.6, 39.4, and 70.8 in. per second. Only the first and second speeds appear to be of practical use. The capstan can give a tractive effort of about 3 tons, using the first and second speeds with four turns of rope. The latter is of hemp, $1\frac{3}{8}$ in. in diameter; breaking load, 7.4 tons; weight per metre (39.37 in.), about $2\frac{1}{4}$ lb. The equipment of the tractor consists of: (*a*) A hemp rope, 60 yards long, provided with a spliced hook at one end—wound on the box-cover of the capstan; (*b*) Steel extension ropes, about 22 yards long, for hauling from distances over 55 yards. With these ropes distances of 66 yards to 109 yards can be reached and the load made to advance in stages. The extension ropes are wound at the back of the seats; (*c*) A pulley-block, so that the pull can be doubled; (*d*) Wedges and spikes for anchoring the lorry during loading operations; (*e*) Non-skid chains for the wheels; (*f*) Two small portable bridges for getting over trenches; (*g*) A handspike, crowbar, shovel, pick, chains, blocks, &c., for various purposes, as required.

SOME RECENT IMPROVEMENTS IN CASE-HARDENING PRACTICE.*

By HENRY L. HEATHCOTE, B.Sc., Coventry.

IT is obviously out of the question for any one man—especially if he be a works' chemist and beset daily with demands only adequately to be met by omniscience—to attempt to give a comprehensive account of recent improvements as suggested by the title of the present paper, since for the most part these are known only to the hardening staff of the several works where they have been evolved, and very few filter through to publication. Not much information on the subject chosen is to be found in the English literature; and the best way for the author to treat it appears to be for him to give an account of what has been done at Rudge-Whitworth works; of how the problem presents itself, and how a solution has been sought; hoping that a frank statement may elicit from other members some account of their own experiences and recent improvements.

Even to the casual visitor and the superficial observer it must be obvious that, generally speaking, the machine-shop is ages in advance of the hardening-shop. In the machine-shop are to be found highly differentiated machine-tools, each the last word in scientific design and construction, embodying the best engineering knowledge and skill of many nations. The tools, as often as not of high-speed steel, and the grinding-wheels are both the outcome of special research in different branches of chemical industry. The men are well trained and well paid, and the organisation of the shop is another testimony of the stage of development arrived at. Not only are its tools, its plant, and its employees of superior grade, but its output is subjected to strict viewing by skilled men using instruments of precision. Needless to say, this reacts on the shop as a whole, and makes for rapid rectification of faults and a high standard in every part.

Compare this state of affairs with that prevailing in a typical hardening-shop some years ago.

Instead of a well-lit, well-ventilated, and comparatively clean shop, we find a dark, grimy shed, something like a miniature gas-works, unbearably hot and reeking with cremated ox-remains and fishy oil. Here a gang of men pound a dusty black mixture into iron pots round some of the articles that have just come from the machine-shop or automatic-shop; there another gang, equally grimy, but more oily, wield tools that Tubal Cain may have used—their plant, crude furnaces, uncontrolled save by the unaided eye.

Not only were their tools and plant crude, their materials and labour were crude too. The labour employed was anything but skilled, and the case-hardening compositions savoured more of quack medicines than British Pharmacopœia preparations. What little viewing was done threw little or no light on the causes of distortion, softness, or cracks. And this was the shop to whose tender mercies much of the machine-shop output was handed over, there to be made or marred.

This, then, was the problem: to raise this outcast, isolated, and forlorn process of chemical industry to the dignity and standing of machine-shop practice; to investigate the materials it employs, and throw light on their mode of action; to provide simple means of controlling the furnaces and of measuring the resultant hardness and resistance to shock; in a word, to do for the hardening-shop what science and industry had already done for the machine-shop.

An Improved Pyrometer. — We started out at the furnace end and decided to instal pyrometers, but were soon met by the fact that an efficient pyrometric outfit for a battery of thirteen muffles is an expensive thing, especially for an industry where the competition is so keen and the work so varied. Moreover, it threatened to cost something to keep it in working order; and, on second thoughts, it seemed very questionable whether thermo-electric and resistance pyrometers would be suitable for a system starting with a hot furnace full of cold work, or for ascertaining the temperature of an isolated article.

The Féry instruments were then unknown, so the author started investigations at the Rudge-Whitworth Research Laboratory, with the object of ascertaining the temperature of red-hot bodies from their colour. On examining the spectrum of a red-hot piece of steel it was found to elongate at both the red and violet ends, and to increase in intensity all along as the temperature rises. This suggested the possibility of ascertaining the temperature of red-hot bodies by means of a direct-vision spectroscope provided with a graduated scale (also used by Hempel), but it soon became evident that the difficulty of seeing just where the green ended precluded the possibility of anything approaching accuracy, and the extension of the red end was not sufficient for the purpose. Attempts were made, by screening off the brighter parts of the spectrum, to render the green or blue end more distinct, but it was found that the end point varied considerably with the same observer, and that many eyes cannot focus a sharp image on the retina when pure blue or green rays are transmitted.

Fig. 1 represents the spectra of red-hot steel in air, as seen by the author. The ordinates are estimated and the abscissæ measured.

Fig. 2 is a diagrammatic representation of two superposed spectra of red-hot steel, one representing a higher temperature than the other. The difference between the radiation at the two temperatures is D. If we could separate this difference from the radiation C common to both and measure it, we should be in the best possible position for ascertaining the temperature of red-hot bodies—much better than, for instance, by comparing the radiation C with C + D. This suggested that a solution just capable of absorbing all the coloured rays from steel at, say, 760 deg. Cent. would transmit the excess intensity and extra wave-lengths of the rays emitted at 800 deg. Cent., and the object would be visible. This was found to be as expected, and a long series of experiments was carried out to try and produce solutions and mixtures of solutions or emulsions, the absorption of which closely followed, both in range and intensity, the radiation curves for steel at different temperatures.

The Selection of Dyes.—Light from an acetylene flame was passed through the coloured solutions, organic and inorganic, and of various concentrations, then analysed by a spectroscope, and the absorption spectra plotted; but the difficulty and endless work involved in determining the intensity (or degree of absorption) of the various colours made it commercially necessary to be content with an approximation to the required curve.

In conducting these experiments the author found that the eye is certainly more sensitive to small variations in the region of the dark red than in any other region, and this led to choosing dye solutions that transmitted an excess of red. A very feeble light, whatever the colour, appears grey or greyish green. This is said to be due to the rods of the retina being more sensitive to light than the cones. As soon as the intensity becomes sufficient the cones respond and give the impression of colour. When the observer is looking through one of these dye solutions the object is either invisible or very faintly visible, and it is found that the change from this grey or greyish green to dark red is far sharper than the change to any other colour tried—particularly the greenish blue at the end of the spectrum of steel at 700 deg. to 1000 deg. Cent. It is found that, with solutions of this kind, a difference of temperature of 5 deg. Cent. can be detected; that is to say, an excess of 5 deg. Cent. sends sufficient radiations to the eye (D in Fig. 2) to render the object visible through the solution in question. Different observers are found to agree closely as to the temperature, showing that the error due to the different sensitiveness of different eyes is but little greater than the experimental error. With untrained observers the error may be 10 deg. Cent.

Permanence of Dye Solutions.—Having found a range of solutions capable of absorbing the rays emitted by red-hot steel at various temperatures, and at the same time suited to the peculiarities and conditions of the eye, the author proceeded to investigate the permanence of the various mixtures in the dark and under the action of light; also their behaviour in contact with retaining vessels such as glass and india-rubber. Some were found to decompose on keeping, some changed in colour, some precipitated; others were found to be soluble in glass. Some were found to withstand the action of light, in contact with glass and india-rubber, without any apparent change. Professor Campion has independently confirmed the stability of some of the dyes chosen by the drastic test of exposing two pairs of cells to full sunlight for over a year. He found no deterioration in the solutions.

Calibration of Dye Solutions.—The chosen solutions were then calibrated by viewing the end of a steel cylinder heated in an electric furnace and taking the temperature of the steel at the moment it ceased to appear visibly red by means of a platinum platinum-rhodium thermo-couple pushed close up to the back of the cylinder end. To remove any possible error due to the temperature of the junction being perhaps not exactly the same as that of the visible end of the cylinder, the calibration of the couple was effected by melting a number of pure substances of known melting-point on a minute ledge on the flat end. For temperatures above the scope of this arrangement the thermo-couple was dispensed with, and the melting of, for instance, nickel and platinum observed through the cells. This is, however, hardly the occasion to enter into details regarding the calibration and the precautions taken to ensure accuracy and some approximation to "black body" conditions.

Design and Method of Use.—In one of its forms the instrument (Fig. 3) has a stereoscope-like eye-shield to guard the eyes from extraneous light. Instead of two lenses there are two pairs of dye solutions well protected by caps, which also serve to keep the light out. This form is suitable when some particular temperature is required. For instance, the case-hardening temperature is now controlled by employing an instrument like this, with one pair of cells containing dye solution adjusted to 900 deg. Cent. and the other to 925 deg. Cent. If the pots are visible through the 900 deg. pair and invisible through the 925 deg. pair, the temperature is considered correct. There is no need to remove the eyes while the pairs are changed; this is done by sliding the aluminium carrier to one side or the other. For reheating work, and for hardening tools, a single pair is all that is necessary. The hardening temperature is attained as soon as the work appears just visibly red. For double reheating two pairs are, of course, necessary—*e.g.*, 760 deg. and 880 deg. Cent. The cells can be interchanged and are readily detachable, so one instrument can be used to ascertain any temperature, provided the object be visibly red hot. The actual container is a glass tube less than 1 in. long, with accurately-fitting glass ends, held together on rubber

* Paper read before the Iron and Steel Institute.

rings by two telescoping brass tubes. In form the cell is much like a short polarimeter tube. The caps on the aluminium slides are provided with springs to prevent the cells falling out.

In another form the instrument is adjustable and is either monocular or binocular. In these the dye solution is contained in expansible cells, and a range of absorptive powers obtained by altering the length of the column looked through. The first of this form was made with two thick glass ends and a length of inner tube from a bicycle tyre. On squeezing the glass ends together, the rubber sides bulge outwards. Fig. 4 is an example of the present form; the actual container is enclosed in this tube, which is provided at one end with an eye-piece shaped to fit the eye and nose, and at the other with a screw-end, which lengthens the cell until the added part is sufficient to just absorb the light corresponding to area D in Fig. 2.

The temperature is then given by the scale engraved on the tube, much as a micrometer is read. This form is, perhaps, not quite so accurate as the form with each cell specially made to one temperature, and according to a National Physical Laboratory report the error may be ± 10 deg. Cent. Within the experimental error from 700 deg. to 1150 deg. Cent., the temperature in degrees Centigrade to which the column corresponds is a linear function of the length of the column of the dye solutions selected. In this form the instrument is 3 in. long by 1½ in. in diameter and is very handy.

This method of determining temperatures is a zero method, and is therefore, *ceteris paribus*, more accurate than one involving a comparison of colours. Furthermore, the critical point occurs when the eye is shaded from extraneous light—that is, when the pupil is dilated and the retina is in its most sensitive condition. In judging temperatures by the unaided eye errors are caused by:—

1. Extraneous light falling on the eye.

a perforated screen between it and the instrument. One way to make an observation is to adjust the instrument to a lower temperature than that expected, and then, by sliding darker cells into position, or by unscrewing (if the adjustable form), darken the image until it just ceases to appear coloured. The temperatures engraved on the cell or the body of the instrument will then indicate the temperature of the hot body, provided that the conditions

Fig. 1.

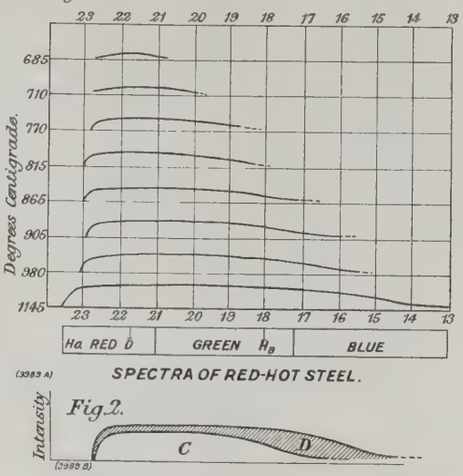


Fig. 2.

periphery inwards. The composition of case-hardening materials varies very widely. The following table shows the range of variation in seventeen commercial "compositions" tested:—

TABLE I.—*Range of Variation in Seventeen Commercial "Compositions."*

	Per Cent.
Moisture	2.68 to 26.17
Oil	0.17 ,, 20.76
Carbon (organic)	6.7 ,, 54.19
Calcium phosphate	0.32 ,, 74.75
Calcium carbonate	1.2 ,, 11.57
Barium carbonate	nil ,, 42.0
Zinc oxide	nil ,, 14.5
Silica	nil ,, 8.14
Sulphates (SO_3)	trace ,, 3.45
Sodium chloride	nil ,, 7.88
Sodium carbonate	nil ,, 40.0
Sulphides (S)	nil ,, 2.8

When these experiments were commenced the mixture of barium carbonate, 40 per cent., and charcoal, 60 per cent., suggested by Guillet had not been put forward, and it was customary to use case-hardening compositions once only or perhaps twice. Another drawback experienced in commercial operation, for instance, with pots 10 in. high by 10 in. in diameter, was the difference in the depth of penetration near the middle and the outside of the pot. Some compositions showed as much as 150 deg. Cent. difference in temperature between the inside and the outside. The author accordingly set out to improve:—

1. Permanence, and to obviate loss of activity and consequent wastefulness.

2. Permeability to heat, and to obviate unequal heating and casing.

Permanence.—The supposition that this loss of carburising power was due to loss of nitrogenous constituents was confirmed by the author's early experiments.

Spent hardening mixture may contain 12 per cent.

OUTSIDE VIEW. INSIDE VIEW.

FIG. 3. PYROMETER FOR OBSERVING TWO TEMPERATURES.

FIG. 4. ADJUSTABLE FORM OF PYROMETER FOR OBSERVING TEMPERATURES OVER A RANGE OF 400 DEG. CENT.

Fig. 5. RISE OF TEMPERATURE OF CHARCOAL OF VARIOUS SIZES CONTAINING ABOUT 6 PER CENT. MOISTURE.

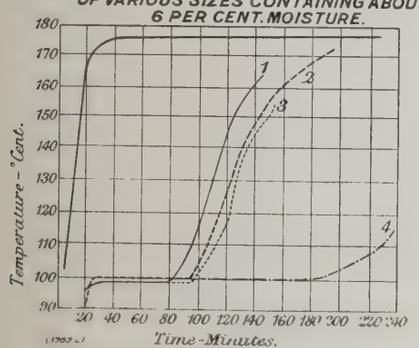


Fig. 6. RISE OF TEMPERATURE OF DRY CHARCOAL OF VARIOUS SIZES.

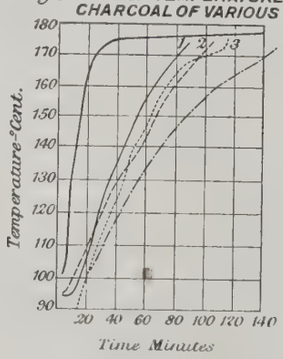
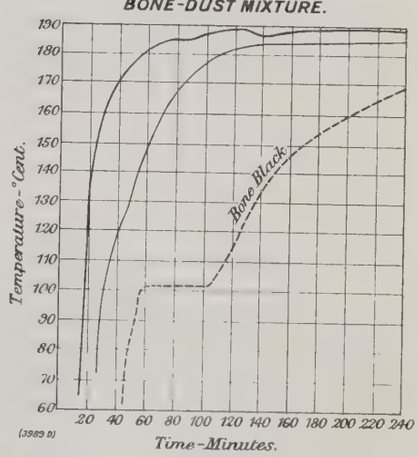


Fig. 7. COMPARISON OF SODA-ASH CHARCOAL MIXTURE & BONE-BLACK BONE-DUST MIXTURE.



2. The difficulty of remembering close shades of colour.

3. Errors of judgment in comparing the image of the colour observed with a series of mental images of colours previously seen.

All these chances of error are eliminated by an instrument of this kind. No extraneous light falls on the eyes and no recollection is required; the hardener has simply to look through, wait about half a minute until his eyes have become accustomed to the darkness, and then see whether the object is visible as a dark-red patch or invisible. Hardeners seem to prefer to use their eyes for telling the temperature, and these instruments provide pyrometric equivalents for limit-gauges and screw micrometers, and at the same time screen the eyes from the glare and heat of the furnace.

The readings are admittedly dependent on the sensitiveness of the eye; if this varies from person to person the temperature readings will vary accordingly, being lower the more sensitive the eye. As already stated, these variations do not affect the accuracy momentously, and from actual experiments carried out with this and with another optical pyrometer working under very similar conditions, the author feels compelled to believe that the variation in sensitiveness, under the actual working conditions of these instruments, is not nearly so great as might be expected.

If the object be a large one, it is advisable to interpose

of the test are as nearly "black body" as those obtaining when the calibration was effected. Fortunately, red-hot iron and steel surfaces have an emissivity of nearly unity, so the error is not large, and can generally be neglected for industrial purposes. Furthermore, any error from this source will not prevent the instrument giving comparative readings under similar conditions, which is all that is necessary in repetition work.

These instruments have been applied with satisfactory results to the heat treatment of steel, carburising, reheating, annealing, and hardening tools of all kinds. One has outlasted two thermo-electric pyrometers, and it is the author's opinion that a pyrometer which indicates its own temperature may convey some idea of the temperature of the work, but will never be the hardener's friend to the same extent as one of the forms of optical pyrometer which can be focussed on the article itself.

Case-Hardening Compositions.—Having provided a simple and effective device for ascertaining the temperature of red-hot bodies, the author set about investigating case-hardening compositions—their nature, mode of action, and effect. Obviously for carburising to occur (1) the heat must first penetrate to the steel and raise it to the gamma condition; it must (2) liberate and maintain a supply of the carburising ingredients; (3) the peripheral layers of the steel must combine with (or dissolve) these ingredients; and (4) the carbide must diffuse from the

organic carbon (total carbon, less carbon in carbonates), and yet, under similar conditions, have far less carburising power than fresh material containing less carbon. Such spent mixture gives indication of only traces of nitrogen. Two similar compositions, one having a much greater carburising power than the other, gave the following results by the Kjeldahl test:—

Composition.	Nitrogen Per Cent.
Good	2.72, 2.60
Bad	0.51, 0.47

Indirect evidence of the influence of gases (possibly nitrogenous) evolved from the mixture is afforded by the results of the following comparative tests, which show that it is possible to carry off the carburising gases by a current of coal-gas in much the same way that oil is removed by steam distillation (see Table II.). On the other hand, heating in gases which contain no nitrogen compounds may carburise mild steel (see Table III.).

Experiments extending over a considerable time and range of compositions have confirmed the following supposition:—1. The depth of case depends chiefly on the temperature the steel attains and the duration of the hot condition. On these factors depend the rate and extent of the diffusion of the carbon or carbide. 2. The concen-

SOME RECENT IMPROVEMENTS IN CASE-HARDENING PRACTICE.

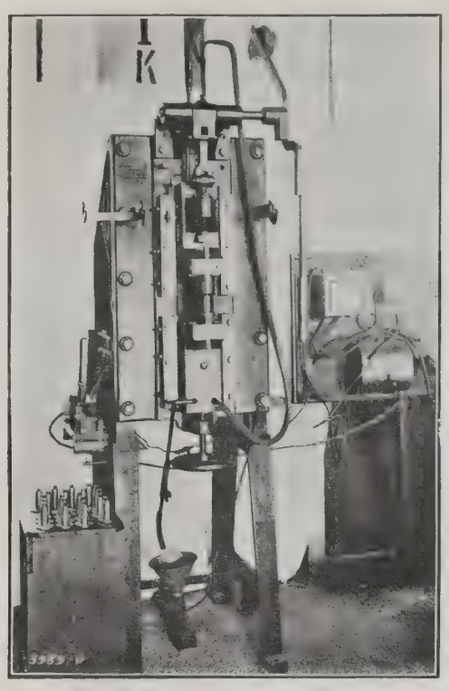


FIG. 8. ELECTRIC WELDER ARRANGED FOR TEMPERING CASE-HARDENED ARTICLES.

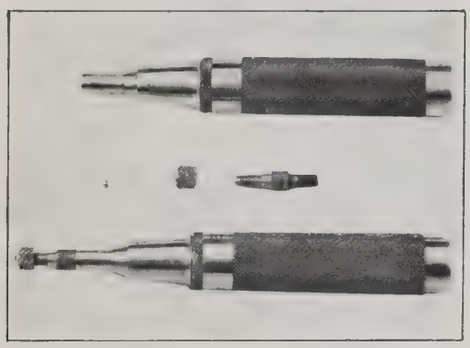


FIG. 9. MODIFIED AUTOMATIC CENTRE PUNCH FOR TESTING RESISTANCE TO IMPACT.

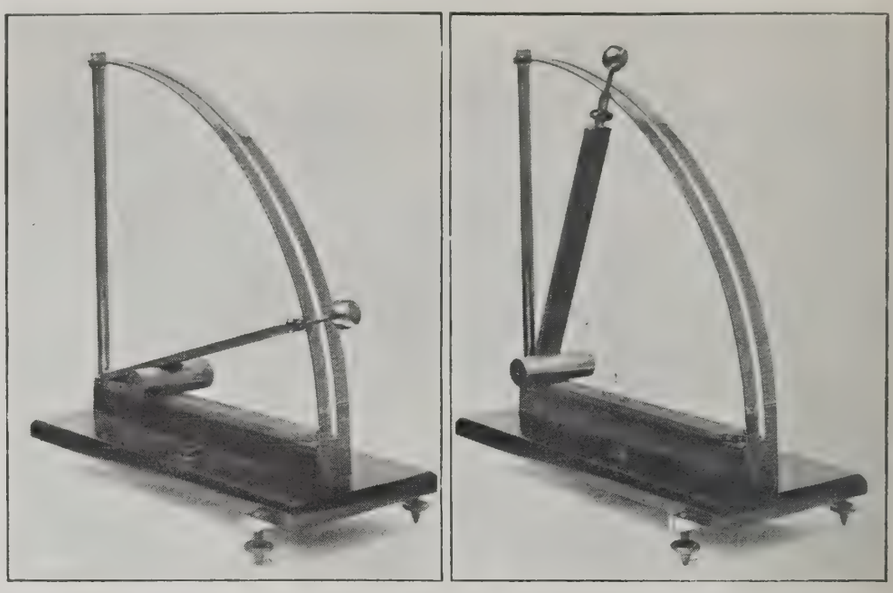


FIG. 10. QUADRANT SCLEROMETER FOR TESTING HARD AND SOFT BARS; TWO-FILE FORM.

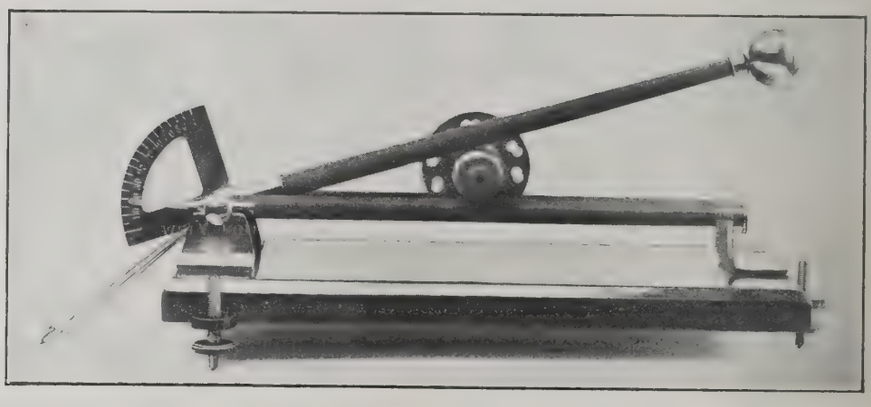


FIG. 11. QUADRANT SCLEROMETER; PORTABLE THREE-FILE FORM.

FIG. 12. QUADRANT SCLEROMETER; PORTABLE THREE-FILE FORM; DETACHED FROM STAND.

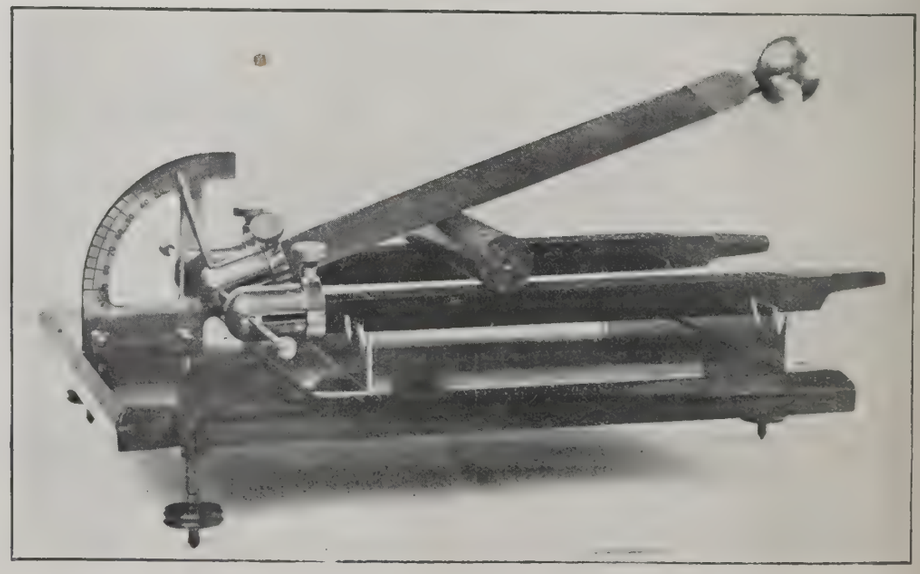


FIG. 13. QUADRANT SCLEROMETER; ADJUSTABLE THREE-FILE FORM.

TABLE II.

Composition : 50 per cent. bone-black ; 25 per cent. bone-dust ; 25 per cent. oil.

Experiment.	Without Coal-Gas.	With Stream of Coal-Gas through Mixture.	
No. 1	Case, 0.0374 in. ; saturated	Case, 0.0296 in. ; unsaturated	Slow stream
No. 2	Case, 0.045 in. ; saturated	Case, 0.038 in. ; unsaturated	Slow stream
No. 3	Case, 0.043 in. ; saturated	Case, 0.024 in. ; unsaturated	Faster stream

Time, 2 hours ; temperature, 900 deg. to 925 deg. Cent. ; rods, ¼ in. round.

FIG. 14. QUADRANT SCLEROMETER FOR TESTING FLAT SURFACES.

TABLE III.—*Case-Hardening in Gases.*

Temperature about 880 deg. Cent. Rods, ¼ in. round.

Gas.	Results.		Case.
Acetylene, pure, ¾ hour	Acetylene completely decomposed ; carbon deposited on specimen		0.0064-in. thick ; unsaturated
Acetylene, 1 vol. ; coal-gas, 3 vols. ; 1 hour	Specimen coated with carbon		0.0117-in. thick ; unsaturated
Acetylene, 1 vol. ; coal-gas, 12 vols. ; 1 hour	Do.	Do.	On one side, 0.0147 in. thick ; unsaturated
Acetylene, 1 vol. ; coal-gas, 20 vols. ; 1 hour	Do.	Do.	On one side, 0.0117 in. thick ; unsaturated
Acetylene, 1 vol. ; coal-gas, 40 vols. ; 1 hour	Do.	Do.	Only where carbon deposited 0.0117 in. thick ; unsaturated
Coal-gas bubbled through carbon disulphide ; 1 hour	Do.	Do.	No case ; layer of sulphide formed

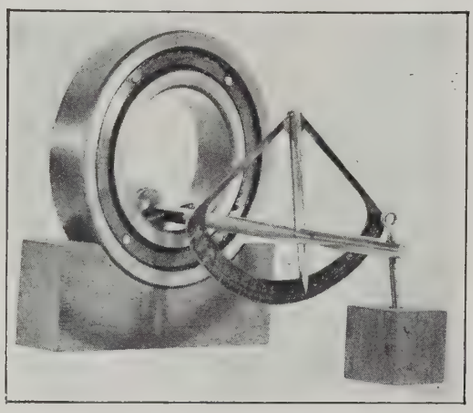


FIG. 15. QUADRANT SCLEROMETER FOR TESTING CONCAVE SURFACES.

FIG. 18. SWINGING HAMMER ARRANGED FOR TESTING SMALL ROLLERS.

tration of the carbon in the case depends chiefly on the "activity" of the mixture, or rate at which it or its products part with carbon to the steel. The concentration of carbon in the surface layers may increase or decrease with temperature, but usually increases as the temperature rises and with the time. 3. The duration of the hot condition for a given time of heating depends chiefly upon the permeability to heat of the case-hardening composition.

Exhaustion Tests.—Comparative depth of penetration has been the subject of a number of investigations, but is so much dependent on factors other than the case-hardening composition that the author has sought for some other test. The one finally adopted is to take a known volume of the composition, and ascertain the volume of the "case" that can be got from it without replenishing. The ratio total volume of case : initial volume of case-hardening material affords a good indication of the efficiency of the composition, and is not so dependent as a single penetration measurement on other factors, such as size of pot, number and size of the articles it contains, loss of heat from furnace-walls when the pot is introduced, &c. These "exhaustion" tests have been made in pots of various sizes, but usually in nickel-plated-steel tubes 7 in. long by 1½ in. in diameter, and heated in a laboratory muffle for 1½ to 2 hours, starting with the muffle hot. A fresh piece of mild steel, such as ⅝ in. round, is used for each heating, and the period is that required to give, at 900 deg. to 930 deg. Cent., a case deep enough for commercial use—viz., 0.015 in. to 0.065 in. Transverse sections are examined microscopically, and the mixture is considered to be exhausted when ferrite bands can be seen between the pearlite grains at the periphery—that is, when the case is unsaturated. With most commercial case-hardening mixtures it is usual to find that the periphery is unsaturated after six or seven heatings of 2 hours each. The results of testing some experimental mixings are to be found in Table IV.

An Improved Case-Hardening Composition.—The last mixture in the above table is eminently suitable on the score of permanence, and can be used over and over again indefinitely, provided that the inevitable waste involved in commercial usage is made up from time to time with fresh composition, and that the ingredients are well incorporated and in the proper proportions. The author was led to combining charcoal with potassium carbonate, sodium carbonate, and potassium hydrate by the results of tests on charcoal. This rapidly loses its carburising power. It also contains traces of potassium carbonate, which would react with red-hot charcoal and produce carbon monoxide.

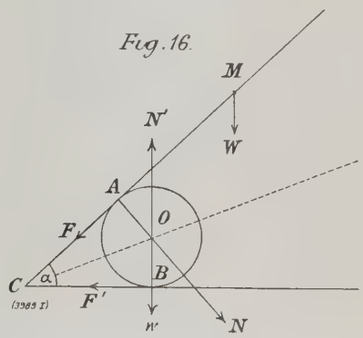
Incorporating a little potassium carbonate with exhausted charcoal is found to restore at once its carburising power and make it give up its carbon more readily than the original charcoal. The same is true when potassium hydrate or sodium carbonate is incorporated.

That the carburising power of such mixtures is due to nitrogenous compounds or cyanides is unlikely. Charcoal soaked in a 5 per cent. aqueous solution of sodium carbonate and dried, after three heatings contained :—

	Per Cent.
Nitrogen	0.12 (Kjeldahl)
Cyanides	nil

Yet this gave a saturated case even after the tenth, eleventh, and twelfth heatings.

The author has not fully investigated the nature of the reaction, but comparative tests show that charcoal in an atmosphere of carbonic oxide does not give quite



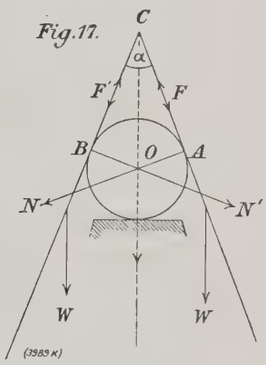


TABLE IV.

Mixture.	Ratio Total Volume of Case : Initial Volume of Mixture.
Anthracite 75 per cent., oil 25 per cent. ..	nil
Anthracite 95 per cent., potassium carbonate 5 per cent.	0.0042
Coke soaked in 10 per cent. aqueous solution of potassium hydrate	0.0048
Anthracite soaked in 10 per cent. aqueous solution of potassium hydrate	0.0061
Anthracite 90 per cent., calcium cyanamide 10 per cent.	0.0109
Crushed bone	0.0122
Anthracite 90 per cent., bone black 10 per cent.	0.0138
Wood charcoal..	0.0140
Charcoal 90 per cent., crushed bone 10 per cent.	0.0262
Wood charcoal 90 per cent., calcium cyanamide 10 per cent.	0.0331
Wood charcoal 90 per cent., crushed bone 10 per cent.	0.0368
Bone black	0.0405
Leather charcoal	0.0405
Wood charcoal 90 per cent., bone black 10 per cent.	0.0451
Charcoal soaked in 20 per cent. caustic potash 90 per cent., crushed bone 10 per cent.	0.058
Wood charcoal impregnated with soda ash	0.116

the same result as the charcoal and alkali mixture. Under similar conditions charcoal alone gave an unsaturated case ; charcoal and carbon monoxide gave a more saturated but still unsaturated case ; and the charcoal and alkali gave a saturated case.

Permeability to Heat.—Having found a composition far more permanent in its properties than any then in current use, the author proceeded to investigate the factors concerned in permeability to heat. Most commercial mixtures consist of, or contain a large proportion of, small particles which it seems reasonable to expect will block up all the interstices and prevent the free passage of heat, for it has been shown that the heat conductivity of insulating materials depends chiefly on their air spaces. To test this point, granular charcoal was employed, and two model case-hardening pots were made, 5 in. high, 3.7 in. in

diameter, and 0.04 in. thick, made of sheet steel and welded together. One contained the charcoal under investigation, and the other was used empty. A thermometer bulb was placed at the centre of each pot, and the apparatus placed in an oven at 180 deg. Cent. Fig. 5 shows the rise of temperature with time. The curve on the left shows the temperature at the middle of the empty pot; those on the right, numbered 1, 2, 3, 4, refer to charcoal of various sizes, each containing approximately the same proportion of moisture and taken from the same sack. The results are given in Table V.

TABLE V.

No.	Weight of Contents.	Charcoal.	Pieces per Gramme.	Moisture Lost at 110 Deg. C.
	grammes			per cent.
1	215	Would not pass through sieve 5 meshes per linear inch	36	6.30
2	209	Passed through 6 but not through 7 meshes per linear inch	130	6.17
3	215	Passed through 7 but not through 30 meshes per linear inch	450	6.23
	296	Passed through 30 meshes per linear inch	—	6.03

Two striking points are brought out by these results:—

1. The arrest of temperature at the centre at about 100 deg. Cent. while moisture is being drived off.

2. The effect of size of grain, and particularly of dust, upon the duration of the arrest.

When the same samples were again heated the temperature rose much more quickly (see Fig. 6). The absence of any arrest is, of course, due to the moisture having been expelled during the previous tests. Needless to say, the temperature at the core of a hardening-pot will not remain at 100 deg. Cent. for nearly three hours if the heating is done in a red-hot muffle; but the author has observed that there is an arrest, and another when other volatile matter begins to be given off, when the model pots are filled with oily bone-black and heated in red-hot lead at about 850 deg. Cent.

A mixture which can be used over and over again possesses the great advantage that moisture, oil, and other volatile constituents have, for the most part, been already expelled by the previous heatings. This is illustrated by the results plotted in Fig. 7. The curve on the right refers to a mixture of bone-black and bone-dust, and the middle one to the soda-ash and charcoal mixture, consisting of three parts used to one part not used, freed from all small particles and dust by means of a sieve with round holes, 0.08 in. in diameter. The two mixtures were heated at the same time, the curve on the left showing the rise in temperature of a similar empty pot.

To see if these results represented anything of commercial importance, the author carried out some tests in pots 10 in. high by 10 in. in diameter, with coarse and fine mixtures having the same composition. The same number and kind of articles were packed in each pot, and test-pieces, 1½ in. by ½ in. square, were placed near the top and bottom and at the middle of the pot. The pots were then heated together for five hours, the maximum temperature being about 925 deg. Cent. These test-pieces were reheated to 760 deg. Cent. and quenched in water to show the depth of the case.

Table VI. represents the results:—

TABLE VI.

	Fine.	Coarse, as No. 3.
	in.	in.
Top	0.025	0.045
	0.03	0.05
Middle	0.02	0.04
	0.025	0.04
Bottom	0.03	0.045
	0.03	0.05

The figures denote the depth of case.

In another test done on a commercial scale the author compared the mixtures referred to in Fig. 7. The test-pieces were placed at the middle only. The pots were 9 in. high by 9 in. in diameter, and heated for four hours side by side, the maximum temperature being about 925 deg. Cent. One pair of test-pieces was then reheated, as in the previous comparison, and the other sectioned and examined microscopically:—

TABLE VII.

One-Third Bone Black, One-Third Crushed Bone, One-Third Spent Bone. Size as No. 3. Not Free from Dust.		Charcoal. Size as No. 2, Impregnated with Soda Ash. Free from Dust.	
	in.		in.
Hard	0.01	Hard	0.03
Soft	0.015	Soft	0.04

The figures denote the depth of case.

Composition of the Case.—Having secured a considerable improvement in both permanence and permeability to heat, it remained to ascertain whether this "composition" imparted a suitable percentage of carbon and gave uniform results from day to day. Mr. W. T. Flather has made a great number of determinations of carbon in the successive layers of the case, and was good enough to carburise some bars of Ubas steel in his standard pot, and under his standard conditions, but using the dust-free charcoal impregnated with soda ash, three parts used to one part fresh already referred to. The results of the carbon determinations (made in the Research Laboratory) are to be found in Table VIII. The bars were ⅝ in. in diameter and 6 in. long, and were carburised 4 hours at 925 deg. Cent. Successive layers, 0.0025 in. thick, were turned off all along, the end ½ in. being left on to avoid end effects. Some of the carbons were determined by combustion, and the others by the colour test, using the former as standards:

TABLE VIII.

	Carbon p.c.		Carbon p.c.		Carbon p.c.
Surface layer	1.050	11th layer ..	0.750	22nd layer ..	0.395
2nd layer ..	1.020	12th ,, ..	0.695	24th ,, ..	0.365
3rd ,, ..	1.015	13th ,, .	0.655	26th ,, ..	0.330
4th ,, ..	1.010	14th ,, ..	0.630	28th ,, ..	0.315
5th ,, ..	1.000	15th ,, ..	0.595	30th ,, ..	0.305
6th ,, ..	0.950	16th ,, ..	0.585	32nd ,, ..	0.305
7th ,, ..	0.880	17th ,, ..	0.535	34th ,, ..	0.275
8th ,, ..	0.840	18th , ..	0.505	36th ,, ..	0.255
9th ,, ..	0.830	19th ,, ..	0.480	38th ,, ..	0.227
10th ,, ..	0.810	20th ,, ..	0.440	40th ,, ..	0.205

The even gradation of the carbon content from surface to core is noteworthy. In a test on a commercial scale, extending over twenty-nine days, test-bars 1 in. in diameter were carburised along with ordinary work at 900 deg. to 925 deg. Cent., the mixture being replenished once or twice a week to make good the inevitable waste. The bars were cooled in the pots, and the surface layer turned off as above and analysed, with the following results:—

TABLE IX.

	Per Cent. Carbon.
New mixture	0.967
End of first day	0.909
,, fourth day	0.981
,, twenty-ninth day	1.06

The author considers 0.9 to 1.1 per cent. carbon satisfactory, and preferable to less than 0.9 per cent. The cementite does not appear to form laminæ unless the percentage of carbon is greater than 1.05; and for work that has to be ground a slight degree of supersaturation at the surface is considered necessary. Charred leather at 1000 deg. Cent. imparts about 1.3 per cent. carbon, at 925 deg. Cent. about 1.2 per cent. carbon, and Guillet's composition (barium carbonate, 40 per cent.; wood charcoal 60 per cent.) at 925 deg. Cent about 1.2 per cent.

These analyses disclose the average carbon content of the layer in question, but they do not give any evidence of uniformity. *A priori* it is quite possible that such large grains may produce local inequalities in the degree of carburisation. To test this point, the author has employed the colouring solution, also the scleroscope and sclerometer referred to later. Even when the case on 1-in. bars of Ubas steel was not more than 0.012 in. deep, the colour developed showed no indication whatever of local paucity of carbon. [The author exhibited a bar carburised in mixture made with No. 1 sized grains of charcoal (see Table V.).] It is uniformly hard all over, even after grinding off the outside layers of the shallow case. Had there been lack of uniformity from this cause it would have made itself evident also in the micro-sections of rods done in the exhaustion tests. This uniformity doubtless connotes a gaseous agent for conveying and maintaining the supply of carburising agent. Bars 1 in. in diameter, bound together, then carburised, separated, and quenched, are quite hard, even when no particles of the mixture could possibly have touched the steel.

It will be readily understood, therefore, that a composition of this kind, replenished regularly with a small proportion of fresh mixture, is capable of giving very uniform results. On account of its low specific gravity comparative freedom from dust, oil, and moisture, the heating-up period is a smaller proportion of the total time, so that less judgment is required in allowing for the size of pots, &c. The productivity of the hardening plant and staff is correspondingly increased, and the steel too is all the better for the shorter heating.

An Improvement in Tempering.—The use of hot tallow and lead for tempering is, of course, well known; but the application of an electric welder, which, the author believes, was originated by V. A. Holroyd, presents some novel and advantageous features. It is particularly useful for local softening or tempering (Fig. 8, page 136), and, unlike tempering in tallow, the core of the article is left softer than the outside. This is specially advantageous for case-hardened articles. The operation is a very quick one, and the surface is left quite clean.

Methods of Testing Hardness.—So far as the author is aware, very little work has been done to provide commercial means for testing the suitability of case-hardened articles. The practice of examining test-pieces carburised, heat-treated, and hardened along with each batch is, of course, sound as far as it goes. The Shore scleroscope and Brinell test have their spheres of usefulness. But still the file is the instrument most used, and perhaps rightly, for it does give an idea of the resistance the surface of the article offers to abrasion under pressure, which is what most articles are case-hardened to withstand. This and the Brinell test are, the author believes, the instruments in commonest use for testing case-hardened work and test-pieces.

For small articles the modified centre punch illustrated in Fig. 9, page 136, is particularly suitable for rapidly getting a working idea as to whether the case is above the minimum permissible depth. It is an ordinary 6-in. Brown and Sharpe automatic centre punch to which the author has fitted a screwed-on container for holding a ⅛-in. bicycle ball, as shown in the upper illustration. The hard point has been removed and the container screwed on in its place. The ball protrudes just sufficiently to prevent the container coming into contact with the article under test. This is very useful for large as well as small articles, and its readings appear to refer more to the case and less to the core than those obtained with a Brinell testing-machine.

An Improved Sclerometer.—On account of the variable element in testing resistance to abrasion with a file by hand, the author sought to devise means for measuring the friction under a given load. A pair of "scissors," with files in place of shears, was found to be cumbersome, and the weight of the article introduced variations according to the position the scissors were held in. Small flat articles can be placed on the top of a file, and the hardness gauged by raising one end of the file and observing the angle when the article slides. This led to placing the article under the file so that its weight causes relative motion, which motion ceases (if not too rapid) when the frictional forces are great enough. This instrument (Fig. 10) is for testing round surfaces. A soft bar holds the top file up so that it makes an angle of about 70 deg. with the bottom one. The actual angle is indicated by figures engraved on the slotted quadrant. A hard bar will not hold the file up until the angle falls to about 15 to 20 deg. A hardened and tempered bar gives readings between these angles according to the degree of temper.

Figs. 11 and 12 illustrate a portable form adapted for measuring the hardness of parts that cannot be brought under the first form. With this it is as easy to measure the hardness concerned in resisting abrasion as it is to weigh with a spring balance. Another form adapted to take larger articles is made with three Δ files, so that the outer two can be moved further apart at will (Fig. 13). For concave surfaces, such as the ball-races of motor-car bearings, a different type (Figs. 14 and 15, page 137) is employed. Its essential part is a short piece of round file which, with its two ends resting on the bearings, slides down one side, or is deflected as the bearing is rotated. The angle taken up depends on the hardness and consequent friction, and is measured on a graduated quadrant.

For flat surfaces a short file is mounted in a holder which slides along a smooth bar until friction arrests the motion (see Fig. 14).

The readings, *ceteris paribus*, are within considerable limits independent of the diameter of the test-object.

Let

a = radius of test-object = O A = O B.
l = half length of upper file = C M.
α = angle between the files.
w = weight of object.
W = weight of upper file.

Consider the equilibrium of the test-body.

Resolving along CO, Fig. 16, we have—

$$(F + F') \cos \frac{\alpha}{2} = (N + N' - w) \cdot \sin \frac{\alpha}{2},$$

$$\therefore \tan \frac{\alpha}{2} = \frac{F + F'}{N + N' - w}.$$

Taking moments about O, we have—

$$F a = F' a,$$
$$\therefore F = F'.$$

Resolving vertically, we have—

$$N' = N \cos \alpha + F \sin \alpha + w.$$

Substituting we get—

$$\tan \frac{\alpha}{2} = \frac{2 F}{N (1 + \cos \alpha) + F \sin \alpha}.$$

Putting $\frac{F}{N} = \mu$, the coefficient of friction, we have—

$$\tan \frac{\alpha}{2} = \frac{2 \mu}{1 + \cos \alpha + \mu \sin \alpha},$$

which shows that the readings are independent of the weight and diameter of the test-body, provided the coefficient of friction does not vary with the diameter.

When used in the vertical position the investigation is somewhat different. Consider the equilibrium of the connected files in Fig. 17.

Resolving along CO, we have—

$$\pm (F + F') \cos \frac{\alpha}{2} = (N + N') \sin \frac{\alpha}{2} + 2 W.$$

The sign of the first term depends on whether C moved down or up just previous to equilibrium.

By symmetry—

$$F = F' \text{ and } N = N'.$$

Substituting we have—

$$\pm F \cos \frac{\alpha}{2} = N \sin \frac{\alpha}{2} + W,$$

or

$$\pm \mu \cos \frac{\alpha}{2} = \sin \frac{\alpha}{2} + \frac{W}{N},$$

$$\therefore \tan \frac{\alpha}{2} = \pm \mu - \frac{W}{N \cos \frac{\alpha}{2}}.$$

Consider the equilibrium of one side. Taking moments about C—

$$W \cdot l \sin \frac{\alpha}{2} = N \cdot a \cot \frac{\alpha}{2},$$

$$\therefore N = \frac{W l}{a} \cdot \sin \frac{\alpha}{2} \tan \frac{\alpha}{2} = \frac{W l}{a} \cdot \frac{\sin^2 \frac{\alpha}{2}}{\cos \frac{\alpha}{2}}.$$

Substituting in the expression containing μ we have—

$$\tan \frac{\alpha}{2} = \pm \mu - \frac{a W \cos \frac{\alpha}{2}}{W l \cdot \sin^2 \frac{\alpha}{2} \cos \frac{\alpha}{2}}.$$

Whence

$$\tan\frac{\alpha}{2} = \pm\mu - \frac{a}{l}\cdot\frac{1}{\sin^2\frac{\alpha}{2}}.$$

In this case, therefore, we should expect the angle to be independent of the weight of the files and test-body and to increase as its diameter decreased, the effect of the variation being less the longer the file.

Experiment shows that the angle is slightly affected by variation in the diameter, but in the opposite direction to that indicated above.

The results obtained with variously treated bars, 1 in. in diameter, are recorded in Table X.

TABLE X.

Treatment.	Quadrant Sclerometer.	Shore Scleroscope.
1-In. Bars Ubas Steel :—	deg.	deg.
As received	75	28
As received. Carburised five hours, cooled in pot	69	29
As received. Carburised five hours, reheated to 760 deg. Cent., quenched in water	20	89
As received. Carburised five hours, reheated to 760 deg. Cent., tempered one hour at 300 deg. Fahr.	28	88
As received. Carburised five hours, reheated to 760 deg. Cent., tempered one hour at 400 deg. Fahr.	33	82
½-In. Bars Ubas Steel :—		
As received	63	27
As received. Carburised five hours, cooled in pot	60	33
As received. Carburised five hours, reheated to 760 deg. Cent., quenched in water	18	76
As received. Carburised five hours, reheated to 760 deg. Cent., tempered one hour at 300 deg. Fahr.	26	71
As received. Carburised five hours, reheated to 760 deg. Cent., tempered one hour at 400 deg. Fahr.	36	70

Both the quadrant sclerometer and Shore scleroscope give lower readings for smaller diameters. With the former the difference is greater for soft, and with the latter for hard, bars. This is probably due to the file teeth in the one case, and the falling weight in the other, throwing up steeper "ramparts" round the depression when the surface is less convex.

For commercial testing of hardened work and within wide limits, the error due to varying diameter is negligible in the case of the quadrant sclerometer. That the instrument is very sensitive is shown by the way it detects slight degrees of tempering. Several are in regular use at both of the Rudge-Whitworth works, where they have to a large extent superseded the cruder hand test with ordinary files. They are handy and quick, and capable of dealing with large quantities of work in a short time. Instead of files, carborundum or alundum sticks or pencils may be employed, but files give very good results and last many months without showing any errors due to wear, provided they are properly made and appropriately aged before use. Various standards have been adopted for different articles, and the angle should come between the specified limits in order to pass the viewer

Production of Colours on Hardened Work to Facilitate Viewing.—Many articles, such as cups and cones, cannot be conveniently tested with a scleroscope or sclerometer on account of their shape. Realising the need for some method which would enable articles of all sorts to be tested in bulk, the author turned his attention to the production of colours on hardened surfaces which would afford an indication of the nature of the steel composing such surfaces. The ordinary solutions employed by the metallographer are unsuitable for commercial application, some because of their inflammability, others because they will not flow evenly over a somewhat oily or greasy surface. A suitable solution which has been found to give satisfactory results consists of—

Alcohol	1 litre
Distilled water	1 ,,
Nitric acid, pure	100 cub. cm.

Articles ground or polished after hardening and immersed in this for ¼ to 1 minute are stained brown or light blue where the structure is martensitic, dark blue or dark grey where there is troostite, and hardly stained at all on ferrite or pearlite.

By treating hardened articles in this way, before viewing, the inequalities are rendered visible, and can readily be detected. The fact that the whole of the surface is tested, and not merely the parts touched by the file, sclerometer, or scleroscope, is an enormous advantage for commercial purposes. The test reveals at once spots that have been splashed before quenching, and contain troostite, also superficial tempering due to a glazed surface on the grinding-wheel or to excessive pressure. It does not appear to be possible to obtain a calorimetric scale of hardness in this way, but when a number of articles are dipped at the same time the eye readily detects those that have a different appearance, and all that is then necessary is to check the odd ones with a file or sclerometer. This test is also suitable for tools and complicated articles that cannot conveniently be tested with an instrument. It also shows the depth of case if a part is left on and ground away, and should prove useful for ascertaining whether an article has been properly tempered.

The swinging hammer shown in Fig. 18, page 137, is the outcome of another attempt to replace the variable muscular force of the tester by the constant force of gravity. Instead of a skilled viewer wielding a hammer a boy utilises this simple instrument, which consists of an ordinary hammer swinging on a support passing through a bushed hole in the handle. The heavy steel block which carries the support is arranged to admit various holders adapted for receiving and, if necessary, clamping the parts to be tested. It has been found very useful for testing small parts, such as the rollers of motor-cycle engine-bearings, the blow being controlled by observing the angle on the graduated quadrant behind the hammer.

In bringing this paper to a close the author takes the opportunity of thanking the directors of Messrs. Rudge-Whitworth, Limited for permission to publish the information it contains.

THE INFLUENCE OF MOLYBDENUM UPON THE CORRODIBILITY OF STEEL.*

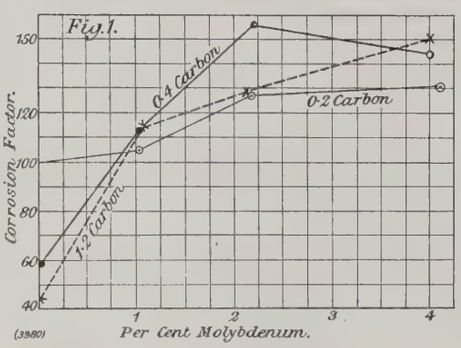
By J. NEWTON FRIEND, D.Sc., Ph.D., and C. W. MARSHALL, Worcester.

IN two recent communications Mr. Thomas Swinden† has given the results of a very thorough investigation of the influence of molybdenum upon the physical properties of steel, and it occurred to the present authors that the results might be made still more complete by a careful investigation of the influence of molybdenum upon corrodibility. They desire to express their heartiest thanks to Mr. Swinden for kindly providing them with samples of his steels with which they have been able to carry out the investigation detailed in the paper. They also desire to express their indebtedness to Messrs. Howell and Co., of Sheffield, who kindly supplied them with carbon steels Nos. 1, 5, and 9, to serve as types.

TABLE I.—THE CORRODIBILITIES OF MOLYBDENUM STEELS.

Steel No.	Carbon.	Molybdenum.	Tap Water (46 Weeks).		Salt Water. (42 Weeks).		Wet and Dry (14 Weeks).		0.05 per Cent. Acid (17 Weeks).		Mean Corrosion Factor.	0.5 per Cent. Acid (10 Weeks).	
			Loss in Weight.	Corrosion Factor.	Loss in Weight.	Corrosion Factor.	Loss in Weight.	Corrosion Factor.	Loss in Weight.	Corrosion Factor.		Loss in Weight.	Corrosion Factor.
	per cent	per cent											
1*	0.14	0.0	0.6478	100	0.6493	100	0.6267	100	0.5906	100	100.0	2.8781	100
2	0.195	1.039	0.6184	95	0.5252	81	0.6500	104	0.5888	100	95.0	2.7990	97
3	0.246	2.176	0.6598	102	0.6494	100	0.7968	127	0.5314	90	105.0	2.8906	100
4	0.190	4.110	0.6540	101	0.6684	103	0.8234	131	0.5834	99	108.5	2.9872	104
5*	0.40	0.0	0.6470	100	0.7292	112	0.3732	59	0.6182	105	94.0	2.9677	103
6	0.445	1.054	0.6200	96	0.6846	105	0.7080	113	0.5600	97	103.0	2.9868	104
7	0.442	2.181	0.6398	99	0.6102	94	0.9776	156	0.5588	95	111.0	2.9726	103
8	0.487	4.009	0.6840	106	0.6436	99	0.9030	144	0.5040	85	108.5	3.0736	107
9*	1.04	0.0	0.6616	102	0.7660	118	0.2756	44	0.6312	107	93.0	3.1117	108
10	1.215	1.096	0.6628	102	0.7016	108	0.7224	115	0 6044	102	107.0	3.1557	110
11	1.210	2.109	0.6790	105	0.6812	105	0.7900	128	0.6046	102	110.0	3.3294	116
12	1.060	4.019	0.6862	106	0.6272	97	0.9486	151	0.6046	102	114.0	3.1286	109

* The results in these horizontal rows are the mean of two sets of experiments.



All the steels were tool-turned and cut into cylinders 1.4 cm. in diameter and 4 cm. in height, and weighed approximately 40 grammes. The surfaces were rendered perfectly smooth with emery.

The analyses of the steels were as follow‡:—

Steel No.	Carbon.	Molybdenum.	Manganese.	Silicon.	Sulphur.	Phosphorus.
	per cent	per cent	per cent	per cent	per cent	per cent
1	0.14	0.0	0.339	0.157	0.036	trace
2	0.195	1.030	0.218	0 047	0.025	0.016
3	0.246	2.176	0.216	0.064	0.026	0.015
4	0.190	4.110	0.242	0.036	0.020	0.017
5	0.40	0.0	0.357	0.084	0.042	trace
6	0.445	1.054	0.230	0.087	0.026	0.014
7	0.442	2.181	0.270	0.075	0.025	0.015
8	0.487	4.009	0.292	0.038	0.024	0.016
9	1.04	0.0	0.253	0.081	0.049	trace
10	1.215	1.096	0.250	0.124	0.032	0.017
11	1.210	2.109	0.238	0.071	0.023	0.015
12	1.060	4.019	0.230	0.039	0.020	0.016

Five series of experiments were carried out, and the results are, for the sake of easy comparison, grouped together in Table I., above. In calculating the corrosion factors for each series the loss in weight of steel 1 is taken as 100.

1. *Tap-Water Tests.*—The samples of steel, resting on discs of paraffin wax, were placed in beakers containing 300 cub. cm. of tap-water, and shielded from light. After forty-six weeks the steels were removed, scraped free from rust, and dried in a steam-oven. They were then weighed, the loss in weight being taken as a measure of the corrosion.

2. *Salt-Water Tests.*—These experiments were carried out in an exactly similar manner to the tap-water ones, the liquid corrosive medium being 3 per cent. salt solution.

3. *Sulphuric Acid Tests* (0.05 *per Cent.*).—In these experiments the corroding liquid consisted of a solution of 0.5 gramme of sulphuric acid in 1000 grammes of water. The liquid was frequently renewed.

4. *Sulphuric Acid Tests* (0.5 *per Cent.*).—In these experiments the corroding liquid consisted of a solution of 5 grammes of sulphuric acid in 1000 grammes of water. The liquid was frequently renewed.

5. *Alternate Wet and Dry Tests.*—In these experiments the steels were laid upon a perforated disc of paraffin wax suspended in a metal bath, which was alternately filled with water and emptied, as described in a previous paper.* The steels were thus exposed to alternate wet and dry action.

Discussion of the Results.—An examination of the table makes clear the following points :—

1. Molybdenum up to 4 per cent. does not appear to exert any marked influence upon the corrodibility of steel when exposed to tap water, salt solution, and dilute sulphuric acid.

2. The results of exposure to 0.5 per cent. sulphuric acid are almost identical with the mean corrosion factors obtained by the exposure of the steels to the other four corroding agencies listed in the table. This is interesting, because it so frequently happens† that the solubility of steels in the stronger solutions of sulphuric acid gives entirely unique results, which are quite untrustworthy guides as to the behaviour of the metal towards neutral corroding agencies.

3. The greatest variation in the corrosive factors is exhibited in the wet and dry tests, the resistance of the steels greatly increasing with the percentage of carbon (see steels 1, 5, and 9) ‡ The molybdenum, on the other hand, tends to increase the corrosion very markedly. The points are clearly brought out by the curves in Fig. 1. It is difficult to say what conclusions we are to arrive at from this, but if, as the writers believe, the wet and dry tests correspond most closely to the conditions under which steel ordinarily corrodes in practice, it is clear that, from the corrosion point of view, molybdenum is an undesirable constituent of steel if present to a greater extent than 1 per cent.

These conflicting results emphasise still more forcibly the "necessity of determining the corrosion of iron and steel under conditions closely similar to those which the metal will be subjected to in practice."§

AMERICAN PETROLEUM.—The United States Geological Survey reports that the production of petroleum in the United States in 1913 was 248,446,230 barrels, as compared with 222,935,044 barrels in 1912. The greatest production in any single State was in California, which yielded last year 97,764,000 barrels. Oklahoma ranked second with a yield of 63,579,000 barrels; and Illinois third with an output of 23,893,000 barrels. Oklahoma is quite a new State, having been carved during the last few years out of the Indian Reservation, and its increasing yield of petroleum is simply marvellous. The 248,446,230 barrels representing the aggregate yield of last year may be analysed as follows :—Appalachian group, 25.921,000 barrels; Lima and Indiana, 4,773,000 barrels; Illinois, 23,893,000 barrels; Mid-Continent, 84,920,000 barrels; Gulf, 8,542,000 barrels; California, 97,764,000 barrels; Colorado and Wyoming, 2,595,000 barrels; and other localities, 34,000 barrels. Petroleum is a mine of wealth to the Americans. Last year the value of the production was 237,121,000 dols.; in 1912 the corresponding aggregate was no more than 164,213,000 dols. It follows that the value increased in a single year to the extent of no less than 72,908,000 dols.

* Paper contributed to the Iron and Steel Institute, May, 1914.

† Carnegie Scholarship Memoirs, 1911, vol. iii., page 66; 1913, vol. v., page 100.

‡ With the exception of the carbon steels Nos. 1, 5, and 9, the analyses are those given by Mr. Swinden, *loc. cit.*

* Journal of the Iron and Steel Institute, 1912, No. I., page 253.

† *Ibid.*, 1913, No. I., page 397.

‡ Contrast the results of Chappell, *ibid.*, 1912, No. I., page 270.

§ Journal of the Iron and Steel Institute, 1912, No. I., page 258.

SAFETY AT SEA.*

By Professor F. P. PURVIS, Tokyo Imperial University.

A GOOD deal has transpired since the reading of my paper before this Society in November, 1912. Principally the International Convention on Safety of Life at Sea has performed excellent work and made thoroughly practical suggestions and rules. In addition, the boat question, and subsidiary matters connected with it, have been attacked in a whole-hearted manner that promises well for a workable solution. The problems of an inner skin on the one hand, and of longitudinal subdivision with access through the dividing bulkheads on the other, have been advanced by practical application on the largest scale. Fire-proof bulkheads above the "margin line" have been made the subject of an article in the International Convention; and the Aquitania stands as at least one instance of their practical application (see Mr. Peskett's recent Institution of Naval Architects' paper). I shall therefore restrict my present communication to the discussion of a few matters which do not seem to me to have received quite sufficient attention. My earlier paper refers to several of them, and part of my present work will be to review my position in relation to what has since transpired.

Take first the matter of an inner skin, which has obviously so much to recommend it. In discussing the advantages of this structural addition I suggested that: "A detail, worthy of some consideration, would be whether the connection between the inner skin and the web-frames should not be rather slight, the inner skin being stiffened by independent frames; injury to the outer skin and the web-frames would then not necessarily involve any part of the inner skin, which might, even with such serious damage as the Titanic's, escape intact." The drawings which have appeared in recent periodicals, representing the arrangement for the inner skin of the Britannic, do not show that the end I had in view has commended itself to her designers; stringers of a very substantial character appear to connect inner and outer plating in a way which would make interaction certain under given conditions. I think the matter is well worthy of further consideration in future designs.

Another matter in my earlier paper has not at present been taken up either by the International Convention or, as far as I have seen, in the design of any modern merchant ship. This matter is the possibility, or rather the practicability, of transverse bulkheads without water-tight doors. Dealing with a very limited class, I pointed out that: "In Atlantic ships, as exemplified by the Titanic or Mauretania, there seems no difficulty in arranging that each stokehold has its own bunkers; in such case the necessity for corporeal communication along the level of the stokehold floor does not seem absolutely urgent." The practical difficulties that would arise from such an arrangement I know are very great; I endeavoured to deal with them. The class of ship, again, in which this would be even possible is a very small one, as counted by units. Measured by other standards it is, perhaps, the most important in the world; exceptional treatment would, therefore, appear to be not unreasonable. Results obtained in this very limited class might lead to the extension of the principle to other classes, but that does not call for immediate discussion.

The value of water-tight decks has received attention during the past year from many students of the general subject. Mr. Hillhouse read a paper last June at the summer meetings of the Institution of Naval Architects, and in it used the words: "Water-tight decks form an exceedingly valuable form of subdivision." In the discussion on this paper Sir Archibald Denny appears to have accepted the statement, but laid stress on some of the difficulties. My own contention a year and a half ago was as follows:—"In collisions with other steamers the area of damage is not at all restricted to the underwater portion of the ship; the impact which might be expected to tear open the ship's side would also tear away a large portion of any deck near the water-line; the stringer-plate certainly would be carried away for practically the same length as the damage of the outside skin; for that length, therefore, the transverse bulkheads would be called upon to play the same part whether the water-tight deck were fitted or not."

That contention, I think, still holds good. Mr. Peskett, in his recent Institution of Naval Architect's paper dealing with the Aquitania, takes account of certain portions of deck as serviceable for the exclusion of water; but this he does to a very limited extent, and in view of other features of construction to which he attaches importance. Even then I do not think he meets the objection which I have stated above; the onus of proof would still lie with him. The International Convention, in Article 30, calls for further study in this and other matters.

Turning now to another of the International Convention's Regulations, a question is raised which is not, I think, solved in a manner entirely satisfactory. Article XV., paragraph 8 (*a*) provides as follows:—"When the number of water-tight doors in the main transverse bulkhead at or about the stokehold level in the machinery space exceeds five, excluding the water-tight doors at the entrance of tunnels, all water-tight doors situated below the load water-line shall be capable of being simultaneously closed." (The context shows that they are to be closed by power.) My objection to the provisions of this article is the large number—five doors. There are many steamers in this and other parts of the world with the boiler-room bunkers far too small for their needs; a large cross-bunker forward of boilers, either permanent or reserve (sometimes both permanent and reserve bunkers), is absolutely necessary; to pass the coal to the boiler-room there is a door or doors which can be shut water-tight. In some steamers there is a passage or tunnel from the boiler-room bulkhead to a light bulkhead separating cross-bunker from reserve; one water-tight door is considered sufficient, and it is placed at the boiler-room end; the bunker and reserve bunker openings are closed by light plates only. Where there is no such passage, and the door in boiler-room bulkhead opens at once into the reserve bunker, little is done, in some ships, to keep the coal clear of the door and the door slides. While visiting one or two steamers on recent occasions I have asked the engineers in charge the question how long, in case of emergency, it would take to close the door—working, say, from the grating above. The answer has been "about 10 minutes." It is to improve this state of things that I think something more should be done; surely every effort should be made to reduce this time interval to a minimum. The preferable method of doing this would be to substitute operation by power for operation by hand. In my earlier paper I made a suggestion with regard to the above-mentioned tunnel to extend its usefulness on the side of safety. Recognising that suggestion as introducing too many difficulties for practical adoption, it seems to me that Article XV., paragraph 8 (*a*) of the Regulations might well be modified to make it compulsory even when there is only one door in the water-tight bulkhead dividing boiler-room from hold in front, that that door shall be operated by power, directed either from the bridge or from some other suitable place. If this were done there would still be the necessity of keeping the coal clear of the door-slides; but on this point the Regulations are clear; Article XV., paragraph 5, provides that:—

"In the case of water-tight bunker doors satisfactory arrangements shall be made by means of screens or otherwise to prevent the coal from interfering with the closing of the doors."

Thus in future, one of the elements of time in closing should be effectively dealt with. My proposal is meant to deal with the other.

In this connection, or partly in this connection, I should like to call attention to what indeed is thoroughly understood—viz., the fact that the Convention for the most part restricts its findings to passenger ships. Clause II. defines the ships in view as "merchant ships . . . which carry more than twelve passengers." The restriction was probably quite unavoidable; as simplifying the problems involved it is eminently reasonable. But it may well become one's duty to take a wider field of view; the safety of cargo ships deserves consideration not much less than that of passenger ships. The regulations applicable to the one class ought in many instances to be applied to the other. In the matter I have just been discussing, for instance, many cargo-ships, as well as passenger ships, have the door communicating between boiler-room and space in front. Such ships designed in the future would probably be influenced by the Regulations, both in this matter and in others to which the Regulations apply. Any discussion of the latter thus becomes of increased importance. Applicable in the first instance only to passenger ships, they will certainly indirectly affect cargo ships. The most important of them will probably in course of time, in most countries, be definitely extended by law to cover the latter class as well as the former. The Regulations of the Convention may, in this respect, be considered as the first of two steps; the second is yet to be taken.

There is much room for discussion and consideration; and there is no doubt that in whatever is done, in whatever it is found possible to do, for the safety of ships, passenger and cargo ships alike, this country—Japan—will ever be ready to take its share.

* Paper read at the Japanese Institution of Naval Architects, June 7, 1914.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

New Zealand: Extracts from the local Press have been received from the office of H.M. Trade Commissioner for New Zealand, from which the following information is taken:—The ratepayers of Wairoa have sanctioned a loan of 4000*l.* for the extension of the electric-lighting system of the town. The Whangarei Harbour Board has approved of a scheme involving the expenditure of 69,000*l.* for harbour extension, and additions are contemplated which will considerably increase this amount. As the Board's borrowing powers are limited to 10,000*l.*, it has been decided to obtain Parliamentary sanction to increase the amount to 100,000*l.* In the meantime, a poll is to be taken on the question of raising a loan of 10,000*l.* to complete the work already in hand.

Morocco: H.M. Chargé d'Affaires at Tangier reports that tenders are invited by the Moroccan Adjudications Commission for the construction of a section, 10.32 km. (about 6⅓ miles) in length, of the road from Rabat to Casablanca. The estimated value of the contract is 759,186 francs (30,367*l.*), and a deposit of 12,500 francs (500*l.*) is required to qualify any tender. Tenders, accompanied by certificates of competency, will be received by M. le Président de la Commission Générale des Adjudications et des Marchés, Dar-En-Niaba, Tangier, up to 11 a.m., on September 5. The contractor must elect domicile in the neighbourhood of the works. A copy of the *cahier des charges* may be seen, and copies of the form of tender to be used obtained, by contractors in the United Kingdom, at the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C.

Italy: The following information is from the report by the British Vice-Consul at Bari on the trade of that district in 1913, which will shortly be issued:—The work in connection with the construction of the Apulian Aqueduct is progressing in a satisfactory manner, and in all probability the Provinces of Bari and Foggia will obtain the water by the end of 1914, and the Province of Lecce about a year later (see page 518 of the *Board of Trade Journal* of August 29, 1912). In accordance with the Government contract, the whole work must be completed by August 6, 1916. The main channel carrying the water from the springs of the River Sele to Apulia—that is, all the way from the Tyrrhenian to the Adriatic side of the Italian Peninsula—is now almost completed. It has a length of 132 miles, and undoubtedly represents the most difficult part of the work, so that the successful execution of the project can now be considered as practically assured. No less than 75 sloping tunnels, some as much as 10 miles long, were necessary for crossing the Appenines and Murge Mountains, and enormous siphons, or large tubular bridges up to 200 ft. high, had to be constructed across the valleys. From the main channel the water will be carried in minor conduits to 128 large reservoirs situated in the vicinity of the principal towns and communities. The total length of these conduits will be about 1000 miles, and another 450 miles of pipe-line will have to be laid in the interior of the towns, making in all 1550 to 1600 miles for the whole aqueduct, including the main channel. The main channel is built in stone with cement plaster, its section is oval, average height, 8½ ft.; width, 7½ ft.; gradient, from 0.40 to 0.25 per 1000. The minor conduits (with diameters varying from 40 in. to 5 in.) are of cement or cast-iron tubes; cast-iron pipes will also be used for the town conduits. A contract for 45,000 tons of cast-iron pipes for shipment to Bari, Barletta, Brindisi and Taranto has been placed recently with an American firm. The quantity of water to be supplied by the company varies from a maximum of 20 gallons per day to inhabitants in the large centres, to a minimum of 10 gallons per day in boroughs of less than 10,000 inhabitants. In all inhabited places small public fountains with a daily water consumption of at least 5500 gallons must be set up in the proportion of one fountain for every 2500 inhabitants. For private persons the price of the water has been fixed at from 1s. 4d. per 1000 gallons in the large centres to 9d. per 1000 gallons in the minor communities, and for industrial purposes from 10d. to 3½d. per 1000 gallons, according to the importance of daily requirements. The quantity of water not required by the inhabited places may be sold for irrigation and agricultural purposes at the rate of 5d. per 1000 gallons.

Spain: The *Gaceta de Madrid* of July 6 states that the Compañia gaditana de minas La Caridad, of Azualcollar, has been granted a 99 years' concession to construct and work a secondary railway line from Azualcollar to Cuchichón. An interest on the working of the line is guaranteed by the State. A deposit of 12,489 pesetas (about 462*l.*) must be paid by the concessionaire, as a guarantee, into the Caja General de Depósitos. Work must be started within three months of the date of the granting of the concession, and must be completed within eighteen months of the same date. The *Gaceta* of July 10 announces that a Royal decree has been issued, authorising the Ministerio de Fomento to acquire, without the formality of calling for tenders, three cranes, which are to be installed at the port of Alicante. The same issue of the *Gaceta* also notifies that the concession for the construction and working of a strategic railway from Pamplona to Logroño, *via* Estella (see page 760 of the *Board of Trade Journal* of March 26 last), has been awarded to the Sociedad Minera Guipuzcoana.

HYDRO-AEROPLANE STATIONS IN SWEDEN.—The first Swedish hydro-aeroplane from the works at Södertelje has now been delivered to the society, which has taken this matter in hand, and it will be stationed at Saltsjöbaden; the society in question intends to present a number of these machines to the Swedish State to be stationed along the entire Swedish coast.

OUR LOCOMOTIVE EXPORTS.—There is every probability that 1914 will be a good year in connection with our locomotive exports, the value of the engines shipped in June having been 308,359*l.*, as compared with 246,524*l.* in June, 1913, and 194,109*l.* in June, 1912; and in the six months ending June 30, 2,083,751*l.*, as compared with 1,252,899*l.* and 1,049,861*l.* In the first half of this year Argentina imported British locomotives to the value of 568,348*l.*, as compared with 298,884*l.* and 209,261*l.* The colonial demand in the first halves of the last three years was as follows:—

Colonial Group.	1914. £	1913. £	1912. £
British South Africa ..	43,539	54,556	135,852
British India	845,078	406,278	210,858
Australia	291,666	182,746	192,367

The prosperity of the Anglo-Indian Railway interest, by reason of the great growth of traffic, has naturally had the effect of rendering necessary large imports of additional locomotives—imports which are still continuing. The existing state of affairs in South Africa leaves something to be desired; but the progress of the Antipodean demand is highly satisfactory. The Australian railway network is steadily growing, to the advantage of British locomotive-makers as well as Australian colonists. There has been a good market this year for British locomotives in Argentina, although Argentine railways have been rather under a cloud, in consequence of declines in traffic.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

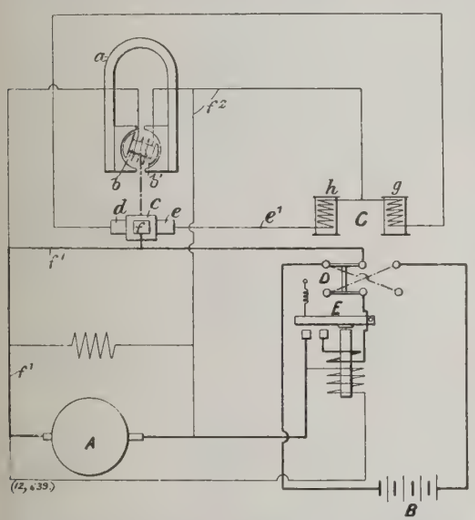
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

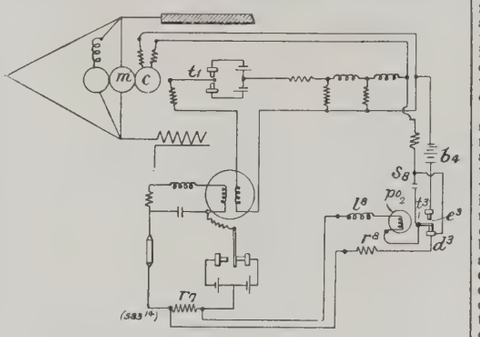
ELECTRICAL APPARATUS.

12,639/13. H. Leitner, London. Charging Accumulators. [1 *Fig.*] May 30, 1913.—This invention relates to improvements in means for reversing the connections between a battery of accumulators which it is desired to charge and a generator which is subjected to constant reversals, as, for example, in petrol electric vehicles in which a dynamo supplies current for an electric-light circuit in conjunction with a battery of accumulators. According to this invention, the system of charging accumulators in which the current is rendered unidirectional comprises a charging dynamo which is subject to reversal, a polarised or discriminative relay, one member of which is wound with fine wire connected in shunt across the brushes of the dynamo, or some part of the dynamo circuit which is subject to reversal, but, preferably, not to great fluctuations of voltage, a commutator directly operated by the polarised or discriminative relay, an electro-magnetic rocking contact reversing switch connected across the dynamo circuit, one or other of the magnets or solenoids of which is energised by the position of the commutator, as determined by the discriminative relay according to the direction in which the dynamo is running, and an automatic cut-in and cut-out having series and shunt windings. A is the dynamo, the polarity of which is liable to reversal, and B is the battery of accumulators. *a* is the permanently polarised field-magnet of a small motor constituting the discriminative relay, and *b* is the shuttle armature thereof, the armature being capable of a rocking movement through an angle of, say, 90 deg., and



being wound with a fine wire winding or coil b^1, which may be across the main brushes of the dynamo, or across any other convenient part of the circuit the polarity of which is subject to reversal with the dynamo and which is, preferably, not subject to great fluctuations of voltage. *c* is the commutator attached to the armature *b*, the commutator *c* having three contacts *d*, *e*, and *f*. C is the electromagnetic reversing switch comprising the two solenoids *g* and *h*, the former of which is connected with the contact *d* of the commutator by the wire d^1, whilst the latter is connected with the contact *d* thereof by the wire e^1; the remaining contact *f* of the commutator is permanently connected with one pole of the dynamo, as shown by the wire f^1. D is the rocking contact reversing switch, E is the usual cut-in and cut-out device inserted between the battery B and the dynamo A. When the armature *b* and commutator *c* are turned in one direction, the contacts *d* and *f* of the latter will be connected so that the solenoid *g* will be energised, as the circuit through it is completed by the wire f^2 to the opposite pole of the dynamo A to that which is in connection with the contact *f*. The energising of the solenoid *g* places the reversing switch D in one position. Similarly, by connecting the contacts *e* and *f*, current is supplied to the solenoid *h*, whereby the switch D is placed in another position, as, for example, that shown in the drawing, the one position or the other determining the reversal of the connections between dynamo A and battery B, as is well understood. (*Accepted May 6, 1914.*)

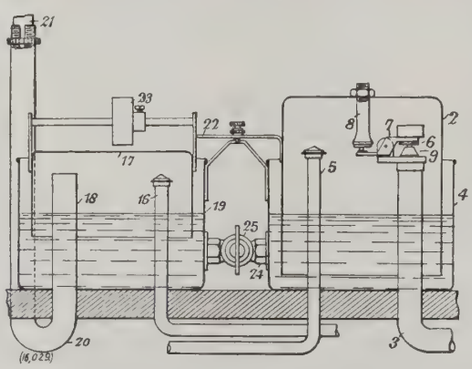
5831/14. W. Judd, B. Davies, and the Eastern Telegraph Company, Limited, London. Telegraphy. [1 *Fig.*] April 25, 1913. This invention relates to improvements in methods of telegraphy through submarine and subterranean cables and is especially adapted for the rapid transmission of signals through long cables having electric constants of considerable values. In the Applicants' system of signalling, described in application No. 9768, of 1913, the dots, as given by the dot-maker at the receiving end, are as perfect as those given by the transmitter at the sending end. The dots are quite unaffected by a moderately bad duplex balance. Not until the balance disturbance is such as to throw the relay-tongue from the centre of the true zero on to either marking or spacing current can the dots be disturbed. The dots are consequently relayed with perfect symmetry as if from a transmitter. This is not quite so with the dashes; they are liable to be lengthened or shortened by a bad disturbance or want of perfect shaping. To remedy this in part the Applicants introduce a special dash interpolator for carving up dashes at the receiving end. The invention consists in an interpolator comprising a single-coil winding to which a transient current is applied at intervals corresponding to the dashes by a source of electromotive force suitably connected in circuit with the coil, a condenser, and relay contacts. In the form illustrated, an inductance l^8 is joined in series with the winding of a post office or other suitable relay $p\,0^2$ and an adjustable non-inductive resistance r^8. This circuit is joined up to the ends of a non-inductive resistance r^7. The electromotive force applied to the relay circuit is thus in phase with the current in the circuit containing this resistance. The tongue t^3 of the interpolator normally rests against a stop d^3 and both form part of the main circuit of the interpolator. The local circuit of the interpolator is connected up to a correction-coil *c* wound with the main receiving-coil *m* through a condenser s^8 and a battery b^4. In operation, consider a permanent current of the dash sign to flow in the non-inductive resistance r^7 with the tongue t^3 resting on the stop d^3. The electromotive force due to this current acts on the circuit containing the inductance l^8 and the resistance r^8 in series therewith. The current in this circuit will rise in accordance with the time constant. This



time constant, together with the "bias" of the relay $p\,0^2$, are so arranged that the current thus rising shall cause the tongue t^3 to break with its normal stop d^3 at the end of an interval represented by a dash. In the act of breaking this contact d^3 contact at e^3 is made, whereby the condenser s^8 is charged from the battery b^4, and a transient current is thus sent into the correction-coil *c*. This transient current is arranged to be such as to bring the tongue t^1 of the dash-maker quickly to the true zero, which is arranged to occur exactly at the end of the dash interval. The interpolator tongue t^3, having broken its own main circuit, returns to its normal position on d^3, at the same time discharging the condenser s^8 and insulating battery b^4. So long as a current of the dash-sign flows in r^7 so long will the tongue t^1 be brought to zero at the end of every dash. If a spacing current is received its only effect is to cause the tongue t^3 to press more firmly on d^3, and no further action takes place. When dots are received the tongue t^3 will remain quietly on d^3, for the reactance of l^8 is so great that the dot current, owing to its high frequency, fails to penetrate in sufficient strength to effect the post office relay. (*Accepted May 6, 1914.*)

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

16,029/13. J. F. Simmance and J. Abady, London. Gas Governors. [4 *Figs.*] July 11, 1913.—This invention relates to improvements in governors for regulating the flow of gas, the pressure or density (or both) of which may vary from time to time. The improvements are in the construction and arrangement of the various parts whereby it is possible to obtain greater sensitiveness and easier access to the important parts on which the accuracy and sensitiveness of the governor depends. The invention consists in mounting the bell at the end of a balance-beam so as to be instantly removable, and mounting the governor-valve and lever inside the bell so as to be instantly removable when the bell has been removed. The main supply of the gas is led inside a bell 2 sealed in a liquid contained in a tank 4, the supply pipe 3 being led upwards from the bottom of the tank 4 through the liquid. The gas then flows by a discharge-pipe 5, passing downwards through the bottom of the tank 4, and on to the burner, calorimeter or other apparatus in which it is burned. The governor proper is placed inside the main bell 2 at a convenient height above the level of the liquid. The governor-valve 6 is mounted at one end of the governor-lever 7, the other



end of which bears against a stop 8 integral with or fixed inside the main bell. The governor-valve 6 is immediately above an orifice 9 at the upper end of the supply pipe 3, and by its distance above the orifice regulates the rate of the flow of the gas. The governor-lever is supported on a "geometric bearing" near the upper end of the supply-pipe. The apparatus for neutralising variations in the density of the gas is arranged as follows:—An auxiliary supply of the gas is permitted to flow steadily by a pipe 16 to the inside of a second or "density" bell 17 sealed in a liquid, from which the gas flows by a pipe 18, passing downwards through the bottom of the tank 19 in which the bell and liquid are contained. The gas then passes along a horizontal pipe 20, and is finally burned, and escapes from the top of a long vertical pipe 21. The two bells 2, 17 are rigidly connected to the ends of a balance-beam 22, fulcrummed in the middle, and provided with adjustable balance-weights 23, by means of which any desired degree of sensibility of the balance can be obtained, and the balance adjusted for any normal density of the gas. The two tanks aforesaid are connected by a pipe 24, provided with a cock 25. Before the gas is turned on the cock is opened, thereby equalising the levels of the liquid in the tanks, both liquid levels being opened to the atmosphere. The cock is then closed, and the gas is turned on. Any upward movement of the density bell 17 due to an increase of the density of the gas above its normal value causes downward movement of the main bell 2, thereby bringing the stop 8 into a lower position, and thus raising the governor-valve 6 further from the orifice 9 at the end of the main supply pipe 3. If the density remains constant, and the pressure in the main increases, the first tendency is to force the main bell 2 and stop 8 upwards, reducing the area of the orifice, as in the usual form of gas-pressure governor, which gives approximately constant volume of flow under small variations of pressure in the main. The two governing actions above described for variations of pressure in the main and for variations of density are independent, and may take place simultaneously. (*Accepted May 6, 1914.*)

10,677/13. Vickers, Limited, London, and G. Bourcier, Erith. Internal-Combustion Engines. [2 *Figs.*] May 6, 1913.—This invention relates to the starting gear of internal-combustion engines, more particularly those intended for use with aeroplanes, hydro-aeroplanes, and similar machines, and the chief object of this invention is to provide improved means by which the engine-crank can be turned by the driver into a suitable position for starting, without necessitating the driver leaving the position he occupies when piloting or driving the machine. According to this invention, the starting-shaft carries a worm that on rotation of the shaft first screws into mesh with a worm-wheel suitably geared to the engine crank-shaft (in some cases through a free-wheel device), and then when fully in mesh drives the worm-wheel on continued rotation of the shaft, a reverse rotation, after the engine is in starting position, freeing the worm from the worm-wheel. A is the worm; B is a worm-wheel geared to the engine crank-shaft; C is a worm-shaft made in two parts, connected together by a screw connection *c* and mounted to slide and turn in the sleeve D carried by the bracket *d*; E is a spring-nut, carried in the sleeve F mounted in the bracket *f*; G is a spring-catch. On the part of the worm-shaft C, adjacent to the spring E, is the screw-threaded portion c^1, of equal pitch to the worm A, and adapted to engage the spring, the coils of which form the thread of a nut into which the screw c^1 can screw. The sleeve F receiving the spring E is provided with the cap f^1 against which the spring abuts. At the opposite end of the shaft C (from which end the connection to the starting-

Fig. 1.

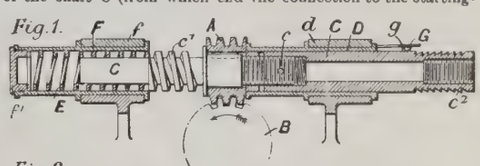
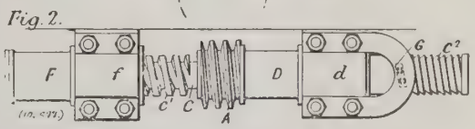


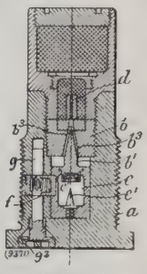
Fig. 2.



handle passes) is the screw-threaded part c^2, shown as a double screw, the threads of which form a ratchet. The stud *g* of the catch G engages this ratchet-screw when the shaft is moved towards the left. In the position of the parts shown in the drawings, the worm has already been engaged with the wheel B ready for the starting operation, and has been brought up against the end of the sleeve D, which forms a stop preventing further movement to the right. Further turning of the shaft C, on which the worm A is keyed, causes the worm to rotate the worm-wheel B slowly in the direction of the arrow, and thus, through the free wheel or other gearing from the wheel B to the engine-shaft, to turn the latter until the charge of one or more of the engine-cylinders is compressed ready for ignition. The operator then reverses the rotation of the shaft C, with the result that the screw c^1 engages the spring-nut E and the shaft and worm are screwed to the left, without action on the wheel B, so that the engine is left in condition for starting. The ignition-circuit is left open until the worm has fully cleared the worm-wheel, a convenient contact device being closed automatically on the worm and shaft reaching a predetermined position. The firing-circuit is then ready to be completed through a button or switch when the operator desires to start the engine. The movement of the shaft C to the left causes the ratchet-screw c^2 to engage the pawl or stud *g* of the spring-catch G, so that when the shaft is released it is held positively against any movement to the right, which would bring the worm into contact with its wheel. (*Accepted May 6, 1914.*)

GUNS AND EXPLOSIVES.

9371/13. R. P. R. Embury and R. H. S. Bacon, Coventry. Projectiles. [4 *Figs.*] April 21, 1913.—This invention relates to base or nose percussion fuzes of the kind in which the detonator to give the initial explosion and the needle for firing it are contained in a closed chamber secured in the body of the fuze, so that in case of a premature explosion of the detonator the flash will be confined to the chamber, and the fuze will not be fired, but on impact with the target the chamber breaks away from its attachment and makes an opening through which a flash can pass to the fuze. According to this invention, the detonator is rigidly fixed in the body of the fuze, so that on

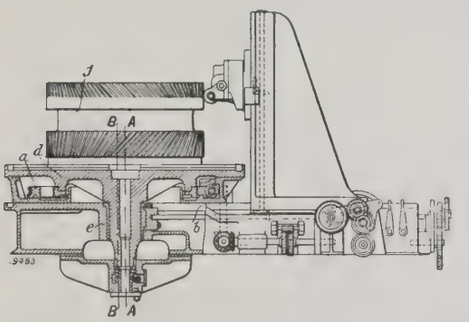


impact it does not move relatively to it, and the needle is similarly fixed in the chamber, and not, as has heretofore been proposed, to a pellet movable in the chamber, or the needle may be rigidly fixed in the body and the detonator in the chamber. The base *a* containing the exploder is screwed into the body of the fuze. The detonator-holder consists of a disc *b* having fixed to it a central stem b^1, at the end of which is a cylindrical cup to contain the detonator *c*. The disc screws into the body at one end of the fuze, and is perforated with holes b^3 to allow the flash to pass to the fuze *d*. The cup containing the detonator fits into and forms one end of a closed chamber *e*, having within it a needle e^1 for exploding the fuze. The chamber is a loose fit in the inside

of the fuze, but is normally prevented from moving by a flange on the cup. On discharge of the gun no movement of the chamber e takes place. On impact, however, the chamber is crushed over the flange of the detonator holder, and the needle e^1 fires the detonator, the flash passing round the cup of the holder and through the perforations b^3, firing the fuze. In case of a premature explosion of the detonator, the flash is retained in the chamber, and no ill effect follows. As shown, the chamber can be further retained in the safety position by means of a centrifugal bolt f, which is secured in the usual way by a projection on a pin g fixed to a copper disc g^2. On discharge the pin g is forced forwards, carrying the projection out of engagement with the bolt f. (*Sealed July* 2, 1914.)

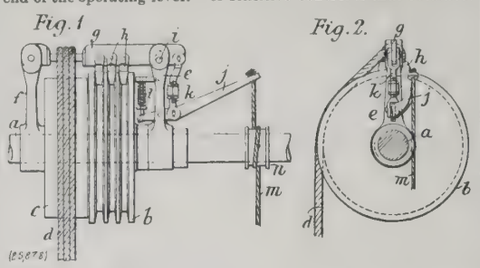
MACHINE AND OTHER TOOLS, SHAFTING, &c.

9483/13. The Hon. Sir C. A. Parsons and A. Q. Carnegie, Newcastle-on-Tyne, and S. S. Cook, Wallsend-on-Tyne. Gear-Cutting Machines. [7 *Figs.*] April 22, 1913.—This invention relates to the method and means for cutting teeth in gear wheels described in Patent Application No. 29,380, of 1912, and comprises an improvement thereon, and has for object to construct such wheels with a higher degree of accuracy than is obtainable with the usual processes at present adopted for cutting gear-wheel teeth. In application for Letters Patent No. 29,380, of 1912, a method and means are described for distributing in spirals irregularities in the work due to local irregularities in the parent gear whereby the periodic correspondence of the irregularities in the work with the irregularities of the parent gear rotating the same were destroyed, this result being attained by providing relative creep between the work and the parent gear. The present invention consists in an improved apparatus for cutting gear teeth comprising a work-carrying table, a ring, the axis of which is non-coincident with the axis of the table, driving means engaging the ring to rotate it about its own axis, and means upon the ring adapted to engage means upon and to impart rotary motion to the table, whereby the necessary shift of phase of errors between the several toothed pairs rotating the work is obtained. The invention further consists in an apparatus for cutting gear, comprising a work-table carrying a ring of teeth, a ring member having two sets of teeth and constrained by spigots or the like to move about an axis not coincident with the axis of the table, with one set of teeth at one point of its periphery in engagement with the teeth of the table, these two engaging sets of teeth having slightly different pitch-circle diameters, and a driving worm or its equivalent engaging the other set of teeth of the ring, whereby in successive revolution of the work-table periodic correspondence of the irregularities formed in the work with the irregularities in the several toothed pairs driving the work is destroyed. In carrying the invention into effect, according to one form, a main driving worm-wheel which takes the form of a ring a is constrained to move about its own axis by such means, for instance, as a spigot b, and is provided with teeth, preferably of fine pitch, which, in this form, are situated upon an inner periphery of the ring. The work-table d carrying the work j is mounted in bearings e, and its position is eccentric with relation to the worm ring a, its centre line A A being so disposed, however, in relation to the centre line B B of the latter, that teeth formed upon a periphery of the table d engage with the teeth on the worm-ring a. The worm-ring a may be rotated by the usual driving means, such, for instance, as a worm engaging teeth on the ring a, and transmits rotary movement to the work-table d by reason of the engagement of the teeth of the ring with the teeth of the work-table, the rate of rotation of the work-table d being greater than that of the worm-ring a on account of the tooth circle of the ring being of larger diameter than the tooth circle of the work-table. The pitches of the worm teeth and of the teeth of the worm-ring and the diameter of the pitch circles of the work-table teeth and the ring teeth are so chosen as to give such a relative creep—viz., an acceleration of the work-table in relation to the worm-ring as will give the desired variation in phase of the errors, chiefly of those errors which arise from inaccuracies of the worm and worm-ring teeth. Slight inaccuracies in the teeth of the ring and the teeth on the work-table are rendered ineffective by the large arc of engagement of these teeth. It is preferable that the worm should be situated in close proximity to the point of engagement between the teeth of the ring and the teeth of the work-table by which means error due to spring of the ring a is eliminated. (*Sealed July* 2, 1914.)



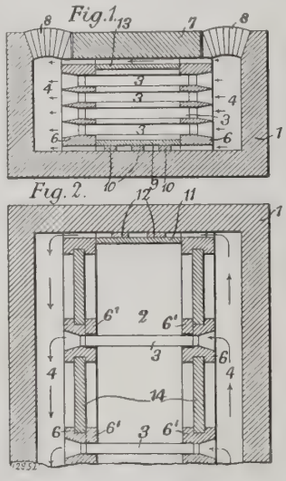
MINING, METALLURGY, & METAL-WORKING.

25,878/13. B. Brett, Hampton-in-Arden, and J. Brett, Coventry. Drop-Hammers. [2 *Figs.*] November 12, 1913.—This invention has for its object to construct an improved lifting mechanism for automatic drop-hammers and the like of the type in which a grooved friction-drum and a guide-pulley for the hammer-lifting belt or the like are secured to a revolving shaft, and a pair of arms loosely mounted on the shaft have arranged between them a lever which carries friction-blocks for engaging the drum. The present invention comprises the combination with one of the arms of spring-controlled lever mechanism for actuating the friction-block lever and causing the blocks to engage or disengage the friction-drum as required. In carrying the invention into effect as shown, a revolving shaft a has secured to it a grooved friction-drum b. Alongside the drum is loosely mounted on the shaft a pulley c, which serves as a guide for the lifting belt or ropes d, to which at the lower end is attached the tup or hammer (not shown). The shaft a also carries a pair of arms e and f, which are loosely mounted thereon, and are situated respectively at the opposite ends of the drum and pulley. To the arm f is pivoted a lever g carrying a number of blocks h, which engage the grooves in the friction-drum b, whilst a pin i, inserted through the other arm e and passing through a slot or like aperture in the lever g, limits the extent to which the lever g can be moved. The lever g is also adapted in the ordinary manner for the attachment thereto of the upper end of the tup-lifting belt or rope d. The arm e has pivoted to it an operating lever j, which is connected by means of a link k to one end of the lever g. A spring l secured to the arm e, and engaging with one end of the operating lever j, actuates the latter in the direction for releasing the friction-blocks h from the grooved drum b, whilst a hand-rope m attached to the other end of the operating lever j provides the means whereby the operative can control the action of the mechanism. Preferably the hand-rope is coiled around a small pulley n fixed to the shaft, in order that by the utilisation of coil friction a relatively small force applied to the end of the rope will cause the application of a large force to the end of the operating lever. A sensitive control is thus obtained.



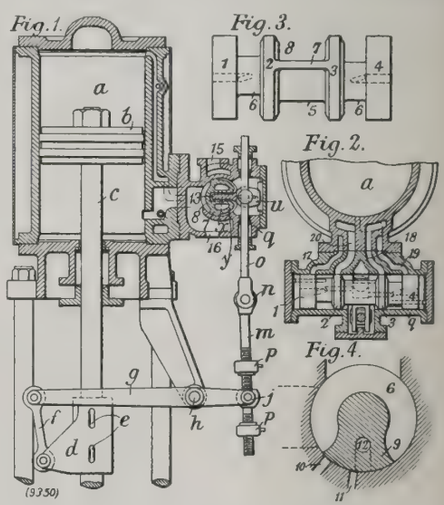
The link k is preferably made in two oppositely screw-threaded parts connected by a coupling-nut to provide for adjustment of the length of the lever. It will be understood that in action the engaging of the blocks h with the drum b, by a pull on the rope m, causes the latter to carry with it, through a certain angular distance, the arms e and f, the lever g, and their associated parts. This causes the upper end of the belt or lifting ropes to be carried round the pulley c, and the weight on the lower end to be lifted to a corresponding distance. Release of the weight is effected by releasing the hand-rope, so that the blocks h can disengage the drum b under the action of the spring l. (*Accepted May* 6, 1914.)

12,952/13. C. D. McCourt, London. Furnaces. [2 *Figs.*] June 4, 1913.—This invention relates to furnaces, kilns or the like for the calcining, burning, or other heat-treatment of bodies and materials, and has reference to that type of furnace or the like wherein it is required to keep the gases of combustion from coming into contact with the body or material undergoing heat-treatment, as, for example, in the manufacture of carbon electrodes, case-hardening operations, and the heating or calcining of pulverulent material. In a furnace or the like, in accordance with this invention, the body or material that is to undergo heat-treatment is contained within a closed chamber, and is subjected to heat-action internally by transmission through the walls of tubes or passages traversing the chamber, and externally on all sides by transmission through the walls of the chamber, said chamber and the furnace body being provided with removable closures that give access to the full length of the chamber, and are such, or so arranged, that heat is transmitted to the body or material through the chamber closure. 1 is the furnace structure of any convenient formation or design, and having therein a chamber 2. The chamber 2 is separated from the side walls of the furnace structure 1 by the flues 4. The flues 4 are in communication the one with the other through the chamber 2 by means of relatively thin-walled tubes 3 or passages. The tubes 3 are grouped or arranged at intervals along the chamber 2. The length of the chamber 2 is, preferably, several times its width, and the tubes 3, as shown, traverse the chamber 2 in the direction of its shorter dimension. The tubes 3 are mounted at their ends in the side-walls 6 of the chamber 2 in such manner as to admit of their ready renewal, and for this purpose the holes in the walls 6 may communicate with grooves 6^1, which, when the tubes have been inserted, are luted or bricked up. Access to the chambers for the whole length thereof, for the purpose of charging and discharging, is obtained by cover-slabs 7 which bridge adjacent flue walls, thus forming with the flue roofs 8 a more or less continuous roof over the entire furnace. Chambers 2, as described, are, preferably, provided with a relatively thin floor 9, composed of fire-clay quarries supported on distance-pieces 10, so as to leave a space below through which the furnace gases pass from one flue 4 to the next flue 4 (as well as by way of the tubes 3), passages being left at the bottom of the walls 6 of the chamber 2 for the passage of the gases from the flues. The ends of the chamber 2 also are preferably composed of relatively thin-walled fire-clay quarries 11, separated from the outer or end wall of the furnace by distance-pieces 12, the furnace gases being also allowed to pass from one flue 4 to the next flue 4 through the space thus created. The body or material charged or packed into the chamber 2 is covered with fire-clay quarries 13 luted in round the edges with fire-clay, a small space being left between the quarries and the cover-slabs 7 of the chamber for the passage of the furnace gases. The quarries 13 are removable and replaceable for the whole length of the chamber. The heat transmission to the chamber contents may be increased by employing relatively thin-walled quarries 14, let into the side-walls 6 as panels, these panels being renewable from within the chamber. (*Sealed June* 25, 1914.)



PUMPS.

9350/13. James Simpson and Co., Limited, Newark-on-Trent and London, and H. D. Shrimpton, New Balderton. Pumps. [5 *Figs.*] April 21, 1913.—This invention relates to combined distributing and auxiliary piston-valves for pumps and the like of the kind in which the valve has longitudinal movement imparted to it by the motive fluid and an angular movement imparted to it by means of a mechanical connection operated by a moving part of the pump. The object of this invention is to provide a valve which, while performing the functions of a combined distributing and auxiliary-valve, shall overcome the disadvantages of such valves heretofore proposed. A piston-valve, made in accordance with this invention, controls the main fluid solely by longitudinal movement by means of segmental channels or passages on the circumference of the valve, there being no internal fluid-pressure chambers in the valve. The cylinder a contains the piston b, to which is attached the rod c. A bracket d connected to the rod c by cotters e is attached to one end of a link f, the other end of the link being attached to one end of a lever g, pivoted at h to a bracket rigidly fixed to the cylinder casting. The opposite end of the lever g is forked, and carries in bearings j a transverse rod, the rod being enlarged sufficiently at its centre to permit of a hole being formed therein, through which passes a rod m connected by a knuckle-joint n to the valve-rod o. The rod m may be screwed, or other provision made whereby the tappets p may be adjusted, one above and one below the transverse rod, on the rod m. The valve-rod o has disposed upon it within the steam-chest q a transverse portion r. This transverse portion r, being held in position on the rod o, rides in bearings in a forked member u. The valve-chest cover has formed upon it a guide disposed between the horns of the forked member u, which prevents lateral movement of the forked member. The forked member is provided with a tongue x protruding in the reverse direction to the horns, and in a plane at right angles to them, the tongue x being arranged to transmit radial movement to the valve y. The valve y is arranged with cut-off portions 1, 2, 3, and 4, fitting within the cylindrical wall of the valve-chest q, and with cut-away portions 5, and 6, 6 serving as ports, bridging strips 7 being provided to prevent live steam from escaping from the cut-away portion 5 into a cut-away portion or pocket 8, and so to the exhaust. The portions of the valves at 6 and 6 are not cut away around the whole circumference of the valve, but have segmental portions fitting the interior of the valve chest for controlling auxiliary inlet ports 10 and exhaust ports 11 disposed in the valve chest, auxiliary ports 12 being also provided in the valve to work in conjunction with the exhaust ports 11. The function of these auxiliary ports being to control the longitudinal movement of the valve. A slot or recess 13 is provided in the valve to accommodate the tongue x of the forked member u, the recess being sufficiently long to allow of the movement of the valve. Space portions are formed in the valve to decrease its weight. The valve chest is provided with a steam inlet 15 and exhaust passage 16. Communicating with the top end of the cylinder and opening into the valve chest are pilot port 17 and main port 18, and communicating with the lower end of the cylinder are pilot port 19 and main port 20, each controlled by the valve y. To describe the operation of the valve, let it be assumed that the piston b is at the top of its stroke in the cylinder a, the bracket d through the link f will therefore have raised the end of the lever g and depressed the transverse rod, and so have moved the lower tappit p downwards, drawing down with it the rods m and o. The downward movement of the rod o will have caused the member u, by reason of its tongue x, to have moved the valve y in a semi-rotary clockwise direction. The position of the valve will therefore be that it is at the extreme limit of its right-hand movement within the valve-case, and turned to its fullest clockwise direction. In this position the right-hand auxiliary port 10 will be uncovered by the right-hand segmental portion 9 and open to steam, the right-hand exhaust port 12 having turned out of communication with its corresponding exhaust port 11. The condition of the left-hand auxiliary ports for this position of the valve will be that the inlet port 10 is closed to steam by the segment 9, and the exhaust ports 11 and 12 will be in communication and open to exhaust. The main port 18 from the top end of the cylinder will be open to exhaust, owing to the portion 3 of the valve having moved to the right and opened communication between port 18 and cut-away portion 8 of the valve. The portion 1 of the valve will have closed the pilot port 17 to steam. The main port 20 will be uncovered by the right-hand movement of the part 2 of the valve to steam, and the pilot port 19 will also have been uncovered by part 4 of the valve to steam. As steam enters the right-hand end of the valve-chest through the port 10, the valve is forced towards the left-hand end of the chest, and opens the main and pilot ports, which were closed by the right-hand movement of the valve, and closes those ports which were previously open, thus imparting a reverse movement to the piston b. As the piston descends it moves the lever g, which, in turn, actuates the upper tappet p, and by the agency of the rods m and o and forked member u, turns the valve in an anti-clockwise direction for a part of its stroke. It will thus be seen, owing to the longitudinal and radial motions imparted simultaneously to the valve, that a point on the circumference of the valve, at least for part of the stroke of the valve, will follow a helical course. The valve will, therefore, as it moves to the left hand open the left-hand port 10 to steam and turn the left-hand port 12 out of communication with its exhaust passage 11. At the right-hand end of the valve the steam port 10 will be closed, and the port 12 brought into communication with the exhaust passage 11. The valve will, in its movement, close pilot port 19 and open port 18 to steam, open port 20 to exhaust and open pilot port 17 to steam. (*Sealed July* 9, 1914.)



THE ARMAMENT OF THE SPANISH BATTLESHIP "ESPANA."

THE first of the new battleships for the new navy of Spain, being constructed by the Sociedad Española de Construccion Naval, at Ferrol Dockyard, under the technical advice of a British committee, embracing representatives of the firms of Messrs. Armstrong, Brown, and Vickers, has just completed the trials of her gun-mountings, and these have given unqualified satisfaction, alike as regards the guns, their mountings, and the structure of the ship. The tests made disclosed no weakness in any respect. By the permission of the Spanish Naval Authorities at Madrid we are enabled to publish on Plate XVII., and pages 144, 145, and 156, drawings of the guns and gun-mountings, in supplement to the illustration of the ship which we gave in ENGINEERING, vol. xcvi., page 175. Before describing the armament of the vessel, it may be said that the España, like her two sister-ships, Alfonso XIII. and Jaime I., has a length of 435 ft., a beam of 78 ft. 9 in., and a displacement of 15,460 tons at a draught of 25½ ft. The machinery, which has also been built at Ferrol, is of the Parsons turbine type, with Yarrow boilers, the designed power being 15,300 shaft horse-power, to give a speed of 19¼ knots, a rate of speed which was exceeded on the trials of the España. The vessel is effectively armoured, the main belt being of 9-in. K.C. armour, while the more vulnerable parts of the gun positions are protected by 10 in. armour.

For a ship of the size, the vessel has a formidable armament, as follows:—Eight 12-in. (30.5-cm.) 50-calibre breech-loading guns, mounted in pairs in barbettes; twenty 4-in. (10-cm.) 50-calibre breech-loading guns, mounted in casemates; two 3-pr. (47-mm.) 50-calibre quick-firing semi-automatic guns on upper-deck mounting; two 3-in. (76-mm.) 17-calibre quick-firing guns, with landing mountings; and two rifle-calibre Maxim guns on naval mountings.

The following table gives the ballistics and principal particulars of these guns:—

Calibre	in.	12	4	1.85	3
Length of bore ..	,,	600	201.16	98.9	51
Total length of gun ..	,,	616.5	208.35	92.6	55
Maximum pressure in chamber ..	tons per sq. in.	19	18	17	11.4
Weight of projectile ..	lb.	850	31	3.3	11.68
Total weight of gun, including mechanism ..	tons c.	t. c. q. lb. 64 13	c. q. lb. 2 1 3 20	c. q. lb. 5 3 14	c. q. lb. 3 0 7
Muzzle velocity	ft.-sec.	3060	3000	2800	1231
,, energy	ft.-tons	53045	1935	180	123

The following are the striking energies and penetrations of the 12-in. and 4-in. guns at various ranges. The 12-in. penetrations are for capped projectiles and K.C. plate, the 4-in. for uncapped projectiles and hard-steel plates:—

Range.	12-In. Guns.		4-In. Guns.	
	Energy.	Penetration.	Energy.	Penetration.
metres	ft.-tons	in.	ft.-tons	in.
3,000	40,490	21.6	730	4.0
5,000	33,440	18.8	370	2.5
7,500	26,140	15.8	215	1.7
10,000	20,545	13.3	—	—
15,000	13,140	9.6	—	—
20,000	10,055	8.0	—	—

The gun trials took place on June 30, when the España proceeded to sea from Ferrol in a condition ready for service. On behalf of the Spanish Admiralty there were present Rear-Admiral Moreno Eliza, Captain-General Barriere, General Gallardo, General Gonzalez, and Colonels Marabotto and Fernandez, while the ship was in charge of Captain Carranza. Sir Trevor Dawson and Captain Paynter represented the firms of Messrs. Armstrong and Messrs. Vickers, who were responsible for the armament. First, the 3-pounder guns on the top of the forward and after barbettes were fired horizontally and at maximum elevation. Following this, two rounds were fired from each of the ten 4-in. guns on the starboard side of the ship, one round being with the gun horizontal, and the other at 4 deg. of depression; the angle of training in each case was different. Ten similar guns on the port side were also fired at various degrees of training and elevation. In every case the results were thoroughly satisfactory. The test of the 12-in. guns was then proceeded with. In the forward barbette the right-hand gun was fired when horizontal, but trained 40 deg. on the starboard beam, while the left-hand gun was fir d at 4 deg. depression and at 45 deg. on the starboard beam. In the case of the starboard barbette guns, the right-hand gun was fired with 4 deg. of depression and 40 deg. training on the starboard beam, while the left gun was fired horizontally at 45 deg. training on the starboard beam. In the case of the port barbette the right-hand gun was fired horizontally at 130 deg. of training, while the left-hand gun was fired at 4 deg. depression and at 135 deg. of training. In the case of the after barbette the angles of training were also 135 deg. and 130 deg. respectively. In every case the gun and mounting were found to be in thoroughly satisfactory order, and the velocity attained was 3000 ft. per second. Finally a salvo was fired by electric circuit from all the guns on the port side of the ship—namely, eight 12-in. guns and ten 4-in. guns. All the guns were trained at full elevation, a condition which was decided upon as constituting the most severe test, not only of the gun-mountings, but of the structure of the ship. The firing was absolutely instantaneous, and a thorough examination of the vessel afterwards showed that there was not the slightest damage done to the ship's structure. The workmanship reflects the highest credit on the officers and workmen of the Sociedad in the Ferrol Works.

The guns are of steel construction. The breech mechanism of the 12-in. gun, illustrated by Figs. 1 and 2, page 144, is of the latest pattern, giving considerable increase of power when closing the breech, and is arranged to be operated either by hydraulic or hand gear. The hydraulic gear is actuated by a three-cylinder hydraulic engine situated in the mounting and connected to the hinge of the breech mechanism by bevel gearing and a horizontal rotary telescopic shaft, lying parallel to the gun axis. On this shaft is keyed a spur-pinion in gearing with a pinion on the same axis as the worm. This in turn engages with the worm-wheel on the hinge-bolt and actuates the breech mechanism, first turning the breech-screw and then swinging the breech mechanism open. The hand-gear for operating the mechanism consists of a hand-wheel on the mounting connected by bevel gearing to the horizontal rotating shaft, and working through the medium of the worm and the worm-wheel. The clutch gearing on the mounting is contained in a metal casing. The clutch is placed between the hydraulic bevel-gear and the hand bevel-gear. This clutch is thrown out of action at any time by means of a hand-lever, and is arranged so that it may instantly be put into hydraulic or hand-gear without involving any danger of having both these gears in operation at the same time. Seventeen turns of the hand-wheel are required to operate the breech mechanism, 12.2 to unlock the breech, and 4.8 to swing the breech mechanism out to the fully open position.

The breech-screw is mounted on the stem of a carrier and retained by interrupted screw-threads. One of the chief features of this mechanism consists in the application of a mechanical couple for the rotation of the breech-screw. In breech mechanisms as at present generally constructed the breech-screw is rotated by a turning moment, which has been found to set up considerable friction, owing to the tendency of such moment to cause axial displacement of the breech-screw. By the application of the couple this difficulty is obviated, and the whole of the available turning force applied to the breech-screw is utilised in seating the obturator. The rear face of the breech-screw is provided with two studs diametrically opposite to each other. Around these studs are fitted two sliding-blocks, which engage with corresponding holes in a lever-plate, having a long grooved arm. The lever-plate is pivotally mounted on the same axis as the breech-screw. It is not, however, directly pivoted on to the stem of the carrier on which the breech-screw rotates, but is mounted on a sleeve surrounding part of the stem of the carrier to the rear of the breech-screw. The interior of the ring of the lever-plate is slightly elongated with respect to the outside diameter of the sleeve, and the holes in the lever-plate, into which are fitted the sliding-blocks on the studs of the breech-screw, are made slightly longer than the blocks themselves; and, furthermore, a greater clearance than is usually allowed is made between the breech-screw and the stem of the carrier on which it turns. This arrangement, together with the clearance just enumerated, absolutely ensures that any small inaccuracies in the manufacture of these parts of the mechanism are automatically adjusted, and also that the breech-screw is mechanically quite independent of the lever itself, except by its engagement through the studs with their sliding-blocks.

Engaging with the groove of the long arm of the lever-plate is a roller-pin projecting forward from a short crank mounted on the carrier. The form of the groove in this arm is such that the maximum possible power is exerted when seating the obturator. The pivot of the short crank is provided with a roller-bearing to eliminate as far as possible the friction of the toggle-joint action of the crank before the final operation of seating the obturator. The arrangement of the crank with respect to the groove in the long arm is such that a locking-point is formed when the breech is closed. On the crank are spur-teeth, which gear with similar teeth formed on one end of the intermediate pinion, which is mounted on a short horizontal shaft, and having at its other end a bevel segment which gears with a bevel-wheel keyed to the hinge-bolt of the carrier. The hinge-bolt of the carrier is operated by the worm and worm-wheel gear at its lower end by the hydraulic or hand-operating gear.

An improved form of lock-operating gear has been instituted, consisting of a series of links connecting up the locks to the crank. By this gearing considerable increase in strength has been obtained, and it has been possible to utilise pin-joints in the place of the old cam-grooves. In addition to this, a safety device has been introduced, consisting of a rod mounted in the carrier, engaging at one end, by means of a roller, with a cam on the crank, and at the other end with a retracting-lever, which is pivoted on the box-slide and engages with the striker or firing-pin of the percussion or electric locks respectively. This gear enables the striker or firing-pin to be withdrawn from the primer, prior to any motion being given to either the locks or the breech-screw, and only permits the striker or firing-pin to come into contact with the primer after the breech-screw has been locked and the locks perfectly centred in their firing position.

The mechanism is provided with separate electric and percussion-locks. The special features of these locks may be briefly enumerated as follows:—The same box-slide is used for either electric or percussion lock. Fitted on the box-slide is a spring tube-retainer, the office of which is to prevent the tube being jerked out when slamming the breech. An extractor is mounted on the box-slide, and is formed in two parts. It is specially strong, and is of a new form, arranged so that during the operation of the lock-frame a fine incline acts on a prolonged toe of the first part of the extractor, and powerfully wedges out the primer previous to its rapid ejection by the engagement of the lock with the second part of the extractor. The box-slide is provided with safety-slides, which are used for both the electric and percussion locks. The percussion lock is fully cocked automatically on opening the breech, and has a "floating" needle arranged so that in its normal position the point of the needle is slightly within the face of the lock-frame, thus providing an additional point of safety to that of the quick-retracting device. Both the electric and percussion locks have spring guide-bolts, which couple the lock-frames with the links actuating lock, which are mounted in the carrier. These spring guide-bolts are so arranged that, should it become necessary to eject the primer owing to missfires or any other cause, the lock-frame may be drawn sufficiently to one side to do this without it being necessary to open the breech.

The 4-in. gun, with its mounting, is illustrated in Figs. 3 to 5, on page 145, while a view of the gun being loaded is given in Fig. 11, on page 156. The mounting is of the usual centre-pivot type, with carriage and pedestal, elevating-gear being placed on the left-hand side of the mounting only, and training-gear on the right-hand side of the mounting only, while the speeds of these gears is such that no difficulty is experienced in keeping the gun on the target, notwithstanding the higher rate of the speed of the opposite target or the rate of roll of the ship. The carriage, which is of the usual form, is provided with trunnion-locking gear, so arranged that the guns can be quickly run inboard when not in use, by means of overhead gear or by deck-bogies. The springs for returning the gun to its firing position are contained in a case which is situated on the top of the cradle; and the hydraulic recoil-buffer, which is arranged to give an approximately uniform pressure throughout the length of recoil, is placed on the under side of the

cradle. The latter is fitted with a control device, so that the gun when running out will be brought gently to rest. The mounting is provided with a casemate shield, which is secured to the carriage, the shield being of such a diameter that the maximum amount of protection is afforded to the gun-layers and also to the mounting. Sights are fitted to the mounting on the "follow the pointer" system. The sights are of the day-and-night sight pattern, and are cross-connected, so that simultaneous movement for range and deflection is ensured. The sight-dials are electrically illuminated for night use, and calibration-gear is fitted to compensate for loss in muzzle velocity due to wear of gun and temperature of charge. Platforms are provided on both sides of the mounting, that on the left-hand side carrying the sight-setter and elevating number, the training number being carried on the right-hand platform.

The breech mechanism for the 4-in. quick-firing guns is similar in principle to that of the 12-in. already described, with the following exceptions:—Owing to the lightness and small size of the breech-screw it is found unnecessary to apply the mechanical coupling principle, so that the grooved arm is in this case made in one piece with the breech-screw. Instead of the worm and wheel-gearing the complete operation of opening and closing the breech is performed by the single motion of a hand-lever. All the other mechanical advantages, however, are retained. The firing-locks, electric and percussion, are interchangeable with those of the 12-in. mechanism, having all the characteristics of safety, and being actuated in a manner similar to that already described for the larger guns. An addition to the mechanism, however, is made in the introduction of a bronze shot-tray, which, as shown in the illustrations, slides across the breech-face and is brought automatically into loading position by the breech mechanism as it is swung open.

The breech mechanism of the 3-pounder (47-mm.) semi-automatic guns consists of a vertical sliding-block, which is automatically brought into the open or loading position during the running out of the gun after recoil. The breech-block slides vertically in the material of the gun at the rear of the chamber, and is actuated by a crank pivoted on the under side of the gun-breech, the other extremity of the crank engaging with two grooves cut in the block. A powerful extractor is pivoted on the under side of the gun, having two upward arms with projections which engage with the rim of the cartridge-case, and two downward-projecting toes which engage with a prepared surface on the breech-block face when the latter is opened. The axis-pin, on which the crank is mounted, is hexagonal in section, except in its bearings, and runs from one side of the gun to the other. At one end is a specially-formed cam, which comes into engagement with a pawl pivoted on the mounting. On the other end of this axis-pin is a bush, and secured to it is a powerful clock-spring, the whole of which is covered by a bronze case fixed by screws to the side of the gun. The outer extremity of this clock-spring is secured to the case. On the extreme end of the spindle is mounted a hand-lever, by which the mechanism is operated when first loading the gun, or when using the gun as a quick-firer.

The breech is opened by the hand-lever, which, in turning, rotates the crank and spindle, and in so doing winds up the clock-spring. The breech-block by its weight assists in this operation. When the crank has been fully rotated the lower extremity of the extractor is pushed by the breech-block into a recess formed in the crank, thereby holding the latter in the open position and preventing its return. The ejecting-arms of the extractor are then in a rearward position, and, when the charge is pushed into the chamber, the rim of the cartridge catches the ejecting-lips of the extractor, carrying the ejecting rims of the extractor towards the chamber of the gun, and the lower extremities of the extractor away from the recess in the crank. The latter being liberated, the clock-spring impels the crank, and with it the breech-block, into the closed position.

On the gun running out after recoil, the breech is automatically opened by the spring control pawl on the mounting engaging with the cam and rotating the latter, and with it the spindle and crank, thereby again opening the breech, the crank once more being retained in this position by the extractor, ready for the insertion of a new charge. For quick firing only, the pawl is placed by a lever into an inoperative position, so that the gun on running out does not open the breech, which is then opened by hand. In this case ease in operating can be facilitated by the removal of the spring-case. Upwards of 30 rounds per minute have been obtained with this gun.

The 12-in. gun turrets are constructed on the most recent principle obtaining in all later battleships, and detailed drawings are reproduced in Figs. 6 and 7, on Plate XVII., while perspective views of various operations are given on page 156, Figs. 8 to 10. The turrets each carry two 12-in. guns and

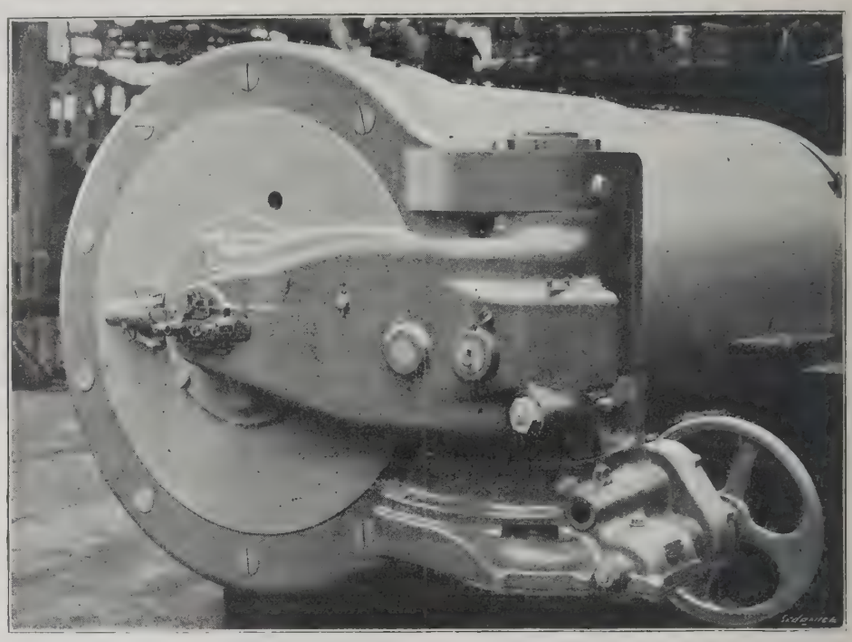


FIG. 1. BREECH OF 12-IN. GUN, CLOSED.

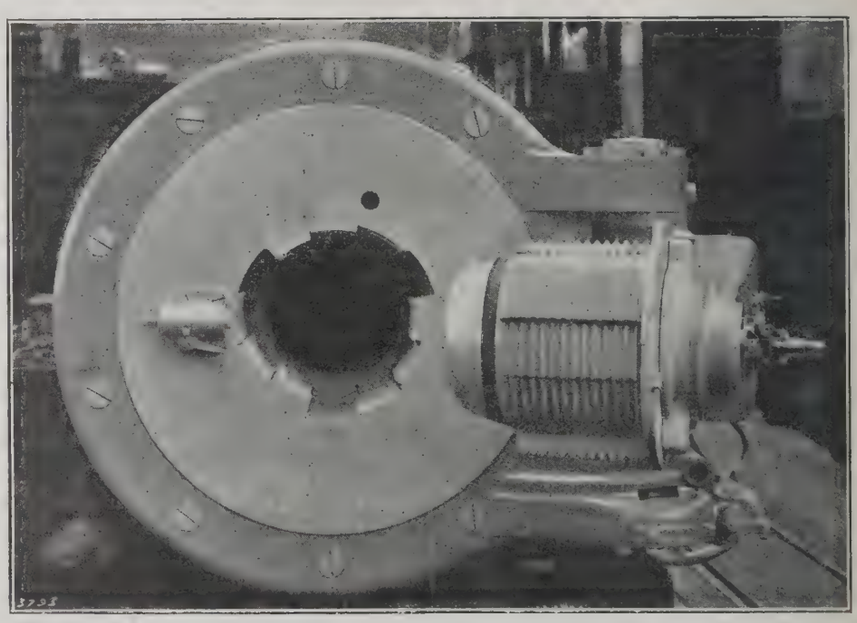


FIG. 2. BREECH OF 12-IN. GUN, OPEN.

are operated throughout by hydraulic power. As to this form of power there is, perhaps, little need to make any comment, considering the great favour in which it is held by armament contractors generally, except to say that it has proved itself extremely reliable and easily controlled. The turrets revolve on a live roller-ring, consisting of a number of flanged conical rollers riding between the two paths, the lower one being secured to the structure in the ship, and the upper one to the under side of the turntable. The rollers are kept at their correct distance from one another by means of a properly-constructed cage, similar in principle to any of the smaller type of roller-bearings, of which there are so many now in existence. The arrangement of the turret is shown generally by the sectional views reproduced on Plate XVII. As will be seen from these illustrations, the turrets are provided with an axial hoist which extends down from the turntable to the magazine and shell-room. There are three main portions of each turret, irrespective of the shield: firstly, the turntable on which the guns are mounted; secondly, a chamber below the turntable conveniently arranged for many of the operating gears and for access to the machinery generally; and, thirdly, the ammunition trunk, which is attached to the under side of the working chamber. All these revolve together as one piece. The guns and the upper part of the turntable and gear generally are protected by an armoured shield consisting of Krupp cemented quality armour, strongly secured to the turntable. The roof of the shield is in large plates, extending transversely from side to side, and sloping upwards to the centre, thus providing a naturally strong formation.

A spur-rack is placed on the supporting structure below the level of the rollers, and by means of this the turning movement of the turret is effected. Into this rack two pinions gear, rotated by hydraulic motors, or, alternately, by the auxiliary electric-power gear with which the turret is provided for the training movements. There are really two training sets with motors in each turret, placed

THE ARMAMENT OF THE SPANISH BATTLESH

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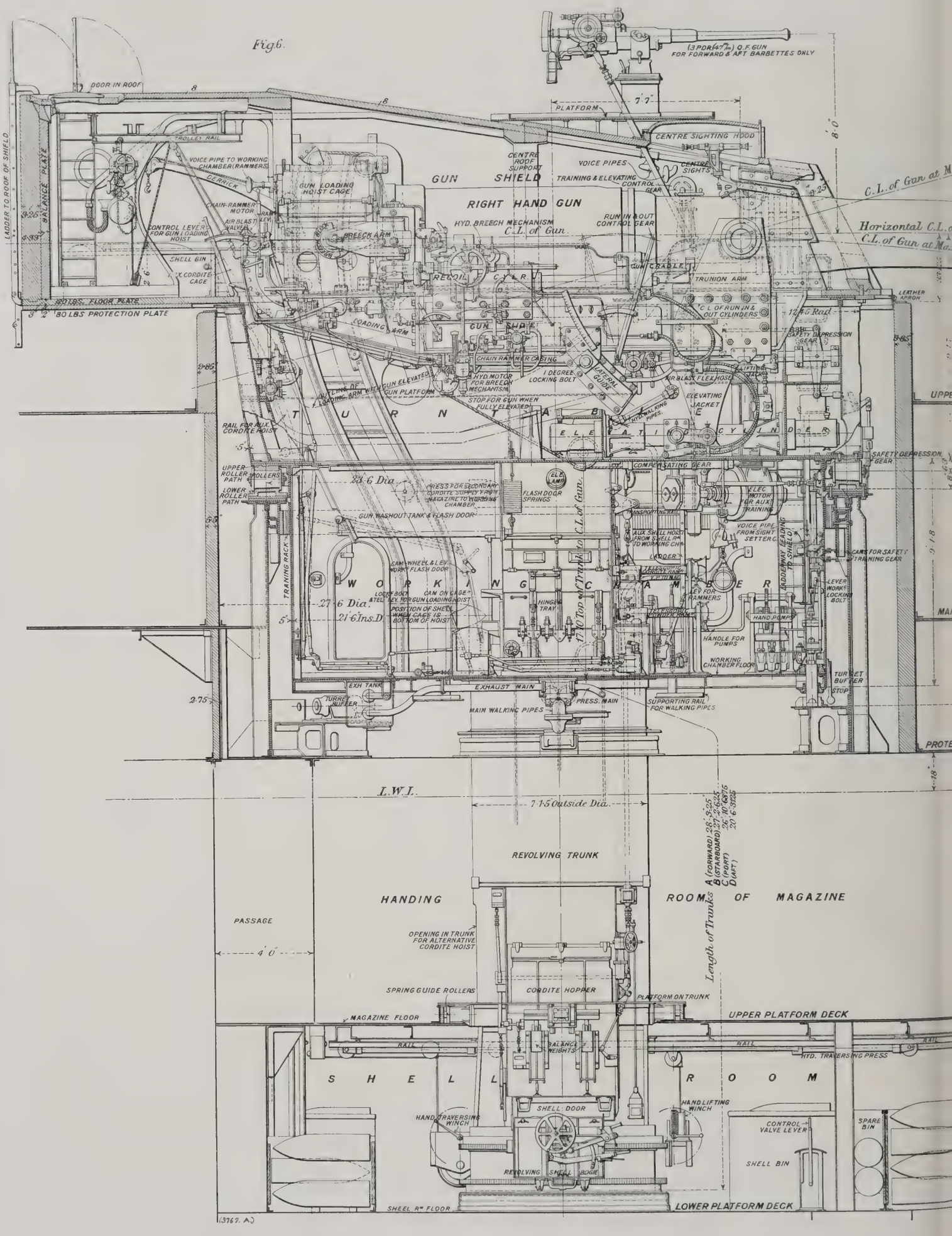
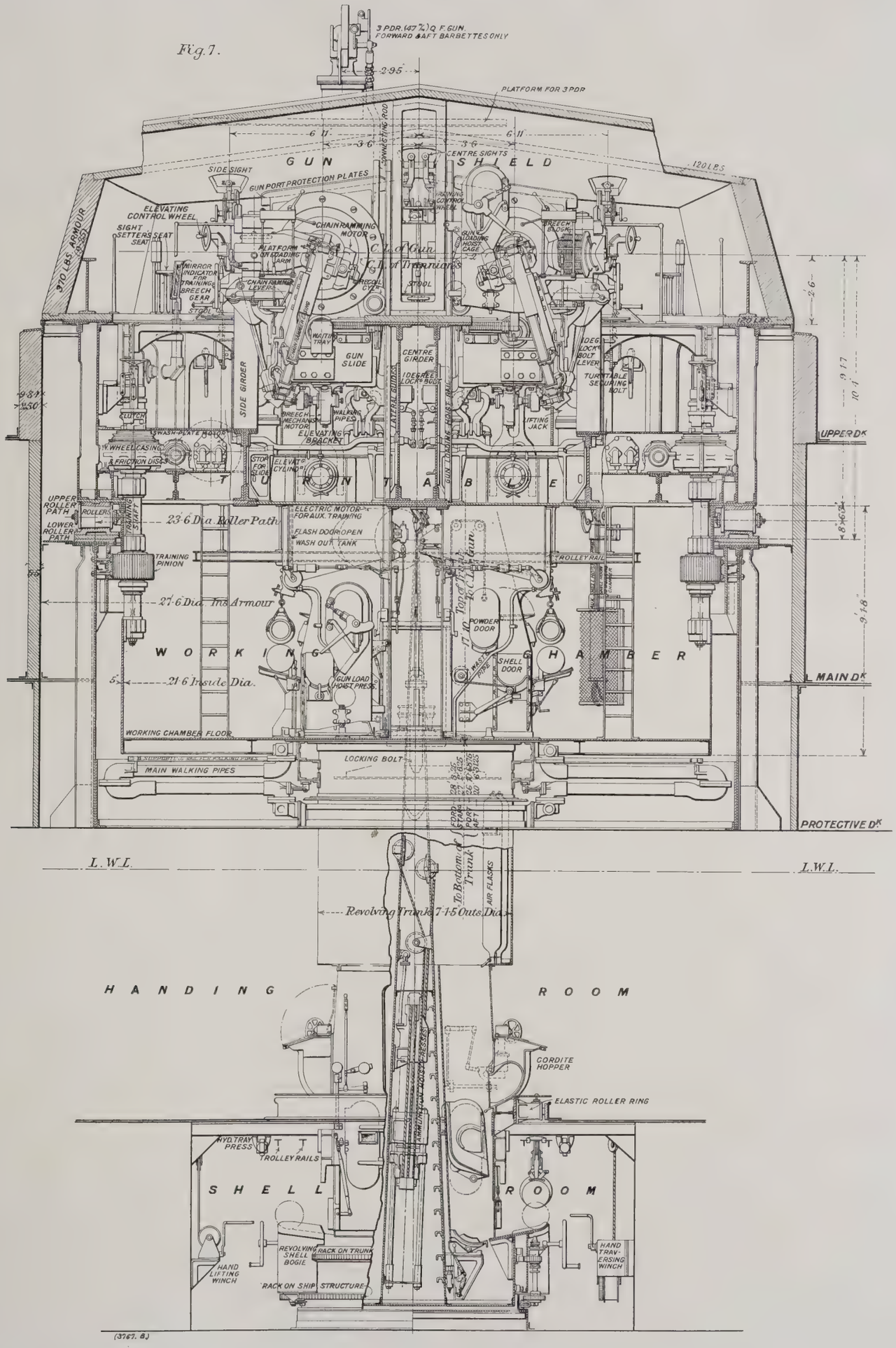


AÑA;" THE 12-IN. GUN BARBETTE MOUNTINGS.

AVAL, FERROL AND CARTAGENA.

143.)

Fig. 7.



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THE ARMAMENT OF THE SPANISH BATTLESHIP "ESPAÑA;" 4-IN. GUN AND MOUNTING.

THE SOCIEDAD ESPAÑOLA DE CONSTRUCCION NAVAL, FERROL AND CARTAGENA.

Fig. 3.

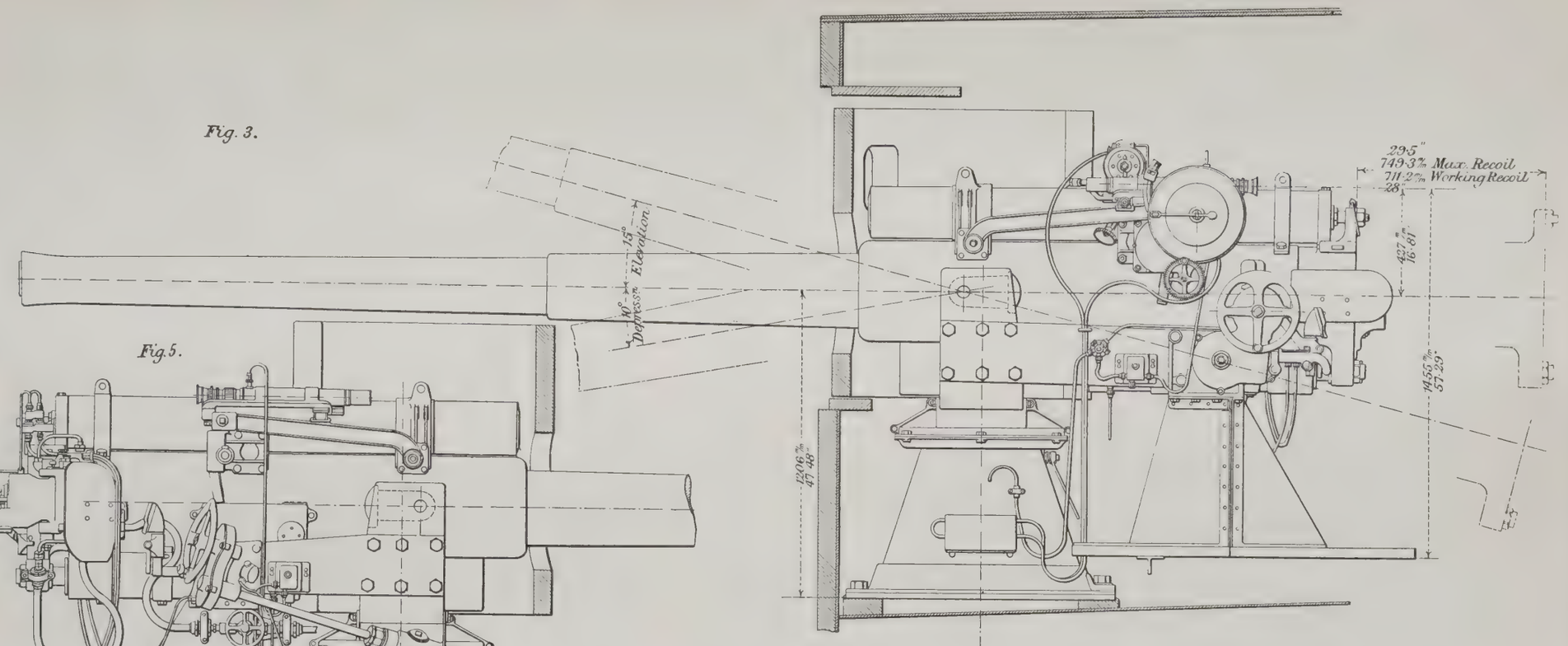


Fig. 5.

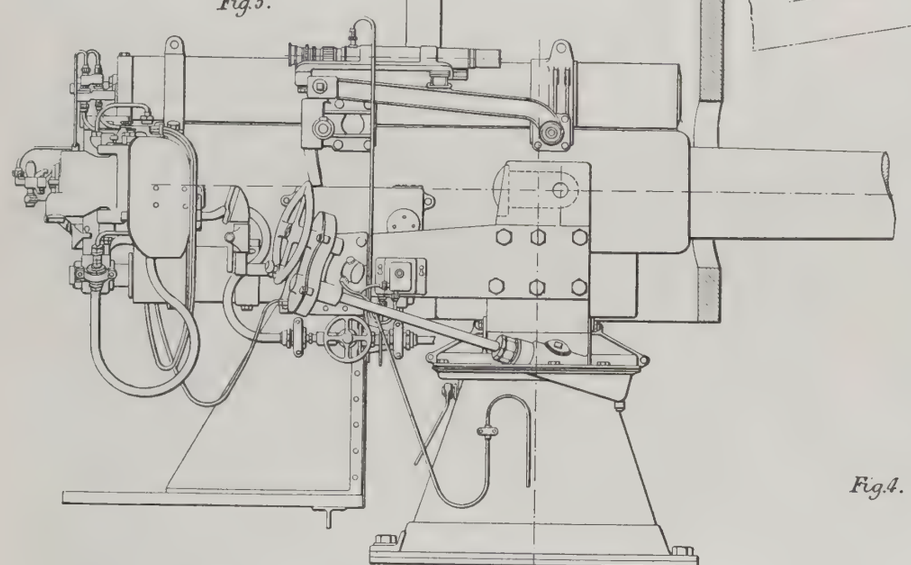
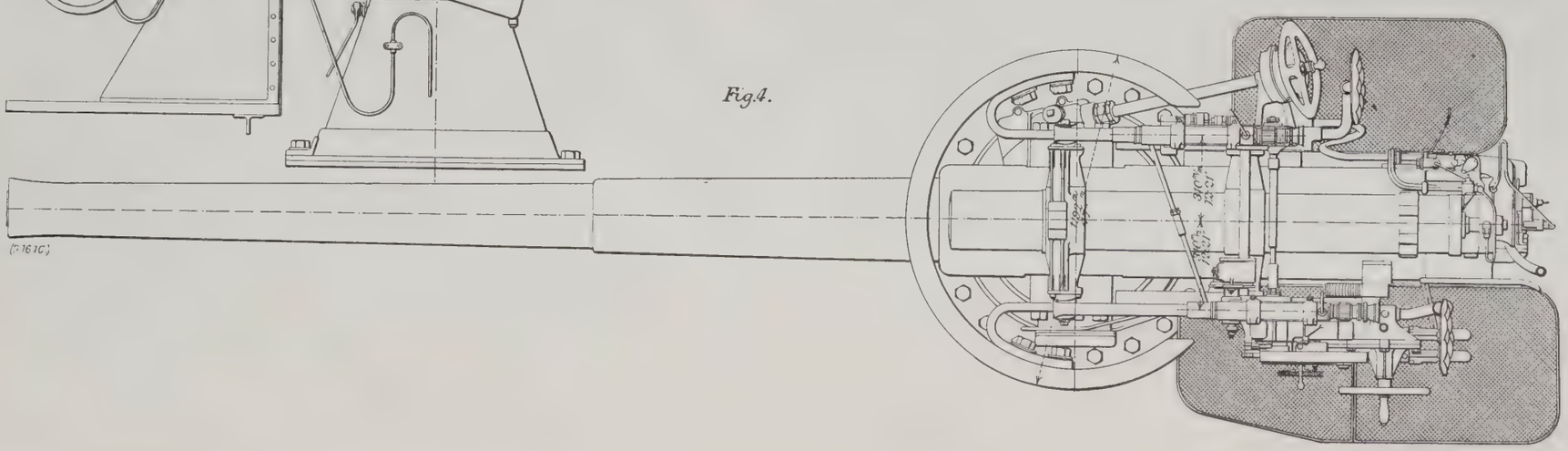


Fig. 4.



at the opposite sides of the turntable, and quite independent of one another, one set being capable of performing all the movements of training at maximum speed. The pinion and racks are of steel, and the accuracy with which these gears are cut enables the backlash to be reduced to a negligible quantity. This is a feature which is very desirable for accurate aiming of the guns. The hydraulic motors are of the multi-cylinder type. They are very compact, and give very smooth running. With the auxiliary electric gear also extreme smoothness in working is obtained. In this gear a universal transmission machine of the Janney-Williams type is employed for transmitting the power from the electric motor. The electric gear is provided as an alternative to the hydraulic system, and is mainly intended to be brought into operation in the event of the latter being inoperative; but it may also be used at any time in place of working by the hydraulic power. Securing-bolts are provided by means of which the turret can be locked in a definite position when not in use. A further bolt for locking the turret is also fitted, which is operated by hydraulic power. There are also buffers fitted as well as automatic stop-gear to arrest the turret at the extreme positions of training.

For elevating the guns the direct-acting hydraulic press is employed. This form of apparatus is both reliable and efficient, as well as being simple. Included in the elevating arrangements is an automatic controlling-gear to prevent the guns being fired in positions which may endanger any part of the ship. This gear acts so as to raise the muzzles of the guns should they be trained while at depression into a zone where their discharge would be dangerous to the ship's structure; the gear also prevents the guns being depressed while in such positions of training.

Both the training and elevating of the guns is controlled from the sighting positions, of which three are provided in the turret. One of these sighting positions is arranged between the guns, and is fitted with two independent sights, one for each gun; the other sighting positions are at the sides of the turret, where one sight is fitted in each case for its respective gun. It will thus be seen that either gun can be laid from two sighting positions. The ordinary variable-power telescopes are used for the sights. These are protected by armoured hoods on the roof of the shield, which are large enough to give ample space for the sighter's head, and to protect at the same time the whole length of the telescope. Steel shutters are fitted on the front of these hoods, which are removed when the sights are in use. Electric firing-gear is provided, and in addition to this there are also the necessary fittings for percussion firing. The circuits and firing-keys of the electric firing-gear are in duplicate.

The carriage for the gun in each case takes the general form of a cradle mounted on a slide-beam. The latter is fitted with trunnion-arms at its forward end, which engage with the pins secured in bearing-blocks on the girders of the turntable. The cradle is secured by keys to the body of the gun, and it is provided with gun-metal liners on all surfaces in contact with the slide. The gun-carriage has two recoil-buffers for absorbing the recoil energy of the gun. The run-out after recoil is effected by means of an hydraulic press placed centrally below the gun and fitted with the usual by-pass valve. There is also included with these fittings the necessary gear for slowing down the run-out movement when the gun approaches its stops in the forward position, in order to prevent undue shock.

The arrangements for the supply of ammunition to the respective guns are entirely independent of one another as regards the main hoisting-gear. From the shell-bins in the shell-room the projectiles are lifted and transported by hydraulic power on runners carried on overhead rails, the projectiles are then deposited on the loading-bogies at the base of the central trunk. The bogies in question are provided with gear which enables them to be revolved into any position to bring them opposite the openings leading to the hoisting-cages. The operation of transferring from the bogie to the hoist is then a very simple one, of merely rolling the projectile into the cage from the bogie. The powder is served to the lifting-cages on the deck-level above the shell-room, the cages being so constructed that one projectile and a complete powder charge is conveyed to the working chamber at each operation. From the hoisting-cage the discharge of the projectile and powder charges is effected automatically into suitably-constructed receptacles in the working chamber, the empty cage is then lowered, and the projectile and charges are transferred bodily by small rammers into the gun-loading cage, by which the ammunition is finally raised to the gun. The gun-loading cage runs on curved rails passing from the working chamber up into the turntable at the rear of the gun, the arrangement being such that the cage when up against the loading-arm is always in line with the gun, so that the loading can be performed at any angle of elevation. The several lifting-cages are raised by the usual form of hydraulic press. The lifting-rope is connected to the cage through a safety gear, so that the cage may be brought to rest in case the rope fails.

For loading the guns a flexible chain-rammer is supported on an arm extending from the gun-slide out to the rear behind the gun. This rammer is operated by an hydraulic motor, and enables the loading for the gun to be performed very rapidly. Independently of the main hoists there is also a system of secondary hoisting-gear installed in each turret, by means of which the projectiles and powder charges can be conveyed to the guns. Air-blast apparatus is included in the equipment of the turret for the purpose of blowing the gases and unconsumed material out of the muzzle end of the guns after firing. The advantage of this apparatus is that the turret is practically always free from the smoke and the roof-plates can be without air-holes. The supply of compressed air is derived from a specially-installed air-compressor in the ship.

Hydraulic power for working the various machines of the turrets is derived from two steam pumping-engines fitted in the ship. The engines are of the compound double-acting type, and each unit comprises two high-pressure and two low-pressure steam cylinders, and two pumps working on a common crank-shaft. These pumping-engines are connected up to the main hydraulic pipe-line carried round the ship on the ring system. Connections are made from the mains to the respective turrets, and the water is conveyed to each by means of two independent sets of pivoted pipes, affording a duplicate supply in each case. The hydraulic connection in the turrets also provides for a duplicate supply to each separate machine. The normal pressure of the hydraulic system is 1000 lb. per sq. in.

THE PANAMA CANAL.—No. XII.

RECENT reports from the Panama Canal show that the mechanical equipment of the locks is rapidly nearing completion. Save for some painting and finishing, the work on the lock-gates was completed in March. The gate-moving machines were completely installed at the end of April, and the mitre-forcing machines were all finished. The progress made with other portions showed generally that the end of this work is near at hand, and it will not, therefore, be without interest if we supplement former articles, which dealt with the mechanical equipment, with some information not available before, dealing more particularly with the behaviour of several of the machines, &c., on trial.

On May 4 ten years of American work closed at Panama, and in that time the canal has been virtually completed. The canal was first put to commercial use on May 19, when a convoy of barges loaded with sugar, ex s.s. Alaskan, at Balboa, was taken through to Cristobal. The trip lasted about 12 hours 40 minutes. The remote-control gear for the locks is well advanced, and one board at Gatun was submitted to a complete test on May 9, except as regards the fender-chain gear not yet wholly installed. This test was made without a vessel, and merely consisted of performing the necessary interlocked operations. On May 11 two vessels were actually locked through, using the central control-board only. On May 12 the first lockage was made, using both the control-board and the towing-locomotives. Other details of the locomotives and their early work on the canal are recorded below.

LOCK-GATES AND OPERATING MACHINERY.

The lock-gates, and the method of their erection, were fully described and illustrated in a previous article of this series.* There are 92 gate-leaves on the canal, ranging from 82 ft. to 47 ft. 4 in. in height. The largest weighed 733 short tons per leaf, the actual shipping weights of all leaves together amounting to 57,552 tons (short). These weights include the metallic swinging parts only, and exclude the pump, float and float-switch, motors, casting for the operating strut, and mitre-forcing machine, as well as the concrete for the footpath, the cement filling for the bottom girder, and the timber fender and sill-pieces. The weight of these additional parts varies per leaf from 18 to 27 tons, the total thus corresponding very closely to the total estimated weight given in the article above referred to. The fixed parts attached or built into the lock-walls, &c., aggregated 8322 short tons. They included reaction castings and anchorages embedded in the lock-walls, and already described in ENGINEERING. The sill reinforcement, anchorage and yoke, and parts supporting the leaves were identical for all gates; the total weight of the reactions castings in the hollow quoin varied naturally with the height of the gates.

The work of erecting the gates commenced at Gatun on May 17, 1911. At Pedro Miguel gate erection was commenced shortly after — viz., August 7, 1911, but at Miraflores it was not entered upon till September 10, 1912. Work at all three places was finished this year. At Gatun it was brought to a close on January 19, at Pedro Miguel on January 3, and at Miraflores on January 17. The contract involved the driving of 5,720,000 field-rivets. The work was originally to be completed by June, 1912, but fell very much behind. Reorganisation of the erection staff improved matters. No less than 165 riveting gangs were employed at one time. The maximum number of rivets driven in one month rose to 660,000, the riveting being all done by West Indian negroes.

The gate-operating machines were described in ENGINEERING, vol. xciv., page 772. The mechanism embodies a spring strut, attached at one end to the leaf, and at the other to a large horizontal spur-wheel driven by an electric motor. The first tests made of this gear were carried out in July, 1912, on two guard-gates at Gatun. The machines were set so that the struts were on the dead centre when the gates were closed, with a compression of $\frac{5}{32}$ in. on the strut of one leaf and $\frac{9}{32}$ in. on the other. The control was effected from the centre wall of the locks, and the limit switches were properly adjusted. The leaves took 1 minute 51 seconds to swing and gave a perfect mitre, though in one case one leaf had a slight lead over the other. Mitre-forcing tests were carried out at the same time. The machines for performing this operation were described in a previous article,* but as a result of the test certain changes were made which resulted in new bids being called for. The machines as described, however, worked quite satisfactorily. In one test one leaf was left against the sill, and the other opened 2 in., and this leaf then forced home by the machine to within $\frac{3}{4}$ in. of a perfect mitre. The operation on being repeated, but with the leaf originally $3\frac{1}{2}$ in. open, resulted in the mitre being closed to within $\frac{5}{8}$ in. In the first test the strut arm of one leaf showed a compression of $\frac{1}{16}$ in. at the start, and $\frac{5}{32}$ in. at the end of the operation. In the second test no compression on one arm at the start was altered to $\frac{23}{64}$ in. compression at the end of the operation. The mitre-forcing machine worked satisfactorily against these compressions.

THE CHAIN-FENDER GEAR.

The chain-fender gear for protecting the lock-gates is considerably behindhand. The chains, made out of bar 3 in. in diameter, are being manufactured at the United States Navy Yard, Boston, and at other American Works, but a recent report states that the work has been delayed. It may be necessary to order some of them in Europe, and tenders have been invited. The chains are composed of links 17 in. long and $10\frac{3}{4}$ in. wide. The average length of the twenty-four chains required is 427 ft., except those at Miraflores, which are each 784 ft. long. They weigh about 85 lb. per foot, and are designed to withstand a working stress of 100 long tons with a factor of safety of 2. The machines and their action were described in ENGINEERING, vol. xciv., page 772. The illustrations then given apply to all fender gears on the canal except those in the lower approach-locks at Miraflores, where the range of the tide has rendered advisable some modifications. The gear

* No. III., ENGINEERING, vol. xcv., page 761.

* See ENGINEERING, vol. xciv., page 772.

adopted in this case is shown in Figs. 203 to 208, on the present and following pages. It embodies the use of an endless chain capable of being drawn taut across the lock at two levels about 11 ft. apart, one being about 6 ft. up-stream of the other, as shown in Figs. 203 and 204. A diagram of this gear is given in Fig. 208. In action it is similar to the others. It includes a centrifugal pump, operating and resistance-valves, &c. Fig. 208 shows the operating-valve in the position for drawing in or raising the chain. When the chain is raised and is struck by a vessel, the pressure in the upper cylinder rises to a maximum of 750 lb. per sq. in., controlled by the resistance-valves. The pressure is not allowed to increase above this, and the chain gradually pays out until the vessel is brought up, the floating cylinder of the machine being gradually drawn upwards. To pay out the chain purposely, so that it may fall properly into the chase when not in use, the operating-valve is turned to the dotted position, and water under pressure is then admitted to the lower side of the floating cylinder. The operating pressure, originally figured at 60 lb. per sq. in., has been raised to 150 lb. The machines for the lower approach-locks at Miraflores, instead of having one end of the chain anchored and the other end capable of being paid out, can pay out either portion of the endless chain through separate hawse-pipes. Two mechanical chain-stops, electrically operated, are provided, one or the other being brought into gear according to whichever chain is to be raised.

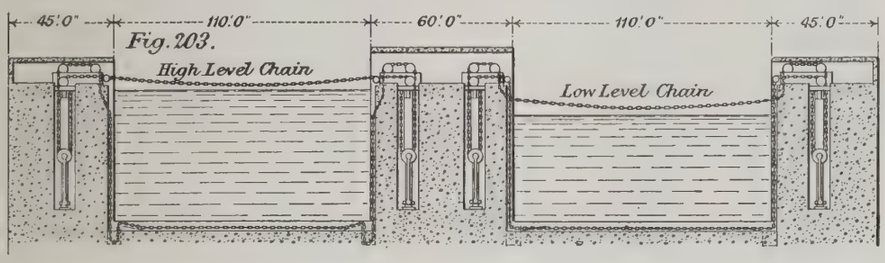


Fig. 203.

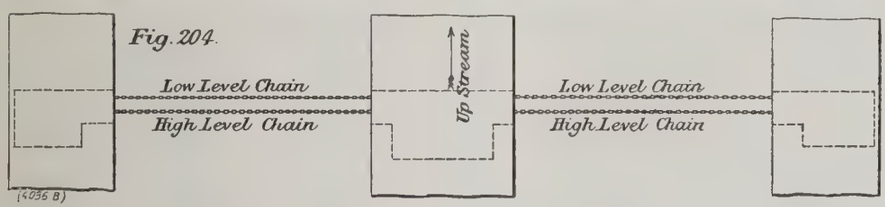


Fig. 204.

Three types of resistance-valves for these chain-fenders were tested at Newark, N.J., on an hydraulic accumulator system. The valve ultimately selected has a main disc $5\frac{15}{16}$ in. in diameter, a lower piston, 6 in. in diameter, and an upper plunger, 2 in. in diameter, all fixed to one stem. There is a slight excess pressure on the high-pressure side of the valve, so that it remains closed except when pressure is admitted to the lower piston by an auxiliary valve. The movement of the main valve depends on the rate of flow through the auxiliary valve. Only a small spring is used in this type of valve, which is substantially a reducing valve. In tests this valve gave very satisfactory results for discharges up to and over 3000 gallons per minute. The pressure curves were free from irregularities and surges. The pressures were recorded by means of indicator diagrams taken on drums revolved by a small motor. This valve and another were subsequently fitted up on a set of fender machinery at Gatun, and trials of this chain-fender gear were conducted during 1913. The first tests consisted merely of raising and lowering the chain as in service. The operation of raising the chain from the lock-floor occupied about one minute. Lowering was accomplished in a similar length of time.

The second series of tests was intended to represent the conditions which would obtain when a vessel ran into the chain extended across the lock. In the first test a Lidgerwood unloader was placed on the far side of the lock about 600 ft. down-stream, and anchored by means of cables to the masonry, &c. The unloader consisted of a 60-ton winding-engine with a $1\frac{1}{2}$-in. steel cable which was attached to the fender-chain. The chain was drawn out against the pressure in the fender-machine cylinder by winding in on the unloader drum. As the chain in this test came to the hawse-pipe at a very small angle, there was a considerable amount of friction between the links and the hawse-pipe bell mouth. This resulted in some oscillations of the pressures, which presumably would have been reduced had the bell mouth been struck to a larger curve. It will be observed in the figures to be rather sharp. The unloader was not sufficiently powerful to overcome both the hydraulic pressure and the chain friction when the former exceeded 350 lb. per sq. in. These tests were made with plunger speeds of 6 ft. to 25 ft. per minute. In order to eliminate the chain friction and obtain results at higher pressures, a snatch-block was placed on the lock-wall opposite the hawse-pipe. The chain was then drawn out normal to the face of the wall. Four runs were made with this arrangement, with pressures up to 370 lb., when the cable parted. A pair of sheaves were then inserted, so as to get additional purchase, and the pressures were run up to about 550 lb. per sq. in., with plunger speeds of 8.4 ft. per minute. The highest pressure reached was 630 lb. per sq. in., but the chain parted in this test. The general results obtained and the pressure curves were considered to be satisfactory on the whole, and the contract for the remainder of the machines was therefore placed. By the end of last April these machines were 50 per cent. completed at Gatun, 47 per cent. at Pedro Miguel, and 24 per cent. at Miraflores.

THE LOCK-CONTROL VALVES.

The control-valves for the locks consist, it will be remembered, of Stoney gate-valves for regulating the flow between the locks, &c., and of cylindrical valves in the centre walls for controlling the flow to or from the centre culverts. In addition to these, there are guard-valves similar to the Stoney gate-valves, but provided with a different type of operating mechanism. The Stoney gate and the cylindrical valves were fully described and illustrated in an earlier article in this series.* The guard-valves are housed in shallow recesses, and their somewhat cramped positions have rendered necessary the design of special operating mechanism. The ordinary Stoney gate-valves, illustrated in our earlier article, are raised and lowered by means of two revolving screws, working a crosshead attached to the valve-stem up or down. In place of this the guard-valves will be operated by chains, and will be provided with counterweights in pits. The chain sprockets are on shafts driven by means of a train of spur and worm reduction gears from a 27.5-horse-power motor, the supply being three-phase at 220 volts 25 cycles.

The fixed castings forming the guides in which these gate-valves work required considerable correction after they had been embedded in the concrete. This was effected by chipping and grinding by means of pneumatic hand-tools in the case of the valves at Gatun, and most of those at Pedro Miguel. For the remaining valves at the latter locks, and for those at Miraflores, this truing up was done by an electrically-driven milling-machine. In this machine a saddle worked up and down between two vertical guides set in the required position, and stayed by cross-bars. The guides had vertical racks, with which geared two pinions on the saddle. The saddle carried an electric motor, reduction gears, and the necessary cutters.

* No. II., vol. xcv., page 689.

Tests of the discharge of the Stoney gate-valves of the type used in the culverts were made with heads varying from 8.94 ft. to 29 ft. above the centre of the valve. The coefficient of discharge, as a result of six observations, was determined as 0 592, but as a good deal of rubbish and drift clogged the screens in front of the valve, other observations were made with the screens removed. Under these conditions fifty-eight observations showed an average coefficient of 0.680. These tests were made on the valves installed at the spillway. The coefficient would be reduced in practice in the case of valves in the culverts, on account of friction, &c.

The tests to which the valve machines have been submitted have consisted of ten cycles of operations at five-minute intervals. The limit of the temperature of the thrust-screws was set at 50 deg. Cent. The motor is nominally run at 500 revolutions per minute. The valves operated in the dry took 63 seconds to open and 58 seconds to close, the lift being 18 ft. The records show the results embodied in the following table :—

	Opening Valve.	Closing Valve.
Weight of valve and accessories, crosshead, and equivalent weight of roller-trains ... ... lb.	31,500	31,500
Side seal friction due to initial tension ... ... lb.	1,000	1,000
Valve, stem, and roller-train friction ... ... lb.	8,000	8,000
Equivalent weight on crosshead ... ... lb.	40,500	22,500
Total machine and valve friction ,,	54,000	38,200
Total force to move valve ... ,,	85,500	6,700
Corresponding motor torque—lb. at 1 ft. radius	510	40
Coefficient thrust screw friction ...	0.073	0.083

The cylindrical valves have also been described in the second article of this series, when it was stated that, as first fitted, they showed excessive leakage, so that certain small modifications were found to be necessary. Several of these valves were tested under a 60-ft. head, and the leakage measured. The worst valve was found to have an average opening round the seat of 0.038 in. This was reduced in successive grindings to 0.0005 in. with a material reduction in the leakage, as in the following table :—

—	Average Opening.	Maximum Opening.	Leakage, 60 Ft. Head.
	in.	in.	sec. ft.
As installed	0.038	0.110	Excessive
After first grinding ..	0.016	0.069	,,
,, second grinding ..	0.011	0.047	0.99
,, third grinding ..	0.0063	0.031	0.455
,, fourth grinding ..	0.0034	0.014	0 060
,, fifth grinding ..	0.0005	0.003	0.0075

This work led to the decision to grind all valves of this type so as to restrict the average opening round the seat to 0.004 in. The leather seals were installed after the grinding had been finished. The machines for working these valves have limit-switches arranged for a slight overrun, so as to bring some pressure to bear on the valve on the seat being reached. Forty of the large cylindrical valves are made of cast steel, but this material was found to give trouble from warping, and the remainder were made of semi-steel. In addition to the main cylindrical valves, 60 in. and 36-in. valves of a similar pattern are used in the auxiliary equalising culverts, &c. The motor torque and time of opening for these valves are as below :—

	Motor Torque. Lb. at 1-Ft. Radius.	Time to Open. Seconds.
Semi-steel cylindrical valve...	79	10
Cast-steel ,,	69	10
60-in. auxiliary culvert-valve	52	16
36-in. ,, ,,	41	10

THE TOWING-LOCOMOTIVES.

As is well known, ships are to be taken through the locks under the control of rack-driven towing-locomotives. The Commission's design for these locomotives was illustrated in ENGINEERING,* and one locomotive of this pattern was built by the General Electric Company. Trials showed this sample locomotive to be unsuitable for the work, and the design was completely recast. The machines to the new design are now being delivered. They are four-wheel locomotives, instead of, as at first designed, having eight wheels and three articulated sections. The new loco-

* Vol. xciv., page 776.

THE PANAMA CANAL; CHAIN-FENDER GEAR AT MIRAFLORES LOCKS.

Fig. 205.

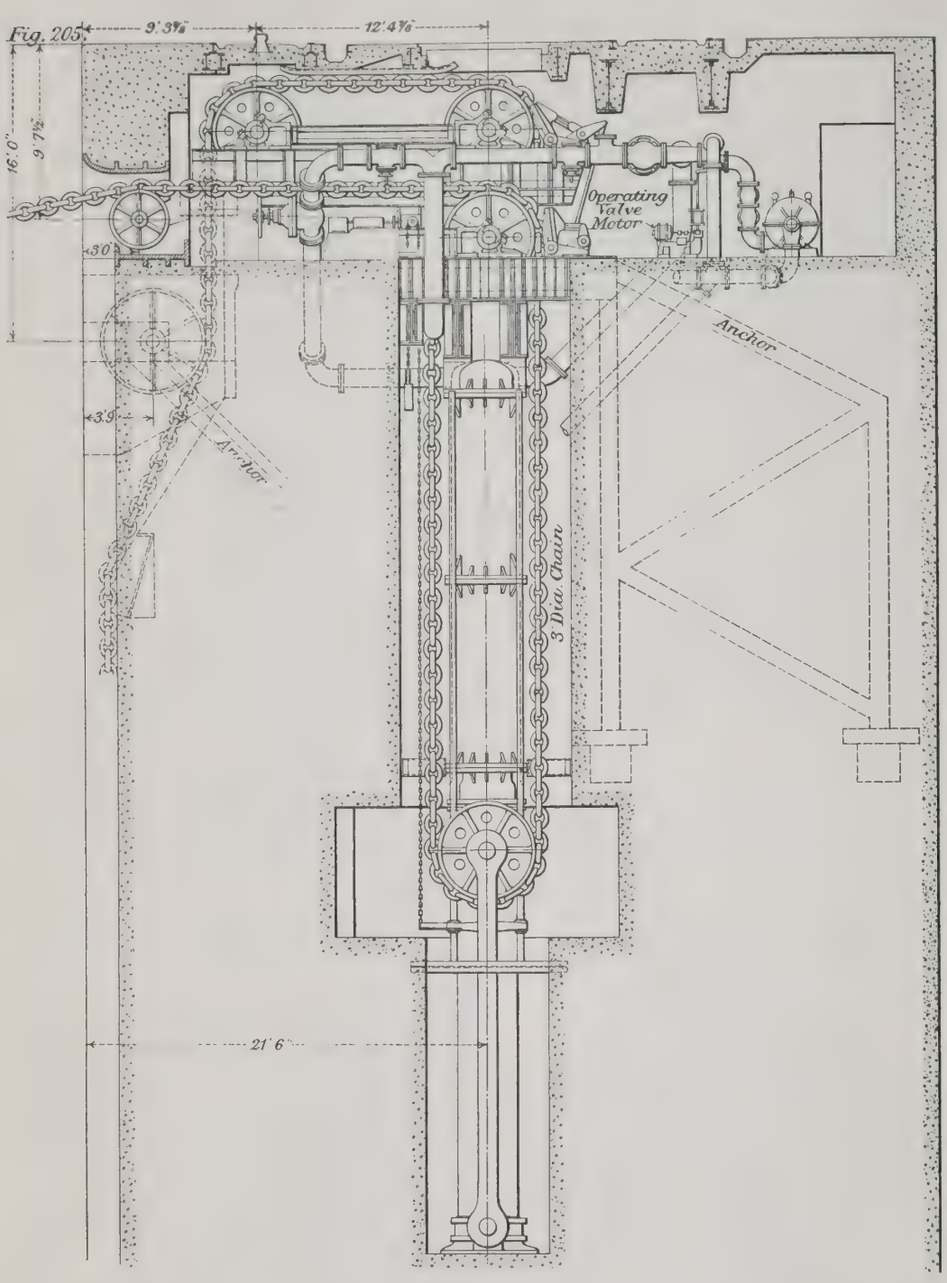


Fig. 206.

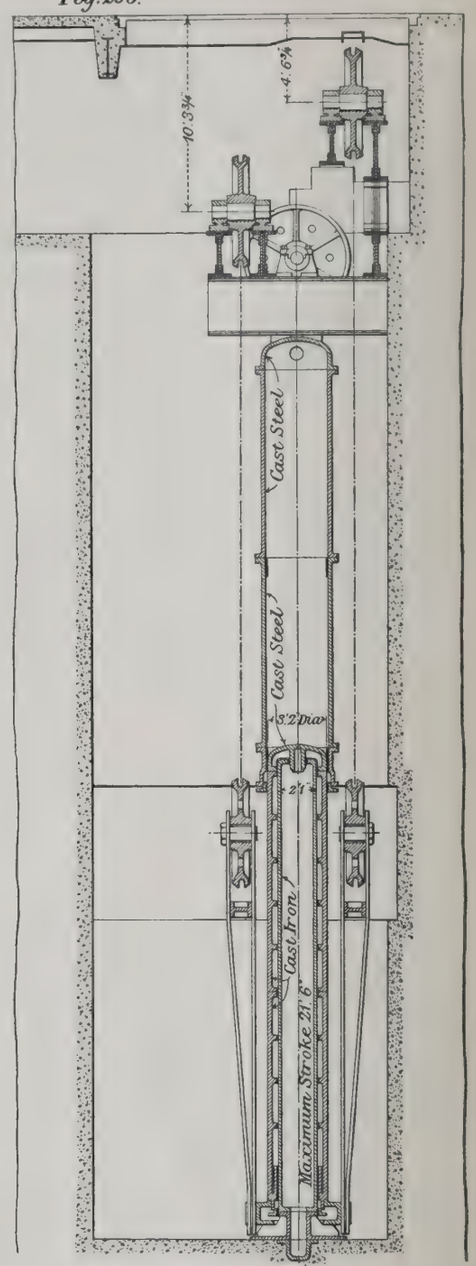


Fig. 207.

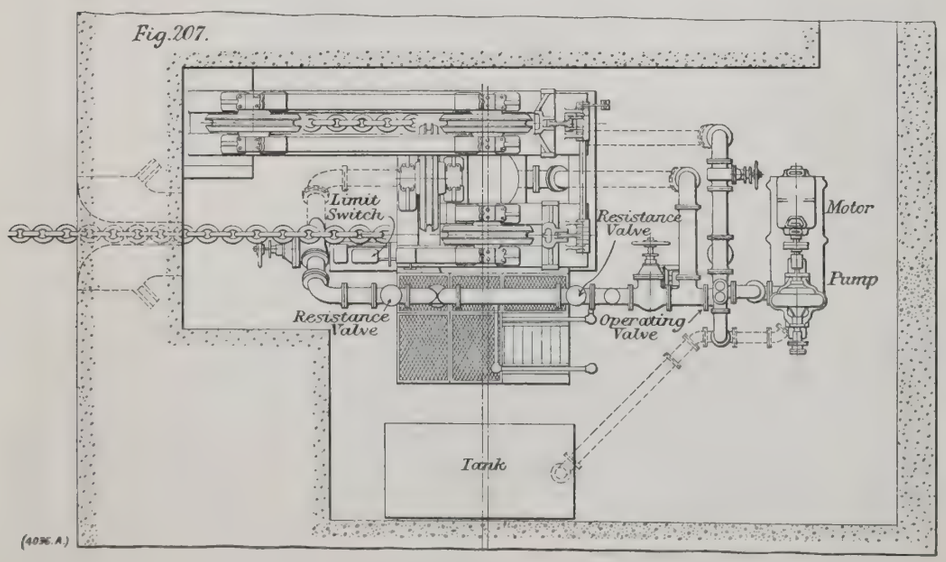


Fig. 208.

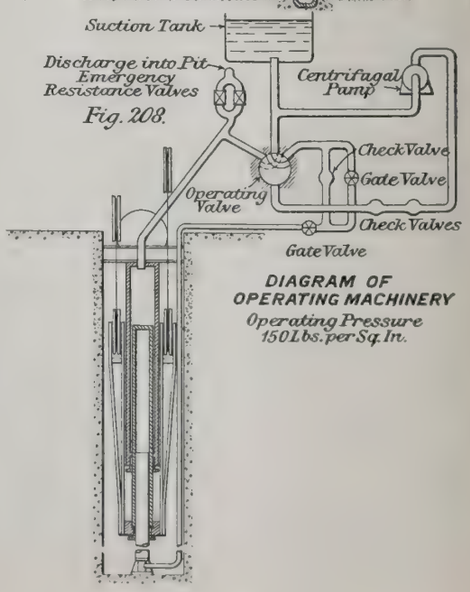
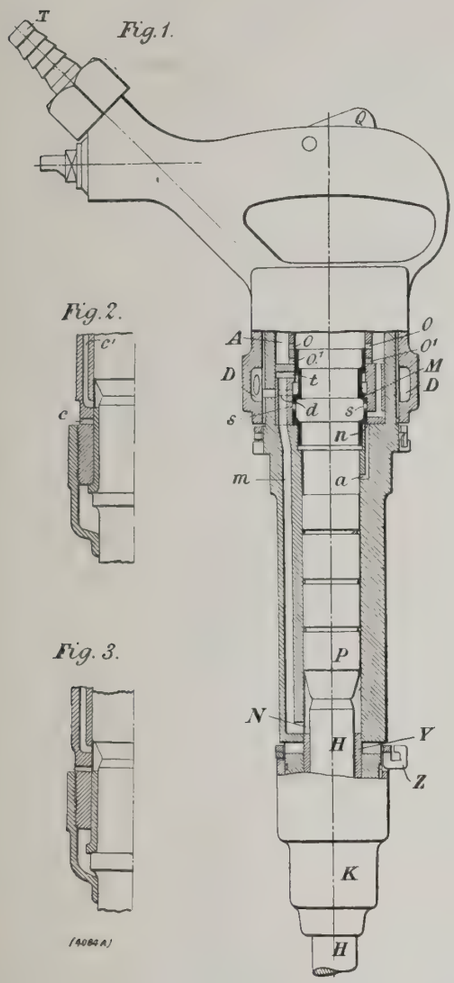


DIAGRAM OF OPERATING MACHINERY
Operating Pressure 150 Lbs. per Sq. In.

THE "ELOY" PNEUMATIC PICK-AXE.



motives weigh 82,500 lb. They are 32 ft. 2½ in. long, and have a width of 8 ft. and a height of 9 ft. 3 in. at either end, where a cab is provided. The longitudinal and transverse framing is of cast steel. The journals are fitted in ordinary axle-boxes, with spiral springs on the top. Each locomotive has two 75-horse-power three-phase 220-volt 25-cycle motors, each motor driving one axle through reduction-gear. The available tractive effort is 47,500 lb. In addition, in the centre of the machine is a windlass capable of a pull of 25,000 lb. The windlass-drum can take 800 ft. of 1-in. steel cable. It is worked by two 20-horse-power motors, one being geared to give a rope speed of 12 ft. per minute for controlling the manœuvring of the vessel being handled, the other giving a rope speed of 200 ft. per minute for paying out or taking in slack. The windlass drive is by friction gear, which can be set from zero to full capacity.

A number of towing tests were carried out in Limon Bay with ships ranging between 3580 and 10,420 tons displacement, to serve as a check on the calculations with regard to these locomotives. In these tests, at various speeds and rates of acceleration, a tug-boat capable of exerting a pull at standstill of about 15,000 lb. was employed. In the 7-in. Manilla towing cable a dynamometer of the spring type was placed, the speed of the tug being measured by a Price current-meter. A start was made from the dock side and observations were made every 30 seconds. Five ships in all were tested. The first locomotive of the new pattern was delivered at the Isthmus on January 27. On April 1 the first use was made of locomotives to control vessels passing through the locks. A hopper barge and a scow were lashed together and, taken in charge by four locomotives, were successfully manœuvred through the flight of locks at Gatun in 1 hour 17 minutes. The first ocean-going vessel to be taken through any of the locks by the towing locomotives was the Allianca, belonging to the Panama Railroad. The passage occupied about 1½ hours in either direction, and was made on June 8 without incident. The locomotives have a speed of two miles per hour on the rack sections and five miles on the return tracks without racks. At the end of April the track installation had been completed at Pedro Miguel, and was 99 per cent. completed at Gatun and Miraflores.

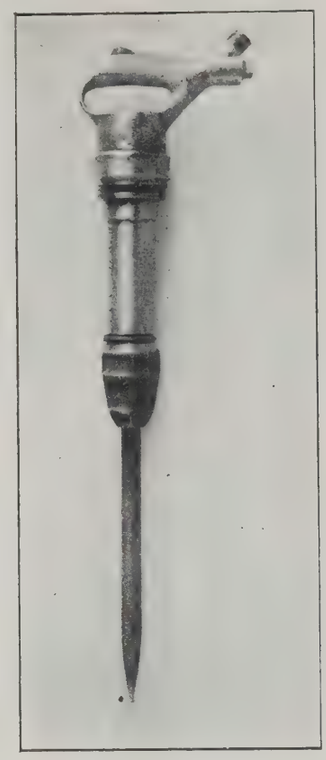


FIG. 4.

THE EMERGENCY DAMS.

When describing the emergency dams provided at the locks,* we mentioned that tests had shown that the panels would only take from 6 to 9 per cent. of their weight to lower them in the current of water. More complete tests have been made since these figures became available, and show that for the first gate the force taken is no more than about 2.6 to 4.2 per cent. of the weight, while for the uppermost gate-panel the force is about 1.6 per cent. of the weight. These figures compare with the specified requirement that the force needed should in no case exceed 50 per cent. of the weight of the gate. The final tests of the first dam to be completed at Gatun were recorded in ENGINEERING, vol. xcvi., page 263. The work on these dams was brought to a close by the completion of the dam on the west lock at Miraflores in March last.

THE "ELOY" PNEUMATIC PICK-AXE.

WE illustrate in Figs. 1 and 4 above the "Eloy" pneumatic pick-axe, which has been specially designed to withstand the rough usage such tools meet with in mines. Care has been exercised to eliminate the main cause of breakages to which this class of tool has been liable in the past. These implements are subjected to great strains when allowed to run light, as, for instance, when the point of application of the work is changed, or when, through breaking away of the coal-face, the resistance to the point of the pick is suddenly relieved. Even with the closest attention on the part of the operator it is impossible to cut off the air sufficiently quickly at such times to prevent the tool, which runs at about 1400 strokes per minute, from hammering against its retaining sleeve for several strokes. The result is that frequent breakages occur, and operators therefore often adopt the dangerous habit of working the tool without its retaining sleeve. Many accidents have occurred from the tool being projected from the cylinder under these conditions.

In the "Eloy" pick-axe this trouble is eliminated by the use of a sleeve which immediately cuts off the air supply as soon as the resistance to the point of the tool is removed. This sleeve acts as a valve, which is instantaneous in action, and out of the control of the operator. It not only removes the risk of breakage, but incidentally reduces the air consumption.

The action of the tool is controlled by the trigger Q, shown in Fig. 1. The pick-axe can be dismantled without any tools, as all the parts are removable as soon as the spring Z is removed. All internal springs have been eliminated owing to their liability to fracture under the repeated shocks to which they are subjected in tools of this character. The tool H, Fig. 1, is held inside the cylinder by the retaining sleeve K, and is hammered by the piston P, which is operated by compressed air admitted at T. The path of the air is controlled by the valve M, and the automatic cut-off is effected by the valve Y. Figs. 2 and 3 show the action of the automatic cut-off valve. In Fig. 2 the tool is pressed against its work and the exhaust-port c is closed by the valve. As soon as the point of the tool is removed from its work, the valve is pushed forward by air in the passage c', and takes up the position shown in Fig. 3, opening the port c, and the tool ceases to work. Very little air is lost; the quantity escaping is limited by the fact that it is admitted through two small ports, only 2 mm. in diameter.

The flow of air through the passages is as follows:—Compressed air, admitted through T, passes through the annular space A, and through a conical filter, entering the cylinder through the ports O. Passing out of the cylinder through ports a, it acts on the face n of the valve M, and moves the latter into a position in which the ports O are closed, and the ports O^1 opened. In this position the ports s, s in the valve are in communication with the exhaust-chamber D through the openings d, and the air can then escape from the rear of the cylinder. At the same time the live air in the annular space A passes through the two open ports O^1 into the passages t and m, and enters the cylinder at N, driving the piston back and compressing the air behind it, so as to force the valve to resume its initial position. The air from N then returns through the passages t and d and exhausts through the chamber D. Pressure is thus removed from the front of the piston, which is again driven forward by the air now admitted through the ports O. The surfaces of the valve acted on by air pressure are proportioned so that when the piston is in the position shown in Fig. 1 the resultant pressure upon the valve M causes it to move towards the handle, whereas when the piston has moved back to the limit of its back stroke the compression of the air behind it suffices to return it to its initial position.

The tool, for which Messrs. Mossay and Co., Limited, 45, Horseferry-road, Westminster, S.W., are the agents in this country and the Colonies, is made for coal-mining in three sizes, weighing 19 lb., 17½ lb., and 13 lb. respectively. The medium-sized pattern takes about 27 cub. ft. of free air per minute for continuous running, but the average when working is about 9 cub. ft. This effect is attained by the prompt reduction in air used by the automatic cut-off. A compressor delivering about 30 cub. ft. to 35 cub. ft. of free air per minute at 80 lb. pressure will thus drive three "Eloy" pick-axes.

* No. VI., vol. xcvi., page 139.

INDUSTRIAL NOTES.

THE quarterly meeting of the Coal Conciliation Board for the federated mining districts in England and North Wales was held last Friday, the 24th inst., in London. Mr. F. J. Jones (Yorkshire), chairman, presided; he was supported by Mr. Stephen Walsh, M.P. The chairman stated that the coal-owners would be prepared to give careful consideration to the new wage proposals made to them by the representatives of the men, and then meet the men's section of the Board for the full discussion; they would also carefully consider any counter proposals prepared by the coal-owners' side of the Board.

We may add that the main proposals submitted by the men as the basis of a new agreement for a further period of three years provide for a new wage standard of 50 per cent. above the present wage standard of 1888, and a higher maximum wage. At the present moment wages in the English federated area stand at the maximum of 65 per cent. on the 1888 standard.

We are informed that some of the mechanics employed by the London and North-Western Railway Company at Crewe, instead of joining their own trade societies, have become members of the National Union of Railwaymen. This has caused some ill-feeling. The engineers and boiler-makers held a mass meeting and passed a resolution stating that if men who were eligible to join the trade societies did not become members, they would tender their notices to the railway company. This resulted in the National Union of Railwaymen asking their members to ignore the threats of the unions of the various trades, adding that they, the National Union, would protect the interests of the men belonging to their society. One of the officials of the National

Union visited Crewe a few days ago and addressed two large open-air meetings. "The first people to organise the shopmen in Crewe," he said, "were the railwaymen, who knew no grade or trade except that they were railway workers; they should get rid of the class distinction that divided the artisan from his brother labourer." Asked whether the National Union Railway trade-card would be recognised in any other than a railway engineering works, he replied in the affirmative. The question, we are told, has excited much feeling, and meetings are being held on both sides. The National Union of Railwaymen say that if the engineers' or boiler-makers' societies put their threats into force, the National Union, with its 150,000 members, will settle the case with the railway companies.

A meeting of 5000 members of the Sheffield District of the National Union of Gas-Workers and General Labourers, held on Sunday last, the 26th inst., in the Corn Exchange, accepted an offer of the employers in regard to wages.

Mr. Charles H. Blackburn, district secretary, presided, and gave a summary of the proceedings of the conferences which had been held between the delegates of the Union and the Sheffield Employers' Federation since March 19 last.

After discussion, the meeting decided by a large majority that the terms of the agreement submitted be accepted, but not as a final solution of the wages movement. The agreement is as follows:—

The parties agree to recommend:—1. An advancement of 6d. per week, to take effect from August 3, 1914, to all able-bodied labourers and semi-skilled workmen of 21 years of age and upwards, at present rated at 25s. per week or less.

2. An advance of 1s. per week, to take effect from August 3, 1914, to all able-bodied semi-skilled men of 21 years of age and upwards, who were not advanced in, or since, July, 1913.

3. The above not to apply to men rated at 35s. per week or more, or to men working under special arrangements or under wage agreement with other societies.

(Note.—As a special concession, the crane-drivers, slingers, and engine-tenders at present rated at 26s. per week, or less, are to receive an advance of 1s. per week irrespective of any advance granted to them in, or since, July, 1913.)

The advances to the semi-skilled workers, combined with a former concession made in relation to overtime rates and the lower-paid grades, will amount to 80,000*l.* a year.

At the close of the meeting a hearty vote of thanks was accorded Mr. Blackburn and his colleagues who had been working on the men's behalf.

Speaking after a launch at Birkenhead last Saturday, the 25th inst., Mr. G. J. Carter, managing director to Messrs. Cammell Laird and Co., Limited, said that their works had been exceptionally free from strikes for some time past. A strike was an ugly weapon, which in many ways hurt those who were not responsible and who had no connection with it. Mothers and families suffered. Tradesmen, workmen, and the employer suffered. That was not the time or place to pass an opinion as to the cause of the strike which was being felt on the river. They would agree with him that it was most sad to think that the town of Birkenhead should be robbed of its rights by an unfortunate rupture in labour on the river. He hoped that good counsels would prevail to end the strike at the earliest possible moment. As far as his firm was concerned, it would interest them to know that two or three days ago an important repair order was to come to Birkenhead. The captain of the vessel had instructions to bring the ship to Cammell Laird's docks, the order amounting to 30,000*l.*, 20,000*l.* of which would have been involved in wages and spent among the people of the town. As soon as it was known that there was a strike on the Mersey, the word "sympathetic" cropped up, and the owners did not know what might occur. The result was that, without consulting Messrs. Cammell Laird's, the ship was taken for repair to Germany.

It is stated by the London Fire Brigade Committee that the chief officer of the Brigade has been handed a petition, signed by 1059 members of the brigade, requesting an increase of pay and certain improvements in the conditions of their service. The petitioners also ask that, in future, negotiations might be conducted on their behalf by the National Union of Corporation Workers. The question of the pay, we are informed, is receiving careful and sympathetic consideration.

Last Saturday, the 25th inst., the Engineers' Association at South Shields telegraphed to the National Joint Committee in London requesting them to interview Mr. John Burns, President of the Board of Trade, to urge upon him the necessity of all marine engineers being signed on at the shipping offices during the strike. This measure was due to the fact that the engineers on the North-East Coast had complained at the shipowners having engaged their engine-room staff on board ship since the strike commenced, a proceeding which, they state, is unfair in times of dispute. There were twenty-four steam colliers detained in Shields Harbour on Saturday for want of engineers. At Tyne Dock several pickets boarded a Sunderland steamer which was being loaded; their presence was resented, and some sharp words were exchanged. The police were communicated with, but the pickets eventually left the vessel, and she afterwards proceeded to sea.

A national manifesto, issued at the Marine Engineers' Association offices at South Shields, states that the number of vessels being held up was increasing, and that shipowners were having a great deal of trouble in getting engineers with certificates. There are now, it is thought, about 200 marine engineers hailing from the Hartlepools on strike.

A strike on the Newcastle tramway system, which had threatened for some time past, has now been averted, the men having accepted the offer of the Tramways Committee of time and a quarter for Sunday work and pay on a weekly basis, with overtime after 54 hours. The concessions made, it is said, will amount to 3000*l.* annually.

The strike of tramway employees in Christiania, Norway, is an action which completely contravenes the agreement with the tramway companies. The question of overtime seems to have had something to do with the conflict, the men refusing to put in the overtime stipulated for in their agreement, and preventing those willing to work from starting when they were unable to finish a run before regulation closing time. The companies would not consent to a compromise unless the men withdrew their threat to strike, and altered their decision as regards overtime; this the men refused to do, unanimously declaring in favour of an immediate strike. The men, we may add, decided amongst themselves to be total abstainers during the time the strike is to last. The companies managed the first day to run the lines to the Exhibition, and are endeavouring gradually to extend the traffic with the help of outside hands.

The annual meeting of the Durham County Colliery Enginemen's Association was held in Durham Town Hall on the 25th inst., when Mr. W. B. Charlton, the agent of the society, presented his report. The balance to the general fund account at the end of 1913 was, he stated, 14,425*l.* 17s. 7d.; to this there was added 717*l.* 16s. 4d., being the credit balances on the last two quarters' workings, and 203*l.* 8s. 8d. interest on investments, plus 25*l.* 5s. 8d. reclaimed income-tax. In addition to these sums, the 456*l.* 3s. 4d. advanced to their Health Insurance Approved Society during 1912 and 1913 had now been repaid. The health insurance department was therefore now absolutely on its own resources, so far as finance was concerned. This reimbursement, with the other items named, made the general fund now 15,828*l.* 11s. 7d., an increase of 2295*l.* 4s. 5d. upon the amount reported last mass meeting day. By the recently created retiring benefit, which was an extra above the provisions of other unions, thirty-eight of their veteran comrades, now retired, had received since the last meeting 285*l.* 15s.

Further, the credit balance to the sick fund account was reported by the auditors to be 5509*l.* 1s. 5d.; to this was added 24*l.* 8s. 2d. from their March quarter's workings, but for the quarter ending June there was a deficit of 8*l.* 10s, leaving a net increase on the half year of only 15*l.* 18s. 2d. Their sick fund was veering too near being dependent upon its investments to meet its liabilities; there were considerations which, perhaps, would account for the extra claims at this period. The fund commenced at the first branch meetings after March 30, 1882, or thirty-two years ago; persons then 30 years of age would now be 62. Their last balance-sheet gave 39 permanently on the funds. The death payments were last quarter abnormally high. They might be passing through a period of special strain; he (the speaker) did not note this in any sense to give alarm, for in comparing income with expenditure for the whole year there was a substantial balance, but he asked that there should be a strict observance of the rules governing that fund. It now amounted to 5624*l.* 19s. 7d., being an increase of 239*l.* 10s. 5d. upon the amount reported last year, making a net credit balance on the year's business in both funds of 2534*l.* 14s. 10d.; this, added to the value of the funds reported last mass meeting day, raised the Association's total worth to 21,453*l.* 11s. 2d., and brought it back to within 50*l.* of the value immediately prior to the strike of 1912.

We read in the *Revue du Travail* that the Belgian trade unions are either affiliated to the Labour Party Committee or to the National Confederation of Christian Unions, according as to whether, in their social action, they are prompted or not by class hatred. Besides these two groupings there are a few isolated unions whose tendency is either distinctly political or towards maintaining a complete neutrality in regard to both the political and the religious standpoints. On December 31, 1913, the members of the unions affiliated to the Labour Party Committee numbered 123,419, those of the "Christian Unions" numbered 70 466, and those of isolated unions 8861, giving a total membership of 202,746. The number of employees in the various industries throughout Belgium at the same date was 1,264,881, giving a proportion of 16 trade-unionists for every 100 employees.

The report for July of the Society of Amalgamated Tool-Makers gives the following figures:—

	June, 1914.	June, 1913.		
Members ...	14,187	9346	Increase,	4841
Unemployed	159	56	,,	103
Reserve funds	44,000*l.*	37,000*l.*	,,	7000*l.*

His Honour Judge Amphlett, K.C., Chairman of the Joint District Board for West Yorkshire, acting under the provisions of the Coal Mines (Minimum Wage) Act, 1912, has given his award upon the application to vary the district rules and minimum rates of wages, which were determined upon two years ago. The following are the amended rates for the district as sub-divided; the old rates are also given for the sake of comparison:—

Eastern Sub-Division.

	New Award per Day.	Former Rates per Day.
	s. d.	s. d.
Class 1. Qualified getters (hand or machine)	7 0	6 8
,, 2. Trammers and fillers ...	6 0	5 8
,, 3. Leading byeworkmen (those in charge of pit bottom or otherwise entrusted with superintendence) ...	6 4	6 0
,, 4. All other workmen (over 21 years of age)	5 4	5 0
,, 5. Boys:—		
14 years of age to 14½ ...	2 1	2 0
14½ ,, 15 ...	2 2½	2 1½
15 ,, 15½ ...	2 4	2 3
15½ ,, 16 ...	2 5½	2 4½
16 ,, 16½ ...	2 7	2 6
16½ ,, 17 ...	2 9	2 8
17 ,, 17½ ...	2 11	2 10
17½ ,, 18 ...	3 1	3 0
18 ,, 18½ ...	3 3	3 2
18½ ,, 19 ...	3 6	3 5
19 ,, 19½ ...	3 9	3 8
19½ ,, 20 ...	4 0	3 11
20 ,, 20½ ...	4 4	4 2
20½ ,, 21 ...	4 8	4 5

At 21 to be regarded as adult workmen.

Western Sub-Division.

Class 1. Qualified getters (hand or machine)	6 6	6 2
,, 2. Trammers and fillers ...	5 6	5 2
,, 3. Leading byeworkmen (those in charge of pit bottom or otherwise entrusted with superintendence) ...	5 10	5 6
,, 4. All other workmen (over 21 years of age)	5 2	4 10
,, 5. Boys:—		
14 years of age to 14½ ...	2 0	2 0
14½ ,, 15 ...	2 1½	2 1
15 ,, 15½ ...	2 3	2 2
15½ ,, 16 ...	2 4½	2 3½
16 ,, 16½ ...	2 6	2 5
16½ ,, 17 ...	2 8	2 7
17 ,, 17½ ...	2 10	2 9
17½ ,, 18 ...	3 0	2 11
18 ,, 18½ ...	3 2	3 1
18½ ,, 19 ...	3 4½	3 3½
19 ,, 19½ ...	3 7	3 6
19½ ,, 20 ...	3 10	3 8½
20 ,, 20½ ...	4 1	3 11
20½ ,, 21 ...	4 5	4 1½

At 21 to be regarded as adult workmen.

There is no change in the rates for ganister mine-workers, which stand as follows, per day:—Class 1, coal-getters, 5s. 6d.; Class 2, trammers and fillers, 4s. 6d.; Class 3, leading byeworkmen (those in charge of pit bottom, or otherwise entrusted with superintendence), 4s. 9d.; Class 4, all other workmen, 4s. 6d. Class 5, boys:—14 years of age, 2s.; 14½ years, 2s. 1d.; 15 years, 2s. 2d.; 15½ years, 2s. 3d.; 16 years, 2s. 4d.; 16½ years, 2s. 6d.; 17 years, 2s. 8d.; 17½ years, 2s. 10d.; 18 years, 3s.; 18½ years, 3s. 2d.; 19 years, 3s. 4d.; 19½ years, 3s. 6d.; 20 years, 3s. 8d.; 20½ years, 3s. 10d.; 21 years, 4s.

The award further states that the rates set out in the above classes specify the wage per day below which no workman included in any of such classes shall be engaged (save as specified in the district rules). This wage is called in the Coal Mines Act, 1912, the "minimum wage." So far as the miners themselves are concerned, it is not anticipated that there will be any such confusion in the interpretation of the award as that which occurred in South Yorkshire following upon Sir Edward Clarke's award. Upon the occasion,

as stated by us at the time, a strike of miners in the Rotherham district precipitated a general strike throughout the county, which lasted a fortnight. The rates in question are apart from any percentages decided by the Conciliation Board for the Midland area. Thus, where a coal-getter prior to the new award was receiving 6s. 8d., plus 8d. for percentage, making 7s. 4d. in all, he will now be in receipt of 7s., plus 8d., making a total of 7s. 8d. Mr. Herbert Smith, President of the Yorkshire Miners' Association, expressed surprise that no advance had been made in the wages of the ganister mine-workers.

Discussing the Navy votes in Parliament, on the 27th inst., Mr. Barnes advocated higher wages for dockyard labourers. Although, he stated, there had been considerable advances during the past few years, these men's wages only stood at 23s., and he urged that they should be brought nearer the rates which private contractors and municipal authorities in dockyard towns paid. He suggested that the men should be given at least 1s. a week more.

Sir F. Flannery supported the appeal, pointing out that it took 20s. to-day to buy what 17s. 9d. would buy eight or nine years ago. Even allowing for the steadiness of employment in Government yards and for the prospect of pensions, he saw no reason why the wages should be 3s. a week less than those paid by the municipalities.

In the course of his reply, Dr. Macnamara said he did not think there was any private employer or public department in this country which had any machinery approaching that which had been set up under the Admiralty for enabling the men to come before a representative of the Board and state their case. This year he suggested to the Board, and the suggestion was approved, that six great classes of workmen should be invited to send representatives to present their case. This was done, and he spent six days with the men's representatives. Last year he heard 424 deputations; this year he had already heard over 300. He would certainly represent to the proper quarter the appeals which had been made on behalf of the lowest-paid labour from all parts of the House. The increases in rates of pay to men granted from January 1, 1906, to October, 1, 1913, amounted to 250,000*l.* a year. He hoped the replies to petitions received from men in various departments would be issued in the next annual review. The establishment has been added to by more than 1000 men last year, 1500 men this year, and in all probability 1500 more would be added next year.

OIL IN PAPUA.—For several months Dr. Wade, an oil expert, has been conducting investigations in Papua on behalf of the Australian Government with a view to testing the value of the Papua oil deposits. He states that the area between the Vailala and Purari rivers has already been carefully surveyed, and that several new oil "blows" have been discovered in the district. The work of examining the country immediately adjacent to the eastern end of the Vailala area has also been completed, and new oil "occurrences" in the district of Keri had come to light.

NEW GAUGE FOR IRON AND STEEL SHEETS AND HOOPS.—We are informed that negotiations between the London Chamber of Commerce and the Standards Department of the Board of Trade have led to the official recognition of the Birmingham Gauge, "B.G.," and to the following schedule:—

Descriptive No.	Equivalents in Parts of an Inch.	Descriptive No.	Equivalents in Parts of an Inch.
No.	in.	No.	in.
15/0 B.G.	1.000	20 B.G.	0.0392
14/0 B.G.	0.9583	21 B.G.	0.0349
13/0 B.G.	0.9167	22 B.G.	0.03125
12/0 B.G.	0.8750	23 B.G.	0.02782
11/0 B.G.	0.8333	24 B.G.	0.02476
10/0 B.G.	0.7917	25 B.G.	0.02204
9/0 B.G.	0.750	26 B.G.	0.01961
8/0 B.G.	0.7083	27 B.G.	0.01745
7/0 B.G.	0.6666	28 B.G.	0.015625
6/0 B.G.	0.625	29 B.G.	0.0139
5/0 B.G.	0.5883	30 B.C.	0.0123
4/0 B.G.	0.5416	31 B.G.	0.0110
3/0 B.G.	0.500	32 B.G.	0.0098
2/0 B.G.	0.4452	33 B.G.	0.0087
1/0 B.G.	0.3964	34 B.G.	0.0077
1 B.G.	0.3532	35 B.G.	0.0069
2 B.G.	0.3147	36 B.G.	0.0061
3 B.G.	0.2804	37 B.G.	0.0054
4 B.G.	0.250	38 B.G.	0.0048
5 B.G.	0.2225	39 B.G.	0.0043
6 B.G.	0.1981	40 B.G.	0.00386
7 B.G.	0.1764	41 B.G.	0.00343
8 B.G.	0.1570	42 B.G.	0.00306
9 B.G.	0.1398	43 B.G.	0.00272
10 B.G.	0.1250	44 B.G.	0.00242
11 B.G.	0.1113	45 B.G.	0.00215
12 B.G.	0.0991	46 B.G.	0.00192
13 B.G.	0.0882	47 B.G.	0.00170
14 B.G.	0.0785	48 B.G.	0.00152
15 B.G.	0.0699	49 B.G.	0.00135
16 B.G.	0.0625	50 B.G.	0.00120
17 B.G.	0.0556	51 B.G.	0.00107
18 B.G.	0.0495	52 B.G.	0.00095
19 B.G.	0.0440		

"HYDROSTATIC CATENARY."

TO THE EDITOR OF ENGINEERING.

SIR,—This problem is the well-known "elastic curve" of James Bernoulli. A solution will be found in Thomson and Tait's "Treatise on Natural Philosophy," vol. ii., page 146, *et seq.* Both the rectangular and intrinsic equations reduce to elliptic integrals. Practically the curve is easily drawn to any desired degree of accuracy as follows:—

We have

$$T = \frac{R\,ds}{d\phi}.$$

Taking A B as the axis of n, $R = wy$,

$$i.e., \rho = \frac{T}{\kappa} = \frac{T}{wy} = \frac{a^2}{y} \text{ (say)}.$$

The curve has two independent parameters—the maximum ordinate e and the tension T (Fig. 1). By choosing a suitable value for T the curve may be drawn for any

Fig. 1.

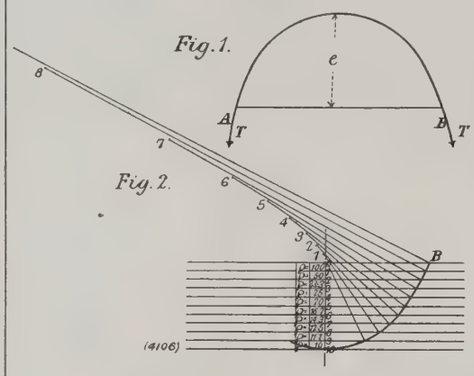


Fig. 2.

value of e, commencing with a small circular arc touching the tangent at the maximum ordinate and continuing by small circular arcs with the properly increasing radii according to the expression

$$\rho = \frac{T}{wy} = \frac{a^2}{y}.$$

As an example, put

$$e = 10,$$
$$\frac{T}{w} = a^2 = 100.$$

Then for

$y =$	10	9	8	7	6	&c.
$\rho =$	10	11.1	12.5	14.3	16.7	&c.

The curve resulting is shown (Fig. 2).

Its area and length can then be measured. The method of working is sufficiently obvious, a few trials giving any size wished for.

Yours truly,
G. P. MANNING.

102, Fordhook-avenue, Ealing Common, W.,
July 23, 1914.

"THE REACTION OF A STEAM JET."

TO THE EDITOR OF ENGINEERING.

SIR,—It may be of some interest to your readers and to the writer of the article on the above subject in your issue of July 24, that recently the general tendency of the formulæ has been confirmed by actual experiment on the Dickson-Corthesy turbine. Some early experiments appeared to leave some uncertainty of the relative value of convergent and divergent nozzles, and the conditions being entirely novel, I determined to test the difference as soon as a convenient opportunity offered itself. In this turbine the steam acts entirely *inside* the rotor-drum, and thus differs from the generality of steam-turbines in which the energy is imparted to blades fixed on its *outer* periphery. I have found it convenient to adopt a system of comparison in our experiments which is based on the "impulse coefficient" or ratio of the actual impulse calculated from the brake-load to the momentum or reaction of the steam. Both factors are calculated on the common basis of the diameter of the nozzle pitch circle, which in bladed turbines would be about the same as the diameter at the mid-length of the blades. The momentum and its corresponding velocity are in all cases computed as the theoretical maxima due to the drop of heat of dry steam between the initial and exhaust pressures. No superheat is used in these experiments, and the steam is supplied from a gas-fired Bonecourt boiler.

With identical construction the impulse coefficients were 94 and 127 per cent. respectively for convergent and divergent nozzles. The formula given in ENGINEERING would make the convergent ratio nearly 105 per cent., and the remaining difference is probably due to the construction not being so well adapted to the greater quantity of steam passing through the convergent nozzles.

In the Dickson-Corthesy turbine the steam travels in the same general direction as the rotor, and steam friction actually assists rotation. There is thus no loss from blade and wheel friction, and the leakage loss so prevalent in bladed turbines appears to be negligible. The impulse is consequently much greater than in ordinary turbines, and permits of lower peripheral speeds without loss in steam economy under similar working conditions.

In a somewhat smaller turbine than the one quoted above, it has been found that the impulse coefficient increased from 104 to 113 per cent. when the peripheral speed was increased from 330 ft. to 355 ft. per second (computed at nozzle pitch), and at a slightly higher speed the coefficient increased to over 116 per cent. In this instance steam was supplied at 120 lb. per sq. in. working pressure through two small nozzles of 0.095 in. diameter at the neck, and expanding to 0.141 in. at the discharge end. The rotor exhausts into the atmosphere, and possibly the exit end of the nozzles might be slightly larger with advantage; but, taking into consideration their extremely small diameter and consequent excessive frictional resistance, the advantage is probably unimportant. Under the above conditions the steam supplied by the two small nozzles produced a rotor velocity of 360 ft. per second, and 1.83 brake horse-power as measured through reduction gearing on a Walker air-brake running at 2970 revolutions per minute. The impulse coefficients are based on the maximum flow through these nozzles, but the actual quantity and its reaction must have been considerably less than these calculated amounts appear to show. Even under these exacting estimates the turbine shows a steam economy better than any I can find recorded for turbines of about the same or much larger (comparatively) brake horse-power. If any reader of this letter would favour me with the necessary data for estimating the exact quantity of steam passing through these small nozzles under the conditions stated, I should feel deeply indebted to him. Apart from the reduction which an accurate estimate would doubtless afford, there are good indications that, following the normal developments of other turbines, an increase in power will be followed by still further reductions in steam consumption.

Yours sincerely,
A. E. TOMPKINS, Engineer-Captain, R.N.,
and Consulting Engineer to the New Dickson Corthesy Turbines, Limited.

57, Warwick-road, Ealing, W.

OXY-ACETYLENE WELDING.

TO THE EDITOR OF ENGINEERING.

SIR,—From the report on a recent paper on "Oxy-Acetylene Welding," which appeared in your issue of the 17th inst., an impression somewhat prejudicial to the process may be conveyed to your readers. Nobody will to-day deny that oxy-acetylene welding has a very wide field of usefulness, but it is just its extreme adaptability to so many purposes, and the ease with which it can be employed, that exposes the process to occasional adverse criticism.

Those who are most closely associated with the development of oxy-acetylene welding have all along realised that the main trouble underlying the whole matter is the dearth of really competent welders. This frequently leads to difficult jobs being allocated to men who are quite unqualified by experience for such work, and what is wanted to-day is organised instruction of welding operators, both in the interests of the workmen themselves and their employers.

Valuable work in this direction is now being carried out by the British Acetylene and Welding Association. Through the generosity of its members this Association has been able to equip welding classes in the leading technical institutions in London (2), Birmingham, Portsmouth, Cardiff, Manchester, Liverpool, Leeds, Newcastle, Glasgow and Belfast. Raw material in the shape of oxygen and carbide is also generously given to these classes by members of the Association, and regular evening courses of practical instruction in the use and construction of welding apparatus are now being carried out at all these schools.

The classes are under the supervision of welding committees, usually consisting of the Chief Engineering Instructor of the Institution and two or more thoroughly experienced members of this Association. These committees grant certificates of proficiency to qualified students at the end of each term, and in this way there is good reason to hope that as time goes on a steady stream of properly instructed and qualified welders will flow from these schools into workshops, where they will be able to turn their training to practical use.

If engineers will make a point of engaging only welders who have been awarded one of the Association's certificates of proficiency, I venture to think that very little will then be heard of defective oxy-acetylene welding.

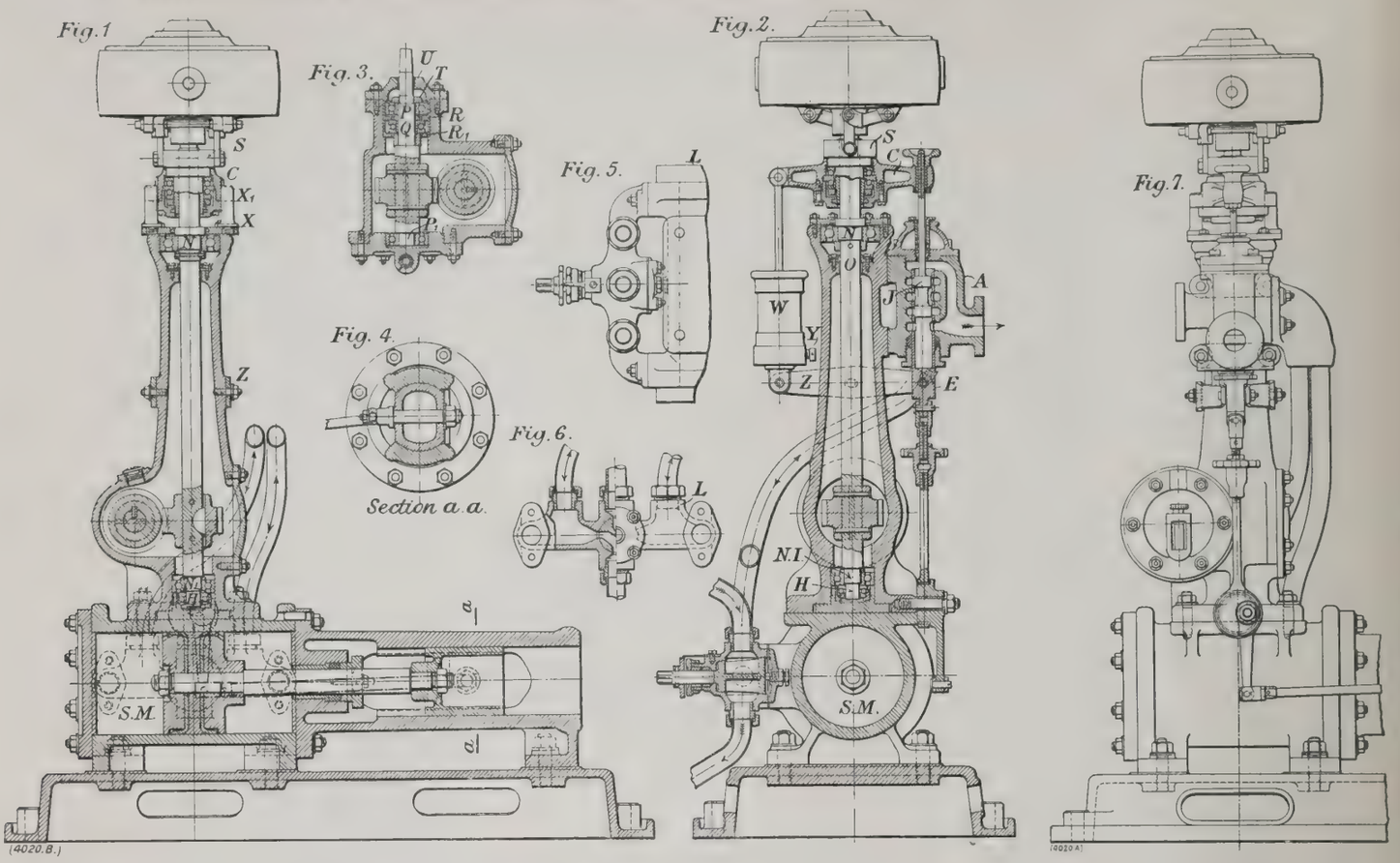
I remain, yours faithfully,
For and behalf of
THE BRITISH ACETYLENE AND WELDING ASSOCIATION,
ROBERT YOUNG, Secretary.

103 and 104, Cheapside, London, E.C., July 24. 1914.

THE HUMBER.—At the last meeting of the Humber Conservancy Board at Hull (Sir W. Wright in the chair), the works committee reported that it had had under consideration a report of the secretary on a proposed 350,000*l.* scheme for the improvement of the river. The engineer (Mr. A. E. Butterfield) reported that erosion still continued between Crabley and Brough, and that from May 18 to June 25 the point of maximum erosion was immediately to the westward of Bank Cottage, where a short length, 17½ ft. wide, had disappeared.

THE SWEDISH NAVY.—The programme placed before the Swedish Parliament by the Ministry comprises, says the *Moniteur de la Flotte*, the construction from 1914 to 1919 of three protected coast-defence ships and two large torpedo-boats; from 1920 to 1924, that of two protected coast-defence ships and four torpedo-boats; from 1925 to 1929, that of one protected coast-defence ship, eight large torpedo-boats, and one mine-laying ship; from 1930 to 1934, that of one protected coast-defence ship and four large torpedo-boats. The cost of these units is estimated to reach 8,000,000*l.*

PITMAN'S RELAY GOVERNOR FOR HYDRAULIC POWER INSTALLATIONS.



We illustrate on this page a governor for water-turbines and hydraulic engines generally, of which the design is due to Mr. Percy Pitman, of 3, Wilcott-road, Acton, London. The control of a dense and inelastic fluid, such as water, cannot be satisfactorily effected by the simple devices permissible with steam. The great inertia and weight of the water, and the large volumes which have generally to be dealt with in water-operated power-stations, make it necessary to employ large and massive regulating-valves, which, if coupled direct to the governor, would seriously interfere with its isochronism. Some form of relay is accordingly always adopted, so that the governor has to overcome directly the resistance merely of the light and small valves of a servo-motor coupled to the main regulating valves of the plant. This method of operation involves, of course, the fitting of an "overtaking motion," by which, as the main regulating-valves move over, they automatically cut off the supply to the servo-motor. In general, this overtaking action is provided by means of the well-known floating lever, but other methods are feasible, and in the governor illustrated in Figs. 1 to 8, Mr. Pitman couples his governor direct to the admission-valve of his servo-motor, the overtaking action being provided for by coupling the sleeve, within which this admission-valve works, to the piston-rod of the servo-motor.

The arrangement is clearly shown in Figs. 1 and 2. A cross-head C is mounted by means of ball-bearings on the governor sleeve S. At the one end the cross-head is coupled by an adjustable rod directly to the piston-valve J, which controls the supply of the working fluid to the servo-motor. At the other end the cross-head is connected to a piston working in the dash-pot W. The sleeve within which the admission-valve J works is coupled to an eccentric mounted on a pin on the governor standard (see Fig. 7), and this eccentric is connected, in its turn, to the cross-head of the relay, the arrangement being best seen in the general view, Fig. 8. A cross-section through this cross-head is represented in Fig. 4. As this cross-head moves in and out it swings the eccentric in the one direction or the other, and the sleeve, in which the valve J works, moves accordingly. The rod between the eccentric and this sleeve can be adjusted in length by the right and left-handed screw-coupling shown in Fig. 2. A cross-beam Z connects the sleeve to the dashpot W, so that when the sleeve moves up the dashpot W is pulled down. Owing to friction the direct effect of an upward motion of the valve sleeve would be a tendency to raise the governor sleeve. This tendency is counteracted by the simultaneous downward motion of W. By means of the adjustable by-pass between the top and bottom of the dashpot which is provided at Y, the downward pull of W can be regulated to a nicety, and very smooth working of the governor is thereby secured. As shown in Figs. 2, 5, and 6, a plug-cock is interpolated in the pipe connections between the relay cylinder and its controlling-valve. By adjusting the opening of this cock the degree of rapidity with which the relay operates can be regulated at will.

As shown in Figs. 1 and 3, the governor spindle is driven by spiral gearing, the axial thrust being taken by double ball-thrust bearings. All the bearings are of the ball type, so that little lubrication is required, and very long runs can be made without attention.

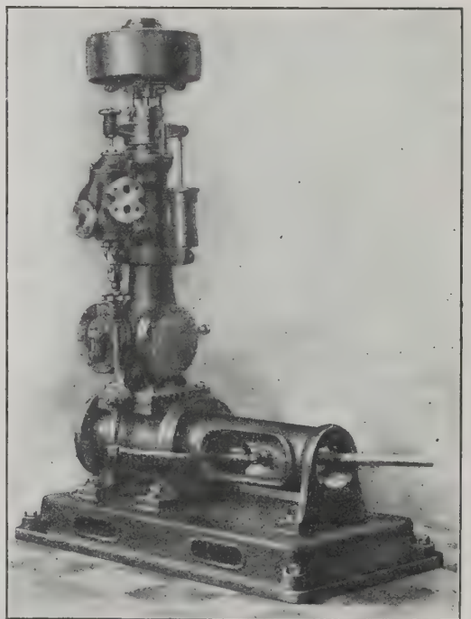


FIG. 8.

UNIVERSAL MOULDING-MACHINE WITH DOUBLE TABLE.

THE illustrations on the opposite page show a form of hydraulic moulding-machine now being made by Messrs. Ph. Bonvillain and E. Ronceray, of 9 and 11, Rue des Envièrges, Paris. It has been specially designed for the class of work in which it is desirable for one man to make both parts of the mould. Fig. 4 shows the machine fitted up for moulding the cylinder of a motor-cycle engine, this being a good example of the work intended to be done on the machine. The output is naturally not so great as that of two separate machines, the object of the design being rather to turn out the best possible work with reasonable rapidity than to increase production.

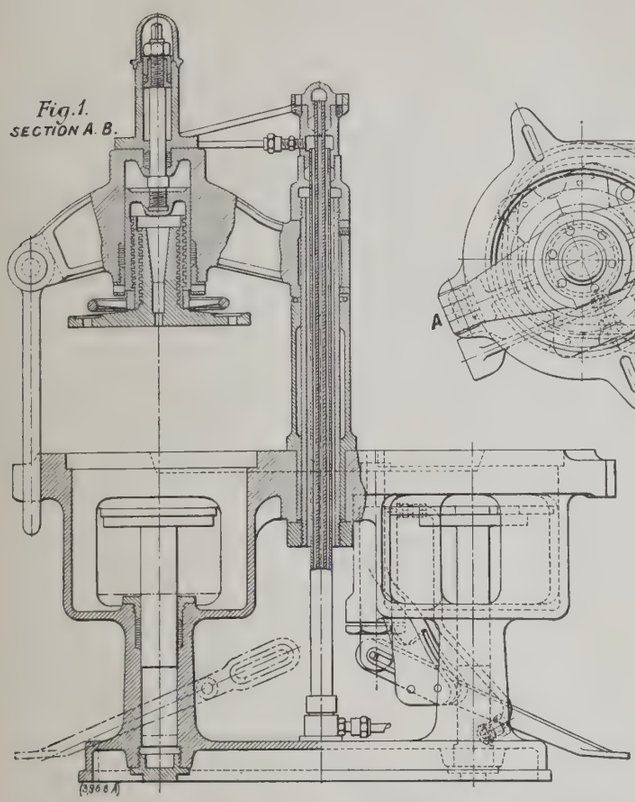
The general features of the Bonvillain and Ronceray moulding-machines and system of moulding were fully dealt with on page 533 of our ninetieth volume, where a description of the firm's method of making pattern-plates and stripping-plates will also be found. We will now therefore deal only with the special features of the double-table machine, referring our readers to the previous description for further particulars of the system.

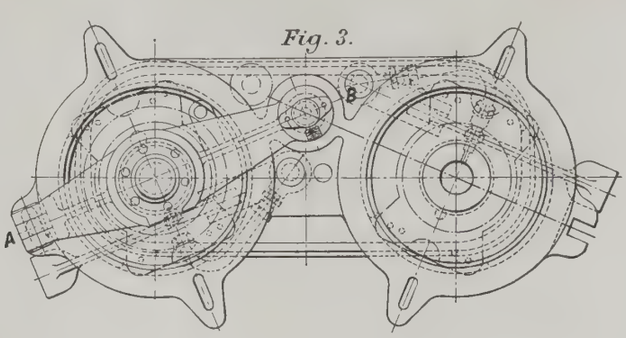
It will be seen that the machine has two circular tables, to which the pattern-plates for the two parts of the mould are fixed. Both tables are served by a single presser-head carried on a horizontal cross-beam, which is pivoted to a central vertical column, and can be swung round over either of the tables. When in position for ramming, the cross-beam is secured to the table by means of a swinging link, clearly shown in Figs. 1, 2, and 4, and having a T-shaped head, which engages with a slotted lug on the edge of each table. Fig. 1, which is a longitudinal section through the presser-head and table, shows the method of conducting water under pressure to the ramming-cylinder, and also to the return cylinder vertically above it. The telescopic screws used to adjust the height of the presser-head to suit moulds of different depths are also clearly shown. This device enables the shortest possible stroke to be used for ramming, and so economises water. Another hydraulic cylinder, formed in the pedestal supporting the table, is also seen in the lower part of Fig. 1. The object of this is to lift the mould clear of the pattern-plate in a manner to be described later.

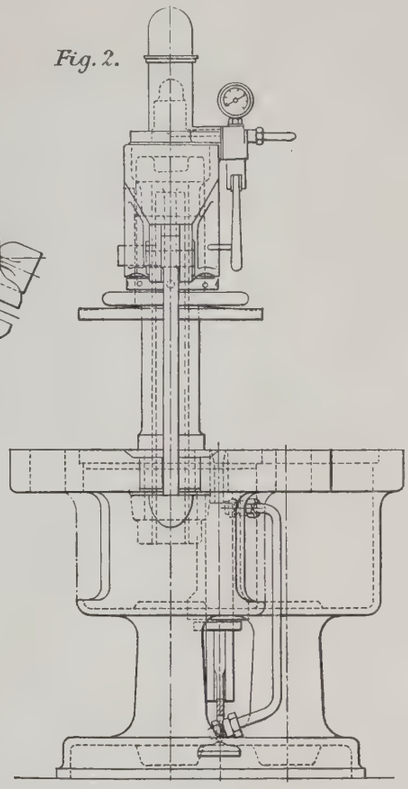
The method of using the machine is as follows:—The pattern-plates for the two parts of the mould are fixed, one to each of the two tables, with the stripping-plates on top of them. The stripping-plates are each

UNIVERSAL MOULDING-MACHINE WITH DOUBLE TABLE.

CONSTRUCTED BY MESSRS. PH. BONVILLAIN AND E. RONCERAY, ENGINEERS, PARIS.







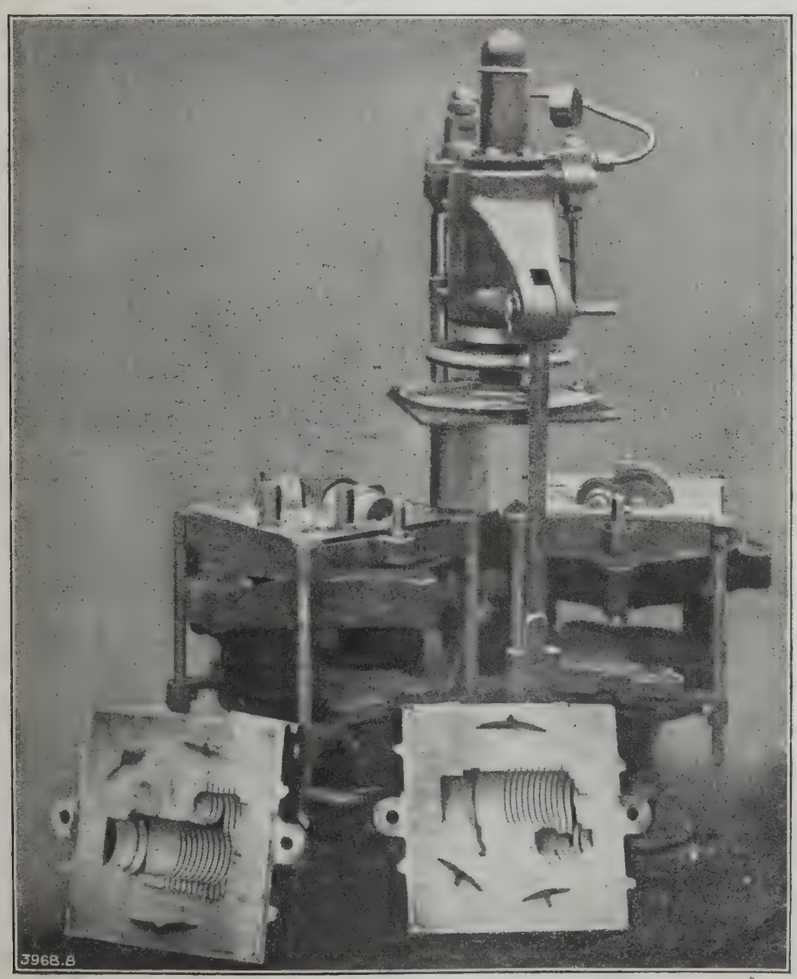


FIG. 4. MACHINE FITTED FOR MOULDING MOTOR-CYCLE ENGINE CYLINDER.

connected to the lifting-cylinder by means of four rods, shown in Fig. 4 only. The moulding-box is then placed in position on a pair of pins fixed in the frame on which the stripping-plate lies. After filling the box with sand, and ramming it by means of the presser-head, the stripping-plate and mould are lifted clear of the pattern-plate by forcing water into the lifting-cylinder, so that the mould can then be taken away from the machine. The lifting-cylinder, it should be noted, is not supplied from the hydraulic mains, but by means of a pump operated by a pedal lever, visible in all the outline drawings, Figs. 1 to 3. The lifting motion can thus be started slowly and steadily, and is at all times under perfect control of the operator. After completing one half of the mould, as above described, a similar series of operations is gone through at the other table, to make the other half of the mould. The principal dimensions of the machine are as follow:—Diameters of tables, 450 mm. (1 ft. 5¾ in.); distance between column and swinging link, 487 mm. (1 ft. 7⅛ in.); maximum distance between presser-head and table, 280 mm. (11 in.); stroke of lifting-cylinder, 150 mm. (5⅞ in.). The pressure on the mould with water at 50 kg. per sq. cm. (711 lb. per sq. in.) is 4800 kg. (4¾ tons). Ordinary packings are used throughout the machine in place of the hydraulic leathers previously employed, as the former have been found to be more satisfactory; this applies to all types of hydraulic moulding-machines made by the firm. Another point worth mentioning is that no foundations are required, so that nothing more than a little pipe-work is involved if it is desired to move the machine.

THE GERMAN NAVY.—According to the *Moniteur de la Flotte*, the German publication *Nauticus* gives the following information on the Derrflinger, the new German armoured cruiser which will soon enter the service. She is the first German unit of this type to be armed with 12-in. 50-calibre guns; these are eight in number, mounted in four turrets on the centre line of the ship, those of the second and third turrets firing above those of the first and fourth turrets. The ship has a displacement of 26,600 tons. Her dimensions are:—Length, 689 ft.; breadth, 95 ft.; and draught, 27 ft. 3 in. She is to be propelled by Parsons turbines, developing 63,000 horse-power, giving her a speed of 26.5 knots. Besides the 12-in. guns above referred to, the armament is to consist of twelve 6-in. 50-calibre guns, twelve 3.5-in. guns, and four under-water torpedo-launching tubes for 19.6-in. torpedoes. The preceding ship of the same class, the Seydlitz, has a displacement of 25,000 tons, and carries ten 11-in., twelve 6-in., and twelve 3.5-in. guns. Her contract speed was 26.5 knots, but she reached 28.129 knots with 89,738 horse-power.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, July 15.

THE fact that the annual midsummer suspension of work in mills for repairs has been limited to only a few days instead of two weeks or more, as is customary, is evidence of the greater activity of demand, and that the corner in depression has at last been turned. The impetus of greater activity has been felt all around. The United States Steel Corporation's unfilled tonnage on June 30 was 4,032,855 tons, against 3,998,160 tons on May 31. The union sheet and tin-plate mills resume with a wage scale practically the same as last year. The majority of the mills are non-union, and have no troubles with their workmen. Pig-iron is produced at the rate of 23,500,000 tons, or 31 per cent. below the highest production ever reached. The total present furnace capacity of the country is 35,000,000 tons a year. Structural steel demand continues to improve, last week's orders being 29,960 tons. Orders for railroad spikes amounted to 12,000 kegs. At Pittsburg three orders amounted to 30,000 tons of pig-iron, and 50,000 tons are under negotiation. General Electric bought 10,000 tons of foundry iron. The increased activity in all lines promises to continue. The larger steel-users recognise that the current low quotations cannot remain very long, even with so much capacity idle. Of the Pennsylvania order, 75,000 tons are 100-lb. sections and the rest 120-lb. There are about 1,000,000 tons of pig-iron at all furnace banks, as compared to 1,400,000 tons two years ago. Agricultural steel is more active than for months past, owing to the covering of requirements for the last half of the year. The agricultural West faces an era of great activity and prosperity. The crop movement has set in, and exports will be larger than usual to meet the European deficit. Anti-trust legislation is being pushed along in spite of business opposition, and in anticipation of it adjustments are being studied out by those interests most likely to be affected.

July 22.

Another week of extraordinary activity has closed with a volume of business surprising even to the most hopeful. Rail orders for the past week were 60,000 tons. Among large pending orders, aggregating 100,000 tons, structural material are 10,000 tons for New York subways, 5000 tons for elevated work, 10,000 tons for Toronto Union Station, 9000 tons for Newark, N.J., Subway Station, 18,000 tons for Kansas City Terminal Station, and 15,000 tons for the projected Metropolis bridge across the Mississippi River. This is the advance guard of an army of orders, and unless unforeseen delays arise, the bulk of the orders named will be placed before the 30th inst. The structural steel requirements are assuming expanding proportions. Bars became suddenly active during the week. Some 75,000 tons were contracted for at Chicago, including 30,000 tons for the Sheldon Axle Company. The Harvester Company is still waiting. Unusual activity prevails all over the Western States. Crop influences are stimulative. The railroads are swinging into line. In view of a general hardening of prices, many large consumers are making tentative purchases, but with a very limited option. Pipe for oil-lines continues to be ordered freely. Steel plate for delivery in the first half of next year is held at a slight advance. Car-builders have just received additional inquiries for steel cars, and an early closing for several thousands is apparently at hand. Pig-iron is feeling the general improvement. Furnace interests show anxiety for new business, but not at concessions. Even for late deliveries higher prices are insisted upon, but the pressure for future deliveries is not pronounced.

PERSONAL.—We are informed that the partnership heretofore subsisting between Messrs. G. P. Knowles, J. B. Knowles, and K. D. D. Grazebrook, carrying on the business of consulting engineers and surveyors and the preparation of candidates for technical examinations at 39, Victoria-street, Westminster, S.W., under the style or firm of "G. P. Knowles," has been dissolved by mutual consent as from June 30, 1914, so far as concerns Mr. J. B. Knowles, who retires from the firm. Messrs. G. P. Knowles and K. D. D. Grazebrook will continue to carry on the business in partnership at the same address.—We are informed that the Power-Gas Corporation, Limited, have appointed Mr. J. F. Pasley, of their head office at Stockton-on-Tees, to be their representative for Lancashire, with headquarters in Manchester. We also learn that Mr. F. G. Fogg, late representative of the North-East Coast, has now been appointed London representative; the London address of the corporation is 39, Victoria-street, Westminster, S.W.—The Executive Committee of the City and Guilds of London Institute have appointed Mr. Alfred J. Margetson, B.Sc. (Lond.), M.Sc., at present assistant professor at the City and Guilds (Engineering) College, Kensington, to the professorship of civil and mechanical engineering at the Technical College, Finsbury, vacated by Professor E. G. Coker on his appointment to the chair at University College.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was steady, but business was confined to one lot of Cleveland warrants at 51s. 5d. eight days. At the close sellers quoted 51s. 5d. cash, 51s. 6½d. one month, and 51s. 7d. three months. In the afternoon the market was quite idle, but the tone kept good, and sellers of Cleveland warrants named 51s. 5½d. cash, 51s. 7d. one month, and 51s. 7½d. three months. On Friday morning the market was unusually active, but the tone was the turn easier. Cleveland warrants amounting to 7000 tons were done at 51s. 5d. and 51s. 4d. fourteen days, 51s. 3½d. twenty-one days, 51s 4d. August 31, and 51s. 5d. two months, and closing sellers quoted 51s. 3d. cash, 51s. 5d. one month, and 51s. 6d. three months. The afternoon session was quiet, and business was limited to one lot of Cleveland warrants at 51s. 4d. seven days, with sellers over at 51s. 4½d. cash, 51s. 5½d. one month, and 51s. 6d. three months. On Monday morning there was again a fair turnover of Cleveland warrants, the dealing being 4000 tons at 51s. 4d. cash, 51s. 3d. nine days, and 51s. 3½d. eighteen days. Sellers' closing quotations were called 51s. 4d cash, 51s. 5d. one month, and 51s. 6d. three months. In the afternoon the tone was somewhat easier, and only one lot of Cleveland warrants changed hands at 51s. 3½d. nine days. Closing sellers quoted 51s. 3½d. cash, and 51s. 4½d. one and three months. Idleness prevailed on Tuesday morning, but sellers of Cleveland warrants quoted firmer at 51s. 4½d. cash, and 51s. 6d. one and three months. Another idle session was recorded in the afternoon, when quotations for Cleveland warrants were easier, with sellers naming 51s. 4d. cash, 51s. 5d. one month, and 51s. 6d. three months. When the market opened to-day (Wednesday) the tone was easier, and 1000 tons of Cleveland warrants were put through at 51s. 3d. seven and eight days, with closing sellers quoting 51s. 3d. cash, and 51s. 4½d. one and three months. In the afternoon Cleveland warrants were inclined to show a decline, but only fractionally. The turnover consisted of one lot at 51s. 3d. one month, and closing prices were 51s. 2½d. cash, 51s. 3½d. one month, and 51s. 4d. three months sellers.

Sulphate of Ammonia.—The holiday feeling still prevails throughout trade circles, and there seems to be little inclination for resuming business. In sulphate of ammonia there has been no pressing demand of late, and now that hostilities have broken out on the Continent the inquiries from that quarter will certainly fall away. What effect that may have on prices remains to be seen, but for the present, at any rate, the quotations are unchanged for prompt lots at 11*l.* per ton Glasgow, and 11*l.* 2s. 6d. per ton Leith.

Scotch Steel Trade.—In normal or busy times all the Scotch steel works would by now have been in full swing, but, unfortunately, the annual holidays are this year being prolonged on account of the dulness of the trade. It will be next week before the resumption is general, and even then there is little prospect of much to start to. The bookings during the vacation have not been large and there is a great dearth of fresh business, and inquiries are only called fair. The accumulation of orders while the works were off has not been very heavy, and little time will be required to run these off. Shipbuilders are well employed, but they have recently been so well looked after by the foreigner that the local maker is only getting a share of what is going, and so long as business is quiet on the Continent the home producer will require to be content with what he gets. Prices are unchanged, but opinion is general that if coal is reduced, there will be a prospect of steel coming down a trifle, but that, of course, is doubtful. The export trade is nothing very wonderful at present, although one or two of the Colonies—India, Australia, and New Zealand—are doing fairly well and sending some satisfactory lines. Taking things all over, it cannot be said that the outlook for the second part of this year is very bright or encouraging.

Malleable-Iron Trade.—The West of Scotland malleable-iron makers, on the whole, have not been anxious to open up their works this week, remembering only too well the hard time they put in during the first half of the year. One or two establishments have made a start, but it will be next week before the resumption is general, as very little work has accumulated during the holidays. Booking has been poor, and inquiry has been extremely limited. Prices show no change, and are based on 6*l.* 12s. 6d. per ton for "crown" bars, less the usual 5 per cent.

Wages of Pig-Iron Workers.—A meeting of representatives of the men engaged in the Scotch pig-iron industry was held in Glasgow to-day (Wednesday) to consider the situation arising out of the refusal of the employers to concede a minimum rate of 4s. per shift. The number of men affected is in the neighbourhood of 1000. The matter of the policy to be followed in the future is being discussed.

Scotch Pig-Iron Trade.—The prevailing conditions in the Scotch pig-iron trade are not very encouraging, and the knowledge that both German and American producers are very quiet does not strengthen the position here, as these makers are shipping lots to some of our markets. The demand all round is quiet, and until the various works get fully under way, there is little prospect of much expansion. The withdrawal by the Scottish miners of the four-days-a-week scheme has certainly eased the tension a little; but as the masters are at the moment considering the reduction of the minimum wage, the horizon has again become clouded, as the miners seem determined to resist that move, and threaten a strike. Should it come to that, the stoppage may be national in character, and this will cause a big dislocation in trade. There seems little doubt but that 1914 is destined to be an eventful year. Hematite is in very poor request at present, and is easy in price. The following are the market quotations for makers' (No. 1) iron:—Clyde, 66s.; Calder, Gartsherrie, Summerlee, and Langloan, 66s. 6d. (all shipped at Glasgow); Glengarnock (at Ardrossan), 70s.; Shotts (at Leith), 66s. 6d.; and Carron (at Grangemouth), 67s.

ASTRONOMICAL, MATHEMATICAL, AND OTHER TABLES.—Messrs. William Wesley and Son, of 28, Essex-street, Strand, W.C., have sent us a copy of a very interesting catalogue of astronomical, mathematical, and other tables offered on the occasion of the Napier Tercentenary. Over three hundred works are included in the catalogue, which is the result of more than fifteen years of professional collecting work; and although, of course, far from complete, it contains practically all the fundamental tables, and includes a large number of works not represented in the library of the British Museum. The catalogue first deals with astronomical, multiplication, trigonometrical, and other tables published before the end of the eighteenth century, including among them some very interesting manuscripts of the fourteenth and fifteenth centuries, written on vellum, as well as early printed works. These are followed by what is probably a unique collection of the mathematical works of John Napier and early tables of logarithms. The remainder of the catalogue is devoted to various tables published since 1800, and it concludes with a list of works on astronomy, mathematics, and physics published by, or on sale with, Messrs. Wesley. The catalogue itself, which is certainly of more than passing interest, can be obtained from the firm post-free for 6d.

A NEW PRIMARY BATTERY.—In a recent issue of *La Lumière Electrique* Dr. E. Bellini describes a new primary battery with which he has obtained some highly interesting results. The negative element consists of plates of lead amalgam obtained by pouring 10 grammes of mercury into 90 grammes of molten lead, whilst carbon is used for the positive element. The electrolyte is a solution of 80 cub. cm. of sulphuric acid and 120 cub. cm. of nitric acid in 1000 cub. cm. of water. When the cell is in action the amalgamated lead is attacked, insoluble lead sulphate being formed, which drops to the bottom of the cell along with some sulphate of mercury and some globules of the latter metal. On open circuit there is little or no loss of lead. The electromotive force remains remarkably constant during many hours' discharge at between 1.0 volts and 1.1 volts. The resistance of one cell tested varied with the strength of the current, being 0.03 ohm with a current of about 0 7 ampere, and 0.128 ohm with a current of 5 amperes. The consumption of lead was about 5 grammes per ampere-hour. Another cell tested had four positive plates and three negative, the total surface of the negative electrode being 900 sq. cm. The internal resistance of this cell was 0.022 ohm under a discharge of 5 amperes. Its capacity was 112.5 ampere-hours, after which the electrolyte required further additions of acid.

THE LATE MR. THOMAS RICHARD BAYLISS.—We regret to have to record the death, which occured at his residence, Belmont, Northfield, on the 24th inst., of Mr. Thomas Richard Bayliss, the chairman and founder of the King's Norton Metal Company, Limited, Birmingham. Mr. Bayliss was born in Birmingham in 1838, the eldest son of Mr. Thomas Bayliss, a brass-founder. Early in his teens he decided to make engineering his profession, and devoted himself to the study of theoretical and practical engineering and metallurgy. At the age of twenty-four he married Mary, daughter of Mr. John Abraham, who founded the Adderley Park Mills. That property was disposed of by his father-in-law about ten years later to the Birmingham Small Arms and Metal Company, and Mr. Bayliss remained at that establishment as its managing director. He held the position till 1889, when, in conjunction with his son, Mr. Thomas Abraham Bayliss, he founded the well-known King's Norton Metal Company. Within a few months of the establishment of the works the business was converted into a limited company. Mr. Bayliss's knowledge of machinery was considerable, and he turned it to account by perfecting machines designed to improve the methods of casting, rolling, and general working up of metals for ammunition. He had a sound grasp of the essentials of ammunition making, and was interested in the manufacture of the first six-pounder case for the Nordenfeldt gun, which was adopted by the British Government. The success of the King's Norton business coincided with a period of much military activity, and the company manufactured for several foreign Governments as well as for the British War Office. Under the direction of Mr. Bayliss and his colleagues the works were well equipped, including the laying down of plant for the manufacture of coinage in its entirety. An important extension of the works was made on 60 acres of land at Abbey Wood, Kent. Mr. Bayliss was the originator of the solid drawing system in cartridge-case manufacture, both as applied to small arms and to quick-firing guns. He was an associate member of the Institution of Civil Engineers, and a member of the Institution of Mechanical Engineers. He was also a member of the Iron and Steel Institute, of the French Société des Ingenieurs Civils, of the American Academy of Political and Social Science at Philadelphia, a Fellow of the Imperial Institute as at first constituted, and one of the first members of the Permanent International Association of Navigation Congresses. Mr. Bayliss took a keen interest in social and municipal work, and was prominently associated with the local authorities of Northfield for many years.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The steam-coal market occupies an exceptionally strong position. The chief cause of the sudden tightening of the market was the outbreak of hostilities on the Continent. Russia and Germany have put pressure upon merchants to quicken deliveries, and as a result shippers are as busily engaged as they possibly can be. Also for local industrial purposes is the demand brisk, though there is a slight easing in the requirements of the lighter trades. Contracting has materially advanced during the past week or so. Producers have presented such a firm front regarding railway coal contracts that, except in the case of secondary grades, they have been able to enforce last year's rates, which are generally regarded as being unusually high. House coal has shed some of its recent weakness. There is a better inquiry from country consumers and from London buyers, but locally the position shows very little change for the better. There is pronounced slackness at dépôts. Slacks are a steadier market. Some stocking has taken place. Coke is still weak. Special sales of blast-furnace coke have been effected at low rates. Quotations:—Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. to 13s.; Derbyshire best brights, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 10s. 3d. to 11s. 3d.; small nuts, 9s. to 10s.; Yorkshire hards, 11s. to 12s.; Derbyshire hards, 10s. to 11s.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.; smalls, 2s. 6d. to 3s. 6d.

Iron and Steel.—Sufficient time has not yet elapsed to give any reliable indication of the nature and extent of the effect the outbreak of war between Austria and Servia is likely to have upon the South Yorkshire iron and steel trades. In the raw-material market conditions are brightening. The slow improvement that set in some weeks ago has been maintained, and though buying is still far below the level of a year ago, the feeling is prevalent that the worst has been left behind. The greatly restricted output is just sufficient to meet the current demand without leaving any margin for stocks. A few more short-dated contracts have been placed, but the bulk of the small amount of business done has been in the purchase of spot lots. Hematites are being sold freely to heavy engineers. West Coast makers maintain their quotation of 73s. 6d. delivered. East Coast hematite is still quoted at 68s. 3d., but orders have been booked at two or three shillings less. There is a fair inquiry for foundry sorts. Lincolnshire makers are quoting 54s. 8d., and Derbyshire makers, 54s. 3d. A greater disparity exists in the case of forge iron, Lincolnshire masters quoting 53s. 8d., and Derbyshire masters only 50s. Bar-iron is flat. The building-trade crisis has caused a slump in the local demand for builders' ironwork. A quiet but wholesome tone prevails in the general steel trades. Few orders of great bulk have this week been booked, but activity is nevertheless maintained at a normal level, and, but for the uncertainty of the outlook, there would be little cause for complaint. Regarding the export trade, manufacturers are somewhat apprehensive of the injury that is likely to result to Russian, French, and German buying owing to the Continental crisis. For machinery parts and agricultural implements Russia has been, and at the present moment still is, one of the healthiest foreign markets, while the French demand upon the productive capacity of special-steel makers has been one of the brightest spots in foreign buying. Railway and tramway material departments have plenty of work on hand. Among the latest booking are orders for springs for East India, and wheels and axles for America. American railway development has for a long time been a source of profit to the South Yorkshire industries. There is no diminution in activity at the big armament works. Speculation has been aroused as to the destination of garrison guns that Messrs. Vickers, Limited, are making for a foreign Power. Billets move very slowly. In the lighter trades orders are less plentiful, though regular employment is maintained. There is a brisk inquiry for all classes of tools. Alloys are an improved market.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The political situation at home and the serious international crisis have checked business here. These disturbing influences, however, have not depressed the Cleveland iron market to the extent that might have been expected. Values are fairly well maintained, but in the present very critical state of affairs buyers and sellers alike hold off. A feeling of general uncertainty exists, and considerable change will have to occur before confidence is restored. A blast-furnace that has been idle has been blown in, but it merely replaces another and larger furnace which is going out for repairs. With business very slack, and pig-iron prices unremunerative, there is little likelihood of the production being increased by the re-starting of idle furnaces. Production is apparently quite adequate, and there is no reason to believe that makers will depart from the policy of restricting output to which they have adhered for some time past. Prices of pig-iron were easier, but buyers are not at all tempted by the rather lower rates named. No. 3 g.m.b. Cleveland pig is 51s. 4½d. f.o.b.; No. 1 is 53s. 9d.; No. 4 foundry, 51s.; No. 4 forge, 50s. 6d.; mottled, 50s. 3d.; and white, 50s. There is little or nothing passing in the East Coast hematite branch of the staple industry, though amongst the visitors present on 'Change this week was one of the principals of a firm of very large Sheffield consumers. Mixed numbers were on sale at 59s. for either early or forward delivery, and No. 1 was quoted 51s. 6d. Extreme quietness rules in the foreign-ore trade, and in the continued absence of transactions, market rates remain nominally on the basis of 17s. ex-ship Tees for Rubio of 50 per cent. quality. Coke for local consumption is in rather better supply, with the result that prices show a tendency to ease, but sellers still ask much higher prices than users consider should be paid. Up to 17s. 6d. is named for average qualities of blast-furnace coke delivered at Tees-side works, but it is understood that contracts over a period have been made at less.

Stocks and Shipments.—The stock of Cleveland pig-iron in the public warrant stores now stands at 82,815 tons, all of which is No. 3 quality. Since the beginning of the month the stock has been increased by 4526 tons. Shipments of pig-iron from the Tees are on a fairly moderate scale. To date this month they average 2398 tons per working day, the total despatches being returned at 59,957 tons, 53,433 tons of which have gone from Middlesbrough and 6524 tons from Skinningrove. To the same date last month the loadings were given at 65,718 tons, or a daily average of 2628 tons; and for the corresponding part of July a year ago the clearances reached 82,045 tons, or an average of 3281 tons per working day.

Manufactured Iron and Steel.—Fairly good reports are given of the manufactured iron and steel industries. Specifications are coming in better, and several new orders have been placed in various departments. A few orders for shipbuilding material have been given out, and a Tees-side firm has made a substantial contract for steel rails. Joists are active. Prices are firm. Principal market quotations stand:—Common iron bars, 7*l.*; best bars, 7*l.* 7s. 6d.; best best bars, 7*l.* 15s.; packing iron, 5*l.* 5s.; iron ship-plates, 6*l.* 15s.; iron ship-angles, 7*l.*; iron ship rivets, 7*l.* 5s.; iron girder-plates, 7*l.* 5s.; steel bars (basic), 6*l.* 5s.; steel bars (Siemens), 6*l.* 5s.; steel ship-plates, 7*l.*; steel joists, 6*l.* 12s. 6d.; steel strip, 6*l.* 5s.; steel hoops, 6*l.* 10s.—all less the customary 2½ per cent. discount; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.*; heavy steel rails, 5*l.* 15s.; steel railway sleepers, 7*l.*—all net at works; galvanised corrugated sheets, 24 gauge, in bundles, 11*l.* 5s. f.o.b.—less 4 per cent.

Iron-Trade Wages.—According to the report of the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England, wages, in accordance with the sliding-scale arrangement for August and September, will be the same as prevailed during the preceding two months. The average net selling price per ton of manufactured iron is certified to have been 6*l.* 13s. 1.91d., as against 6*l.* 14s. 9.33d. in the preceding two months.

Cleveland Miners' Wages.—The representatives of the Cleveland Ironstone Mineowners and the Cleveland Miners' Association again met at Middlesbrough this week to consider the question of wages to be paid to the miners during the ensuing three months. The owners sought a reduction, but an arrangement was effected whereby wages will be reduced by 0·50 (one-half) per cent. The reduction takes effect from July 27.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Fresh business has been restricted to comparatively narrow limits, most buyers having completed their arrangements for loading up to the August Bank Holiday, and being inclined to pursue a waiting policy. Meanwhile, in view of the threatening aspect of affairs in Eastern Europe, holders of the best Admiralty coal have shown a disposition to stand out for higher figures. Upon the whole the tendency for August has been firm, sellers anticipating that the reduction of output resulting from holiday stoppages will involve some shortage. The best Admiralty large steam coal has made 21s. to 23s.; best secondary qualities have brought 18s. 6d. to 19s. 6d.; other secondary descriptions, 17s. 3d. to 17s. 9d.; best bunker smalls, 10s. 3d. to 10s. 6d.; and cargo smalls, 7s. 6d. to 8s. 3d. per ton. The best household coal has brought 19s. to 20s.; good households have made 17s. to 18s.; No. 3 Rhondda large has realised 17s. 6d. to 17s. 9d.; and smalls have brought 12s. to 12s. 6d. per ton. No. 2 Rhondda large has been quoted at 12s. to 13s.; and No. 2 smalls have brought 8s. to 8s. 6d. per ton. Special foundry coke has been quoted at 25s. to 29s.; good foundry coke at 20s. to 23s.; and furnace coke at 17s. to 19s. per ton. As regards iron ore, Rubio has made 16s. to 16s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Foreign Coal Contracts.—Within the last few days ten or twelve steamers, representing a burthen of 50,000 tons, have been chartered to load steam-coal for the Piræus within the next fortnight. The Vulcan Coal Company, a German exporting concern, is stated to have taken up most of the steamers required. The shipments of Welsh coal to Greece this year have already amounted to 240,000 tons, or 80,000 tons more than the shipments in the corresponding period of 1913. Inquiries have been received for best Admiralty coal required for the Austrian Navy. The amount for which tenders are invited is 50,000 tons, to be delivered over twelve months from October. The Central Aragon Railway Company requires patent fuel, to be delivered at Valencia.

Cardiff Corporation Tramways.—At a meeting of the electric lighting and tramways committee of the Cardiff City Council on Monday, Mr. Adcock, the city treasurer, reported that for the year ending March 31 the traffic receipts of the Cardiff electricity undertaking had been 142,040*l.*, showing an increase of 12,776*l.*, as compared with 1912-13. Including accessory items, the increase was carried to 15,573*l.* The working expenses of the last twelve months were 99,563*l.*, as compared with 84,292*l.*; and after meeting loan charges, &c., the net revenue surplus for 1913-14 was 18,594*l.* Of this surplus, 6946*l.* was carried to the depreciation fund and 4800*l.* was applied to the relief of local rates. The amount raised on loans for the development of the undertaking to the close of March was 787,291*l.*, of which 273,232*l.* had been repaid.

Bristol Docks.—Proposals have been made for extending accommodation at the Royal Edward Dock to meet the requirements of growing traffic, especially in refrigerated produce. The imports of this produce having increased fourfold since 1910, the proposal is to provide a new warehouse with room for 300,000 carcases of mutton, against the 100,000 carcases which can now be accommodated. Bristol Docks (Various Powers) Bill, now awaiting the Royal assent, empowers the City Council to raise 100,000*l.* for new cold storage. The warehouse will be on the pattern of the tobacco warehouse, and will be erected on a site behind the "O" shed. It is also necessary to provide a new deep-water berth for ships with general cargoes.

The Ebbw Vale.—The half-yearly meeting of the Ebbw Vale Workman's Sliding Scale Fund was held at Ebbw Vale last Saturday, Mr. W. Jones in the chair. Mr. Sweeney, in reporting as to wages, said Mr. Mills, the managing director of the Ebbw Vale Works, contended that the tin-bar sent from the Ebbw Vale Steel Works to the sheet mills should be included in the audit. The men urged that the tin-bar mentioned was not invoiced goods as laid down in the sliding-scale agreement, and could not be included. Tin-bar was sold at a lower rate than steel rails, and, if it was included in the audit, instead of there being an advance of 3½ per cent., there would be a reduction of 8¾ per cent. With reference to the blast-furnacemen's dispute, a notice has been posted up stating that as soon as sufficient applications have been received from the workmen necessary to make preparation to restart Nos. 1 and 2 furnaces, Victoria, those furnaces would be put into blast.

ELECTRICITY IN WEST HAM.—Every half-year the electricity department of the West Ham Corporation publishes a bulletin for the information and guidance of manufacturers and power-users in the district. The chief object of the publication is to extend the use of electric power by illustrating its many applications in various local industries, but the book also serves to attract other manufacturers to the district by giving particulars of vacant sites suitable for factory buildings. A copy of the July issue has just reached us, and this time the principal feature of the bulletin is an interesting illustrated account of the extensions recently made to the Corporation's generating-station. A new 5000-kw. turbo-alternator, with the necessary switch-gear and auxiliary machinery, has been installed, and two Babcock and Wilcox marine type boilers have been added to the boiler-house. The coal-handling and storage plant has been increased and brought up to date, and the ashes are now handled by a suction plant. The bulletin also deals with the use of electric-battery vehicles for industrial purposes. Many of these vehicles are now running in the borough, and data as to running costs can be supplied by the Sales Department, who also arrange for persons interested to have the use of demonstration vehicles on trial; arrangements have also been made for the regular charging of electric vehicles. Copies of the bulletin, and other information relating to the supply of electricity in the district, can be obtained on application to the engineer and manager, 84, Romford-road, Stratford, E.

STEAM TRIALS OF THE OTTOMAN BATTLESHIP "SULTAN OSMAN I."—The battleship built by Sir W. G. Armstrong, Whitworth and Co., Limited, at their Elswick works, for the Brazilian navy, and named originally the Rio de Janeiro, but subsequently sold to the Ottoman Government, and re-named Sultan Osman I., has completed her contract trials. The vessel is 637 ft. in length, 89 ft. in breadth, and on a draught of 27 ft. displaces 27,500 tons. She carries fourteen 12-in. guns and twenty 6-in. guns, with a number of smaller weapons. The armour on the broadside, as well as on the barbettes, is 9 in. thick, while the 6-in. guns are protected by 6-in. armour. The machinery, which was constructed by Messrs. Vickers, Limited, at their works at Barrow-in-Furness, is of the Parsons turbine type, while the boilers are of the Babcock and Wilcox type, also made at Barrow. After being dry-docked at Devonport Dockyard the vessel was run on the measured mile at Polperro at "continuous cruising speed" on the 17th inst. On this trial the engines were required to develop 24,000 horse-power, and this, it was anticipated, would give the ship a speed of 20 knots. The power was easily exceeded, and the mean speed on the measured distance was 20½ knots. This rate was continued for eight hours, and for the succeeding twenty hours the speed was 20 knots. During this thirty hours' run the vessel steamed to the Forth, where the bunkers were replenished with coal, the vessel being brought down again to the designed draught. The full-power trial consisted of six runs over the measured mile at St. Abb's Head. On the first day that the vessel went out, the 20th inst., there was so much haze that the mile-posts could not be discerned, and the vessel had to return to her anchorage. On the 22nd inst. the vessel made six runs over the measured mile. It was anticipated that, with the designed power of 32,000 shaft horse-power, a speed of 22 knots would be realised. Again the power was easily exceeded, and the mean speed over the measured course was 22.52 knots. The vessel returned to Messrs. Armstrong's yard on the Tyne for completion. Sir Percy Girouard, of Messrs. Armstrong, and Mr. James McKechnie, of Messrs. Vickers, were on board during the trials.

THE ARMAMENT OF THE SPANISH BATTLESHIP "ESPAÑA;" THE MOUNTINGS OF THE 12-IN. AND 4-IN. GUNS.

THE SOCIEDAD ESPAÑOLA DE CONSTRUCCION NAVAL, FERROL AND CARTAGENA.

(For Description, see Page 143.)

FIG. 8. CLOSING THE BREECH OF 12 IN. GUN IN TURRET.

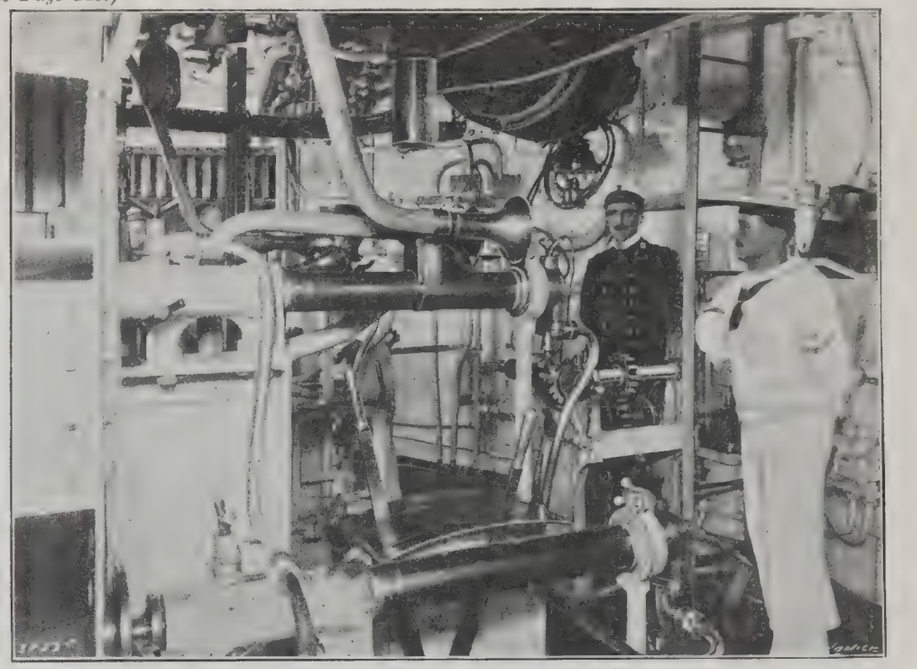


FIG. 9. VIEW IN WORKING CHAMBER IN BARBETTE.

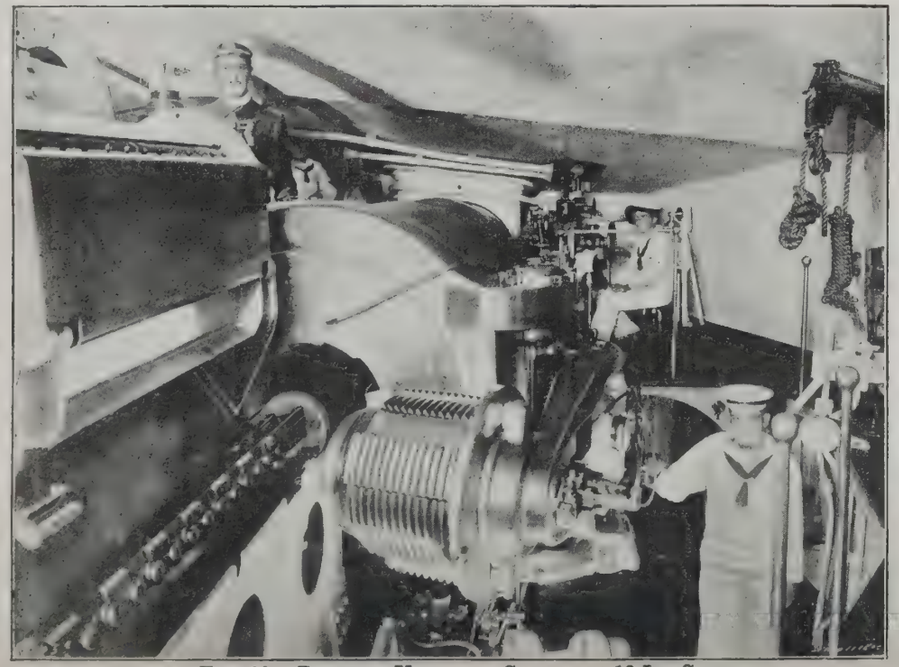


FIG. 10. RAMMING HOME THE CHARGE IN 12-IN. GUN.

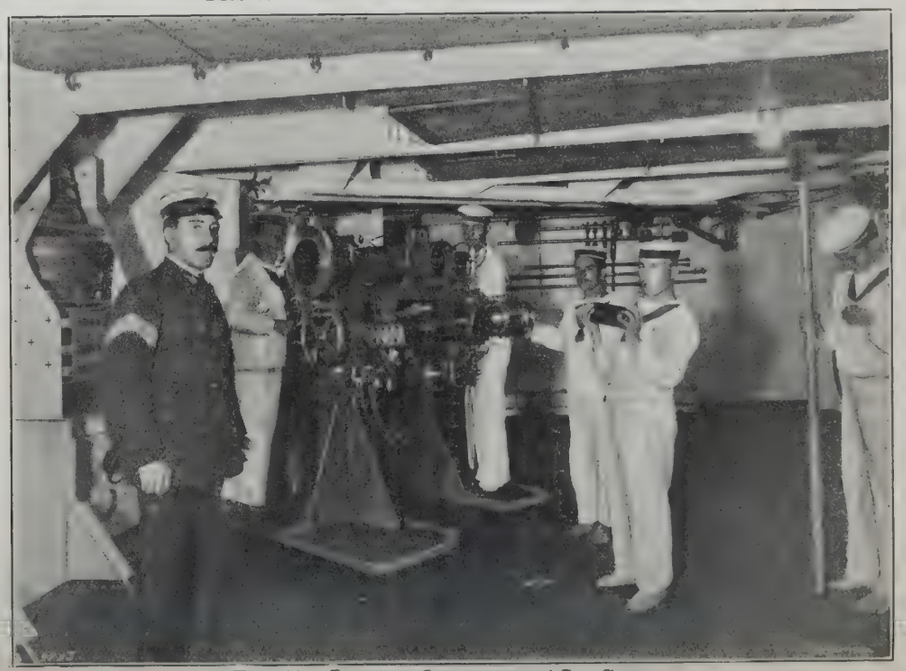


FIG. 11. LOADING ONE OF THE 4-IN. GUNS.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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With a Two-Page Plate of the ARMAMENT OF THE SPANISH BATTLESHIP "ESPANA;" THE 12-IN. GUN BARBETTE MOUNTINGS.

NOTICE OF MEETING.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—The annual general meeting will be held in the Wood Memorial Hall, Newcastle-upon-Tyne, at 2 o'clock on Saturday, August 1. The President will appoint scrutineers for the election of officers for the ensuing year. The Secretary will read the minutes of the last general meeting, report the proceedings of the Council, and read the annual reports of the Council and of the Finance Committee. Election of representatives on the Council of the Institution of Mining Engineers. Election of members, &c. Nominations of members, &c. The following papers will be open for discussion:—"Notes on a New Process for the Washing of Coal at the St. Nicholas Pit of the Société des Charbonnages de l'Espérance et Bonne Fortune, near Liége, Belgium," by Mr. Leo Dorey Ford. "Notes on the Working of the St. Nicholas Pit of the Société des Charbonnages de l'Espérance et Bonne Fortune, near Liége, Belgium, with Special Reference to the Hydraulic Packing of the Goaf," by Mr. Leo Dorey Ford. "A Westphalian By-Product Coking Plant which also Supplies Town Gas," by Mr. Leo Dorey Ford. "The Utilisation of Exhaust Steam for Collieries, Iron Works, &c., and the Cost of Electric Current Generated," by Mr. W. C. Mountain. A fire-damp indicator or methanometer will be exhibited, described, and demonstrated by Mr. Alfred Williams.

ENGINEERING.

FRIDAY, JULY 31, 1914.

THE NAPIER TERCENTENARY.

SCOTLAND has been doing honour to the memory of one of her greatest sons. Three hundred years ago there appeared a small quarto volume, "Mirifici Logarithmorum Canonis Descriptio," whose influence upon the development of mathematics it is difficult to overestimate. It was the first set of logarithm tables, and was the evidence of a new thought and a new power, destined to revolutionise arithmetical calculations. Scotchmen, justly proud of this achievement of John Napier, of Merchiston, to whose genius this progressive movement was due, therefore invited the representatives of the mathematical societies of all nations to assemble last week at Edinburgh, in commemoration of so significant an event. Doubtless some of those who accepted the invitation have made us see Napier's work in a brilliant and convincing light; but it is a difficult task to demonstrate to the "man in the street" wherein lies Napier's claim upon the gratitude of the world. The benefits that science renders are used by many, but acknowledged only by few. The man who invented the multiplication table was a great benefactor of his species, though his name is forgotten, and we have used his device so frequently that we think but little of it. But let anyone try to work a multiplication sum with Greek characters, as practised in ancient Athens, and he will view the matter in a different light. So it is with Napier. In teaching his generation how to construct tables of logarithms, he devised an artifice that with accuracy and facility solves a number of problems that previously could be dealt with only by the expenditure of much time and the cumbrous method of simple arithmetic. It was a great achievement, only possible to a profound thinker; but it is so easy to turn up a table of logarithms that we forget the labour involved in forming the first. We appreciate as little the industry and patience needed, as we do the clearness of thinking and the training required to take a new step in a direction in which there are no pioneers. It was a wise decision, therefore, to organise a tercentenary commemoration, and so oblige us to reflect how much the development of mathematics in various ways owes to Napier's happy inspiration and perseverance.

Though logarithms figure mostly as an instrument for facilitating calculation, that is not the form in which the problem presented itself to the inventor. A far more general principle engaged his attention. He sought to determine the motion of a point which moved in a straight line with varying velocity, the velocity being proportional to the distance of the moving point from a given point. He asked what was the length of the line passed over in each case in equal increments of time, and in that way was led to perceive the relation between two series of numbers—one increasing in arithmetic progression, the other in geometric. Doubtless to Napier there appeared no other way of approaching the subject. But there are widely different methods of arriving at the same truths; for in mathematics, more often than in other branches of science, it has been shown that results which seemed so remote and concealed that they could only be successfully attacked in a certain direction, prove to be singularly simple when viewed from another standpoint. Much more simple ways of apprehending the thought that underlies logarithmic construction have been suggested, and in these latter days ruled papers are arranged to solve the equation $y = a x^b$, and to do much the same work as logarithms. The slide-rule is another application, though many may fail to recognise Napier's master-thought in its construction. A slide-rule could be used to construct the commercial logarithmic paper, and *vice versâ*. With no other assistance than paper ruled to square millimetres, it is easy to construct a curve in which the ordinates are the logarithms of the abscissæ to base 2, and by reading off the curve find the logs. of intermediate numbers. It is a little vague to find the log. of 10 by interpolation between log. 8 and log. 16; but to one who knew nothing of logarithms such a plan would give a general notion of how a logarithm varies as the number varies. We are only anxious to show here that there is a very simple meaning underlying logarithmic construction, which can be apprehended without attacking the exponential theorem or other recondite device, so that those unacquainted with the subject may take an intelligent interest in the proceedings which have been held in Edinburgh. But to assign Napier his proper place in the hierarchy of mathematicians, it must be remembered that he knew nothing of algebraical series, the exponential theorem, or the representation of powers of numbers by indices.

The opening meeting of the tercentenary celebration took place in the hall of the Students' Union, Edinburgh, on Friday last, the Lord Provost presiding. The choice of Lord Moulton to deliver the inaugural address was exceedingly happy, for his lordship was a distinguished mathematician before he was a great lawyer. By his additions to Boole's "Calculus of Finite Differences"—a subject that is in close continuity with the construction of logarithms and various kinds of mathematical tables—a certain historical continuity is maintained between the earliest and latest exponents of this branch of inquiry. Few could have been so well qualified to exhibit Napier as a mathematician and as an inventor, or to analyse the process by which one gifted with both faculties would accomplish his aim. This was the distinguishing feature of the address, though naturally Lord Moulton did not fail to urge that Napier's name was a glory in the land, and its bearer prominent among the small band of thinkers who had substantially increased by their discoveries the powers of the human mind as a practical instrument. But analyses rather than eulogy attracted Lord Moulton, and to this course he was led because so much had been said and written about Napier of late in all centres of learning that the task of saying anything new and appropriate had become very difficult.

Every fact known about Napier, said Lord Moulton, had become commonplace. They were all aware when he was born and when he died; that he wrote at length on the Apocalypse; that he was suspected of trafficking in black magic; that he proposed wonderful and futile methods of defeating the King's enemies, &c. What was known left the man very imperfectly disclosed, but sufficed to show him strong and self-reliant, of solitary habits, of profound and untiring industry, and he was content with such a delineation of the man of whom he was about to speak. How greatly Lord Moulton admired Napier and how desirous he was that his merits and his labours should be appreciated would sufficiently appear from his remarks. In this connection he would, however, make one remark at the outset of an address, dealing well-nigh exclusively with that marvellous invention of logarithms which had immortalised Napier's name. It must not be thought that Napier's greatest work was his sole claim on our gratitude. His other works had long since been left behind by the growth of knowledge since Napier wrote and taught, but he would remind them of two matters that appealed to the gratitude of all. No mathematician could afford to think lightly of the man who first discovered and treated with respect those beautiful entities which were so dear to their souls—impossible quantities. He had, too, laid the world of practical life under an immense obligation by his introduction of the decimal point and the examples he gave of its use. In Napier's works this device was found as firmly established as it was universal at this day. Rejecting then the temptation to indulge in history, or mere eulogy, Lord Moulton had, he stated, had some perplexity in deciding on the nature of his address. What

new contribution could he bring either to the knowledge of Napier's work or to the appreciation of its merits, when so many skilled mathematicians had already worked at the subject and made full utterance thereon?

There was, however, one aspect, as it appeared to Lord Moulton, in which he might perhaps find something to contribute, even though it should prove but a widow's mite. The invention of logarithms came on the world as a bolt from the blue. No previous work had led up to it; nothing had foreshadowed it or heralded its arrival. It stood isolated, breaking in upon human thought abruptly, without borrowing from other workers, or following known lines of thought. It reminded him of those islands in the ocean which rise suddenly from great depths, and which stand solitary, with deep water close around their shores. In such cases they might believe that some cataclysm had thrown them up suddenly with earthrending force. But could it be so with human thought? Did this come as a revelation to Napier, bursting upon him as a light from heaven, or was it the result of a slow growth, the evidences of which were now obliterated? The undoubted fact that Napier worked for some twenty years at logarithms before he published his first book relating to them gave a decisive reply on this point. It must have been a slow and gradual evolution, even though that which remained furnished so few traces of the earlier efforts. Was it then possible from the records left, and out of the circumstances of the time, to read the history of this evolution, to reconstitute the process of discovery by deciphering the half-effaced records of this growth. It was in this direction that Lord Moulton thought something of interest might be found, and, at all events, he would have a congenial subject. He thought he might claim wide experience in what he might term the infancy of ideas. In the course of his career at the bar, he had had great opportunities of studying inventors and their inventions. He had learnt, on the one hand, that pioneer inventions were rarely made in the way that seemed most probable. A man groping in the dark felt his way by devious paths, often guided by trivial and immaterial indications, which he had not yet learnt to disregard. It was only after the light had been reached that he saw what would have been the direct path. And, on the other hand, experience had shown how difficult it was when once the day had broken, to put oneself back into the twilight and see things with the hazy, unrecognisable outlines which they had possessed, and which made recognition so impossible. All this experience had made him, he hoped, in some degree equal to the task of tracing out the probable course of discovery, where the traces were not too absolutely obliterated, and he had used what skill he had gained from the past in trying to discover how, and by what means, Napier had advanced from the darkest night, which had existed when he first took up the problem, to the full daylight which he finally gave to the world.

Lord Moulton then proceeded to discuss the question, What set Napier to work on the lines he did, seeing that there was no antecedent work to suggest a plan, and to indicate what were probably the different stages of the discovery? It was urged with increasing probability that Napier, seeing that trigonometrical tables enabled a product to be found without actual multiplication, conceived the idea of constructing special tables which would do the same work in a more thorough and expeditious manner; it was probable that originally Napier contemplated nothing further than repeated multiplication by a factor near to unity, so that each multiplication reduced, very slightly the number operated upon, and that the word "logarithm," signifying "the number of the ratio," preserved that idea. In the second stage of the discovery, the notion of multiplying by a factor gradually gave way to the idea of taking an aliquot part from the number arrived at by the preceding operation, and that this thought led Napier to pass from the idea of figures to the geometrical representation of the quantity by a line, and to find that his repeated operations were perfectly repeated by cutting off the same fraction of the same diminished length. Further, that at this stage Napier took the simple and obvious step which ultimately proved of momentous importance, completing his discovery, and putting him in a position to commence the calculation of tables.

What deeply impressed Lord Moulton was the tenacity of aim shown by Napier, combined with his receptivity of new ideas for attaining it. From first to last it was a table of logarithms of sines that Napier proposed to make, and he did not permit himself to be turned aside from that purpose till it was completed. His subject evidently widened as he proceeded, and he must have been sorely tempted to turn from his comparatively restricted task to other schemes. But he wisely resisted the temptation. He saw that he must first create a model table, and give that to the world, or his task was unperformed. Would that every inventor had been equally wise! "One of the saddest memories of my life," continued Lord Moulton, "was a visit to the celebrated mathematician and inventor, Charles Babbage. He was very advanced in age, but still quite vigorous in mind. He took me through his workrooms. In the first I saw the parts of the original calculating-machine, which many years before had been shown in an incomplete state, and had even been put to some use. I asked him about its present form. 'I have not finished it, because in working at it I came upon the idea of my analytical machine, which would do all that the old machine could and much more. Indeed, the idea was so much simpler that it would have taken more work to complete the calculating-machine than to construct the other, so I turned my attention to the analytical machine.' After a few minutes' talk we went into the next room, where he showed and explained to me the working of the elements of the analytical machine. I asked if I could see it. 'I have never completed it,' he said, 'because I hit upon an idea of doing it by a different and far more effective method, and this rendered it useless to proceed on the old lines.' Then we went into a third room. There lay scattered bits of mechanism, but I saw no trace of any working machine. Very cautiously I approached the subject, and received the dreaded answer: 'It is not constructed yet, but I am working at it, and it will take less time to construct it altogether than it would to complete the analytical machine from the stage in which I left it.' I took leave of the old man with a heavy heart. When he died a few years later, not only had he constructed no machine, but the verdict of a jury of kind and sympathetic scientific men, who were deputed to pronounce upon what he had left behind him, either on paper or in mechanism, was that all was so incomplete as to be incapable of being put to any useful purpose."

But, continued his lordship, returning to Napier and his work, once the discovery had seen the light, and its claim to practical usefulness enthusiastically acknowledged, then Napier proceeded, most justifiably, to destroy the scaffolding which had been so serviceable in the erection af the building. If they had understood him aright in his endeavour to trace out the path by which Napier arrived at his epoch-making discovery, it would appear that his aim had not been to make it appear more wonderful, or to diminish the greatness of the achievement. He had only sought to make it less mysterious. As it stood in his written work, it was well nigh uncanny. Both his books were written after Napier had attained his full knowledge, and no traces of his early efforts remained. Hence the whole burst upon them as though it were due to magic. It was no slight task to connect Napier's conceptions and methods with anything of his date, or since, or even with logarithms as they were now conceived For his own part he preferred to think of Napier's work as more human, as the persistent effort of a great man to perform a task which he had deliberately set himself, and which step by step he pursued to the end. At the outset it required faith to believe that it was a possible task, that it was not a vain chimera. When that fear had been overcome it must have seemed an impracticable task, too great for mortal achievement. But Napier allowed nothing to turn him; he asked for further insight into the subject and further suggestion for devices, whereby these difficulties could be overcome. It was thus working that Napier appeared greatest. The fascination of reading of the first climbing of a mountain was the history of seizing upon all the little helps that the mountain afforded. The demonstration that there existed an easy and comfortable path might merit more gratitude, but it excited less interest. Napier took twenty years to do the work, many of which —probably the greater part—were spent in arriving at the method. It would be sad to think that most of these years were, so to speak, wasted, because the solution came by a lucky chance at the last. In the speaker's view all these years did their share, and he had tried to show how gradual and continuous was the process. As to the greatness of the achievement, it was needless to speak. Logarithms had played well nigh as important a part in mathematical theory as in practical work. They knew infinitely more of their nature and relations than Napier, or any man of Napier's age, could possibly have known. They had means of calculating them so effectively that if all the logarithm tables in the world were destroyed the replacing of the loss would be but the work of a few months. But not all the three centuries that had elapsed had added one iota to the completeness nor the scope of the two existing systems of logarithms as they were left by the genius of John Napier of Merchiston.

It is not our intention here to give anything like an account of the Napier tercentenary celebration generally, but we may mention that at a meeting, subsequent to that referred to above, papers of a more technical character were read. Among these should be noted that by Dr. J. W. L. Glaisher, who contended that, as a product of the time, the conception of logarithms in Napier's mind was little short of marvellous. He had no notation such as they had now to guide him, and in mathematical development a good notation was of primary importance. Napier, by dint of hard thinking, solved a problem which they would now express as a differential equation, and one that could be solved with ease by analytical methods. As regards arithmetic notation, it would appear that Napier was the first to use the "point" in expressing decimal fractions, a notation far superior to that devised by Stevinus, and widely used even in Napier's day. The more they examined the method of Napier the more were they impressed by his greatness as a mathematical thinker. Referring to Lord Moulton's address of the previous day, Dr. Glaisher said that he had been much interested in Lord Moulton's construction of the probable stages through which Napier passed to his final conception of the logarithm. He had himself always assumed that the geometrical form in which the invention was given to the world was the original form, but Lord Moulton's suggestion was well worth careful consideration.

Some other contributions of interest may be mentioned. Dr. G. Vacca, of Rome, presented through the Secretary a brief note on the first Naperian logarithm, calculated before Napier's date. In a book on arithmetic, published in Florence in 1494, of which the author was Luca Paciolo, the problem is given to find in how many years a sum of money would double itself at a given rate of compound interest. The answer suggested by the propounder was divide 72 by the rate of interest, and the quotient is the required number of years. This number 72 was shown by Dr. Vacca to be approximately 100 times the Naperian logarithm of 2.

Professor Gibson discussed the question of the transition from Napier's original logarithm to those of base 10, first calculated by Briggs. By reference to the written statements of Briggs himself, it was shown clearly that the system suggested by Briggs to Napier was not what was now called the natural or Briggean log, but that it was Napier himself who suggested to Briggs to construct the tables of common logarithms, and that Briggs carried out the calculations. The familiar theorem that the sum of the logarithms of two numbers was the logarithm of the product, was not accurately true for Napier's original logarithms, nor would it have been true in Briggs's improved form. The evidence was clear that it was Napier himself who first suggested making the logarithm of unity, zero.

Professor Eugene Smith, of New York, read a paper on "The Law of Exponents," as illustrated in the works of the XVI. century. The nature of the geometrical progression and its correspondence with a parallel arithmetic progression was traced through the works of Chuquet, 1484, and Boethius, 1499, to the writings of Rustollf, 1525, and Stifel, 1544, to those of a later date. It was this line of development which influenced Burgi, whose "Progress Tabulen" contained what was an antilogarithmic table. The importance of these arithmetical relationships, clearly conceived by the Teutonic school, was recognised by Cardan. These relationships approach so closely the idea of the logarithm, that it was a cause for wonder that the works of Napier and Briggs were not anticipated.

Professor Cajori, of Colorado Springs, read a paper on algebra in Napier's day and the alleged prior inventions of logarithms. Claims had been made in this connection in favour of Regiomontanus, of Wright, and of Burgi. Wright was the first to translate Napier's "Descriptio" into English, and never himself made any claim to the original invention of logarithms. Burgi was an independent discoverer of the logarithmic method, but was six years later than Napier in the publication, and probably a corresponding interval later in beginning his calculations. Napier's method was the more thorough and profound.

Not the least interesting feature in connection with the celebration was a visit to Merchiston Castle School, where members of the Congress had an opportunity of seeing the room which John Napier occupied as his study. An exhibition of relics, of which we may possibly have more to say, was also held in the large Examination Hall of the University. It is eminently desirable that some permanent result should issue from the congress. What form this will take is at present uncertain, but the suggestions that have been made include a facsimile reprint of the original edition of the "Descriptio," the construction of a table of co-logs to seven figures, and the publication of a part of Dr. Sang's great volumes of manuscript tables of logarithms and sines.

SHORTAGE OF LABOUR IN THE COTTON INDUSTRY.

AT the moment the cotton industry of this and other countries is passing through an extremely trying and critical period. The contributory causes are not far to seek, but one of the chief is the overbuilding that has taken place during recent years. Some 16,000,000 spindles have been added in Lancashire alone, even though it was recognised that only during periods of extreme boom would the whole of the new spindles installed about 1907 be completely engaged. Periods of depression follow periods of boom in the cotton trade with almost exact cyclic regularity, so that the spinner and manufacturer almost know what to expect. There is a growing feeling that a fully representative committee should dictate or, at least, pronounce upon the necessity or otherwise of new mills, and thus safeguard the trade as a whole. The short time worked in these constantly recurring periods—although comparatively high wages are paid—is not conducive to the attraction of young labour, and no doubt it is due to the uncertainty of constant regular employment that the shortage in efficient labour may be attributed. This problem—shortage of labour—is the most serious one that spinners and manufacturers will have to face in the future, as the general tendency in all trades is to keep young people out of the mills and factories until much older than hitherto. Much work done by half-timers is non-productive, although very necessary, and if comparatively high wages are to be paid for it, the spinner or manufacturer will be severely handicapped.

In the issue of ENGINEERING of February 10, 1905, on page 186, we published an article entitled "The Lancashire Cotton Industry," dealing with the so-called "American" methods employed in weaving-sheds. Since that time, many mills in this country have largely adopted modified labour-saving and distributing means of this type, and have further installed labour-saving American machinery. This deficiency of good labour is no new thing in the United States and on the Continent of Europe, and has been to a great extent overcome by the adoption of special automatic machinery and apparatus. Many operations, which it is not necessary to detail here, hitherto performed by hand are now completely accomplished with greater facility, and in a less space of time, by machines. In the United States no less than 800,000 automatic looms are at work, one weaver to every 16 or 24. In this country there are not more than 8000, and with ordinary plain looms one weaver tends only four, or at the outside six. The reduction in labour in this particular case alone is enormous, but it must be recognised that the capital value of a weaving-shed with automatic looms of the Northrop type is four to five times what it is for a weaving-shed in this country completely fitted with ordinary plain looms. It is the shortage of labour that dictates the conditions, but it is not absolutely necessary to instal such high-priced automatic machines, owing to the fact that attachments have been devised which can be applied to existing looms at small cost, rendering them automatic.

Throughout the mill there will be a continued growth in the use of automatic and semi-automatic machinery, and with it will come a scheme of management determined on more scientific lines than at present. If it were possible to commence afresh, the mill could be designed to suit the new conditions, and one very notable feature would, undoubtedly, be the provision of central power-stations instead of the individual power units which are at present so universal. Overhead runways, conveying pipes through which the material can be conveyed from point to point or machine to machine by pneumatic means, will materially reduce handling, and the latter can be made to act as cleaning means also. Dust and waste can be removed by exhaust methods, and it appears to be well within the bounds of possibility that complete pneumatic plant will be installed in the mills for a variety of purposes, the operation of certain machines or parts of machines not being the least important of these. Already cleaning by pneumatic means has been adopted in the United States. Labour-saving devices will be increasingly used. Take, for example, the operation of "doffing," or the removal of the full bobbins from the spindles. This used to be performed by half-time labour, but now it is impossible to get sufficient youths for the purpose at 18s. 3d. a week. It must be remembered that this is non-productive work, as the machines are stopped while it is being done. Apparatus applicable to worsted and flax-spinning frames has been devised automatically to doff the full bobbins, and place empty ones on the spindles. Recently a new type of device has been specially devised to perform the first-named purpose for cotton-ring frames. Between the spinning and weaving processes foreign labour-saving machinery has completely altered the working conditions, one machine alone accomplishing the work of several operatives. Up to the present, the necessity to employ automatic machinery has not been so great, and the alleged slowness of the cotton industry to accept and instal new-type machines is due to this fact. In the future, however, the more complete use of such improved labour-saving apparatus and machinery will be absolutely necessary. Further invention will be induced, and signs are not wanting that engineers generally, but particularly electrical engineers who have interested themselves in textile-machine driving, are applying their knowledge of the use of other forces in improving existent machines. One patent fact is apparent—namely, that the cost of textile machinery will be increased. At the present time, on both sides of the trade, spinning and manufacturing, the cost of the machinery is very low. It is not the fault of the machinist that this is so, but the demand of the user, who will, if he is to meet future conditions, have to alter his outlook on the matter.

PERMEABILITY TEST FOR PAINTS AND VARNISHES.

THE great enemy of materials exposed to the weather is moisture, and resistance to the passage of moisture is one of the most important properties of a covering material. In testing the protective power of paints and varnishes it is very difficult to make the investigation under ordinary working conditions, except by superficial observation. It is also difficult to obtain comparative results, owing to differences in the densities of paints, even of the same class and used for the same purpose, and also owing to variations in the thickness of the coats applied. It is, further, necessary to take into account the effects of weathering and alterations in the coat due to age.

A very simple means of making comparative quantitative measurements of permeability, and of artificially reproducing natural weathering conditions, is due to Mr. A. M. Muckenfuss.* He holds that permeability must be entirely distinguished from porosity, and has made experiments demonstrating the probability that in any paint, with dried linseed oil as binder, the ability of the linoxin from the oil to absorb water is the determining factor in the passage of water through the coat.

Permeability is measured by the amount of water passing through a given coating in a given time. This is the "actual permeability" for the given coat. For comparative purposes, this is reduced to "weight permeability" or "volume permeability," which will be a physical constant for the particular combination tested. For coats on a given area, the weight permeability is taken as the weight of vapour passing through it in twenty-four hours divided by the weight of the coat. The permeability depends on the thickness, rather than on the specific gravity of the material, and therefore the "volume permeability" would seem a better basis. This is the weight of water vapour passing in twenty-four hours, divided by the volume of the coat, and is readily obtained by dividing the weight permeability by the specific gravity of the dried coating. Still another basis is suggested—namely, "oil permeability"—and oil permeability : actual permeability : : weight of film × per cent. of oil : 400. This is based on the fact that most protective coverings contain some 40 per cent. of drying oil, so that oil permeability really measures the permeability of a film over a given area covered with paint containing 4 units (grammes, &c.) of fixed oil. If the material contains no fixed oil, volume permeability is probably the best basis.

The tests are made on circular screens of cloth, paper, wire mesh, wood veneer, or cement discs, a suitable size being about 7¾ in. in diameter. The average weight of a coat on this is about 10 grammes of paint. The screen is placed over water, and above it is a weighed dish of fused calcium chloride, so arranged that water vapour can only reach the chloride by passing through the screen. The materials to be compared are coated on the screens as nearly as possible at the same time, and subjected to exactly the same conditions of drying and exposure. The drying takes place in a constant-temperature room. In order artificially to reproduce weathering effects, a special exposure tank is required to give heat, light, and spray. The exposure tank used by Mr. Muckenfuss is cylindrical, 7 ft. in diameter, 4 ft. high, on castors, so that it can be wheeled under the spraying or lighting cover, as desired. Rain is imitated by an ordinary garden whirling spray, and sunlight by means of a Cooper-Hewitt mercury-vapour quartz-tube lamp (Y type, 110 volts) of 1000 candle-power, with a cluster of three Mazda tungsten lamps, 800 candle-power. A fan supplies air for ventilation, by which the temperature is regulated. The tank can be surrounded by duck-cloth tubes attached to a window, so that the warm air may flow out, and cool outside air flow in. A week-day exposure was as follows:—7 A.M., lighting cover fitted, lights turned on, fan started to keep the temperature at about 130 deg. Fahr.; 6 P.M., lights and fan switched off, tank placed under spraying cover, water turned on; 11 P.M., water cut off, cloth tubes fitted to window till 7 A.M. next morning. In later tests the tank was kept at 100 deg. Fahr. during the day, water was turned off at 11 P.M., cover then raised for the tank to dry, but no cold outside air let in. At any convenient intervals the screens are removed from the tank and tested. Under these conditions ordinary commercial paints can be quantitatively examined and conclusive comparisons made. The results obtained were on such lines as:—Some implement paints broke down with as little as three days' exposure; most outside paints could be examined for over 100 days; three cement coverings broke down before two days; varnishes held out about 5½ days. But there is no doubt about the contrasts shown. The complete results are represented on a time permeability curve which illustrates very clearly the relative resistance powers of the coatings tested.

Commercial paints, even if mixed according to a given formula, will vary on account of differences in oils, driers, or pigments, or the degree of intimacy of mixing. The permeability is also very sensitive to changes of temperature, humidity and sunlight, and also varies continually according to the age of the coat. Moisture passes more easily through a paint coat from the covered surface to the outside air than the reverse. The drying of the coat is chiefly by means of chemical changes, and emanations are given off which can be absorbed by the calcium chloride, and which affect the measurements in the case of fairly new coats.

The experiments referred to indicate a most simple and inexpensive method of obtaining decisive quantitative results as to the resistance to moisture on the part of protective coverings, which can be

* "Report on a Permeability Test for Paints and Varnishes," by A. M. Muckenfuss, published by the American Society for Testing Materials.

carried out in any ordinary testing laboratory, and it would be a very small matter to modify the apparatus to compare the effects of exposure to carbon dioxide, sulphuretted hydrogen, acid fumes, and the like. The results also agree very closely with those observed in practice. It is certainly well worth the consideration of every manufacturer, as well as of engineers, for there is scarcely any engineering work done for which the question does not become important at some stage.

The results obtained by Mr. Muckenfuss suggest further research to determine the exact effect of the various weathering agencies on each particular ingredient, and more exact methods of reproducing such weathering by artificial means, the nature and cause of permeability, the relation of permeability to other necessary properties of a good covering material, the changes taking place in a drying coat, how the velocity of such changes is influenced by each constituent and by outside conditions, the causes of each different form of decay, as chalking, checking, blistering, cracking, or scaling, in all of which testing on screens would play a large part.

FRENCH SEA FISHERIES.

ALTHOUGH it is quite common to hear complaints as to the inadequacy of the profit derived from the maritime fisheries of France, these fisheries, nevertheless, occupy a prominent place in the activity of a number of ports, while they supply to an important extent the traffic on French railway lines. On the other hand, it is a fact that the productivity of the French sea fisheries is far inferior to that of the same industry in Great Britain, largely due to the circumstance that the French industry still remains in a very primitive condition from the standpoint of the craft employed. Nevertheless, at certain points on the coast of France fishing has developed remarkably, and a few figures on the subject will be found of interest.

French fisheries enjoy a peculiar *régime*, and in this connection we may mention the *Inscription Maritime** and the privileged position of the inhabitants of the coast, who, after they have completed their period of military service in the French Navy, not only receive pensions by continuing in some maritime employment, but have also a monopoly of the fishing. Moreover, the industry has for a long time received encouragement in the form of premiums for deep-sea fishing, chiefly cod-fishing. Of course, it is impracticable here to enter into the special scheme of bounties, which has not, in any sense, contributed to the development of maritime fishery in France; indeed, the contrary may be said, inasmuch as cod-fishing, favoured by bounties, shows a tendency to decline, while the fishing of fresh fish, unassisted by subvention, has developed remarkably.

Every year the French Admiralty Board, which is concerned with the welfare of the coastal population, and directs the latter in nearly all the phases of its life, industrial or otherwise, prepares statistics of the products of sea fisheries in France. These statistics are far from being absolutely exact, particularly when the attempt is made to evaluate the fishing done by hand along the coast, the products of which generally do not reach the market; the fishermen sell such products direct, and it is only possible to make an approximate estimate of the value of the takings. Be that as it may, it appears, on reference to the statistics, that the value of the sea fisheries in France in 1810, practically a century ago, was estimated at only 440,000*l.*; it was 560,000*l.* in 1820, 680,000*l.* in 1830, 800,000*l.* in 1840, 920,000*l.* in 1850, and 1,320,000*l.* in 1860. The large increase in the latter figure was due, beyond doubt, to the contemporaneous development of the railways, which at about the same period facilitated the transport of salt-water fish to certain, at least, of the points of consumption. As a matter of fact, in 1868 the value of the fish taken off the French littoral or in the open sea was estimated at 2,680,000*l.* Naturally, as the demand increased, efforts were made by the producers to increase production. In 1875 the value exceeded 3,080,000*l.*, reaching nearly 3,720,000*l.* in 1885 and 4,320,000*l.* in 1890. As a result of circumstances not easy to explain, between 1890 and 1902 there was a sort of crisis in French sea fishery, the yield falling as low as about 3,720,000*l.*, and rising, though laboriously, to 3,920,000*l.* in 1900.

Since that time, however, the figures registered have been much more favourable. Thus in 1904 the total value of the takings was 4,680,000*l.* Subsequently, totals considerably exceeding 4,800,000*l.* were reached, and in the last year for which statistics have been published—as usual, with much delay—the value of sea-fishery products is estimated at nearly 5,400,000*l.* But it is necessary to go beyond these figures, and take account of certain industries which, although not precisely fishery, represent sea products, and associate themselves therewith in any valuation of profits derived from the sea. We refer here to oyster culture and to the culture of other shell fish, which represent in the course of a year products of the value of nearly 1,120,000*l.*; that is to say, the products of the sea amount in total value to about 6,520,000*l.*

We have seen that since the commencement of the nineteenth century, and, even more notably, since 1860 and 1865, the sea-fishing industry of France has had a remarkable development. Yet it cannot be said that the development it has now reached is in any way comparable to the advances made either in the same country forty or fifty years ago, or to those which are being, and have been, achieved in other countries. Certain fishing ports, such as Boulogne, Fécamp, and La Rochelle, have progressed materially, but on the whole the industry suffers from stagnation. The boats, speaking generally, are only slightly modified and improved, for the reason that they are the property of quite small owners, who have not the capital necessary to adopt machinery or to construct larger units.

The number of fishermen is estimated at 160,000, but, in fact, there are scarcely 110,000 men who practise boat fishing properly so-called. On the other hand, there are about 50,000 individuals, men, women, and even children, devoting themselves to fishing by hand at low tide, with various appliances and tackle; the products, appreciably important, are valued by estimate at about 280,000*l.* The total number of boats dedicated to French sea fishing, whether on the coast or in the open sea, is something like 30,000; but of these a very large number are quite small units. At the present moment the number of steam-boats thus employed is only 270 to 280, a very small proportion relatively to the whole fleet. These steamers have a collective tonnage of 36,000 tons, and a value of something like 1,120,000*l.* As for the other boats, which are, for the most part, simple sailing-vessels of small tonnage, the total value is calculated at little less than 2,280,000*l.* for a registered tonnage of about 197,000 tons. It will be at once understood, therefore, that this means a very slight unit value for the sailing vessels—scarcely a mean of 2000 francs (80*l.*). The engines and gear used is estimated at nearly 1,080,000*l.* more for the whole of France. It is this extremely weak proportion and very low absolute value of the steam fishing-boats in France which explains the relatively insignificant traffic in fish in the French maritime ports, as compared with the imposing figures shown by the ports of England.

As M. Marcel Herubel has pointed out in a book which has now become an authority on such questions, the steam fishing-boat of Grimsby or Hull is the only really efficacious factor for great production, and, at the same time, the only regular feeder of the market. While France possesses about fifteen times more sailing-vessels than Great Britain, the total production of the latter country is five times greater than that of France. In order to show better the difference existing between the fisheries of the two countries we may point out that in France the sailing vessel used in fishing is almost invariably of small dimensions in comparison with the sailing vessel employed for the same purpose in Great Britain. On the other hand, it is interesting to note that the mean annual production per steam-fishing boat, measured in tons of fish, is greater in France than in Great Britain, being in France 152 tons, an average which does not appear to be reached in Great Britain. This productivity often varies according to ports. At La Rochelle, for instance, it is 130 tons, and it is nearly the same for Boulogne; at Arcachon it amounts to 230 tons, and advances to 400 tons at Lorient.

Up to 1871 sea-fishing was conducted solely by sailing-boats. From 1901 onwards the economical superiority of the steam fishing-boat was shown even in France, although the number of the French steam fishing-boats did not increase very rapidly. When considering the fishing ports of France, it is seen that the greater number of steam fishing-boats belong to a few ports only. Thus, while Boulogne possesses more than 110, there are 40 at Arcachon, about 15 at La Rochelle, practically as many at St. Jean de Luz, 20 at Lorient, and 12 at Dieppe. Even though the craft and gear be good, it seems that the methods followed, and especially the economic organisation, are not always what they should be. Fishing in France is defectively organised, particularly when compared with Great Britain. A comparison of the yield for each French fisherman with that of the British fisherman shows marked inferiority in the case of the former, and the French fisherman's earnings are much lower than those of his British *confrère*. Further, the price of the ton of fish is very much lower in England than in France, and here, doubtless, is one of the reasons why fishing in France does not yield such good results.

Interesting information on this subject can be found in the complete statistics which are published by the Chamber of Commerce of Boulogne. No information could be more precise, having regard to the predominance which the port of Boulogne possesses in the matter of maritime fishing. Until 1871, when only sailing-boats were employed, the price of the ton of fish was 16*l.*, and in the best years the ship's ton yielded only 46*l.* per year. As always, the recourse to machinery has lowered the cost price of the product, and therefore the price of the ton of fish sold to the consumer. In the 'nineties, thanks to the steam-boats, a ship's ton yielded 60*l.* and more. Ultimately the price of the ton of fish rose appreciably, for the reason that the quality of the product was very superior, as a consequence of the rapidity with which the boats were able to bring in the fish. Since, however, this mean price has been lowered by competition, but, as always happens, it has left a fair yield to the boats devoting themselves to fishing, the mean yield per ship's ton being rather more then 49*l.*

There has, however, been a certain crisis in steam trawling in France, notably severe at Dieppe and La Rochelle, where some trawlers and other steam fishing-smacks have been idle for a somewhat lengthy period. The causes of this crisis have been manifold. Steam fishing has frequently been undertaken by private persons whose available funds were inadequate; the crews in some instances have been too numerous and the general expenses too high.

Again, the State, which professes to encourage sea-fishing and assists it financially, has, upon occasion, manifested hostility to steam fishing. The sailing-boat fishermen all along the coast have many times protested to the Minister for the Navy against the competition of the steamboat. Such agitations led to diplomas, somewhat complex in character, being made obligatory upon the mechanics in charge of the engines. This has involved the raising of the wages paid by the companies or owners in the steam trawling business.

The French steam fleet comprises three types—the trawlers, the line fishing smacks, and the drifters. Generally speaking, the trawlers are constructed of iron, and are of 300 to 400 tons gross, fitted with engines of 400 to 600 horse-power. The largest have a length of 40 m. (130 ft.) to 50 m. (164 ft.), with a crew averaging twenty to thirty. These boats have a low freeboard in order to facilitate the hauling up of the drag-net. The deck is clear to facilitate dealing with the haul. The holds into which the fish are stored are to the rear of the foremast. A very powerful windlass is placed in front of the wheel-house, with return pulleys upon the deck. The screw is well protected. In addition to the fish-holds, which are spacious and provided with shelves, there is a hold containing ice or, although more rarely, refrigerating apparatus. It must be remembered that in spite of construction bounties, the French owners have frequently ordered, and still order, their boats in England.

In order to diminish first cost in the case of mechanically-propelled boats a certain number of master fishermen, and even companies, have had recourse to boats provided with internal-combustion motors. At the present time quite a respectable number can be counted at Boulogne along the coasts of Normandy and Brittany, and on the littoral of La Vendée and of La Charente Inferieure—*i.e.*,

* Record of all persons who in France live by some maritime employment.

between St. Nazaire and Bordeaux. Some of the herring-boats have been provided with two internal-combustion engines, one of 150 to 200 horse-power, to actuate the screw; the other, of 25 to 30 horse-power, to work the capstan. Certain sailing schooners engaged in lobster-fishing are furnished with engines of the "Dan" type for propulsion in the somewhat frequent case of calms. These are of 50 horse-power, have four cylinders, and work a screw of about 1.5 m. (59 in.) in diameter. It was towards 1902 that herring-boats of this duplex type were constructed for the first time at Boulogne, and since then the number of small trawlers and line-fishing smacks, which may be described as "automobile" boats, has increased very materially. A curious transformation, from the point of view of the adoption of the motor, has been effected in the neighbourhood of Arcachon. Some years ago only small sailing-boats were seen in that region, these boats using oars when there was no wind, in order to get out to sea for sardine-fishing. To-day there are several hundreds of small craft for sardine-catching equipped with small motors. These boats present no particular features, but, as characteristic of the type of fishing-boat which is beginning to increase along the French coast, we may note La Tour d'Auvergne, which has a length over-all of 13.80 m. (45 ft. 3 in.), a water-line length of 11.5 m. (37 ft. 9 in.), and is 4.5 m. (14 ft. 9 in.) broad, with a draught of water of 1.85 m. (6 ft. 1 in.). She is equipped with a Swiderski single-cylinder motor of 20 effective horse-power, and with a reversible two-bladed propeller, 90 cm. (35½ in.) in diameter. The capstan is actuated by the motor, with the aid of a special coupling. The man in charge of the motor has all the levers within easy reach. The sails are of quite moderate dimensions, not being often required. This boat has been given a displacement of barely 25 tons, because beyond that burden the French regulations are severe with regard to working, hygiene, and safety. Her speed on trial approached 7 knots. It should be observed that, although the boats provided with internal-combustion engines tend to increase in France, not more than 300 could be found at the present time along the whole littoral.

We have said that the evolution of sea-fishing in France is still greatly behindhand. But under the influence of the steam-trawler it is being industrialised, and there is a gradual introduction, particularly in the neighbourhood of Boulogne, of the fixed wage, as adopted in ordinary works on land. Further, thanks to the introduction of mechanical propulsion, wages have steadily increased, and frequently amount to 5*l*. 12s. a month. Often, it is true, the wage does not exceed 4*l*. to 4*l*. 15s.; but it must be remembered that, in addition, the man is fed. It should be observed that this favourable condition of affairs is far removed from that of the sardine fishers, to whom successive crises have presented themselves in France, one quite recently. The sardine-fishers have remained in the most primitive state of organisation, using only sailing-boats of the smallest possible dimensions—of course, outside of the Arcachon district.

In conclusion, we may remark that the French Government distributes every year for the benefit of the deep-sea fishing enterprise more than 500,000 francs (20,000*l*.) in fitting-out bounties, and about 3,700,000 francs (148,000*l*.) in other bounties. The cost of supervising the fishing stations must also be taken into account; this amounts to about 1,300,000 francs (52,000*l*.). Altogether the expenses of subventions, bounties, &c., exceed 21 per cent. of the value of the total production of this branch of the sea-fishing industry.

NOTES.

LLOYD'S WRECK STATISTICS FOR 1913.

THE statistics of steamers and sailing vessels lost or condemned during 1913 have just been issued by Lloyd's Register of Shipping. During the year 542 vessels, totalling 608,235 tons, were removed from the list of the world's shipping; but these figures only refer to vessels of over 100 tons, and exclude cases of breaking-up, condemnation, &c., not dependent upon stress of weather. Of the total number, 295 vessels were steamers, making 445,265 gross tons, and 247 were sailing ships, aggregating 162,970 net tons. These figures are remarkably low, lower, in fact, than have been recorded for several years. For purposes of comparison we may mention that during the previous year 720 vessels, making 748,965 tons, were removed from the list, while the figures for 1911 were 636 vessels, totalling 629,326 tons. The following table shows the distribution of the losses among the principal maritime nations for the year 1913:—

—	Total Vessels Owned.		Percentage Lost	
	No.	Tonnage.	Of Vessels.	Of Tonnage.
United Kingdom ..	9214	18,696,237	1.23	1.07
British Colonies ..	2073	1,735,306	1.78	1.16
United States .	2696	2,998,457	3.38	2.38
Austria-Hungary ..	427	1,011,414	0.70	0.55
Denmark	811	762,054	1.60	0.86
Holland	759	1,309,849	0.53	0.10
France	1552	2,201,164	1.93	1.57
Germany	2321	5,082,061	1.34	1.11
Italy	1114	1,521,942	2.33	1.77
Japan	1037	1,500,014	—	—
Norway	2191	2,457,890	2.78	2.47
Russia	1216	974,178	2.38	2.45
Spain	607	840,995	2.14	1.89
Sweden	1436	1,047,270	2.09	1.65

The nations enumerated account for 506 vessels, of 565,549 tons in the aggregate; the remaining 36 vessels, totalling 42,686 tons, were owned by other countries. It should also be explained that the figures given for the United States do not include vessels trading on the Great Lakes, and that the percentages lost by Japan cannot be given, because Japanese sailing vessels are not embraced in Lloyd's Register.

THE PORT OF LONDON.

The fifth annual report of the Port of London Authority just issued shows that the tonnage using the port is steadily increasing, having risen from 37,676,142 tons in 1912 to 40,080,282 tons in 1913. That the position of London as the principal port of the United Kingdom remains unimpaired is well shown by the following figures, giving the value of the foreign trade at the six leading ports:—

Total Imports and Exports.

	£
United Kingdom	1,403,555,065
London	411,792,149
Liverpool	370,779,413
Hull	84,604,417
Manchester (including Runcorn)	56,717,969
Southampton	53,569,213
Glasgow	54,756,626

During the year a reorganisation of dock labour has been effected, the point aimed at being the elimination, so far as is practicable, of the casual labourer. This, it appears, is not wholly feasible, since there are certain seasonal trades, such as those in wool and fruit, which require the temporary engagement of a large number of additional hands. Many of these, however, only come to the docks when attracted by the larger earnings then practicable. The plan adopted has involved the formation of a large staff of permanent labourers, whose engagement is terminable on either side on seven days' notice. The wages commence at 28s. per week and rise to 30s., with extra pay for overtime. These labourers will be given six days' leave annually in addition to the statutory holidays. They will not receive pensions, but may in exceptional cases be granted retiring allowances. The total revenue of the port for 1913 was 3,434,453*l*., and the expenditure 2,217,822*l*., leaving a net revenue of 1,216,631*l*. Of this, fixed charges absorb 932,786*l*., and after provision for sinking funds, the writing off of certain extraordinary outlays for repairs and renewals, and the transfer of 100,000*l*. to the general reserve, a balance of 91,904*l*. is carried forward. Many costly improvements are being made in the facilities of the port, and the work is to be continued and extended in the future. During the year Mr. R. Philipson retired from the general managership, and the occasion was seized to consider the reorganisation of the staff into three divisions, respectively under the manager, the chief engineer, and the secretary. The vacant post of manager was filled by Mr. C. Lowndes, previously assistant to the chief goods manager of the London and North-Western Railway.

LONDON ELECTRICITY SUPPLY.

Some time since we discussed in these columns the complicated subject of the supply of electricity in the London district, in the light of a report made by Messrs. Merz and McLellan to the London County Council. Since the date of that report, which was of a technical nature, the question of embodying its recommendations in a practical scheme has been considered by the London County Council Special Committee on London Electricity Supply. Preliminary suggestions have now been schemed out by this committee, and have been embodied in a report, which was submitted to the Council on Tuesday last, but of which the consideration has now been unfortunately postponed till after the summer recess. The report deals only with broad suggestions, and does not lend itself to detailed discussion, since criticism of the scheme advanced must necessarily rest largely on the manner in which many of the points are finally worked out. Moreover, there is at present no indication that the suggestions have the approval of parties whose consent is essential to its success. Briefly stated, it is proposed to constitute an authority, less cumbersome than the Metropolitan Water Board or the Port of London Authority, to represent the interests of the public in the London County, portions of five other counties, and in three boroughs, covered by the area selected, which has been so chosen for technical and practical reasons. It is proposed that this authority shall issue stock and shall take over existing undertakings, and furnish two-thirds of the capital required for new works. The remaining one-third would be provided by a company which, under control of the authority, would manage the actual supply. The stock issued by the authority would be in the form of debentures, with a first charge upon the profits realised of 4 per cent. After a contribution to a sinking fund, payment of interest on the shares issued by the company would be made up to 4 per cent. From any surplus then remaining payment at ½ per cent. per annum would have to be made to a reserve fund, after which additional amounts would be payable on the company's share capital till the interest on this reached 8 per cent. per annum. If anything still remained, it would go partly in rebates and partly to the company and the authority. In this way it would be to the company's interests to make the enterprise a success, since it would benefit materially by so doing. At the same time the public interests would be safeguarded by the control exercised by the authority. On the degree of this control will rest to a large extent the success or failure of the scheme, and at present it is not possible to say how far it will be consistent with, or detrimental to, sound commercial management. It is, however, satisfactory to notice that, in order to ensure some continuity of policy, it is proposed that the executive of the authority should consist of a small technical permanent committee of engineering and financial experts. It should in this way be possible to prevent undesirable political influence being brought to bear on the operations of the undertaking. The object of the scheme is, of course, the supersession of the present heterogeneous collection of power-stations and supply systems by a unified system, of which the generating-stations would be advantageously placed on the river, or even, perhaps, at the coal-fields. There is no idea of abolishing plant which is now efficient, but the scheme would offer to the present undertakings a means of handing over their affairs to the authority, or, if their business extends, of increasing their efficiency by obtaining the necessary additional supply from the authority.

WEIGHING FEED-WATER.—A new machine for weighing feed-water is being manufactured by Messrs. L. and C. Steinmüller, of Gummersbach, in Rhenish Prussia. The special feature of the device is that the tilting of the measuring tank does not take place before the tank is really quite full, and that hence the weight of water is determined within an accuracy of $\frac{1}{10}$ per cent., which is certainly unusual. One of these machines installed in the turbine works of the Allgemeine-Elektricitäts Gesellschaft, of Berlin, is, indeed, said to exceed this accuracy. The two tanks rest on knife-edges, and are balanced by cast-iron weights. The water enters above through a trough resembling an inverted U, which sends the water either into the left-hand or into the right-hand tank. This trough is tilted by the float in the respective tank, and the main supply to the tank is thus cut off. The trough is, however, connected with a by-path, an auxiliary channel, through which the water continues to flow until the tank is really full. At that moment the tank is tilted, and the channel is at the same time discharged through a siphon; the discharge through this siphon again continues until the tank is quite empty. Meanwhile the empty tank has already begun to right itself; in order to soften the shock of the reversal of the movement, a glycerin dashpot has been added to the device. The tilting operations are counted and recorded in the usual way.

LITERATURE.

Fire Protection in Buildings: A Practical Treatise for Engineers, Architects, Surveyors, and Property-Owners. By HAROLD G. HOLT, A.R.I.B.A. London: Crosby Lockwood and Son. [Price 8s. 6d. net.]

THE fundamental principles underlying the practice and objects of fire insurance are frequently misunderstood. Many suppose, or appear to suppose, that by the payment of certain premiums and the observance of certain arranged conditions they are relieved from all the losses occasioned by fire. It rarely occurs to those who have carefully protected themselves that the basis of the whole arrangement is nothing more nor less than a general co-operative compact for mutual aid, and that the so-called fire insurance company is not in any real sense a company for insuring them against losses by fire, but simply the medium through which the operation of mutual aid is carried out. It is a medium that indemnifies the individual at the expense of the community. It is evident that when a fire has done its work, the world is poorer by an amount which represents the difference in value between the original goods and the heap of ashes. No juggling with premiums, or recovery from accumulated funds, can alter that stubborn fact, however much it may be hidden by the smooth working of excellently devised machinery. Recognising that inevitable loss is entailed by every fire, it must be for the common good to reduce material losses by accidental fires in all reasonable ways, the most obvious of which would be to prevent the outbreak of fires by careful and judicious building, and, secondly, by the provision of the necessary appliances for extinguishing fires, with a staff adequately trained to the use of these means. It is because the author has emphasised these points so admirably that we welcome the appearance of this book. By his careful compilation of rules, by his examination of principles and plans, and by his collection of much varied experience, Mr. Holt is to be regarded as affording true protection against fire, by which the only real insurance can be effected.

If we consider what constitutes careful and judicious building—referred to by Mr. Holt as the structural aspect of the problem—we shall find that it consists mainly in the combination of suitable materials with good design, implying the adjustment of height, shape, and cubical capacity to the purposes of the building. Coming to details, we need properly-constructed walls, roofs adapted to the general structure, well-placed and protected internal divisions, floors adequately adjusted to the weights to be carried, and suitable staircases, whether internal or external. It cannot be too strongly urged that it is on the proper combination of all such factors that a fire-resisting building has to rely. A chain is no stronger than its weakest link. Too frequently a disproportionate view is taken of the importance of some one factor, and other equally material elements neglected. For instance, cast-iron girders and metal work, being regarded as fire-proof, are not thought to need any protection. Concrete floors are provided and carefully constructed on modern lines, but insufficient care is bestowed on the supports. "It is an absolute waste of money," says Mr. Holt, "to construct highly efficient fire-resisting floors *per se* in a building where the main structural columns are of unprotected steel, cast iron, or reinforced concrete, unprovided with sufficient protection against fire and water." This seems to be an axiom, and yet it is one of a class to which the public are indifferent. The building as designed, apparently without inflammable material in its construction, is so different from the same building when a destructive fire is at work on the contents, that it is difficult for the imagination to realise the magnitude of the forces or the behaviour of the materials.

The author, however, not only gives good advice on the choice of materials and the principles of design, but drives home his points by many examples. He indicates defects of construction, and, unfortunately, is able to illustrate many by recalling disasters that have followed the neglect of precautions. He describes many ingenious devices that have been contrived for better resisting fire, and naturally many patented processes and adaptations. He is, however, spared the need of drawing any invidious distinctions on the relative merits of many of these, owing to the admirable and trustworthy reports of the British Fire Protection Committee. The work of this Committee should be better known outside the expert area, and its deserts more fully recognised. The Society exists for the purpose of collecting reliable data concerning the fire-resisting power of the various materials and systems of construction used in building practice, and to give precise particulars, independent and scientific, on all fire-preventive and warning and extinguishing appliances. Under certain conditions, the Committee will submit materials and devices used in ordinary practice to fire tests on their own initiative; but, as a rule, firms interested in the production of fire-resisting materials will offer their contrivances and inventions for test, in the hope of securing a certificate. The character of the tests, into the details of which we cannot enter here, is sufficiently severe, and after successful examination certificates are granted at three different stages of efficiency: Temporary protection, which implies a resistance to fire for 45 minutes at least; partial protection, or capability to resist fire for at least double that time; and full protection, or power to resist fire for at least two and a-half hours. This Committee is doing useful self-denying work, and deserves both support and encouragement.

There is another side to be considered. Improved construction to prevent a possible outbreak of fire covers only one half of the subject. It may become necessary to extinguish a fire when it has broken out in premises more or less inflammable. Those who live in houses, or carry on their work in buildings erected before all the resources of the fire engineer were employed to ensure safety, are more interested to learn how they may diminish the risk of fire hazard. Particularly is anxiety felt in the case of buildings, such as hotels, theatres, schools and hospitals, where large numbers are temporarily housed. It is gratifying to know how much has been accomplished and how great is the care that is perpetually exercised, either voluntarily or to meet the requirements of legislation. It is even more satisfactory to know the means adopted to prevent a disaster. Mr. Holt therefore devotes the second part of his book — the extinctive or palliative aspect — to a description of the safeguards and appliances for quick extinction after outbreak. Fire-alarms seem to have attracted very general attention, and many simple devices depending on the expansion of metals with rising temperature are in use. It would have been very interesting if the author could have given any statistical information concerning the percentage of cases in which these devices have proved their utility. To provide the possibility of attacking a fire at its outbreak is a matter of vital importance. Everything depends upon being quickly on the spot with the means of extinction at hand, and these fire-alarms are arranged to give notice when the temperature in the neighbourhood of the fire rises to an unexpected height. One would like to know with what degree of frequency this form of mechanism has proved effective. Statistics, however, must be very difficult of collection, because we hear only of those fires that reach a destructive stage. Those that are quickly extinguished attract no attention, and it is frequently to the interest of those concerned not to allow the information to be published.

Two admirable chapters are given on the means of fire extinction. The author, not writing for professional firemen, deals only with those methods of extinction which are likely to be used on emergency and at short distances. The most usual is that of projecting on the burning material a small stream of water, or preferably water charged with carbon dioxide, formed from some salt of soda by the action of acid liberated from a tube, either by fracture or inversion. These forms are doubtless greatly in evidence, and very satisfactory results have been obtained when tested by the Fire Prevention Committee, but we doubt if they are often used or if any effective fire drill is maintained in the establishments where they are prominently exposed. Of more importance and more ingenious are the automatic fire-extinctors, known as "sprinklers," an arrangement that admits of the discharge of water from a series of horizontal pipes fixed near the ceiling or roof of buildings when some piece of mechanism, such as a solder cap, is melted by the heat from the fire below. There are many forms on the market, and all are well described here, but the weak point of each consists in the "fusible link" that starts the water supply. The solder is supposed to melt at a temperature of about 155 deg. Fahr., and no doubt does, when immersed in water heated to that degree, but practically the length of time to set the valve in action must be very uncertain, owing to many variables connected with the spacing of the overhead outlets and the methods of ventilation. Pumps, drenchers, hydrants, all receive adequate attention in this practical treatise, the outcome of long and intimate acquaintance with the mechanical details of an industry that is advancing in importance and efficiency.

Application of Electric Power to Mines and Heavy Industries. By W. H. PATCHELL, M. Inst. C.E., M.I.E.E., M.I. Mech. E. London: Constable and Co. [Price 10s. 6d.]

THIS book is the outcome of a course of lectures delivered at King's College last winter, and we agree with those responsible for the arranging of the course that the information collected is well worthy of being recorded in permanent form. The extensive practical experience of the author in the subject-matter of the book gives the greater value to his candid expressions of opinion on the apparatus used in the application of electrical machinery to mines. The too frequent fault of authors of describing recent installations in detail without critical consideration of the reasons for and against what has been done is carefully avoided in the volume before us. We find instead expert advice on detail, which will make the volume invaluable to all engaged in mining.

The first chapter, on the "Legislation Concerning Electricity in Mines," forms no exception in this respect. The reader is spared the reproduction *in extenso* of the numerous Acts of Parliament and Home Office rules dealing with the subject, and given instead a *résumé* of what danger each action by the Government has proposed to reduce. The inadvisability of legislation on scientific matters, rather than leaving them to be dealt with by departmental regulations, which can be periodically amended, is pushed home by a specific example worth quoting. In the 1911 Coal-Mines Act a clause was inserted absolutely prohibiting the use of electricity in any part of a mine as soon as the percentage of inflammable gas in that place is found to exceed 1¼ per cent. This was inserted by a Parliamentary Committee when they heard that a new form of electric gas-detector readily gave notice to the miners of the percentage of gas present. As soon as the Act was passed it was proved that the electric detector in question, while quite accurate for coal-gas, gave no indication with the percentage of fire-damp specified. The Act, of course, has not been modfied, and the clause without the detector is in danger of becoming a dead letter. The statistics given in this chapter as to the number of fatal accidents occurring in mines due to the use of electricity are carefully classified. This shows what a large proportion of these accidents are caused by the disregard of the precautions provided, or of the rules laid down by the Home Office. The total number of fatal accidents due to electricity for 1910 were only 1.15 per cent. of the number of deaths occurring in mines that year. Other statistics clearly show that in those countries where labour is more expensive, the introduction of machines to save labour has raised largely the output per person employed. It is the large area underground over which such machinery is needed in a mine that has led to the more extensive application of electricity for driving.

After a consideration of the choice between continuous and three-phase current for work in mines, the author passes on to the generation question. He shows that the power supply companies in Great Britain have not yet found a ready market in the mining industry. This is, perhaps, due to the diversity of ownership in this country and the want of proper financial arrangements between the mine-owners and the power companies. The success of the Victoria Falls Power Company in the supply of electric power to the gold-mines on the Rand is an instance of what can be done. The author, in Chapter VII., on "Winding Engines," shows how much simpler and more economical an electric winding-engine can be made when the demand on the power-station is large compared with the power required for an individual winder. In South Africa a large number of three-phase winders are at work, taking their supply direct from the network, with or without motor gene-

rators, but in either case without any auxiliary flywheel or equalising apparatus. The saving in the first cost over the apparatus frequently installed to reduce the drain of a winding-engine on a small power-station is considerable, and the energy required per wind is also much less. On page 156 a typical case showed 4.26 units required per ton of coal raised with a flywheel equalising winder, as against 2.94 units for a direct-acting winder with no flywheel.

The second chapter, dealing with cables, will be appreciated by mining engineers as a help to them when purchasing cables. The author freely recognises that cable-makers having to guarantee results have done more than independent engineers can do in perfecting cables to meet the special conditions in mines. He describes the present practice of the best firms in a way that must be exceedingly gratifying to them. Chapter III. deals with coal-cutters, and gives details of the types which are now fighting for supremacy under the trying conditions of underground working. Safety-lamps are also dealt with in this chapter, and the influence of light on output is referred to. We agree with the author that oil safety-lamps which give only 0.66 candle-power must in time give way to lamps of higher candle-power, as more light will enable output to be increased.

The next chapter, on "Haulage Gears and the Rates of Haulage," is typical of the author's method of handling his subject. He shows the futility of trying to design on academic lines when the power required can be varied by so many factors which cannot be predetermined. As he says, "the only rational way is to put in a motor large enough for the most onerous conditions of working. In other words, the breakdown torque of the motor is the prime consideration." Figures of actual haulages are given, as a guide to the use of electricity for this purpose, in which an electric motor has many advantages over steam and compressed air. For this purpose in fiery mines flame-tight motors are recommended in preference to the so-called gas-tight motors. It is obvious that in such positions the motor must be able to withstand either an external or internal explosion. The cost of haulage is an important factor in the working of a mine, and the author gives some valuable figures, and also references as to where more can be obtained.

Chapters VI. and VII., on "Winding-Engines and Electric Winders," open up a subject on which a larger volume than the one before us could easily be written, and yet the author has given a comprehensive, but concise, review of the subject. The mechanics of the problem alone can be varied in numerous ways, being affected by the number of stages, type of drum, ropes, &c.; but the author gives enough about each to enable the application of electricity to be intelligently studied with the different mechanical variants. The electrical winders are considered in two classes—*i.e.*, that including winder-motors worked directly off the supply mains, and, secondly, winders where the motors work in conjunction with equalising apparatus for levelling the peak and diminishing the maximum demand from the supply main. While the second class has some subsidiary advantages, such as allowing a wind to be completed if the supply fails, the primary advantage, as we have mentioned above, becomes of less importance if a large number of mines are supplied from the same power supply system. The tables, giving details of actual winding equipment, will be found to be of great value.

In Chapter VIII., on "Ventilation and Air-Compressing," mention is made of Dr. J. Harger's experiments, which tend to prove that a man can work without discomfort in an atmosphere which, from its low percentage of oxygen, will not permit of explosions of either fire-damp or coal-damp. He considers that absolute protection against explosions could be obtained by an atmosphere with 17½ per cent. of oxygen and ½ to 1 per cent. of carbon dioxide. If this is confirmed in practice, the Coal Mines Act of 1911, which insists on 19 per cent. of oxygen, may have to be revised in the best interests of the miners. The electrical side of the ventilation problems is well explained, and the different methods of speed regulation described.

Chapter IX., on "Electric Pumping," completes the mining section. The practical hints which are given by the author on the choice of the type of pump to meet different conditions, as well as on the type of motor most suitable for driving the different pumps will commend the book to any mining engineer who has not had much electrical experience.

The three remaining chapters—on "Rolling-Mills," "Machine-Tools and Cranes," and "Electrical Welding and Furnaces"—have no doubt been included as referring to the "Heavy Industries" mentioned in the title. They hardly appeal to mining engineers, and the space allowed is too little for the large subjects in question. Perhaps in the next edition the book may be divided, and these last chapters expanded into a second volume.

We think that, as a guide to the use of electrical power in mines, Mr. Patchell's book will be of great service to the engineer engaged in this large industry, and its value is increased by liberal references to other publications, which help the reader to easily amplify the information given.

Principles of Flight. By A. E. BERRIMAN. Published at the offices of *Flight*, 44, St. Martin's-lane, London, W.C. Second Edition. [Price 2s.]

THIS volume is intended for the use of those who wish to know the general principles on which flight depends, but who have not the time to study the more elaborate and expensive treatises on the subject. It follows the general lines of the first edition in giving a broad outline of the principles which govern the construction of both the balloon and aeroplane, but has been considerably enlarged, and now includes a scale drawing of a Deperdussin monoplane and of the "Gnome" engine. There are numerous illustrations, and the volume should be of great use to those who wish to begin their study of flight with an inexpensive work.

BOOKS RECEIVED.

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Chinese Self-Taught (in Chinese and Roman Characters) by the Natural Method. With Phonetic Pronunciation. By J. DARROCH, Litt. D. London: E. Marlborough and Co. [Price 4s., wrapper; 5s., cloth.]

The Motor Manual. Compiled and Illustrated by the Staff of *The Motor*. Seventeenth Edition. London: Temple Press, Limited. [Price 1s. 6d. net.]

Smithsonian Institution: Report on the Progress and Condition of the United States National Museum for the Year ending June 30, 1913. Washington: Government Printing Office.

Festigkeit der Schiffe. Von FELIX PIETZKER. Berlin: Ernst Siegvried Mittler und Sohn. [Price 7 marks.]

How to Understand Aeroplanes. By S. L. WALKDEN. London: Percival Marshall and Co. [Price 1s. net.]

The "Japan Gazette" Japan Year-Book, 1914. Yokohama: The *Japan Gazette* Company, Limited; London: Kegan Paul, Trench, Trubner and Co., Limited. [Price 15s. net.]

Complex Integration and Cauchy's Theorem. By G. N. WATSON, M.A. Cambridge: The University Press. [Price 3s. net.]

The Mechanical Design and Construction of Generators. By R. LIVINGSTONE. London: The *Electrician* Printing and Publishing Company, Limited. [Price 9s. net.]

Molecular Physics. By JAMES ARNOLD CROWTHER, M.A. London: J. and A. Churchill. [Price 3s. 6d. net.]

Heat. Prepared in the Extension Division of the University of Wisconsin by E. M. SHEALY. London and New York: McGraw-Hill Book Company, Inc. [Price 8s. 4d. net.]

Commercial Paints and Painting. By ARTHUR SEYMOUR JENNINGS. London: Constable and Co., Limited. [Price 6s. net.]

The Design and Construction of Oil-Engines, with an Appendix on Marine Oil-Engines. By A. H. GOLDINGHAM. New York: Spon and Chamberlain; London: E. and F. N. Spon, Limited.

Marine Engineering: A Text-Book. By Engineer-Captain A. E. TOMPKINS, R.N. (Ret.). Fourth Edition, revised and partly rewritten. London: Macmillan and Co., Limited. [Price 15s. net.]

Rahmenformeln. Gebrauchsfertige Formeln für einhüftige, zweistielige, dreieckförmige und geschlossene Rahmen aus Eisen-oder Eisonbetonkonstrution nebst Anhang mit Sonderfällen teilweise und ganz eingespannter Trager. Von Dr.-Ing. A. KLEINLOGEL. Berlin: Wilhelm Ernst und Sohn. [Price 10 marks; bound, 11 marks.]

Puerto de Valencia. Memoria sobre el Estado y Progresso de las Obras durante el año 1913. Valencia: A. C. de M. Gimeno.

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Coast Sand Dunes, Sand Spits, and Sand Wastes. By GERALD O. CASE. London: St. Bride's Press, Limited. [Price 5s. net.]

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Harper's Gasoline-Engine Book. By A. HYATT VERRILL. New York and London: Harper and Brothers. [Price 5s. net.]

Influence Diagrams for the Determination of Maximum Moments in Trusses and Beams. By MALVERD A. HOWE, C.E. New York: John Wiley and Sons; London: Chapman and Hall, Limited. [Price 5s. 6d. net.]

Hydraulics for Engineering Students and Engineers in Practice. By W. M. WALLACE, Wh. Sc., A.R.C.Sc., London: The Technical Publishing Company, Limited. [Price 4s. net.]

Gearing: A Practical Treatise. By A. E. INGHAM. London: Methuen and Co., Limited. [Price 5s. net.]

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Proceedings of the Davenport Academy of Sciences. The Nazca Pottery of Ancient Peru. By Dr. MAX UHLE. *The Davenport Collection of Nazca and other Peruvian Pottery.* By EDWARD K. PUTNAM. Davenport, Iowa: Davenport Academy of Sciences.

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Water Works Engineering: A Practical Treatise on the Construction of Water Works for the Use of Engineers and Students of Engineering. By FRED. C. UREN, M. Inst. C.E.I. Bristol: Castle Litho., Limited.

General Foundry Practice; being a Treatise on General Iron Founding, Job Loam Practice, Moulding and Casting of the Finer Metals, &c. By WILLIAM ROXBURGH, M.R.S.A. London: Constable and Co., Limited. [Price 6s. net.]

Scales for Ascertaining the Dimensions of Pipes, Drains, and Sewers. By C. E. HOUSDEN. London, New York, Bombay, Calcutta, and Madras: Longmans, Green and Co. [Price 1s. 6d. net.]

The Theory of the Solid State. By Professor WALTHER NERNST. London: Hodder and Stoughton. [Price 2s. 6d. net.]

The Making of High Roads. By ALFRED EDWARD CAREY. London: Crosby Lockwood and Son. [Price 2s. 6d. net.]

Oil Fuel for Steam Boilers. By RUFUS T. STROHM. New York: The McGraw-Hill Book Company, Inc.; London: Hill Publishing Company, Limited. [Price 4s. 2d. net.]

Foundations of Bridges and Buildings. By HENRY S. JACOBY and ROLAND P. DAVIS. New York: The McGraw-Hill Book Company, Inc.; London: The Hill Publishing Company, Limited. [Price 5 dols.; 21s. net.]

A Primer on the Storage of Petroleum Spirit and Carbide of Calcium for the Use of Local Inspectors and Motorists. By Major A. COOPER-KEY, C.B. London: Charles Griffin and Co., Limited. [Price 2s. 6d. net.]

Memorials of Henry Forbes Julian. By HESTER JULIAN. With Introductory Notices by the Rev. J. O. BEVAN and H. LIVINGSTONE SULMAN. London: Charles Griffin and Co., Limited. [Price 6s. net.]

Transactions of the American Institute of Mining Engineers. Vol. XLV. *Containing the Papers and Discussions of the New York Meeting, February*, 1913. New York: American Institute of Mining Engineers.

A Practical Treatise on Sub-Aqueous Foundations, Including the Cofferdam Process for Piers and Dredges and Dredging, with Numerous Practical Examples from Actual Work. By CHARLES EVAN FOWLER. New York: John Wiley and Son, Inc.; London: Chapman and Hall, Limited. [Price 31s. 6d. net.]

The Theory of Relativity. By L. SILBERSTEIN, Ph.D. London: Macmillan and Co., Limited. [Price 10s. net.]

United States Department of Commerce: Geodetic Survey. Results of Observations Made at the United States Coast and Geodetic Survey Magnetic Observatory at Sitka, Alaska, 1911 *and* 1912. By DANIEL L. HAZARD. *Results of Magnetic Observations Made by the United States Coast and Geodetic Survey between July* 1, 1911, *and December* 31, 1912. *Special Publication No.* 15. By R. L. FARIS. Washington: Government Printing Office.

La Construction en Béton Armé: Théorie et Pratique. By A. V. MAGNY. *Avec une Préface* by PAUL PIKETTY. Paris and Liége: Ch. Beranger.

Pratique de la Construction en Béton et Mortier de Ciment Armés ou non Armés, Avec stablissement Rationnel des Prix de Revient. By W. TAYLOR and S. E. THOMPSON. Translated and adapted by M. DARRAS. Paris: H. Dunod and E. Pinat. [Price 27.50 francs.]

MECHANICAL MILITARY TRANSPORT.—In our last volume, on pages 709 and 715, we gave information concerning the trials of lorries to qualify as type vehicles suitable for earning the War Department subsidies. We are now informed that all vehicles which are entered for these trials must be presented for the first part of the trial, ready for running on the road, to be inspected by a member of the Mechanical Transport Committee, not later than Wednesday, September 16, at 11 a.m., at such place as may be appointed by the War Department. The second part of the trial commences at Aldershot, on Thursday, October 8, when vehicles will be presented for final inspection. The first run under observation will take place on Saturday, October 10. The latest date of entry is August 3.

THE DEVELOPMENT OF THE GERMAN MINING INDUSTRY.

A DANISH consular report, just issued, contains some interesting data about the development of the German mining industry, which is called the backbone of German national economy, and which absorbs an ever-increasing capital.

During the years 1900-1913, the production of coal rose from 109,000,000 tons to 190,000,000 tons, the production of coke from 19,000,000 tons to 32,000,000 tons, the production of pig-iron from 8,500,000 tons to 19,000,000 tons, and the production of steel from 6,750,000 tons to 18,500,000 tons. The greater part of this marked increase took place in the years after 1905. This increase in the mining industry was accompanied by great changes in the whole industrial life of Germany, notably by a pronounced tendency towards centralisation. A striking feature of the period has been the formation of large mining industrial combines, which embodied the principle of an amalgamation of the entire processes of production, from the mining of the coal to the manufacture of finished iron and steel goods in large works. The movement was advanced both by the large mining combines within the domain of raw materials and half-finished goods, and by the development of economical technical methods, more especially the utilisation of the hitherto wasted blast-furnace gases. In the first instance, the amalgamated works became independent of the price policy of the combines respectively controlling raw material and half-finished goods; and, secondly, they, as members of these combines, can inaugurate a price policy, which in the market for finished goods gives them a start of the works which have no raw materials of their own. To these advantages are added gain by the reduction in the cost of manufacture resulting from better plant and the utilisation of by-products.

In addition to several other works, four large concerns came to the fore as types under this category —viz., the Gelsenkirchener Mining Company, the German-Luxemburg Mining and Iron Works Company, the Phœnix Company, and the Thyssen concern. These four firms produce one-fourth of Germany's total coal and iron output, and their share in the aggregate production of finished goods, which it is somewhat difficult to determine accurately, is no doubt still greater. Their influence on the market is unquestionably still greater than one would surmise from the actual figures. This fact is made manifest by their position within the combines, as well as in the competition in the market of non-syndicalised products. These four concerns, however, are not entirely alike, inasmuch as the internal concentration is greater within one than in another. The Phœnix Company makes a special leading feature of finished products, whilst the Gelsenkirchener Company still sells chiefly raw materials and half-finished goods.

The financial formation of these large mining concerns has been attended by numerous fusion transactions, in addition to which there has been a material influx of new capital, which, during the years 1906-1913, for the Gelsenkirchener Company, the Phœnix Company, and the German Luxemburg Company, amounted to some 530,000,000 marks. Of this sum, about 300,000,000 marks have been raised by issue of new shares and debentures, whilst about 230,000,000 marks have been taken from profits on working. The other mining concerns, though their increase of capital has been kept within comparatively narrow limits, have moved in the same direction, and the aggregate of their capital now represents a formidable figure.

This imposing development meant for the industries in question a rapidly-increasing home consumption of all their different products. But the extension or building programme appears to have reached its maximum for the present, and as the conditions on the money market were also adverse to further expansion, the home demand began to flag during 1913. This state of affairs was further enhanced by the depression within the building trades, and, as a result, last year witnessed a tangible dulness within the German mining industry.

This fact does not to a great extent transpire from the various companies' reports for 1913, apart from the fact that the boards, generally speaking, have shown greater inclination to increase the reserve funds, in the first place to ensure the greatest possible stability in the matter of dividends, and, secondly, so as to become more and more independent of high bank-rates, by always having money at their disposal.

In spite of this cautious policy the dividends on the whole are higher than for the preceding year. The average dividend for the financial year 1912-13 of eight mixed concerns—that is, concerns which deal both in raw material and more or less finished products—in Rhineland-Westphalia was 13 per cent., against 12.8 per cent. for 1911-12 and 11.8 per cent. for 1910-11. At four mixed concerns in South-West Germany the figures were respectively 10.1 per cent., 10.5 per cent. and 9.4 per cent.: the reduction for 1912-13 arises from the fact that the German-Luxemburg Company reduced their dividend from 11 to 10 per cent. At five mixed concerns in Upper Silesia the figures were respectively 9 per cent., 6.5 per cent. and 5.7 per cent.; all Upper Silesian works were able to increase their dividends considerably. For eleven purely coal-mining concerns the average dividends were respectively 12.5 per cent., 10.3 per cent. and 9.3 per cent. With six iron and steel works the figures averaged respectively 10.1 per cent., 8.4 per cent. and 7.1 per cent.; and with three zinc works respectively 10.8 per cent., 11 per cent. and 11.4 per cent. (the Hohenlohe works reduced their dividend from 11 to 8 per cent.). With forty-one companies in the mining industry the dividends averaged 12.3 per cent., against respectively 10.9 and 10.1 per cent. A comparison between the year 1912-13 and the year 1910-11 shows an increase in the absolute aggregate of dividends of 61,700,000 marks and in the share capital of 277,000,000 marks.

THREE-STAGE AIR-COMPRESSOR ELECTRICALLY DRIVEN

CONSTRUCTED BY MESSRS. PETER BROTHERHOOD, LIMITED, PETERBOROUGH.

(*For Description, see opposite Page.*)

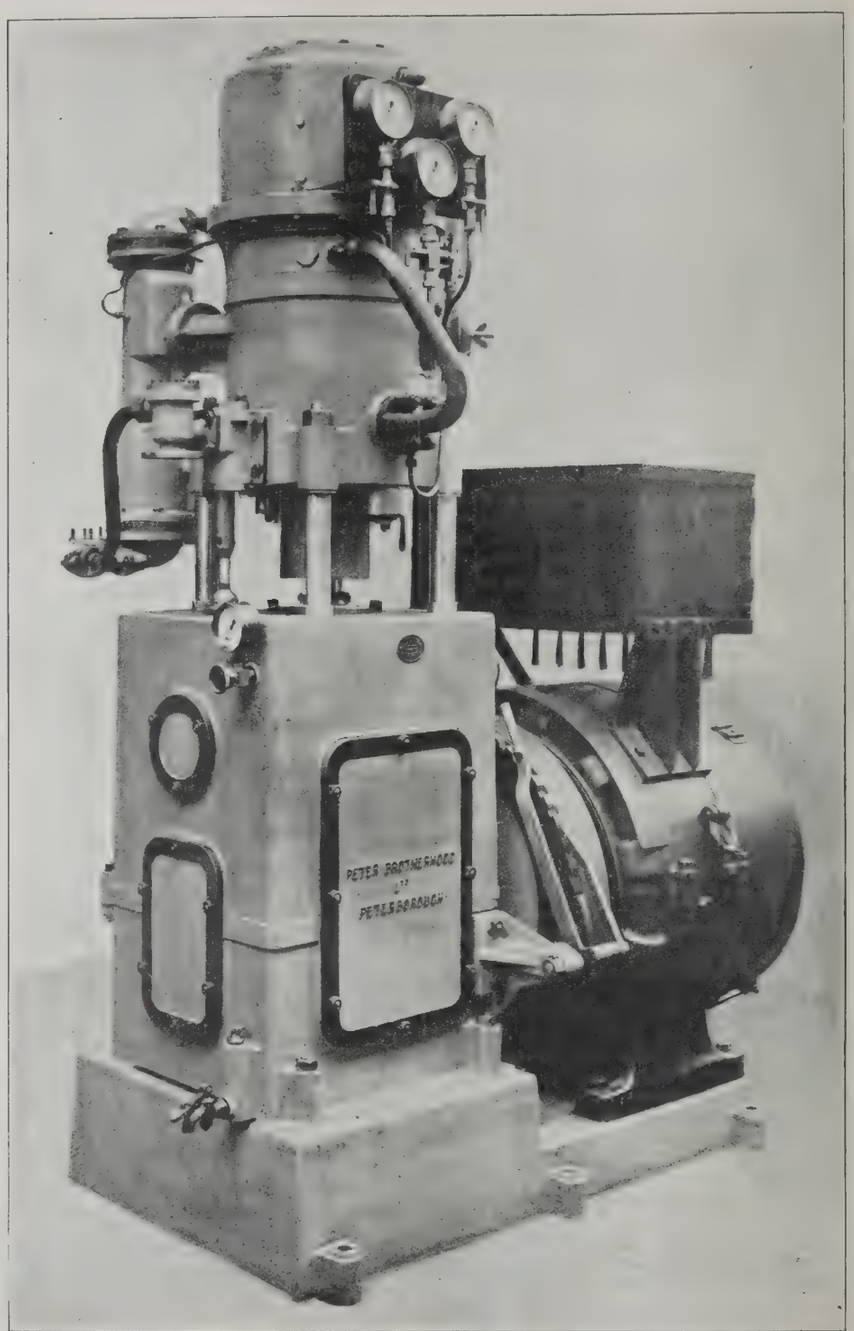


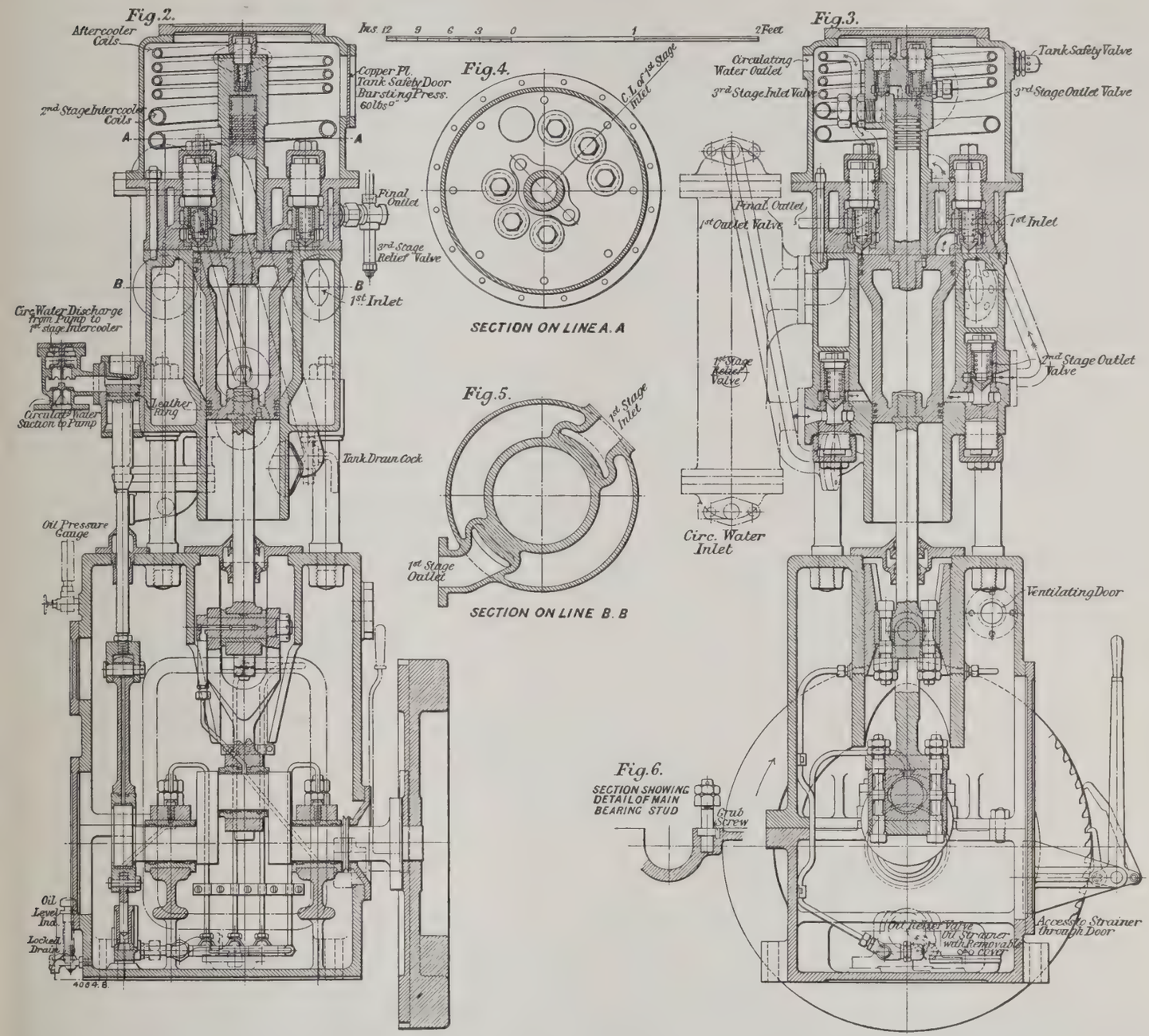
FIG. 1

THE FULLAGAR ENGINE.—We are asked by the Fullagar Engine, Limited, South Shore-road, Gateshead-on-Tyne, to state that the demonstration engine which was exhibited to so many engineers during the recent meetings of naval architects at Newcastle-on-Tyne "was built to the order and to the designs of the Fullagar Engine, Limited, Gateshead-on-Tyne, on whom have fallen the whole work and cost of developing the system, and who, as owners of the patent rights, will arrange for its manufacture under licence."

H.M. TORPEDO-BOAT-DESTROYER "METEOR."—H.M.S. Meteor was launched from the yard of Messrs. John I. Thornycroft and Co., Limited, at Southampton, on the 24th inst. The vessel is one of two ocean-going torpedo-boat-destroyers under construction by the firm for the 1913-14 Naval Programme. They are of special design, and show an advance in armament and speed over the ships of this type previously built, a speed of 35 knots being anticipated. The leading dimensions are approximately: length 275 ft., and breadth 27 ft. 6 in. The propelling machinery consists of two sets of Parsons turbines, steam being provided by four large water-tube boilers burning oil fuel. The accommodation for the crew is on a liberal scale, several new features being introduced to add to their comfort. It is expected that the sister vessel, H.M.S. Mastiff, will be launched in about a month's time.

THREE-STAGE AIR-COMPRESSOR ELECTRICALLY DRIVEN.

CONSTRUCTED BY MESSRS. PETER BROTHERHOOD, LIMITED, PETERBOROUGH.



IN Fig. 1, on page 164, and Figs. 2 and 3, above, we give illustrations of a type of electrically-driven three-stage air-compressor, constructed by Messrs. Peter Brotherhood, Limited, of Peterborough. This machine forms a reserve compressor for the Diesel-engine plant on board a large motor-vessel. The aim in the design has been to retain the best features of reciprocating-engine practice with which sea-going engineers are familiar. Points in the design to be noticed are the crank-shaft, with white-metal, force-lubricated bearings, the connecting-rod big end, and the bronze-slipper crosshead, also force-lubricated. The crosshead slippers are of liberal dimensions, and all thrust is taken by them, thus avoiding the cylinder wear common with trunk pistons, especially in the case of compressors in which lubrication cannot be more than barely sufficient.

The compression is carried up to 1000 lb. per sq. in. The first two stages are effected above and below a stepped cast-iron piston in a cast-iron cylinder. The third stage is completed by a single-acting plunger in tandem with the first and second-stage piston, of steel hardened and ground, with piston-rings adjustable for axial clearance and wear. This plunger works in a cast-steel cylinder. There is only one flat joint exposed to air pressure, that being in connection with the low-pressure (first-stage) cylinder-cover. All the valve-seating covers, &c., are of metal-to-metal knife-edge joint type. Each valve is arranged so that its seating can be independently and quickly removed.

The intercooling arrangements have been carefully designed. The first and second-stage cooler is a separate apparatus, of the tubular type, with a vertical cylindrical body attached to the compressor-cylinder casting. The second to third-stage cooler is in the form of a large pipe-coil accommodated in the domed water-jacket surrounding the third-stage cylinder. The final or after cooler is a coil of smaller piping similarly accommodated. The compressor has a water-circulating pump driven by an eccentric. The valves are of the conical type and are interchangeable. The lubrication of the cylinders is positive and adjustable, the oil being fed with the ingoing air.

The capacity of the compressor illustrated is 80 cub. ft. of free air per minute when discharging against a pressure of 1000 lb. per sq. in. and running at 275 revolutions per minute. The motor is of the shunt-wound direct-current type for 220 volts. The official works test was for twenty-four hours at full pressure and capacity, without any appreciable drop in either volumetric or mechanical efficiency. These conditions were easily complied with. No wear of the valves or seatings was observable after a 26½ hours' run, and only a very slight trace of carbon deposit. The mean air temperatures were for the inlet 53 deg. Fahr., and the discharge 82 deg. Fahr., showing the cooling arrangements to be thoroughly effective. The cooling-water temperature was 66 deg. Fahr. at the inlet and 86 deg. Fahr. at the outlet.

REACTION OF A STEAM-JET: ERRATUM.—In the third line from the end of the article on this subject, on page 130 *ante*, the equation :—

$$R = \overline{R} - p\,a$$

should read :—

$$R = \overline{R} + (0.58\,P - p)\,a,$$

as correctly given in the second column of the same article. Also in the following line "(4)" should read "(3)."

THE AUSTRO-HUNGARIAN NAVY.—According to the *Reichspost*, the new Austrian Dreadnoughts will have a displacement of 24,500 tons, and will be propelled by machinery aggregating 31,000 horse-power. Their armament is to consist of ten 13.7-in. guns, 45 calibres in length, weighing 69 tons, firing, at a muzzle velocity of 2600 ft. per second, a projectile weighing 1410 lb., and containing a 79-lb. explosive charge of "ammonal." The guns are to be mounted in two triple-gun turrets and in two double-gun turrets, in two groups fore and aft, the double-gun turrets firing above the adjoining triple-gun turrets. The secondary armament is to consist of fourteen 6-in. 50-calibre guns, and of a number of 3.5-in. 45-calibre guns of a new pattern. Each ship will carry besides four submarine torpedo-launching tubes. The propelling machinery is to consist of Parsons' turbine sets.

DESIGN OF HYDRO-AEROPLANE FLOATS.

*Some Notes on the Design of Floats for Hydro-Aeroplanes.**

By G. H. MILLAR, B.A., Associate.

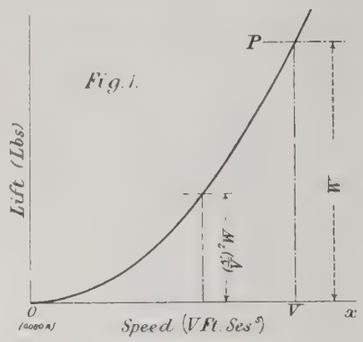
§ 1. THIS paper is founded on a series of experiments made by Mr. G. S. Baker and the author at the William Froude National Tank, at the instance of the Advisory Committee for Aeronautics. The work consisted of designing and running a large number of models of hydro-aeroplane floats, some of which have been subsequently built to The special apparatus employed and methods of experiments are described in the Appendix, while the complete results are included in the Official Aeronautical Reports for 1912-13 and 1913-14. It should be borne in mind that the statements here made, and conclusions arrived at, are founded mainly on these model experiments, while many details can only be decided as the result of experience with actual machines.

§ 2. Hydro-aeroplanes may be divided, broadly, into two classes :—(1) Those in which the machine follows the same general lines as a land machine, with floats substituted for the landing-gear ; (2) those in which the fuselage is in the form of a boat containing the crew, and sometimes the engine. The term "hydro-aeroplane" is usually confined to machines of the first class, those of the second being termed "flying boats." These two classes are being developed side by side ; in some cases both are built by the same manufacturers. The second class is specially popular in America. It is as yet too early to say which will ultimately prove the more useful, but possibly both types will persist, each for its own purpose. This paper is mainly concerned with the first class, the hydro-aeroplane proper, although most of the conclusions come to are applicable also to the "flying boat." At first sight the latter may appear to be the more seaworthy device ; but with a large open cock-pit it is exposed to great risk of swamping. The Curtiss flying boats are fitted with water-tight bulkheads, and have a very large total buoyancy (usually four and a-half times the weight of the machine), but this necessitates a large boat, which even then cannot altogether take the place of the fuselage of the land machine, especially if the engine is carried overhead.

§ 3. Turning now to the hydro-aeroplane proper, the machine may be supported either (*a*) by a single broad main float, with small subsidiary wing floats, or (*b*) by a pair of floats side by side at a suitable distance apart. In either case a small tail float is usually fitted, which may rest on the water at the lowest speeds, or may be clear of it even when the machine is at rest, and only relied on to prevent the tail of the machine dipping if it is thrown backwards by a sudden gust of wind. It is, however, usually preferred to have the centre of gravity of the whole machine aft of the centre of buoyancy of the floats, which, of course, requires that the tail float shall take some of the load at rest. This also makes the machine float more steadily in a short sea, and allows an underwater rudder to be used to assist manœuvring on the water at low speeds. In any case the load on the tail float is small, and its design of no particular moment.

§ 4. Considering the main floats, the general balance of opinion seems to be decidedly in favour of twin floats. With a single float the lateral stability (on the water) is small, unless the float is unduly broad for its length, and wing floats become essential. On the other hand a pair of floats placed too far apart may cause a severe slewing strain if one becomes more deeply immersed than the other. As regards efficiency, experimental results show that if a pair of floats be replaced by a single one of similar design but double the breadth, much the same results will be obtained, although the water disturbance is more noticeable. The performance of twin floats is not appreciably affected by their distance apart, provided that the gap is not less than the breadth of either float. It is generally agreed that the total buoyancy of the floats should be at least twice the dead-weight of the machine, and water-tight bulkheads are frequently fitted. These incidentally prevent any water that may leak in from flowing from end to end of the float when in the air. The air resistance of the floats must be taken into considerations, and their construction is a matter of some difficulty, great strength being required with a light weight.

Fig. 1.



§ 5. The design of hydro-aeroplane floats is naturally very closely allied to that of hydroplane boats, though with some important differences. Since the lift of the aerofoils increases continuously with the speed, and ultimately becomes equal to the weight of the whole machine, it might be thought that any fine lined ship-shaped form would be suitable for a float, but this is not the case. Fig. 1 shows the curve of lift for an aeroplane of "W" pounds total dead-weight designed to leave the water at a speed of V foot-seconds, it being assumed that the angle of attack is constant throughout. This curve is simply a parabola described to touch the axis O*x* at the origin, and to pass through the point P (V, W). The ordinate at any speed *v* (less than V) is, of course, $\left(\frac{v}{V}\right)^2$ W. Now it will be seen that the lift is comparatively small until a high speed has been attained ; at half speed it will be only one-quarter of the dead-weight of the machine. But even this speed is a very high one for the length of the float, and consequently for a float not designed on hydroplane principles the resistance and wave-making will become enormous before the air lift becomes appreciably great, and the machine will never reach its flying speed, unless with a strong head wind.

§ 6. It may here be well to consider the principles on which hydroplane design is based. Any normal form of vessel will rise and skim along the surface of the water if she is towed fast enough. But in the case of a ship designed for low speeds, the speed at which she begins to rise is a very high one, and up to this point wave-making and resistance will increase to a prohibitive extent.*

Now, a hydroplane is so designed that when a high speed is attained the normal pressure of the water on the hull shall have a large vertical component, which raises the boat and so decreases her displacement, and, consequently, the wave-making. The simplest way of attaining this result is to provide the boat with a flat bottom, which, at high speeds, shall have an inclination of about 5 deg. to the horizontal in a fore-and-aft direction.

Figs. 2, 3 and 4, on this page, show the results of some experiments made on flat plates at the William Froude Tank. The plates were 1 ft. wide, and were towed on the surface of the water at a series of small angles, and at speeds of 600 ft., 800 ft., 1000 ft., and 1200 ft. per minute. The immersion was also varied independently, and the vertical force P and horizontal force R on the plate were measured. In the figures V is the speed in feet per second, and A the area of plate immersed in square feet. The plate being 1 ft. wide, the number denoting this area also denotes the length of plate immersed and the ratio $\frac{\text{length immersed}}{\text{breadth}}$, which is the inverse of the aspect ratio. These results cannot be taken to be very exact, as there was a considerable variation of $\frac{P}{A V^2}$ and $\frac{R}{A V^2}$ with speed, although an uncertain one. This may have been due to two causes—to the variation with speed of the actual area immersed for a given value of A (which was the area immersed when the plate was at rest at the same angle and height) ; or to errors in estimating the position of the centre of pressure, which could not be directly measured with the apparatus then in use.

FLAT PLATE RESULTS.

Fig. 2. LIFT/DRIFT CURVES AT FIXED IMMERSION; VARYING INCLINATION.

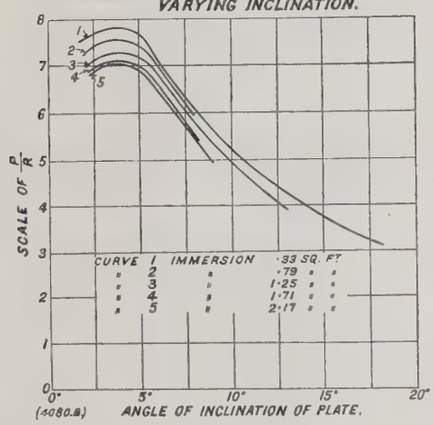


Fig. 3. LIFT/DRIFT CURVES AT FIXED INCLINATION; VARYING IMMERSION.

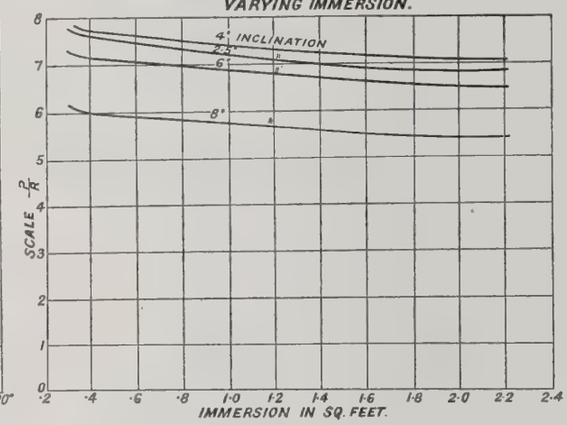


Fig. 4. LIFT COEFFICIENT CURVES AT FIXED IMMERSION; VARYING INCLINATION.

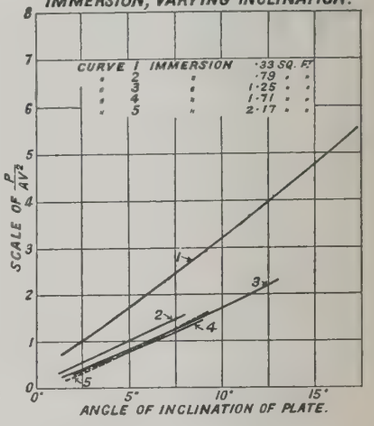


Fig. 5. RESISTANCE CURVE FOR FLAT PLATE, 6" WIDE, AT 6°. P=4·86 LBS. AT ALL SPEEDS.

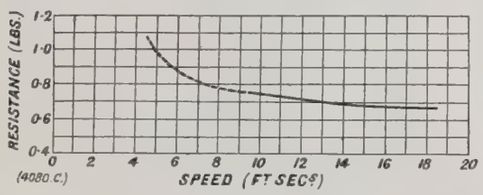


Fig. 6.

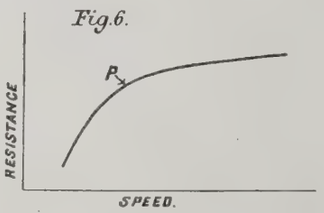


Fig. 7.

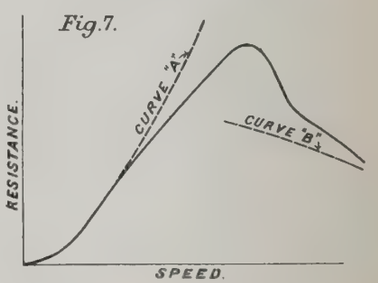


Fig. 3 shows that the efficiency of such a plate increases with increase of aspect ratio, but that the effect is not a very marked one, over the range here considered. At large aspect ratios the efficiency seems to increase considerably, and, with single-plane floats at high speeds and small loads, efficiencies of as much as 10.5† have been obtained, although this was perhaps a little too high. With a plate of an aerofoil section and an aspect ratio 6 : 1, having its chord at 4½ deg., and its leading edge just above the water surface, an efficiency of 11.8† was obtained.

Fig. 5, above, is deduced from Figs. 2, 3 and 4, by calculation, and shows the resistance of a plate 6 in.

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* Paper read at the joint meeting of the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, and the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle-on-Tyne, July 8, 1914.

* In the case of a mercantile form model run at the William Froude Tank, for a ship 400 ft. long, the E.H.P. required at 14.8 knots was 4115, and at 16.5 knots was 10,900, the resistance increasing as the 16th power of the speed between these points.

† This is the value of the ratio $\frac{P}{R}$.

wide at a constant angle of 6 deg. and a constant load of 4.86 lb. at speeds of 10 ft. to 18 ft. per second. It will be seen that the resistance actually falls as the speed increases over this range. The curve cannot be extended down towards zero speed from the experimental results, but it will be obvious that at a very small speed a very great length of the plate must be immersed to support any load; hence the curve, if produced towards zero speed, must be of the nature shown by the dotted line—*i.e.*, asymptotic to the axis of resistance.

§ 7. Fig. 6 shows the general appearance of the curve of resistance to a base of speed for a hydroplane (having a constant load). It will be seen that at the point P the rate of increase of resistance rapidly falls off. This is the point at which the boat commences to rise in the water, and after this the resistance only increases very slowly. In the case of a hydro-aeroplane float running at a constant angle the load is constantly decreasing; the load at a speed v is $W\left(1-\frac{v^2}{V^2}\right)$, where V is the speed at which the machine begins to fly and W the dead-load. Hence, the curve of resistance to a speed base takes the form shown in Fig. 7, having a "hump" (which may be sharp and peaky or flat and spread out) at the point where the float begins to rise in the water, and afterwards falling off rapidly till at the flying speed it denotes the air resistance of the float. In the same figure, curve "A" denotes the resistance the float would have if constantly kept at the same vertical height and prevented from rising; curve "B" denotes the resistance of a flat plate carrying the same load as the float. The curve for the actual float tends to follow curve A at moderate speeds and curve B at planing speeds, the hump representing the intermediate stage when the float is rising sharply in the water.

§ 8. The problem of designing a hydroplane that shall have a small resistance at a planing speed is a comparatively simple one. But the requirements for such speeds differ considerably from those for low resistance at moderate speeds. As a matter of fact, at speeds up to the "hump" speed any hydroplane is a very bad boat. Consider first the requirements at planing speed. Fig. 8, above, shows the wave system generated by a flat plate towed along the surface at a high speed and small angle (6 deg.), the fore end of the plate overhanging. It will be observed that the plate scoops out a hollow in the water, which does not fill up until some way astern of it. The water which passes underneath the plate issues at the back in a smooth stream, which at first follows the direction of the plate, but gradually turns upwards again. From the crests of the bow diverging waves the surface slopes down to this smooth region, meeting it in a well-defined line. At the points K, K two converging waves appear to leave the inner walls of the diverging waves, and these meet to form a curious "fan" of partly broken water. At the after end of the "fan" another diverging system starts with a smaller one inside it. This system is really a continuation of the converging waves which cross at the "fan."

The whole system is merely an extreme case of that of an ordinary high-speed ship, where the "fan" occurs as a region of high pressure under the after end of the ship. The diverging system aft of the fan corresponds to the ordinary stern diverging system. In a high-speed destroyer the "fan" may sometimes be seen clear of the stern. If it is just underneath the stern, the space bounded by the diverging waves aft of it will appear as a plateau of broken water.

§ 9. Fig. 9 shows a transverse section of the plate and the bow diverging wave. The latter will change from type 1 to type 2, and from type 2 to type 3, if the speed be decreased, or the depth of immersion of the element is increased, and the same gradual change occurs as we go aft along the plate. That is to say, the inner wall of the wave becomes steeper and more convex up to the point where the crest has its maximum height. Now, suppose the plate to form the bottom of a float with vertical sides. Type 1 wave will go clear of the sides, type 2 will just do so, but type 3 will force a thin film of water up the side of the float, which will add very considerably to the resistance. Again, where the wave is of type 1, the sides may be flared considerably without touching the wave, and where the wave is of type 3 they must "tumble home" from the bottom to clear it. With a vertical sided and flat-bottomed float thin filmy waves will always rise against the side of the float at a moderate speed, which will gradually move aft as the speed increases till they leave it altogether. The sketch in Fig. 10, below, shows their appearance when the speed is reached at which they start to leave the float. These clinging waves may, however, be thrown clear of the sides by the use of bilge-planes (better known, perhaps, by the facetious title of "mud-guards").

§ 10. The waves set up by our elementary plate will not be affected if we build up a boat form upon it, provided that the total load is the same, and that no part of the boat except that formed by the plate touches or comes very near to the surface of the water. In particular it may be observed that by forming a step at the back edge of the plate we may build on a tail to the boat aft of this point, which will be completely clear of the water at a certain speed. To make the sides of the boat clear of the waves at the lowest possible speed, they should have an increasing tumble-home towards the after end, while they may be flared a little at the forward end. The use of tumble-home on the after part of the sides is, however, not without its objections in the case of a hydro-aeroplane float, as it tends to throw the water up when turning. We have so far considered a boat or float having only a single "planing" surface. We may, however, have any number of such surfaces separated by steps. Each plane will then set up its own system of waves, and the diverging crests from one plane may even cross the crests from the plane ahead of it.

§ 11. It is not difficult to design a float which shall have a good efficiency at "planing" speeds. But this is not nearly so important as the behaviour of the float at lower speeds. From a resistance point of view, the important range of speed is that up to the "hump" on the resistance curve, during which it must be considered as a displacement boat.

The essentials for good "planing" are:—

1. Considerable overhang at the forward end with short immersed length and suitably-shaped bottom.
2. That the water should leave the bottom of the boat on a sharp edge both at the stern and at the sides.

For a fast displacement boat we require:—

1. A fine curve of sectional areas, and consequently great length with small beam, or light draught.
2. No sharp corners or edges in contact with the water; they produce eddy-making, and consequent waste of power.
3. Smallest possible wetted surface to reduce surface friction. This is not so important as condition 1, except at very low speeds.

We have, therefore, to try and satisfy two sets of conditions which are in some respects antagonistic.

§ 12. First as regards length. At speeds below the "hump," increase of length and decrease of breadth produce considerable improvement. At "planing" speeds they are slightly detrimental, and will probably cause the "hump" to come at a slightly higher speed, but in the case of a stepped float this may be partially counteracted by the fact that the narrower float will require less air at the steps. On the whole a float can always be improved by increasing the ratio of length to breadth up to an excessive limit. From a practical standpoint very long floats are highly undesirable; a good float can be got out on a length to breadth ratio of about 5½ to 1, and in the author's opinion a ratio of about 6 to 1 should not be exceeded, although a good many floats have a ratio of 7 to 1 or more.

§ 13. It has been seen that for a flat plate the most efficient angle is 4 deg., and for a float having a flat planing surface the best results would be obtained with the surface at the same angle. In practice, however, it is better to design the floats to run at a slightly greater angle, so as to give a greater margin of safety when alighting. In the series run at the William Froude Tank the normal running angle was taken to be 6 deg. for the forward or main planing surface, or in the case of a cambered surface the mean angle was 6 deg. The model floats were made to a scale of $\frac{1}{5.67}$ for a machine of 2200 lb. weight designed to leave the water at a speed of 67 ft.-sec. in a calm. For convenience these figures will be taken as the standard for the rest of the paper.

It might be thought that the pilot would be able to run the machine on the water at any angle he desired, just as he can in the air; as a matter of fact, the water forces on the float may introduce very large trimming moments, quite outside the pilot's range of control. The magnitudes of the moments brought into play are therefore a very important part of the design. Suppose that for a given float, or pair of floats, running at a given angle and speed, the reaction of the water on the floats is represented by vertical and horizontal components P, R lb., and a moment of M ft.-lb., about some point O; these quantities can be determined from model experiments. Let G be the centre of gravity of the whole machine (including the floats), and let the horizontal and vertical co-ordinates of G relative to O be $(g\ h)$ ft. Let T be the thrust of the propeller, and t the distance of its line of action from G.

Also let the force on the elevator and tail-plane be E lb. acting in a line distant e from G, and let S be the resultant resistance of the machine (apart from the floats) acting in a line distant s from G.

Then for angular equilibrium we have, with the convention of signs shown in Fig. 11:—

$$E\,e + T\,t - S\,s = M + P\,g - R\,h,$$

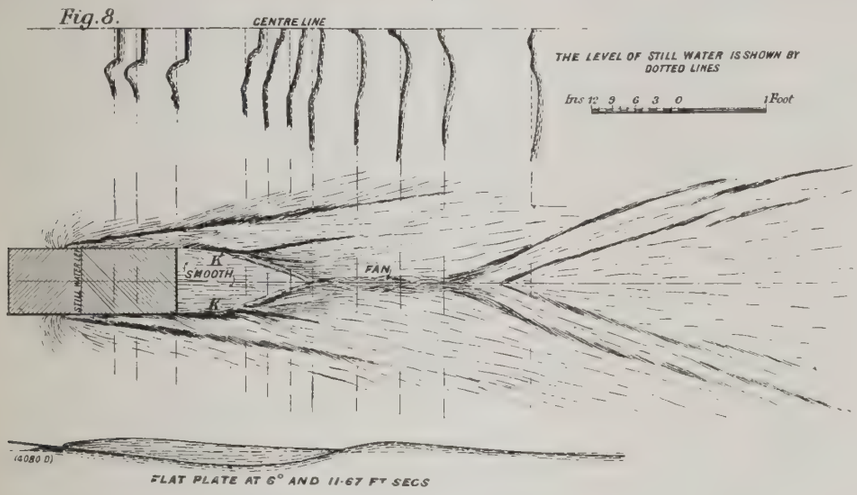
the trimming moment being reckoned positive when it tends to depress the tail of the machine. The expression $T\,t - S\,s$ is usually very small; for a machine of the weight considered, at a speed of from 30 to 40 ft.-secs., it will probably not exceed 150 ft.-lb. at the most; and a calculation of the elevator control $(E\,e)$ for a specific machine of this weight gave the following maximum values:—

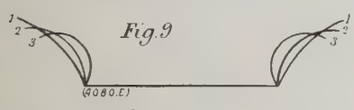
Speed, ft.-secs.	10	20	30	40	50	60
Control, ft.-lb.	68	272	632	1088	1700	2528

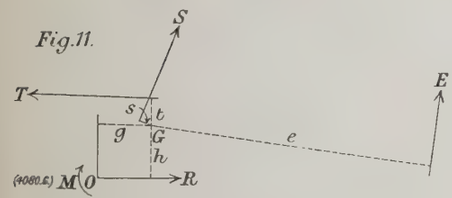
We can therefore calculate the limits within which the moment $M_o \equiv M + P\,g - R\,h$ must be kept if the machine is to be run at its designed angle, although these limits may be exceeded momentarily.

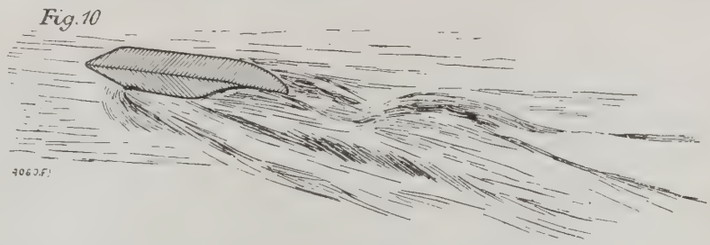
§ 14. The value of M_o at any speed and angle is, of course, very largely dependent upon the position of the floats relative to G—that is, on the value of $g.\ h$. For the machine considered G is at a height of about 6.3 ft. above the bottom of the floats, so that the part of $M - R\,h$ due to resistance is of some importance. Now the height of G, and, therefore, the value of h, will be decided on in the early stages of the design. We therefore require a simple means of determining the most suitable value of g. One method of doing so is as follows:—The values of M, P, R, referred to a definite point O, are determined from model experiments for a range of speeds and angles and the value of h is decided on. Consider, first, the case in which the angle is constant (say 6 deg.) and the speed varies. Then $M_o = M - R\,h - (-P\,g)$.

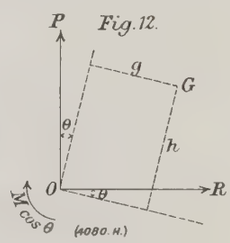
On a base of speed plot the values of $-P\,g$ ft.-lb. for $g = 1$, *i.e.*, of $-P$ ft.-lb. (see Figs. 21, 24, and 26, page 169). The result is an inverted parabola, which, by distorting the abscissa scale, can be reduced to a straight line. $P\,g$ will now for every value of g be represented by a











straight line, all such straight lines radiating from a point in the base line. At the distorted abscissa points erect ordinates denoting the values of $M - R\,h$ and join up the ends of these ordinates to form an open polygon. Then, taking any desired value of g, the value of M_o is given by the distance from the corresponding $P\,g$ line to the polygon curve, being positive if measured upwards, and negative if measured downwards. We can thus see by inspection the effect on the moments of altering the value of g.

We also require cross-curves showing the value of the moments at constant speed and varying angle, which will show us what change of trim (if any) is likely to take place at any speed. Similar diagrams can be prepared for this case. In the model apparatus used at the William Froude tank the value of M as read is only strictly correct at 6 deg. inclination of float. At any other angle (6 deg. + θ deg.) the true moment is M cos θ, while, whatever the angle, P and R are always measured vertically and horizontally.

Hence (see Fig. 12) the moment is now—

$$M_o \equiv M \cos\theta + P\,(g \cos\theta + h \sin\theta) - R\,(h \cos\theta - g \sin\theta),$$

which may be written:—

$$M \cos\theta + h\,(P \sin\theta - R \cos\theta) - [-g\,(P \cos\theta + R \sin\theta)].$$

We now plot $-g\,(P \cos\theta + R \sin\theta)$ ft.-lb. to a base of angle for $g = 1$, and distort the abscissa scale to make it a straight line; then plot $M \cos\theta + h\,(P \sin\theta - R \cos\theta)$ at the new abscissa points, and proceed as before (see Figs. 22 and 23). In this case, θ being small, a rough approximation may be obtained by plotting $-P$ instead of $-(P \cos\theta + R \sin\theta)$ and $M - R\,h$ instead of $M \cos\theta + h\,(P \sin\theta - R \cos\theta)$, and spacing the ordinates at any convenient distance apart. If the variation of P with angle be also neglected,* we get a straight line parallel to the base.

§ 15. We require some point of reference for the horizontal position of the C.G., and the most convenient one is the position of the centre of buoyancy of the float when fully loaded and inclined at the standard angle of 6 deg. The value of g to bring this point vertically under the C.G. is then calculated, and the corresponding line drawn on the moment diagram. We can then readily see the effect of placing G at any desired distance aft of the C.B.

§ 16. It is now proposed to consider some float designs in detail. Fig. 13, above, shows a type of float that has been more widely employed than any other. It is simple to construct, and has given good service in practice. It has a rectangular water-line at all speeds, and therefore should have fine bow-lines; but, as usually made, the curve of areas is not particularly fine forward. This is, however, partially compensated for at moderate speeds by the large amount of lifting surface, which causes the float to start rising in the water at quite low speeds. As noticed in § 9, clinging waves form against the sides, and do not leave them until rather a high speed is attained. The long overhang required forward makes the float very stable at small angles, but otherwise is so much wasted length. Such a float naturally tends to "slam" badly in a short lop. Floats of this type are sometimes fined at the forward end by pinching in the sides.

§ 17. Figs. 14 and 15 show two floats of a very different type that were included in the series of floats evolved at the William Froude tank. Of these, type 3 (Fig. 15) is the better, its flat under surface being all at the most efficient angle. Both these have tail appendages, which leave the water completely before the hump speed is reached if the floats are maintained at an angle of 5 deg. to 6 deg.

Considering the form of the bow, it will be seen that type 2 is really an intermediate form between types 1 and 3. The curves of resistance show that type 3 is a good deal the better. With these flaring bows the "mud-guards" shown are essential. The first model made of type 2 was run without "mud-guards," and with no air-holes to the step. The result was that a filmy wave ran up the side of the model, no air could get to the step, and the resulting suction held the float down

* The effect of neglecting this is to decrease the moment numerically at angles below 6 deg., and to increase it numerically at angles above 6 deg.

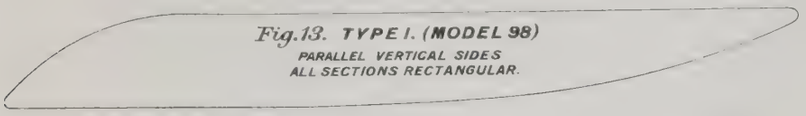


Fig.13. TYPE 1. (MODEL 98)

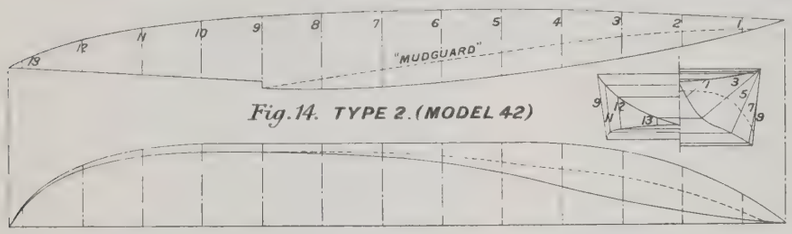


Fig.14. TYPE 2. (MODEL 42)

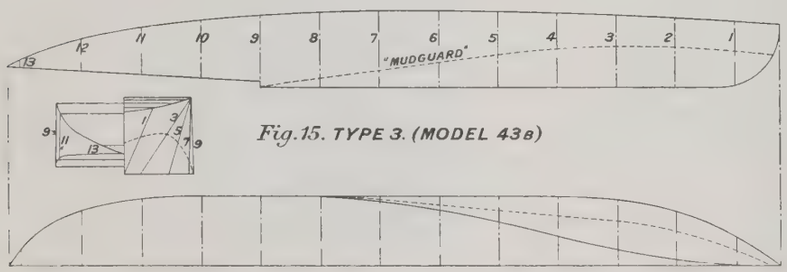


Fig.15. TYPE 3. (MODEL 43B)

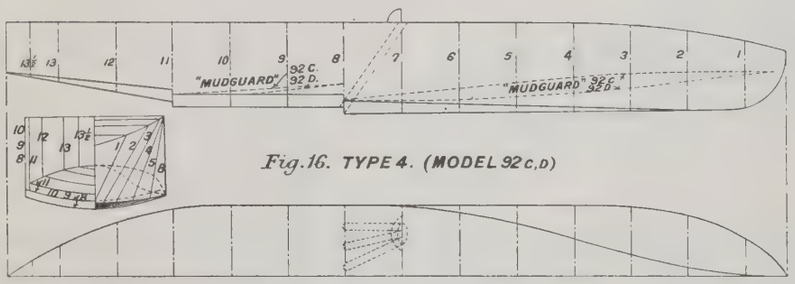


Fig.16. TYPE 4. (MODEL 92C,D)

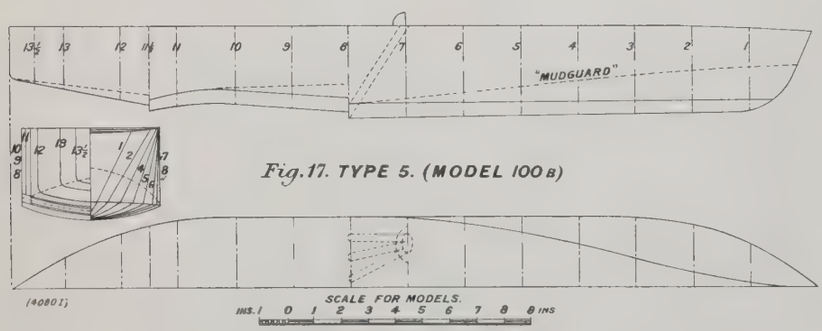


Fig.17. TYPE 5. (MODEL 100B)

FIGS. 18, 19, 20 IN MODEL UNITS (ONE FLOAT)

Fig.18.

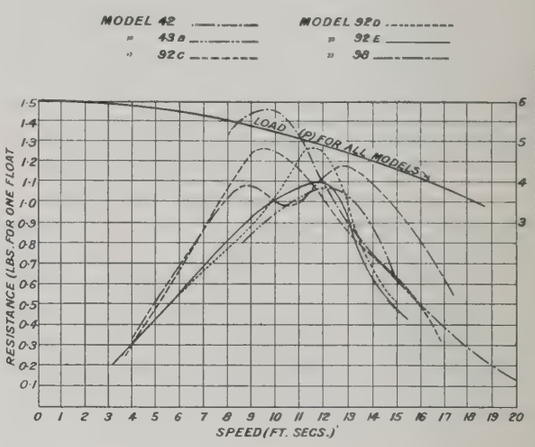


Fig.19.

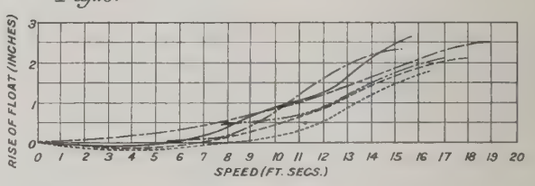
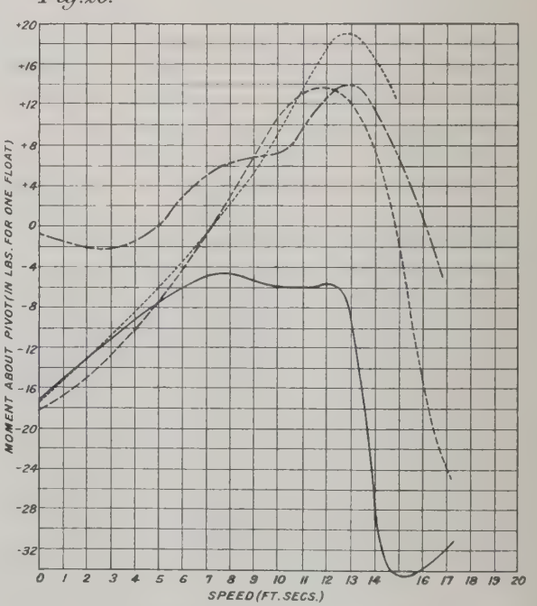


Fig.20.



so firmly that it never rose at all. The "mud-guards" throw the water clear of the sides, and at the same time derive a large lift from it.

The type 3 float, although quite satisfactory from a resistance point of view, was found to induce an excessive positive trimming moment at about the "hump" speed, which would naturally tend to tilt the machine at this speed until the tails of the floats were in the water. This was confirmed by tests with an actual machine fitted with such floats. To obviate this trouble a series of experiments were made with models having two planing surfaces, of which that shown in Fig. 17 (type 5) proved the most successful. It will be noticed that the shape of the after termination has been altered from a pointed one to one with a vertical stern-post, and its chines rounded off to reduce eddy-making at the low speeds during which it is in the water. The flat bottom of type 3 has now been replaced by a cambered one of circular section. This is much stronger and less liable to slam, and the loss of efficiency is negligible. It is, however, important, if using a cambered bottom, to make the camber constant or decreasing from forward to aft. A surface in which it increases going aft will be extremely inefficient.

The shape of the bow has been altered slightly to increase the stability at small angles, and the "mud-guards" have been straightened out and lifted at their fore ends for the same reason. Although the flaring bow makes for stability in the same way as the overhang of type 1 float, it must be remembered that it also will throw up the water as soon as the fore ends of the "mud-guards" are submerged. As the resistance term tends to reduce the righting moment, the upper water-lines should be kept reasonally fine.

§ 18. The results obtained with the six models illustrated are shown in Figs. 18 to 27. The model denoted by 92*c* consists of the fore body of 92*c* with the middle body and tail of 100*b*, while model 100 differs from 100 *b* in having the hollow of the after plane filled in.

The first point of interest is the comparison of the curves of "linear rise" with those of resistance. The "linear rise" of a float denotes the vertical height of the float above the statical position under full load, its angle being maintained constant. The study of a large number of such curves of rise shows that normally there is a speed at which the rate of rise becomes rapid, and this speed is always just below the "hump" speed on the resistance curve. If there is a good deal of steady rise before this speed is reached, the corresponding part of the resistance curve will be lowered, and the "hump" will occur at a rather later speed. This is particularly noticeable in the case of model 92*c*, where the second planing surface is 7 deg. steeper than the first, and has therefore a greater efficiency than if parallel to it. Model 98 (type 1) has quite a different curve—a long, steady rise—and it will be noticed that the resistance curve has two humps, the space between them covering about the middle third of the rise. It was found that in every case where a float rose evenly and gradually the hump on the resistance curve was flat and spread out, or there were two humps with a hollow in between. The peaky curves usually show traces of a second hump some way down the slope. In the case of model 98 it is practically certain that the second hump is due to the suction of the waves against the sides near the stern (see § 16 and Fig. 10), and it will be noticed that there is an exactly corresponding increase of the positive moment owing to this cause. When these side waves leave the stern the resistance and moment curves both come down.

Clinging side waves of this type do actually occur against the sides of the tail in the case of the other models, but only at a much lower speed. They pass off astern at a speed of about 9 foot-seconds for the model. It may be said generally that the drop after the hump on the resistance curve shows that there is no longer any appreciable resistance to the float rising in the water. Provided that the bottom is of a suitable hydroplane type, it will always give a good lift even at speeds well below the "hump," and such resistance is due either to the suction of waves against the sides of the float, or to suction on the bottom caused by an unsuitable shape or an insufficient supply of air to the step or steps. Experiments with stepped models, with and without air-holes, always show that the model without air-holes rises later, and, consequently, has a later and bigger "hump" on the resistance curve. In the double-stepped models air-holes were only fitted to the forward step, it being impracticable to fit them to the second step owing to the after weight pocket being over it. It is highly probable that an improvement would result from fitting them, and that the later "hump" on the curve of 92 *c* (as compared with 92 *c*) is due to greater suction aft of the second step, its greater angle deflecting the water more downwards, and so leaving a bigger vacuum to be filled.

§ 19. Any form of float in which the waves tend to cling to the sides needs "mud-guards" of some kind to throw the water clear; and, to render them really effective, they should be of a fair breadth. With a float, whose sides are vertical, a sharp chine at the junction of the sides and bottom, without any projecting plane, will be fairly effective. The experiments with double-step floats showed the desirability of fitting "mud-guards" to the second step as well as to the first. The angle of the "mud-guards" should not be too great, or they will have a high resistance. On the other hand, their forward ends must be well up to give safety at small angles, and the almost straight ones of model 100 *b* seem to be the most suitable.

In racing hydroplane boats the "mud-guards" are always made convex downwards, and they were so fitted in 92 *d*, which only differed in this respect from 92 *c*. They then had a much smaller effective angle, and gave a smaller lift at all speeds below the "hump," but also had a smaller resistance. The float rose very little till the "hump" speed was reached. It will be seen that in spite of this the whole resistance is greatly reduced at moderate speeds, but the "hump" is a good deal later and of a considerable height, owing to the waves tending to cling to the sides aft of the second step. On the whole, therefore, little is gained from this shape of "mud-guard," while the stability at small angles is decreased. But in the case of multiple-step floats, where the "mud-guards" are of a restricted length, it may be useful to curve them in this way, so as to keep their forward ends up with a smaller effective angle.

§ 20. As was mentioned above, floats with two planing surfaces offer advantages in respect of the trimming moments involved. The line joining the steps should be at about 5½ deg. to the mean forward planing surface, and to render the second surface effective it should have a greater angle than the first. This is shown very clearly by the remarkable difference in the moment diagrams for models 92*c* and 92*e*. If, however, the distance between the steps is increased, the angle of the second step should be correspondingly decreased. This is obvious from a consideration of Fig. 8. The second step also decreases the resistance considerably. All experiments showed that where a double-step float at a planing speed could be made to run either on the forward plane alone, the back plane alone, or both planes, by slightly altering its angle, the smallest resistance was obtained when running on both planes. This is to be expected, as we have two planes immersed of a larger aspect ratio in place of one plane of a smaller aspect ratio.

It is not, of course, in any way a necessity to fit the overhanging tail shown on the models. If desired, the second step may be at the after end of the float, and the upper surface sloped down to it, so that the float terminates in a horizontal edge.

§ 21. There seems no reason to increase the number of planing surfaces beyond two. With a greater number it will be difficult to divide the work equally between them, while the length of entrance will be decreased, and the "mud-guards" if any, will need to be steeper. Each additional step means more eddy-making, and therefore greater resistance at low speeds and greater constructional difficulties.

§ 22. The importance of the horizontal position of the centre of gravity of the whole machine has been referred to above. The question of longitudinal trim may be attacked in three ways:—

1. The designer may attempt to design his floats so that at all speeds they shall run at any reasonable angle without introducing large trimming moments, either positive or negative. It is doubtful if this is at all feasible.

2. He may attempt to design a float which shall run steadily at nearly the same angle at all speeds, and shall resist any attempt to make its angle larger or smaller.

3. He may, by the judicious use of the tail float, produce a machine which will start off at a large angle and gradually come down to a small angle at high speeds, with or without the use of the elevator.

In the author's opinion, Condition (2) is the most desirable one to aim at. It is obvious that the machine will get off much more quickly if it is running throughout at its most efficient angle.

A float of type 1 has a tendency to run at a large angle at moderate speeds and a small one at high speeds; and, although at a high speed the angle can be readily increased by the use of the elevator, there will be a sudden change of moment when the machine leaves the water, which may cause the tail of the machine to come down and hit the water.

Condition (2) seems to be most easily satisfied by a double-plane float approximating to type 5. Here the designer has a number of variables to deal with. He can shift the position of the C B. at rest by shortening or lenthening the tail of the float, and can alter the position of either or both steps. It will be seen that for float 92*e* the maximum positive moment occurs at a low speed—about 6½ ft.-seconds for the model, equivalent to 15 ft.-seconds for the full-size machine. Hence, the machine can start off at a large angle with a considerable load on the tail-float, and can, therefore, manœuvre comfortably on the water at very slow speeds, while taking up its most efficient angle at a moderate speed. It will be noticed that

Fig. 21–27. IN MACHINE UNITS (TWO FLOATS.)

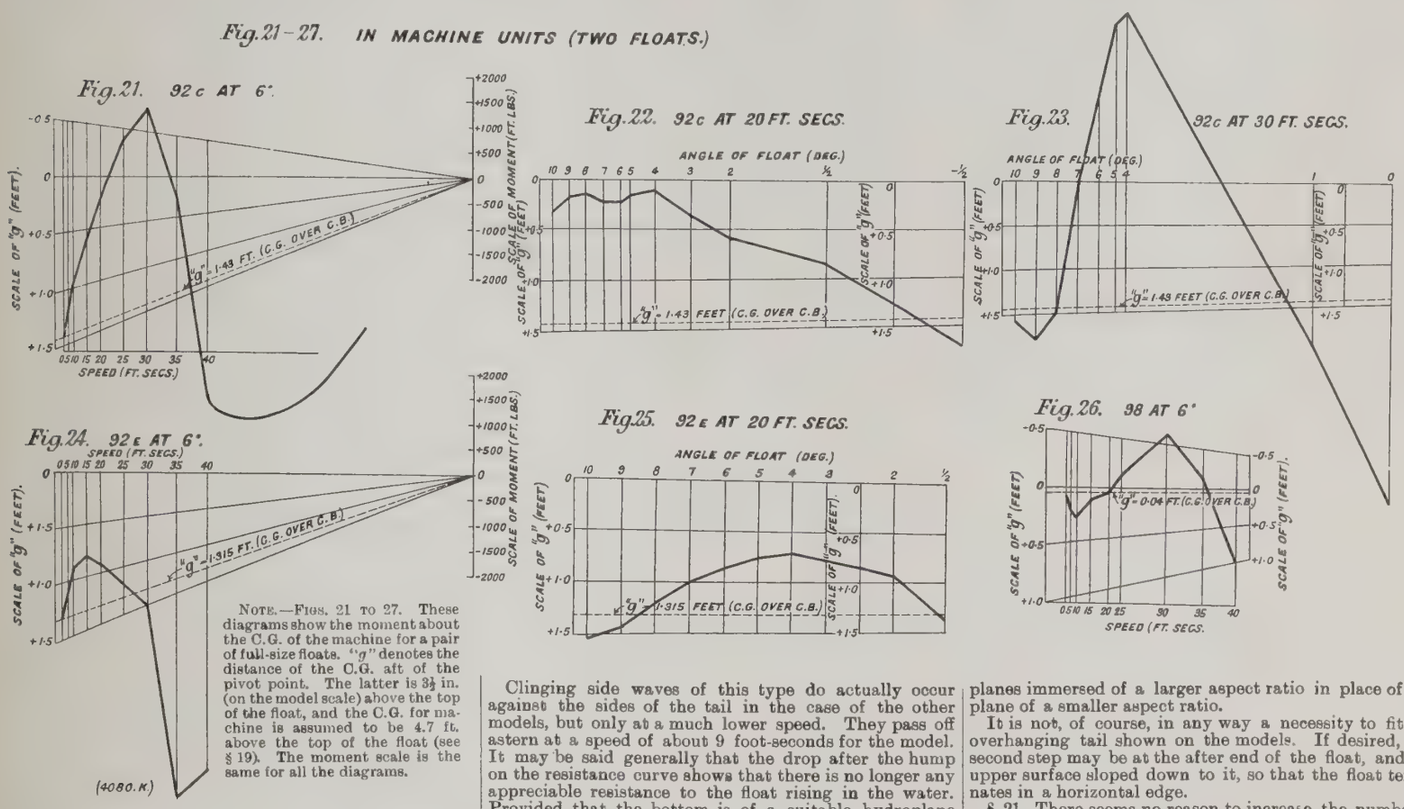
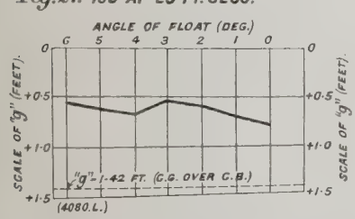


Fig. 21. 92 c AT 6°.
SCALE OF "g" (FEET).
SCALE OF MOMENT (FT. LBS.)
"g" = 1·43 FT. (C.G. OVER C.B.)
SPEED (FT. SECS.)
Fig. 22. 92 c AT 20 FT. SECS.
ANGLE OF FLOAT (DEG.)
"g" = 1·43 FEET (C.G. OVER C.B.)
Fig. 23. 92 c AT 30 FT. SECS.
ANGLE OF FLOAT (DEG.)
"g" = 1·43 FEET (C.G. OVER C.B.)
Fig. 24. 92 E AT 6°.
SPEED (FT. SECS.)
"g" = 1·315 FT. (C.G. OVER C.B.)
Fig. 25. 92 E AT 20 FT. SECS.
ANGLE OF FLOAT (DEG.)
"g" = 1·315 FEET (C.G. OVER C.B.)
Fig. 26. 98 AT 6°
"g" = 0·04 FT. (C.G. OVER C.B.)
SPEED (FT. SECS.)

NOTE.—FIGS. 21 TO 27. These diagrams show the moment about the C.G. of the machine for a pair of full-size floats. "*g*" denotes the distance of the C.G. aft of the pivot point. The latter is 3½ in. (on the model scale) above the top of the float, and the C.G. for machine is assumed to be 4.7 ft. above the top of the float (see § 19). The moment scale is the same for all the diagrams.

(4080.K)

Fig. 27. 100 AT 20 FT. SECS.



(4080.L.)

the moment diagrams show a large negative moment at high speeds. But at these speeds a reduction of 1 deg. to 2 deg. in the running angle will change this to a large positive moment, so that the machine will run quite steadily at an intermediate angle. The natural running angle can be varied by varying the relative depths of the points of the two steps. The positive moment at any speed can be increased to any desired extent by increasing g—*i.e.*, by placing the floats further forward.

It must be remembered that the experimental results only hold for smooth water. The effect of rough water will be to increase the resistance considerably, and hence to reduce the positive moments.

§ 23. A point that must receive careful consideration is the possibility of the machine coming down at too high a speed and too small an angle through the pilot misjudging his distance from the water. Unless the floats are stable at small angles this is very likely to cause the machine to turn a somersault (see §§ 16 and 17). The same requirement holds for running on rough water if the floats are to ride over the waves, and not plough through them.

§ 24. In conclusion,* the author wishes to acknowledge his great indebtedness to Mr. G. S. Baker, at whose suggestion this paper was written, and in conjunction with whom the whole of the experimental work was done, and to Mr. J. L. Kent, who assisted in this work. Also to the Advisory Committee for Aeronautics for their kind permission to make use of the experimental work done for them, and to reproduce a number of diagrams from the Official Reports.

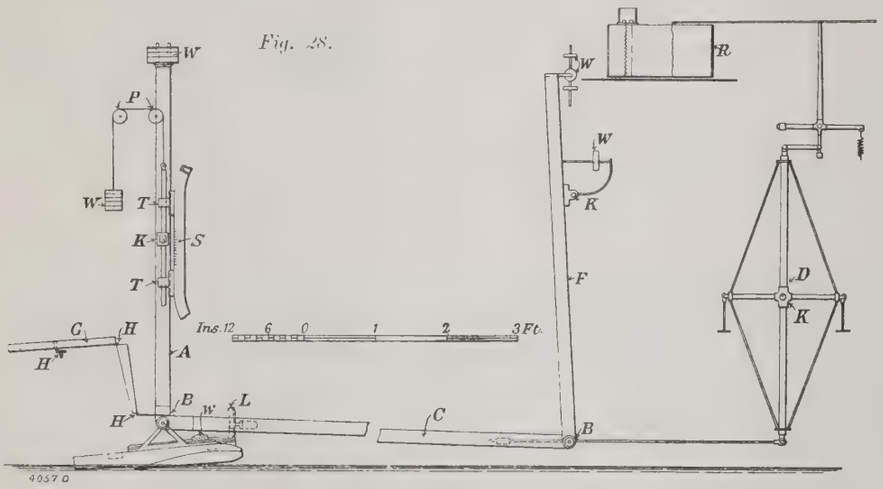
The complete experimental results will be found in the following reports by Mr. G. S. Baker and the author, which are already published or in the Press:—Report No. 70, November, 1912; Report No. 98, November, 1913; Report No. 99, March, 1914.

APPENDIX.

Methods Adopted for Testing Hydro-Aeroplane Floats in the William Froude National Tank.

1. *Apparatus.*—The apparatus used for testing the floats is shown in Fig. 28. The floats are made with a flat upper surface which is parallel to the forward mean planing surface, and are screwed on to an aluminium carrier, at the forward end of which is a graduated arc L.

Fig. 28.



The carrier is attached by ball-bearings B on a transverse horizontal axis to a vertical frame or gate A and a horizontal gate C. The forward end of the gate C is attached by other ball-bearings to the vertical gate F, and by a light-balanced steel rod to the dynamometer D. The forward frame F is supported on knife edges on fixed bearings and has balance-weights W, W. The after frame A is also supported on knife edges, but the seatings are not fixed, but are suspended in vertical slides by light wires which pass over ball-bearing pulleys P, P, and carry weights on their other ends. Pointers are attached to the knife-edge seatings, and their height can be read off on vertical scales S, S. The frame A has balance-weights at the top, which are adjustable in amount, and two sliding weights on the upper arms, and a horizontally-sliding weight (not shown on diagram) to balance the frame. G is a three-hinged frame to prevent lateral movement of the float. A stop can be clamped at any point on the arc L, which engages with adjustable jaws attached to the frame C. These jaws are opened just enough to allow the float to rock through a small angle (about ¼ deg. each side of the mean).

The method of running is as follows:—The weights of all parts of the apparatus are known, and the forward frame is first balanced about K, a weight equal to that of the towing-rod and the proper share of the weight of C being suspended from B. The after frame is then balanced with everything in place, and the float just clear of the water and balanced about the axis B, so that there is no pressure on the stop. In any given run the correct load "P" is applied to the float by attaching suitable weights to the suspending wires, and the resistance (R) is measured by the dynamometer D. During the run, and before taking the resistance record, the float is accurately balanced about the pivot point B by means of movable weights on it, and a sliding weight on the float-carrier, so as to get the stop on the arc just floating between the jaws. From the position of the weights in conjunction with their position when the model is balanced in air at the same angle we deduce the moment (M) of the water forces about the pivot.

Let S be the dynamometer record (in pounds).

W_1 the weight of frame F acting at a height g_1 above K.

W_2 the weight of frame A acting at a height g_2 above K.

a_1 the radius K B for forward frame F.

a_2 the radius K B for after frame A.

X the load on the wires carrying after knife-edges.

w_1, w_2 the components of the weight of C at the forward and after bearings.

θ_1, θ_2 the inclinations of frames F and A to the vertical.

ϕ the inclinations of frame C to the horizontal.

W the weight of float, carrier, and sliding weights and (f, g) the co-ordinates of their centre of gravity relative to the pivot

P, R the vertical and horizontal components of reaction of water on floats, and (p, r) the co-ordinates of the centre of pressure relative to the pivot.

Then it can be shown that—

$$S = \left(w_1 - W_1 \frac{g_1}{a_1} \right) \theta_1 + \frac{1 + \theta_1 \tan \phi}{1 + \theta_2 \tan \phi} \left[R + \left(- P + W + w_2 - W_2 \frac{g_2}{a_2} \right) \theta_2 \right] \quad . \quad (1)$$

and

$$P = (W + W_2 + w_2 - X) + \frac{\tan \phi}{1 + \theta_1 \tan \phi} \left\{ \left(w_1 - W_1 \frac{g_1}{a_1} \right) \theta_1 - S \right\} \quad . \quad . \quad (2)$$

$$P p - R r - W f = 0 \quad . \quad . \quad . \quad (3)$$

By our method of balancing we make—

$$w_1 - W_1 \frac{g_1}{a_1} = 0,$$

and

$$W + w_2 - W_2 \frac{g_2}{a_2} = 0.$$

Also $\theta_1 = \theta_2$ approximately, and both θ_2 and ϕ are small.

Hence equations (1) and (2) reduce to

$$P = (W + W_2 + w_2 - X) - S \tan \phi.$$
$$R = S + P \theta_2.$$

The angle ϕ is obtained from the vertical height scale, and θ_2 from the position of the resistance record on the drum. The air resistance of the apparatus at different speeds is obtained by experiment and deducted.

2. *Reduction of Results.*—No correction is made for surface friction in reducing the results for model to full-size float. The models are on a comparatively large scale, while they are actually so small that the frictional coefficient is rather doubtful. Moreover, the amount of wetted surface varies greatly with the speed, and the speeds are so high for the length of float that the skin friction resistance is a comparatively small part of the whole. The error involved in neglecting the correction is only of the order of 3 to 4 per cent., and is always on the safe side.

This being the case, if the ratio $\frac{\text{model}}{\text{full-size float}} = \frac{1}{\lambda}$, then, if P, R are forces in pounds for model at a speed of v foot-seconds, and M is moment in inch-pounds for model at the same speed, the corresponding forces and moments for the full-size floats at a speed of $v\lambda^{\frac{1}{2}}$ foot-seconds are $P\lambda^3$ lb, $R\lambda^3$ lb., $\frac{M\lambda^4}{12}$ ft.-lb. For the instance given above (see § 13) $\lambda = 5.67$, $\lambda^{\frac{1}{2}} = 2.381$, $\lambda^3 = 182.28$ $\frac{\lambda^4}{12} = 86.13$.

* Since writing this paper the author has come across a paper giving the results of some tests with models of flying-boat hulls made in the tank at Washington ("Hydromechanic Experiments with Flying-Boat Hulls," by H. C. Richardson, Naval Constructor, United States Navy—Smithsonian Miscs. Collections, vol. 62, No. 2, April 20, 1914). The results obtained seem to be in general agreement with those here described, but the information given is rather scanty, and the greater part of the paper is devoted to submerged experiments to determine the air resistance. (At the National Physical Laboratory this is determined more directly by means of the wind channel). No attempt was made to measure the trimming moments when running on the surface.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Board of Trade, Commercial Intelligence Branch, 73, Basinghall-street, London, E.C.

New Zealand: The Imperial Trade Correspondent at Dunedin reports that tenders are invited by the Corporation of Invercargill for the supply, delivery, and erection of a telescopic two-lift steel gas-holder of not less than 250,000 cub. ft. capacity, together with tank. Sealed tenders, marked "Tender for Gas-Holder," and accompanied by duplicate plans of the gas-holder and tank it is proposed to supply, will be received by the Town Clerk, Invercargill, New Zealand, up to 4 p.m. on November 28. A cheque for 5 per cent. of the value of the offer, drawn on a bank in Invercargill, must accompany each tender as a preliminary deposit.

Egypt: The *Journal Officiel* notifies that tenders are invited by the Egyptian Ministry of Public Works, on behalf of the Municipality of Port Said, for the building of the air-compressing station and laying the engine foundations at Port Said (Contract No. III.). Sealed tenders will be received, up to noon on August 15, by the Controller-General, Main Drainage Department, Ministry of Public Works, Cairo. It will be observed that the time for the receipt of tenders is limited, and owing to forms having to be obtained from Egypt, this intimation may be of use only to firms having agents in that country who can be instructed by cable.

Norway: H.M. Legation at Christiania reports that the Storthing has recently granted four important concessions for the exploitation of water-power to four Norwegian companies—viz.:—The Saudefaldene Company, the Hoiangfaldene Company, the Osa Foss Company, and the Bremanger Power Company. The terms under which the concessions are granted stipulate that the directorate of each company must have its domicile in Norway and consist entirely of Norwegian subjects, and shares can only be assigned or mortgaged to Norwegians. The company binds itself to make use of Norwegian materials for the works, provided that these can be obtained sufficiently quickly and of as good quality as foreign articles and at a price not more than 10 per cent. above the latter. The power generated must be supplied at a maximum price of 20 per cent. above the cost of production. At the termination of 65 years from the date of the grant of the concession, the waterfall canals, works, installations, &c., revert to the State without compensation. H.M. Legation adds that the Parliamentary Committee dealing with the matter has recommended that no large water-power concession be granted to foreign companies until the law on the subject has been remodelled.

Russia: H.M. Embassy at St. Petersburg reports that, according to the *Pravitelstvennei Vyestnik*, St. Petersburg, sanction has been given to the Municipality of Tiflis to raise a loan of 336,000 roubles (about 35,500*l.*) for the extension and improvement of the existing water supply; and to the town of Piatigorsk to raise a loan of 1,000,000 roubles (about 105,500*l.*) for the improvement of the water supply, the construction of an electric-power station, a covered market, cold-storage accommodation, a "people's palace," and additions to the town hall.

China: H.M. Commercial Attaché at Pekin reports that the Chancellor of the Chinese Government University at Pekin is desirous of obtaining samples and models of engineering products of United Kingdom manufacture that would be representative of the best and latest work. The University, which has been in existence for over fifteen years, since 1908 has been specialising in the various branches of the sciences, and is now developing into such a position that it is expected the various Chinese Government services will be able, within the next few years, to fill their responsible offices from amongst the University graduates. Chinese students have not the same opportunities as those of Western countries, where manufacturing processes may be seen in actual operation, and the University is anxious to obtain representative collections of samples, models, or other methods of demonstration which cover the following branches of technical science:—Material used in road-building; material used in building construction; constructions in reinforced concrete; railway materials and signal systems; bridge and roof constructions; constructions of cranes; various metals with data regarding strength, &c.; bolts and screws; wire rope with data regarding strength, &c.; modern sewage schemes and irrigation schemes and harbour constructions; mining machinery, stamping-mills, &c.; cupolas for the various processes; tools used in mining, various kinds of safety-lamps, &c.; valves and cocks; various constructions of steam-engines, steam-turbines, and boilers; workable size of oil-engines; workable size of dynamo, motors, and transformers; electric cables and wires; telegraph and telephone equipment; water-wheels and turbines; pumps; gas-producing plants; various technical-chemical processes. The advantages which may be gained to British trade through the students learning from samples and models of British make are too obvious to need enumeration. The consulting engineer to the University is now in the United Kingdom in

connection with this matter, and will be glad to hear from United Kingdom firms who are willing to assist. His name and address may be obtained by United Kingdom firms on application to the Commercial Intelligence Branch of the Board of Trade.

FATAL EXPLOSION OF AN OIL-SEPARATOR.

A FORMAL investigation has been conducted by the Board of Trade, at the Stephenson Memorial Hall, Chesterfield, under the provisions of the Boiler Explosions Act, 1882, respecting the cause and circumstances of a boiler or "oil-separator" explosion which occurred on April 2 last at the Devonshire Works, Barrow Hill, near Chesterfield, belonging to the Staveley Coal and Iron Company, Limited. The Commissioners were Mr. Archibald Bence-Jones, barrister-at-law (presiding), and Mr. Arthur J. Maginnis, M. Inst. C.E., M.I. Mar. E., consulting engineer. Mr. George C. Vaux conducted the proceedings for the Board of Trade, and there were present, as representing the Staveley Company, Mr. C. P. Markham, J.P., the chairman of the company, and Mr. G. M. May.

In opening the proceedings, Mr. Vaux gave a detailed description of the separator, and said that the question was not likely to arise that the separator was not of sufficient strength for the purpose for which it was intended.

Mr. Markham laid before the Court a model of the separator, and was congratulated by the President on the completeness of its mechanism.

In continuing his statement, Mr. Vaux said that Mr. Markham was responsible for the laying out of the plant at the Devonshire Works, and he appeared to have personally superintended the arrangements with regard to the exhaust-pipes of the separator, which was made in 1906. At that time Mr. Robert Fowler was acting as assistant-engineer to Mr. Markham; but early in 1912 he was appointed chief engineer, and since that time he had had full control of the machinery. The separator was not inspected or insured by any insurance company, but about a year before the explosion took place it was inspected by one of the Staveley Company's boiler-makers, and some slight repairs were made. On April 2 last the turbine was being driven by the exhaust steam from the blowing-engine only, the exhaust steam from the dynamo-engines passing into the water-tower tank from the separator. The gate-valve was closed and the change-over valve was in its usual position. About 4.30 p.m. it was found necessary to divert the dynamo-engine exhaust into the main line with the turbine, and Mr. Fowler proceeded to the top of the separator to make the change, taking with him Samuel Wilson (journeyman engineer), Martin Stops (a labourer), and four other men to assist in case the change-over valve proved stiff to move, and, presumably, to make the change-over rapidly to prevent any irregularity in the running of the turbine. On arriving at the separator the gate-valve appeared to have been opened by Wilson, assisted by Stops. Stops seems to have been working the gate-valve wheel, and was standing, unnoticed by the other men, between the left hand of the balance-lever and the body of the gate-valve chest. The gate-valve being open, a connection to the turbine-pipe and the butterfly or change-over valve swung over, as intended, closing the opening to the water-tower. The balance-lever of the left-hand side got Stops between itself and the body of the gate-valve chest, jamming his legs. It was impossible to release him without stopping the engines, and Mr. Fowler appeared to have turned away to give orders for this to be done. At the same moment Wilson closed the safety-valve again, apparently thinking this would release the pressure on the body of the unfortunate man who was being crushed. Almost immediately afterwards an explosion occurred, leaving a passage for the exhaust steam from the dynamo engine to escape. Mr. Fowler was thrown down from the top of the separator, but escaped unhurt; Wilson was also thrown down, and was injured and generally scalded. Martin Stops, when extricated, was found to have both legs broken, and other injuries, and died soon after.

Various witnesses were then examined.

Mr. Markham gave evidence bearing out Mr. Vaux's statement, and said he took the whole responsibility for the laying out of the plant at the works. He was not at the works when the explosion occurred, but had been there in the morning and had given instructions to get the valve changed over, because more steam was required for the turbine. Ten minutes after the explosion he was present, and found that the man Stops had been fearfully crushed. He had put his leg over the lever in some extraordinary way, and not having a perfect knowledge of English he misunderstood what was going to happen.

Mr. Vaux: In designing the separator did you consider it to be practically perfect?

Mr. Markham: I did. It was as near fool-proof as one could make it; so perfect did I consider it that I had not effected any alteration since the explosion.

Mr. Maginnis: I presume when it had been fitted previously there was no such liability of closing both outlets, as was the case when the accident occurred?

Mr. Markham: No; I hardly think so. It was on to a big surface-condenser.

Mr. Maginnis: And I presume you agree with me that if the gate-valve had not been there it would not have been possible to have brought about such an explosion with this separator?

Mr. Markham: No. If we had thought that there was the slightest danger, we should not have put one in.

Mr. Ronald Fowler, in his evidence, said there had not been any difficulty with the separator before the explosion, which was caused by the back pressure.

In answer to Mr. Markham, witness said he explained to the man Stops (who was a German) exactly what to do.

Mr. Maginnis: In the light of this inquiry as to what has happened, would you now say where there was a chance of closing the two outlets of any exhaust chamber of a light construction that relief-valves should be fitted?

Mr. Fowler: Yes; I think it is advisable.

Mr. Bence-Jones (President): Are you quite clear in your opinion about there being no need for a separate valve for the separator?

Mr. Fowler: Yes, sir; I thought it was perfectly safe.

Mr. Bence-Jones: It is perfectly safe unless some excitement renders people incapable of using their wits.

Further evidence was given by Mr. Drabble (foreman electrician), Mr. William Bentley (engine-fitter), Mr. Samuel Wilson (journeyman engineer), all of the Devonshire Works, and Mr. A. L. Haslett, engineer-surveyor to the Board of Trade, who said he agreed with Mr. Markham as to the cause of the explosion—namely, an accumulation of back pressure caused by the closing of both exhaust passages from the change-over valve-chest whilst the dynamo engines were running. There was no weakness of the strength of the separator.

The Court then adjourned until the following day, when Mr. Bence-Jones delivered judgment. Mr. Maginnis and himself were, he said, both of opinion that the inquiry showed the imperative necessity of fitting a safety-valve not liable to be shut off, on all steam receptacles, pipe ranges, &c., whether exhaust or otherwise, when there was even the remote chance, as in the present case, that all outlets might be closed. At some length Mr. Bence-Jones then touched on the evidence that had been given, and gave answers to the various questions which had been put to the Court by Mr. Vaux on behalf of the Board of Trade as follow:—

Question 1: When and by whom was the separator which exploded made, and when was it fitted up at the Devonshire Works? At what pressure was it worked thereafter?

Answer: It was made in the year 1906 by the Baker Oil-Separator Company, Limited, now of Hunslet, Leeds. It was fitted at the Devonshire Works some months later by the Staveley Coal and Iron Company, Limited. Thereafter it was worked at exhaust pressure up to 9 lb.

Question 2: Was the separator fitted with adequate mountings, and was the arrangement such as to ensure safety in working?

Answer: Yes, under normal working circumstances.

Question 3: Were proper measures taken by the Staveley Coal and Iron Company, Mr. Charles P. Markham, the chairman of directors, and Mr. Ronald Fowler, engineer of the Devonshire Works, to ensure that the separator was worked under safe conditions?

Answer: Yes.

Question 4: What was the cause of the explosion?

Answer: Efforts to release a workman who was fatally jambed by the lever of the change-over valve, which efforts consisted in hurriedly closing an outlet valve on the exhaust system, and so allowing undue pressure to be put upon the shell of the separator.

Question 5: Are the Staveley Coal and Iron Company, Mr. C. P. Markham, Mr. R. Fowler, and Mr. S. R. Wilson, or is any, and which, of them, to blame for the explosion?

Answer: No; as the explosion was brought about by an accident to one of the workmen. We therefore make no order as to the costs of this formal investigation.

In closing the inquiry, the President said the Court wished to thank Mr. Vaux for his clear presentation of the case, and also Mr. Haslett for the careful drawings placed before them, and for the assistance he had rendered at the inquiry. The Court also wished to express appreciation of the useful model of the separator and its connections, which had been supplied by Mr. Markham on behalf of his company.

LIFE-SAVING AT SEA.—We have received from Mr. O. Pettersson a pamphlet illustrating and describing a floating mattress he has invented for the purpose of saving life at sea. The mattress, which is constructed of waterproof material and stuffed with reindeer hair, is normally used in the berth, but in the case of accidents it can be unfolded in such a way that it forms a sort of boat, in which the passenger can float until picked up by another vessel. Each mattress is provided with a sea-anchor, to keep it facing the wind and waves, and also with a pump, to clear it of water. It is also furnished with an acetylene flare, which lights automatically when thrown into the water, and serves to attract the attention of a passing ship. The mattresses are made by Mr. K. M. Lundberg, of Stockholm.

THE "GEORGES" CORONATION GIFT TO THE KING.—His Majesty the King having expressed the desire that the greater part of the fund subscribed for the purpose of commemorating His Majesty's Coronation by subjects of His Majesty bearing the Christian name George in all parts of the Empire should be invested and utilised for the benefit of junior officers of the Royal Marines who may find difficulty in meeting the cost of the final stage of their military training, the sum available has been invested, and the income arising therefrom will be devoted to the institution of scholarships termed the "King George Prize Scholarships." One scholarship will be awarded each year to the officer in His Majesty's Royal Marines who shall, as a result of the annual competitive examination. be selected by the Admiralty for admission to the Military Staff College at Camberley. Each scholarship will be tenable for two years, and will ordinarily consist of half the net income for the year derived from the fund, estimated approximately at 97*l.* 10s. The first scholarship will be awarded in 1914.

CATALOGUES.

Drying-Stoves for Foundry Use.—M. George Piron, of 19, Avenue du Boulevard, Brussels, Belgium, has sent us a booklet illustrating and describing his patent portable stove, fired with coke-dust, and used for drying foundry moulds in position. A stationary stove for drying moulds and cores is also dealt with.

Portable Electric Drills and Grinding-Machines.—Particulars of "Bahco" portable electric drilling and grinding-machines have reached us in the form of a booklet from Messrs. Morris and Lister (London), Limited, 3 and 4, Palace Chambers, Bridge-street, Westminster, S.W., who are the sole agents for these drills for the Midlands, South of England, and Wales. Full particulars, with prices, are given of drills of various sizes, capable of drilling holes up to 2 in. in diameter. Combined drills and grinders, and separate grinders of the bench and tool-post types are also listed. All these appliances are made for use with continuous or three-phase current.

Portable Drawing-Benches.—We have received from the Able Manufacturing Company, 51, Colebrooke-row, N., a circular giving particulars of Ablett's patent drawing-benches. As far as can be judged from the illustration, the drawing-bench consists of a shallow box, the lid of which is formed by the drawing-board. The board is hinged at the front, and can be adjusted to any convenient angle by means of struts at the back. The whole is supported on a pair of sloping legs, which can be folded up flat against the under-side of the box part when the bench is not in use. Prices are stated for the bench only, so that customers can fit their own boards; but boards can be supplied if required.

Pneumatic-Power Hammers.—A copy of their latest catalogue of pneumatic-power hammers has reached us from Messrs. B. and S. Massey, Limited, of Openshaw, Manchester. These hammers, it will be remembered, resemble a steam-hammer in principle, but have a double-acting pump driven by belt or by an electric motor to supply air to the top and bottom of the hammer-cylinder for each stroke. They are listed in nine sizes, in which the weight of the falling parts ranges from ½ cwt. to 1 ton. The catalogue gives full particulars, with illustrations, of each size, and also illustrates examples of work done; accessories for power-hammers, smithy tools, &c., are also dealt with. The catalogue is very nicely got up, and is provided with a thumb-index so that each section can be found instantly.

Marine Motors.—Messrs. J. W. Brooke and Co., Limited, of Adrian Works, Lowestoft, have sent us a copy of their catalogue of marine motors and motor-boats. Full particulars, including prices, shipping weights, and dimensions, are given of engines ranging in convenient steps from 3 to 300 horse-power. The prices stated are for petrol engines, with or without reversing-gears, stern-tubes, propellers, shafting, &c.; paraffin carburettors can, however, be supplied for all sizes except the three-horse-power engine. This engine works on the two-stroke-cycle, whereas the others are all of the four-cycle type. The firm, as is well known, are also boat-builders, and the catalogue illustrates several examples of passenger and cargo-launches for sea and river use, racing launches, hydroplanes, and other craft of which they have constructed the hulls as well as the engines. The book is well printed and illustrated, and is altogether a useful and creditable production.

Tramway Trucks.—The J. G. Brill Company, of Philadelphia, Pa., U.S.A., whose London office is at 110, Cannon-street, E.C., have sent us a copy of a fully-illustrated pamphlet relating to the Brill "Radiax" tramway truck. These trucks, as their name implies, are of the radial-axle type, and the frame, which is of forged steel, is slung from the axle-boxes by swinging links. These links work in ball-and-socket joints at their upper ends, and at their lower ends have two transverse pins or trunnions, on which rests a casting bolted to the frame. When the link swings, owing to an irregularity in the track, one of the pins comes out of the groove in which it rests, thus throwing the weight on the other pin, and this effect tends to restore the link to the vertical position. The same device also draws the axles back to their normal state of parallelism when the car runs on to a straight piece of track after leaving a curve. The whole action is fully explained in the pamphlet, and several other special features of the trucks are pointed out. They are suitable for cars up to 26 ft. long, measured between the body corner-posts, and, by providing a much longer wheel-base than is possible with ordinary four-wheeled trucks, they eliminate the pitching motion which occurs when the car-body overhangs the truck to any considerable extent.

THE INSTITUTE OF MARINE ENGINEERS.—A party from the Institute of Marine Engineers visited the Grosvenor-road Pumping-Station of the London Hydraulic Power Company on Saturday, the 18th inst. The company, which has been in successful operation for thirty years, supplies motive power in London from street mains on the high-pressure hydraulic system, available day and night all the year round, at a pressure of 700 lb. per sq. in. Nearly 178 miles of hydraulic mains are at present laid in London, being chiefly used for operating cranes and hoists, passenger-lifts, hydraulic motors, presses, fire hydrants, vacuum cleaners, capstans, boiler feed-pumps, and many other purposes. The Grosvenor-road station is the largest and most important of the company's five pumping-stations. The output from the five pumping-stations of the company, which are situated from 2 to 3 miles apart, averages 23 million gallons per week, supplying over 7200 machines.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

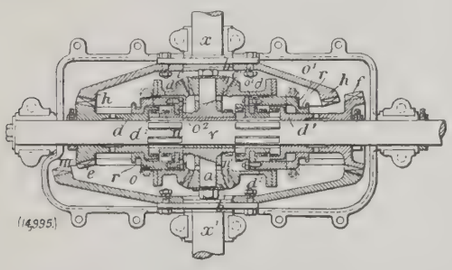
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

AGRICULTURAL APPLIANCES.

14,995/13. F. M. Waller, Wembley. Agricultural Implements. [1 *Fig.*] June 30, 1913.—This invention relates to transmission gear for mechanically-propelled agricultural implements of the type which enables either or both of the driving road-wheels to be positively driven or both of the said wheels to be driven through a differential or balance gear, and it consists of an improved construction whereby the driving power can be positively transmitted to either or both of the driving road-wheels without passing through the differential or balance gear and without the use of sliding gear-wheels, the object being to enable the transmission of the driving effort to be adapted to the varying conditions under which such vehicles work. A transmission gear for mechanically-propelled machines or vehicles comprises, according to this invention, a differential gear, the carrier for the planet wheels of which is mounted free on the driving-axle, and the sun wheels of which are carried by transmission sleeves mounted loosely on the driving-axle, bevel-pinions mounted on the said sleeves and adapted to mesh with bevel wheels carried by the two parts of the driven axle, a sliding clutch adapted to couple either the carrier for the planet pinions of the differential gear or one of the transmission sleeves to the driving-axle, a sliding clutch adapted to lock the other transmission-sleeve to the driving-axle, and means for operating the clutches. The carrier a for the planet or driving-pinions b of the differential gear is mounted to rotate freely on the driving-axle v, and the two driving-wheels c and c^1 of the said gear are carried by sleeves d and d^1 respectively, herein called "transmission sleeves," which are also loosely mounted on the driving-axle v, one on each side of the planet carrier a. On the outer ends of the transmission-sleeves d and d^1 are formed or fixed bevel-wheels e and f, the former of which gears with a bevel-wheel h on one half x of the axle through which motion is imparted to the driving-wheels, herein called the "driven"



axle, and the other f of which gears with a bevel-wheel m on the other half x^1 of the driven axle. The transmission-sleeves d and d^1 are each of step-like formation, preferably formed in two parts, as shown, for convenience in construction, so as to form annular spaces d^2, within which are sliding clutches n and n^1 of the dog type, which are mounted in driving connection with the driving-axle v. The sliding clutches are operated by means of sleeves o and o^1, which respectively carry fingers or forks o^2, which engage with grooves or recesses in the clutches. One of these clutches, hereinafter called the primary clutch n^1, is a double one, capable of being engaged either with the planet carrier a of the differential gear or with the transmission sleeve d^1; and the other clutch, hereinafter called the secondary clutch n, which is a single one, is capable either of being engaged with the other transmission-sleeve d or of being disengaged therefrom. To obtain the differential drive, the primary clutch n^1 is operated to couple the planet carrier a of the differential gear to the driving-axle v, and the secondary clutch n is retained in its neutral position. To obtain a positive drive of one of the driving road-wheels, the primary clutch n^1 is brought into its neutral position, and the secondary clutch n is operated to couple the transmission-sleeve d to the driving-axle v. To obtain a positive drive of the other of the driving road-wheels, the primary clutch n^1 is operated to couple the transmission-sleeve d^1 to the driving-axle v, and the secondary clutch n is brought into its neutral position. To obtain a positive drive of both of the driving road-wheels, both the primary clutch n^1 and the secondary clutch n are operated to couple the respective transmission-sleeves d^1 and d to the driving-axle v. To operate the clutches, grooves r are formed in the ends of the sleeves o and o^1 which are adapted to slide on the exterior of the transmission-sleeves d and d^1. (*Accepted May* 13, 1914.)

ELECTRICAL APPARATUS.

7252/13. J. G. P. Thomas and the Thomas Transmission, Limited, London. Charging Accumulators. [2 *Figs.*] March 26, 1913.—The present invention relates to a system for charging a battery with a substantially constant current, so that a substantially constant output is taken from the prime motor. In addition to the battery, the system comprises motor and generator elements which are essentially of the series type. These motor and generator elements may be separate machines, or may be united into a single machine. The excitation of the field winding or field windings is derived from the battery opposed by the back electromotive force of the motor element, while the generator element is connected directly across the battery. Where the elements are united in one machine with a single armature and field winding, the field winding is inserted between one main brush and an auxiliary brush or auxiliary brushes on the commutator. But this system is distinguished from other single-machine systems inasmuch as the auxiliary brush is quite close to one main brush, for the system does not depend for its operation on armature reaction. Rather the field winding and the portion of the armature between the auxiliary brush and the more distant main brush are to be regarded as constituting a series motor, the back electromotive force of which always approximates to that of the battery and opposes it in the field-winding circuit. In the arrangement shown in Fig. 1 use is made of two substantially identical series-wound machines, the armatures 1, 2 of which are upon a common shaft. For the purpose of charging the battery 3, the field winding 4 of the machine 1 is joined in series with the field winding 5 of the machine 2 and with the armature 2 across the battery, and the terminals of the armature 1 are joined directly to the battery. In order that the electromotive force of the machine 2 may at a given speed be slightly less than that of the machine 1, its field winding 5 is shunted by a suitable diverter 6. Where the prime motor which drives the shaft of the armatures 1, 2 is not self-starting, the motor 2 may be used as a starting device. In that case the field windings 4, 5 and armature 2 are first connected across the battery before the circuit of armature 1 is completed. As the prime motor comes into action the back electromotive force of the motor 2 diminishes the current passing through the field windings 4, 5 to such a value that the open-circuit electromotive force of the machine 1 is sufficiently greater than that of the battery 3 for charging purposes. In this condition both fields must be well below saturation. When the circuit of the armature 1 is completed, a charging current is sent into the battery, but the machine also continues the supply of current through the field windings 4, 5 and the armature 2. If the speed should fall, the electromotive force of the armature 2 diminishes and a larger current is sent through the field windings 4, 5, thus tending to increase the electromotive force of the machine 1 to compensate for the fall of speed. Conversely, when the speed increases, the back electromotive force of the armature 2 checks the current, and the field 4 is approximately proportionately diminished. By this means the machine 1 is caused to give a substantially constant voltage. If this combination is applied

Fig. 1.

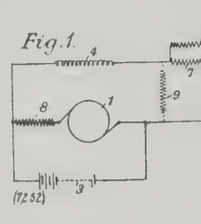
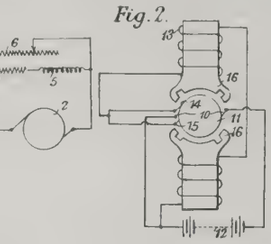
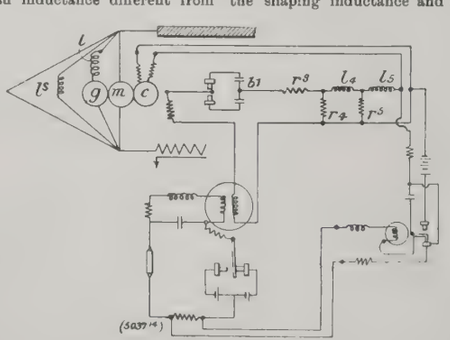


Fig. 2.



to charging a battery that is almost completely discharged, surging of current is liable to occur. On this account it is better that the diverter 6 should not be immediately across the field winding 5, but across the field winding and a resistance 7 in series with it. Surging may also be largely prevented by suitable adjustment of the brushes, say, of the generator, and such adjustment is a convenient means of slightly altering the relation between the two machines. It may further be desirable to insert a steadying resistance 8 in series with the armature 1 in a position to carry both the charging current and the field current. If the two machines are working upon different portions of their characteristic curves it may further be necessary to place a resistance 9 in shunt across the machine 2, 5, so that a portion of the exciting current of the machine 1, 4 is independent of the auxiliary machine. It is clear that these two machines could be combined into a single machine in the manner illustrated in Fig. 2. The main brushes 10, 10 of the armature 11 are connected directly to the battery 12. The field winding 13 is connected between one of the main brushes 10 and a brush 14 adjacent to it. Thus the field current may be considered as supplied by the whole electromotive force of the armature opposed by a major portion of it. For the sake of symmetry a second brush 15 may be placed on the opposite side of the adjacent main brush 10 and joined with the brush 14 to the field-winding circuit. To prevent sparking at the brushes 14, 15, the pole-cores 16 may be cut away opposite to the conductors to which the brushes are for the time being connected. Throughout the range of operation of the machine the iron of the field magnet should be unsaturated. This determines the maximum current allowable in the field windings, and therefore the minimum speed at which the system will operate. Subject to this condition, the battery which forms part of the system, and is charged in its operation, may be of any desired voltage within wide limits. Where the prime motor which drives the system is not self-starting, the motor element may be used as a starting device. In that case the battery is connected to the auxiliary brushes 14, 15, and the right-hand brush 10 before the connection to the left-hand brush is made. (*Accepted May* 6, 1914.)

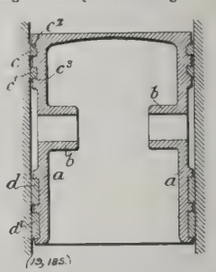
5037/14. W. Judd, B. Davies, and the Eastern Telegraph Company, Limited, London. Telegraphy. [1 *Fig.*] April 25, 1913.—This invention relates to improvements in methods of telegraphy through submarine and subterranean cables, and more specifically to methods for the elimination of troublesome earth-current effects, especially in systems for the rapid transmission of signals through long cables having electric constants of considerable value. The invention consists in means for eliminating the effect of earth and like currents, comprising an inductance different from the shaping inductance and of



much greater inductive value than that inductance connected in series with a neutralising coil or connected as a simple leak. In the form illustrated, the earth-current effect is eliminated by placing in series with the earth-current inductance a neutralising coil g of a few turns wound with the main coil m of the dash-maker to balance the earth current flowing through the signal winding by another of equal but opposite effect due to a current flowing through the earth inductance l and the neutralising winding g. The inductance l is separate and distinct from the inductance l_2 provided for shaping the signals. Further, the inductance l should be high—for example, 10 to times the value of the shaping inductance l_2. The inductance l is made as high as convenient in order that its reactance shall be such as not to affect the amplitude of the signals appreciably, but not so high as to offer an appreciable obstruction to the flow of the earth current beyond that given by its simple ohmic resistance. Although the effect of the earth-current inductance l on an individual signal is inappreciable, it has a slowly-acting effect on a long spacing current or a long series of dashes unrelieved by any dots or spaces. This results in a wandering zero. To neutralise this effect and produce a straight zero line a compensating effect or local correction is obtained, due to a slowly-varying current obtained from a resistance-capacity device or an inductance leakance device shown by way of example in the drawing. This comprises resistance r 3 and inductance l 4 and l 5 in series with the correction coil c on the relay coil and resistance r 4 and r 5 in parallel therewith. The current for this is obtained from the relay local battery b 1. The effect of the current thus obtained should be approximately equal, and opposite to that of the current flowing through the earth-current inductance at any instant due to signalling. These conditions are secured by adjusting the inductance l 4 and l 5, leakances r 4 and r 5, and resistance r 3. (*Sealed July* 16, 1914.)

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

19,185/13. Vickers, Limited, London, and G. Bourcier, Erith. Internal-Combustion Engines. [1 *Fig.*] August 23, 1913.—This invention relates to the pistons of internal-combustion engines and other engines in which pistons of the trunk type are employed, the chief object being to overcome the wear arising from the tilting of the piston around its gudgeon-pin when the crank of the engine passes over a dead-centre. The pistons are usually made of steel, and in order to avoid undue wear of the cylinders, are provided with one or more guide-rings or liners made of some suitable metal or alloy, such as phosphor-bronze. It is found in practice that the aforesaid tilting of the pistons has a prejudicial effect on the duration of the guide-rings or liners, as it causes the same to be worn unevenly, so as to require frequent renewal. To avoid this difficulty, it is necessary to retain the piston and guide-rings or liners at all times in alignment with the axis of the cylinder, and to prevent the aforesaid harmful tilting action from taking place when the engine-crank is passing over one or other of its dead-centres. According to this nvention, the tilting of the piston and guide-rings, or so-called



liners, is overcome by providing the piston with one or more (preferably two) split piston-rings, which are tapered in such a manner that one of them is expanded on the explosion or out-stroke, and the other on the compression or in-stroke of the piston. These piston-rings are advantageously arranged in proximity to one end of the piston remote from the guide-rings or liners, which are arranged at the other end thereof. a is the body of the piston, which is provided with the usual bosses b, b for receiving the gudgeon-pin; c and c^1 are the two tapered piston-rings, arranged in proximity to one end of the piston, and oppositely tapered as shown at c^2 and c^3. The taper c^2 on the ring c is such that, when the piston is performing the explosion or out-stroke, it will cause the ring c to expand, while the taper c^3 on the ring c^1 will cause the latter to expand in a similar manner at the compression or in-stroke of the piston. The piston-rings c and c^1 are arranged on the piston at the end remote from the guide-rings or liners d and d^1, so that the piston-rings and guide-rings or liners are disposed on opposite sides of the gudgeon-pin bosses b, b. In this manner the piston is effectively stayed on both sides of the gudgeon-pin, and the tilting of the piston around the pin at the dead points is prevented. (*Sealed July* 16, 1914.)

MISCELLANEOUS.

22,795/13. C. Tomkinson and J. T. Williams, Liverpool. Centering for Concrete Floors. [3 *Figs.*] October 9, 1913.—This invention has for its object an arrangement of centering or platform suspended entirely from girders, by means of suspension devices having no tendency to slip sideways, and wedges and abutments so designed that the abutments on the girders are held immovable thereon so long as the wedge or wedges are tight, and the wedge, wedges, or equivalent tighten the suspension device, so as to hold such abutment tight against the girder and flat against the centering joists, the whole being so arranged that, by simply knocking out one wedge at each end, the whole centering can fall down from the girders, leaving the ferro-concrete previously fixed thereon *in situ*. According to this invention, the centering joists are carried from the girders either by means of the straps round the joists holding the wedges, one of which in each case rests with its end on the

Fig. 1.

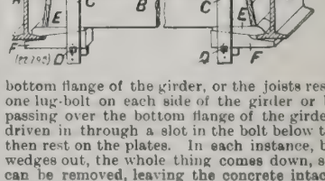
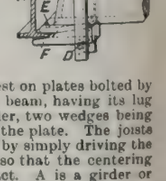


Fig. 2.



bottom flange of the girder, or the joists rest on plates bolted by one lug-bolt on each side of the girder or beam, having its lug passing over the bottom flange of the girder, two wedges being driven in through a slot in the bolt below the plate. The joists then rest on the plates. In each instance, by simply driving the wedges out, the whole thing comes down, so that the centering can be removed, leaving the concrete intact. A is a girder or beam, B the centering joist, C a strap suspended over the joist, and having a bolt or abutment D. E is a wedge or plate holding on to the lower flange of the beam A, and held up by wedge F, driven in between the abutment D and the wedge or plate E. By driving out wedge F, the whole thing comes down. K is the sheathing holding up the concrete. It is obvious, however, that the straps and wedges can be nearer the beam, and consequently the wedges shorter than shown; also that the strap can be a complete ring strap, the bottom acting as an abutment instead of a bolt. (*Accepted May* 6, 1914.)

LITERATURE.

Recent Works on Physics. (1) *Sound. An Elementary Text-Book for Schools and Colleges.* By I. W. Capstick, M.A. (Camb.), D.Sc. (Vict.). Cambridge University Press. [Price 4s. 6d.] (2) *Mechanics and Heat.* By William B. Anderson, Ph.D., Associate Professor of Physics, Iowa State College. New York and London: McGraw-Hill Book Company. [Price 8s. 4d. net.] (3) *Molecular Physics.* By James Arnold Crowther, M.A. Reprinted from the *Chemical World.* London: J. and A. Churchill. [Price 3s. 6d. net.]

(1) This elementary treatise is arranged to meet the wants of two classes of students: the physical student pure and simple, to whom it offers an introduction to the mathematical basis of acoustics, and the executant in orchestras, for whom it caters by supplying information concerning the principles underlying the construction of musical instruments in general. Put in another way, the author has endeavoured to make his treatise serve as an introduction to Helmholtz's "Theory of Consonance," and also to the more analytical works of Lord Rayleigh or Professor Lamb. If by this double purpose he has added to the interest, he has also increased his difficulties, because his two classes of readers approach the subject by different roads and demand different kinds of information. One asks for general principles, the other for the application of those principles, or for final results, without caring for the intermediate steps by which those results are reached. Neither is sent empty away; but perhaps neither is quite satisfied.

The author finds himself severely hampered by his restricted use of mathematics, and the student of physics is asked to exercise faith where demonstration fails. He has to accept facts that he cannot prove at this stage of his scientific career. The musician suffers less. If his mathematical attainments are deficient, the experimental evidence will appeal to his practised ear. The man who is tone deaf, insensitive to musical sounds, is at a great disadvantage in acoustical study. Only those who suffer know how utterly incomprehensible is much that is taught concerning overtones and similar phenomena. Without mathematics and without a musical ear one can still make some progress. "My aim," says Mr. Capstick, "has been to make the least possible use of mathematical methods in order that the reader may not be led to evade the mental effort required for the appreciation of the physical connection between the phenomena described." This principle is sound, for no doubt a fatal facility can be acquired in the manipulation of mathematical symbols that tends to conceal many difficulties. By careful adherence to his declared intention, the author is able to treat very successfully many problems connected with vibrations and waves in general: resonance and forced vibrations. The reference to Fourier's theorem and its applications is hardly adequate, and from an educational point of view this section might have been omitted. With the introduction of periodic curves the author enters on the subject of musical notes, and follows the phenomena through the conditions imposed by organ-pipes, reeds, membranes, bells, &c. He also gives a chapter to the phonograph, microphone, and telephone. Within the imposed limits the treatment is very satisfactory, and if many of the difficulties connected with the theory are mercifully hidden from the beginner, he may be thankful for the guarded reticence. The last three chapters appeal more closely to the musician. Here the theory of consonance comes under review: musical scales and temperament are discussed in what should prove an illuminating manner, and, finally, the acoustical theory developed in the preceding chapters is shown to be applicable to the use and construction of orchestral instruments. A number of problems set by the examiners of the Universities of Cambridge, London, Dublin, and the National University of Ireland, are quoted and solved. The character of these questions indicates the degree of proficiency of the student, for whom the book will be exceedingly useful.

(2) Of the making of books on elementary mechanics there is no end. Many teachers, conscious of success, believe that they have realised better than others the difficulties that beset students, and know how to remove them. In this case the author has filled the offices of both examiner and teacher, and brings to bear the experience he has acquired in the twofold capacity. The lectures that he has given to his class, and no doubt frequently revised, he now collects into book form, and submits them more particularly to those who are interested in the practical side of education. This phrase is rather doubtful, but we should understand by it that Professor Anderson is more anxious about the end than the means. His object is to arrive at a goal, to place the student in possession of a number of facts to enable him to follow with advantage what practical instruction he may receive in the technical school or workshop. One of the requirements that the student stands most in need of is the habit of clear thinking, and this book is arranged to assist him. It may be said to require no mathematical knowledge, to go little beyond definitions, and yet the author manages to indicate to his pupils the importance of possessing an exact appreciation of fundamental principles. The examples illustrating the various laws appear to be well selected, and so arranged that it is not possible to work through them without mastering the text very thoroughly.

The treatise is divided into three parts. The first is devoted to the discussion of various kinds of motion, the second to the so-called properties of matter, and the third to heat. In this last section the author includes two short chapters on meteorology, and on steam and internal-combustion engines. Perhaps the author would have been well advised to have confined himself to general principles, as he has done in the earlier sections. These last chapters are fragmentary and unsatisfactory. They are not marked by thoroughness nor by novelty of treatment, and detract, as we think, from the very evident merits of the earlier portions. We are not prepared to subscribe to the assertion that there is a continuous belt of north-east or south-east trade winds all round the globe, a theory that seems to belong to the time when the author began his lectures. The theory of cyclones, too, seems to be lacking in precision, and does not convey a clear perception of the physics of the phenomena they present. The information here is not quite up to date. In another connection, we think that if the old lectures had been less used, the Professor would not have written so confidently of the existence, behaviour, or function of the ether. Doubtless in the present condition of our knowledge of the electro-magnetic nature of light, the ether is a very troublesome subject for treatment in an elementary work: the greater reason for omitting such vexed topics.

(3) Mr. Crowther's little book deserves a wide recognition. It unfolds in a lucid way that can be "understanded by the man in the street" the history of a research that constitutes one of the most fascinating tales in the whole history of discovery. It reveals secrets that seemed successfully hidden by the minuteness of the mechanism in which they operated. It describes achievements won by the penetrating power of the human mind and its capacity to follow obscure clues. It discloses a marvellous ingenuity in devising experiments to test hypotheses, and a wonderful readiness in interpreting confused phenomena. We ought to want to know how such surprising results have been derived from questioning particles, whose minuteness not only defies the resolving power of the microscope, but of which the imagination utterly fails to construct an adequate mental picture. We have accepted the assertions of astronomers who have told us of suns at inconceivable distances, controlling the motions of planets circulating about them, but infinite space furnished a noble theatre in which these operations could be carried on. We are now invited to believe that within the atom, whose minuteness evades our conception, a similar mechanism exists, with ample space for the orbital motions of crowds of satellites. This is no fanciful conjecture, but a demonstrated truth. The problems of celestial mechanics are not more real than those presented by the tiniest atom. The problem of three bodies, that has puzzled the mathematician since Newton enunciated the principle of gravity, is dwarfed into insignificance in face of the mobility of swarms of electrons. The astronomer counts the worlds, and finds them but a few hundred millions; the physicist, equally busy with the infinite minute, asserts with no less confidence that in the highest attenuated vacua, when the pressure of the gas is not more than the $\frac{1}{10,000}$ of a millimetre of mercury, the number of atoms or molecules in a single cubic millimetre are to be reckoned by thousands of millions. He will demonstrate their objective reality, he will make them reveal their presence on the photographic plate, he will measure their temperature, and teach us much about their behaviour. Surely we are not so devoid of curiosity as not to wish to know how such marvellous results have been secured. It should give no satisfaction to quote such facts or to repeat such figures with gaping wonder; but to understand the process by which such facts have been elicited, and to weigh the evidence on which they rest, should be a worthy ambition. With Mr. Crowther's guidance, and by the aid of illustrations to which he appeals, it is possible without special training to enter into the realm of the infinite minute, to break down matter as we know it into its constituent parts, and force the atom to declare the number of electrons it contains, their arrangement, distribution and motion throughout the molecule.

As we follow the successive stages on the road of this new physical inquiry we shall obtain an intelligent insight into many curious phenomena that have perplexed us. Cohesion, adhesion, inertia, acquire new meaning; the conduction of heat and surface tension take on new aspects as we become familiar with the action of the electron. Most remarkable of all is the fact, which stands out decisively after repeated tests, that the electron has no mass, no association with anything in the nature of matter as we understand the term. It is an electrical charge: apart from its charge it has no existence, no properties. It might be urged that just as the atom has lost its pride of place in the scale of minuteness, so it might be reserved for the physicist of the future to prove that the electron is divisible and conceals a mechanism of its own. But in the electron we reach the ultimate constitution of matter, and the possibility of probing inquiry further in that direction is withdrawn. It is possible, however, to ask whether all mass is electrical, whether there may not be two or more kinds of mass. The answer to this question will depend upon the advance of our knowledge into the nature of the positive charge, about which we know practically nothing. At present it would be rash to draw a definite conclusion and on this ground. The mass of an electron is about $\frac{1}{1700}$th part of the mass of a hydrogen atom; that is to say, it would require 1700 electrons to make up the hydrogen atom. This is not impossible, but experiment has failed to prove it, and, indeed, suggests a very much smaller number. Mr. Crowther has devised and carried through a series of experiments, here described, to determine the number of electrons in the atoms of the various elements experimented upon. This result is ambiguous, owing to the uncertainty of the nature of positive electricity. If the positive electricity is distributed uniformly over a sphere the size of the atom—a very plausible hypothesis—Mr. Crowther's experiments indicate that the number of electrons in an atom is three times that of its atomic weight. If we suppose the positive electrification to be located at the centre of the atom, and that the electrons revolve round it in the manner of the rings of Saturn round the planet, the number of electrons in a hydrogen atom is unity, the number in an atom of any other substance being equal to its atomic weight. The physical consequence of this second result needs not to be emphasised, but for our present purpose it is sufficient to say that the number of electrons in an atom is probably a very small multiple of its atomic weight. Under these conditions it is impossible to assign any appreciable fraction of the mass of the atom to the negative electrons it contains. "For the present," says the author, "our belief in the electro-magnetic nature of all mass remains an expression of our faith that all the varied phenomena with which we have to deal are manifestations of some single principle or essence which underlies them all."

The function of the electron is by no means exhausted. It can be pursued in other relations, and wins a great triumph by explaining the chemical property of valency. It is more than a conjecture that valency is determined by the number of loosely-connected electrons contained in the atom, these electrons being identical with those which produce the dispersion of light. In another connection the electron explains the presence of lines in the spectrum. Balmer's equation receives an explanation, suggestive, if not complete. Light is thrown on the puzzling behaviour of particular lines on the spectrum, and ready suggestions are produced to account for the numerical relationship existing between the spectra of different elements

belonging to the same group of the periodic table. It is not contended that the explanation is complete, or that exact demonstration is provided. It is not well to go too fast, it is not sufficient to explain only some of the phenomena. If our theory is perfect it will explain all. There are still difficulties, but our engine for investigation is powerful. One obvious objection arises from the number of lines in some spectra, to be counted in some instances by hundreds. We have just seen that the number of electrons in an atom is limited, and, it may be, extremely limited. There are not enough electrons to produce the variety exhibited. If, as mentioned, hydrogen has only one electron, it can have only three degrees of freedom and only three modes of vibration; and as these would all have the same period, they would coalesce into a single line. But the spectrum of hydrogen has many lines. Iron has many hundreds, and apparently we have to face a contradiction. Some other hypothesis is needed, and Sir J. J. Thomson is not at the end of his resources. He suggests that the lines of hydrogen and of many other elements are not emitted by the atoms of the elements at all, but by systems which only exist when the gas is thrown into a luminous condition. Here we are permitted a glimpse into the dark and mysterious hinterland, where science is in the making. It may be that the hypotheses of yesterday will be the demonstrated truth of to-morrow. But there is always the equal possibility of losing ourselves in the quagmire of fascinating, but groundless, speculation.

Photo-Electricity. The Liberation of Electrons by Light, with Chapters on Fluorescence and Phosphorescence and Photo-Chemical Actions and Photography. By H. Stanley Allen, M.A., D.Sc. London: Longmans, Green and Co. [Price 7s. net.]

In the progress of every scientific inquiry there comes a time when it is necessary to sift hypotheses, to determine the points of fundamental importance that are firmly established, trace the bearings and connection on cognate investigations, and discover the most promising road for further research. This stage has arrived in the difficult, but fertile, subject of photo-electric action, of which Dr. Allen assures us no detailed comprehensive survey has yet been attempted. A quarter of a century has elapsed since Hertz showed that the incidence of ultra-violet light on a spark-gap facilitated the electric discharge, and led to much of the work that Sir J. J. Thomson, Lenard, and others, have achieved, bringing, in its final development, doubts of the sufficiency of the accepted theory of radiation and of the undulatory theory of light, scientific conclusions that were regarded as unassailable, but now seem to require modification in order to embrace the results of recent observation and deduction.

Professor Allen's book is particularly valuable on account of its complete historical survey of a group of facts that demand the reconsideration of fundamental theories. He makes it possible to trace the steps that experiment has taken for verifying suggested hypotheses, or in providing explanation of observed phenomena. We may charge our memories with the fundamental fact that electrons are liberated in a vacuum where a polished metal plate is illuminated by ultra-violet light, but such an isolated fact is of little importance compared with the mental satisfaction of comprehending how a particular result has been obtained, and of appreciating the wider outlook over the field of research rendered possible by the accumulation of a consecutive series of sound experimental data. There should be, and the author makes it evident that there is, both a great education and a great charm in following the lines of thought that able experimenters have pursued in tracking an important inquiry. In this case the education consists in watching the consummate skill and unwearying patience exhibited, together with the exercise and the control of the scientific imagination. The increase in delicacy of manipulation, the elimination of sources of error, the simplification of the conditions of the problem whose solution is sought, and the attainment of success by following sound lines of investigation, all convey lessons to those who are willing to learn. We do not see what perhaps would prove even more instructive, the failures due to the presence of unsuspected conditions, the trials that prove abortive owing to imperfect realisation of the problem, the plausible, but unsound, suggestions that were sternly crushed by competent criticism and ruthless examination. The charm lies in correctly appreciating the certainty of unexpected results and the bearing on physical problems of these; in the ingenuity shown in changing the conditions of the experiment, and in tracing the variations that follow. To demonstrate the existence of a photo electric current, to make the effect of the negative electrons perceptible, is no mean feat, but such success by no means satisfies the curiosity of the physicist. He wants to know what is their velocity; is it the same for incident and emergent light; how are they affected by varying the conditions of temperature; does a difference of wave-length in the exciting illumination modify the results; how does the orientation of the plane of polarisation operate; what influence does the strength of the electric field exert. These are only a few of the possible conditions to which the photo-electric current has been submitted, without by any means exhausting the ingenuity of experimenters. The field of inquiry is large, has been explored in many ways, and the results are not always accordant. The time has come when it is necessary to collect and to sift. Dr. Allen has undertaken this task and accomplished it satisfactorily, preserving sufficient details to enable the several processes to be clearly apprehended, without obscuring the definite issue.

To those who are content to accept results without knowing the steps in the proof, we may set down the answers to some of the questions that have been propounded. Experiment has demonstrated that the number of electrons emitted, and their velocity of emission, are independent of temperature. *Primâ facie* this result would not have been anticipated, since with increased temperature we usually associate greater velocity; but the rule holds from the temperature of liquid air on the one hand, to about 800 deg. Cent. on the other. With regard to the effect of the intensity and character of the incident light, two important conclusions have been reached: first, that the intensity of the light does not affect the velocity of the electrons; and, secondly, that the number emitted is directly proportional to the intensity of the light. The relation of photo-electric phenomena to the wave-length of the exciting light cannot be stated with the same decision and brevity. If we confine attention to the effect of wave-length on the velocity of emission, we may regard it as proved that the maximum energy of emission is a linear function of the frequency of the light. "For a particular metal a certain minimum frequency is necessary to produce any liberation of electrons at all. As the frequency increases so does the energy of emission, or the positive potential required to prevent the emission."

To attempt to bring home to the uninitiated the care and skill requisite to carry these experiments to a successful issue, and to interpret the result correctly, would prove a hopeless task. It must be understood that the author, in describing the niceties of manipulation, is addressing those who have had some experience. If, too, the collection of facts is attended with difficulty, so the explanation of the phenomena is neither simple nor decisive. That is to say, that the necessary linkage with demonstrated theorems and accumulated knowledge compel the introduction of hypotheses which cannot be verified by unimpeachable evidence, but have to be accepted on the negative ground that they do not contradict any known fact or deduction. In the progressive position of the inquiry, alternative hypotheses are not excluded; but this very uncertainty lends an enhanced interest to the consideration of the processes and mechanism by which photo-electrons are liberated. Of the main fact there is no doubt, the incident light falling upon the metallic surface supplies a source of energy which enables the electron to escape, but the method by which that energy is made operative is not so clear. It may be that the incident light is directly effective, operating as an explosive force, or the electron having some motion in the atom, as shown by the Zeeman effect in modifying the spectrum, has that motion increased to such an extent that it is able to break away from its confinement. In such a case the light would act by resonance, the energy of the orbital motion of the electron being greatly increased by "tuned" light vibration, till rupture of the atom follows. It cannot be said that either view is in opposition to known results.

A fact recognised quite as fully as the photo-electric effect is that of photo-electric "fatigue," or the decrease in activity with lapse of time. This diminution falls off rapidly at first, and more slowly later. In early experiments this fatigue was attributed to the direct action of light, but Hallwachs showed that fatigue could proceed in complete darkness, so that light cannot be the primary cause of the change. It is, however, doubtful whether fatigue effects can be perceived with clean, unpolished metal surfaces in a very high vacuum, or how they may be accelerated or diminished by a change of environment. It is sufficient to say that no less than five distinct theories have been put forward to explain the causes. We have no intention of discussing these suggestions. It will probably be found that fatigue is due to a combination of causes playing different parts as the material and circumstances change. Our object is simply to illustrate the wide-reaching influence of the inquiry, its importance in the general problem of atomic structure, implying the possibility of recasting accepted theories. Professor Allen has done much original work in these delicate investigations, and is thoroughly conversant with the extensive literature. We regret that we cannot accompany him in his researches on the allied phenomena of luminescence and phosphorescence that have led to most interesting results. Similarly, the physical theory of the formation of the latent image of the photographic plate in terms of the electron theory is a promising inquiry. It is part of the larger question of photo-chemical action, generally to be explained most easily by supposing that the action of light is analogous to that of a voltaic cell, or essentially electrolytic.

BOOKS RECEIVED.

Aus Theorie und Praxis des Riementriebes, mit besonderer Berücksichtigung der "Riementriebe Boesner." By Fritz Adolf Boesner. Berlin: A. Seydel. [Price 5 marks.]

Die Tiroler Bergbahnen, technisch und landschaftlich dargestellt. By Karl Armbruster. Vienna, Berlin, and London: Verlag für Fachliteratur. [Price 10 K. = 8.50 M.]

Handbuch der Mineralchemie: Bd. III. 3 (Bog. 21-30). By Hofrat Professor Dr. C. Doelter. Dresden and Leipzig: Verlag von Theodor Steinkopff. [Price 6.50 marks.]

Dictionary of the Inorganic Compounds. Band II., Lief. 17-19 (Schlusslieferung des II. Bandes). By M. K. Hoffmann. Leipzig: Johann Ambrosius Barth. [Price 12 marks.]

The Law of Building, Engineering, and Shipbuilding Contracts, and the Duties and Liabilities of Engineers, Architects, Surveyors and Valuers; with Reports of Cases and Precedents. By Alfred A. Hudson, K.C., assisted by C. S. Rewcastle, B.A., LL.B., Barrister-at-Law. Fourth Edition. Two Volumes. London: Sweet and Maxwell, 3, Chancery-lane, W.C. [Price 3*l.* 3s.]

Nouvelles Recherches sur la Résistance de l'Air et l'Aviation. Par G. Eiffel, Ancien Président de la Société des Ingénieurs Civils de France. Two Volumes (Texte et Atlas). Paris: H. Dunod and E. Pinat. [Price 50 francs.]

Modern Plumbing Practice. Volume I. *An Account of Practical Lead Working and Plumbers' Materials.* By J. Wright Clarke, M.R.S.I., and Walter Scott, A.R.S.I. With upwards of 400 illustrations from the author's drawings and from photographs. London: B. T. Batsford, Limited. [Price 10s. net.]

Electric Traction. By Lionel Calisch, A.M. Inst. C.E., London: Locomotive Publishing Company, Limited, 3, Amen Corner, E.C.; Calcutta: The *Indian Railway Gazette*, 59, Park-street. [Price 2s. net.]

Machine Construction and Drawing. Book II. By A. E. Ingham. London: George Routledge and Sons, Limited. [Price 3s. net.]

Rapid Methods for the Chemical Analysis of Special Steels, Steel-Making Alloys, and Graphite. By Charles Morris Johnson, Ph.M. Second Edition, re-written. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 12s. 6d. net.]

Filters and Filter-Presses for the Separation of Liquids and Solids. From the German of F. A. Buhler. With additional matter relating to *The Theory of Filtration and Filtration in Sugar Factories and Refineries.* By John Joseph Eastick, F.I.C. London: Norman Rodger, St. Dunstan's Hill, E.C. [Price 12s. net.]

Das Trocknen und die Trockner. Anleitungen zu Entwurf, Beschaffung und Betrieb von Trocknereien für alle Zweige der mechanischen und chemischen Industrie, für gewerbliche und für landwirtschaftliche Unternehmungen. Von Ingenieur Otto Marr. Zweite Auflage. Munich and Berlin: R. Oldenbourg. [Price 14 marks.]

The Tinplate Industry, with Special Reference to Its Relations with the Iron and Steel Industries: A Study in Economic Organisation. By J. H. Jones, M.A. London: P. S. King and Son. [Price 7s. 6d. net.]

Data-Book for Shipbuilders and Naval Architects. Second Edition. Revised by the Author. Trieste: Libreria Ettore Vram. [Price 2s. 10d., post free.]

SETTING OUT WORK.

By R. H. LEE PENNELL, Assoc. M. Inst. C.E.

(*Concluded from page* 118.)

IN the previous article the setting out of a straight line and measuring its length has been fully discussed. There is, however, a little to add with regard to theodolite stations and the marking of the points as set out.

On a very large work the main theodolite station is often in a small building specially constructed for the purpose, and the theodolite is never moved from its position, but is permanently fixed on the axis-line of the work. But more usually after every day's work the instrument is taken back to the office, the theodolite station being in the open, and formed of a brick pillar of a convenient height for the eye, and with a pin of about ¼-in. iron bar, built into the middle and centre-punched. The theodolite stands on its levelling-screws on top of this pillar.

With some theodolites it is very difficult to see when the instrument is exactly over the centre point. Therefore, when using a theodolite which has no centre plate, instead of the pin on top of the pillar, it is often more convenient to bolt down a flat iron or lead plate, with the positions of the levelling-screws of the theodolite slightly bored out in its surface. The theodolite can always be set up without trouble on this plate by simply standing the levelling-screws in the cavities bored in the plate for them. The centre of the triangle of which these holes form the apices must be punched in the plate, in order to have a point from which to measure distances. The pin or the centre plate (whichever is adopted) must be properly bolted down into the brickwork, and not simply secured by cement rendering on the top of the brick pillar.

With regard now to the actual marking of the points, set out as described in the last article, the most satisfactory points are copper tacks with large heads let into cement pats. The cement pats should not be formed of a very rich mortar; 2 : 1 or 3 : 1 sand and cement is quite rich enough; if they are made richer, they are much more likely to crack in the sun and get broken up. The masonry on which they are to be placed must be carefully cleaned and watered, and until properly set they should be covered with a wet sack. The pats should be made just before the work of setting-out is started, and the tacks put in while the pats are still soft. The heads of the tacks have then to be centre punched to give the actual point required.

The quickest way to do the work is to go over the line three times.

1. Give the line for the position of the pats. This does not require much accuracy, and can be done very quickly.

2. Start from the beginning again, and give the position for, and put in, the tacks.

3. Punch the heads of the tacks.

Working in this order, the cement pats should usually be hard enough set to allow of centre-punching the tack by the time the engineer is ready to do this operation. If there are only one or two pats to do, warming the cement before mixing, or mixing the cement with hot water (from a boiler, for example) instead of with cold water, shortens the time of setting enormously.

It is better to get the centre-punch marks on the tacks before the cement sets quite hard, as sometimes a tack requires moving over a little. Finally, make the workmen understand that to obliterate a mark, when obliteration could be avoided, is a sin of great magnitude. Some men seem to think that an engineer's marks are specially meant to drop ashlar stones on to.

Setting Out Curves.—It is not proposed to touch on railway curves in these articles, as that is a special subject in itself, and, moreover, there are many excellent text-books dealing with the matter. For curves of quite small radius, say up to 100 ft., and when it is possible to get at the centre point, it is very much quicker to sweep the curve out with a chain or wire than to set it out by ordinates from a tangent or chord. To do this proceed as follows:—Set out a right angle from the tangent point, and on this line tape the length of the radius so as to get the centre. At the centre put in a peg or, if possible, an iron pin. Fasten a wire to the pin and lay it back over the radius-line just measured, and mark the length of the radius on it. Then set out the curve with this wire.

To carry out the above a very even piece of ground, free from obstructions, is desirable, and this you seldom get. But it is often possible to trace the curve in the way described above, if the wire is held up so as to be clear of obstacles. To do this a chairman must stand at the centre point to hold up the wire, using a plumb-bob; and if the length of the radius is too great to pull the wire taut easily, a spring-balance must be put on, and when marking the length of the radius on the wire the tension of the wire must be noted, and this tension kept the same when plumbing down to mark the points on the curve.

If it is impossible to reach the centre of the curve, but it is possible to get at the intersection

Fig. 7.

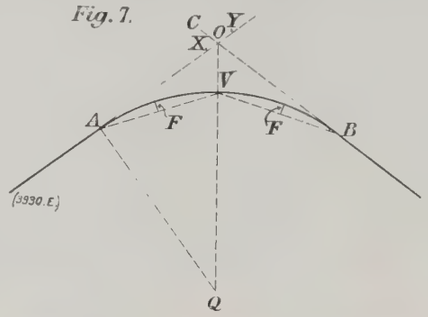


Fig. 8

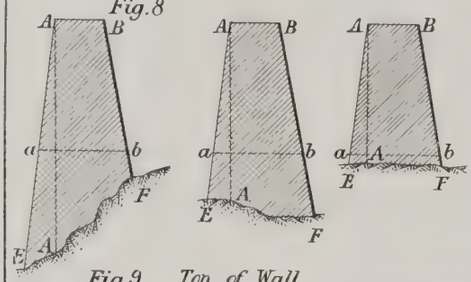


Fig. 9. Top of Wall

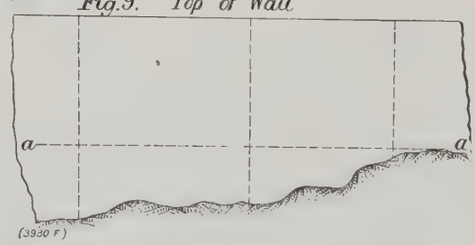
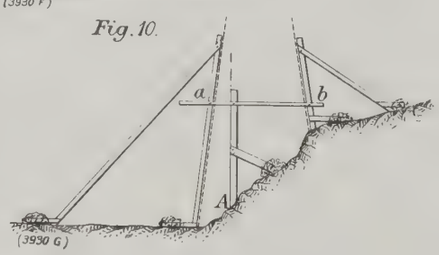


Fig. 10.



of the tangent points, the central point on the curve can very quickly be obtained, giving three points on the curve altogether, the two tangent points and this central point.

Firstly, to obtain the intersection point of the tangents. Referring to Fig. 7, suppose the theodolite is set up at A, one tangent point, and B is the other tangent point. With the theodolite put in the two points X, Y, keeping them on each side of the tangent B, C, which can be ranged up by eye. Move the theodolite to B, stretch a string from X to Y, and put in the point of intersection O.

Set up at O, bisect the angle A O B, and put in the point V.

$$\text{O V} = \text{radius} \times (\text{cosec. A O Q} - 1).$$

Since A O = radius × cot A O Q, the point O might be put in direct, but the method described usually gives a sweeter junction at B in practice. Two other points on the curve can now be easily obtained, if required, by measuring the chord A V or V B, and setting out the offset F. With short chords on curves with large radii,

$$\text{F} = \frac{(\frac{1}{2}\ \text{chord})^2}{2\ \text{radius}}.$$

Otherwise, more accurately,

$$\text{F} = \text{radius} - \sqrt{\text{radius}^2 - (\tfrac{1}{2}\ \text{chord})^2}.$$

There are many other various methods of setting out curves, but since, as previously stated, the matter is fully treated in many text-books and pocket-books, it is not necessary to go into them here. Before setting out work, curves or otherwise, it is well to consider the degree of accuracy required in the finished work when built.

Taking, for example, a curving parapet wall. All that is usually required is a wall that will look very nice when finished. This can be assured, without having to set out a large number of points on the curve with a theodolite, by passing a string over the points set out and working the string into a nice curve between these points by eye, keeping it in the required position by bricks or otherwise (the string will really be in a series of short chords, but this will not be found misleading).

Sometimes, however, extreme accuracy may be essential, as, for example, is the case when it is required to set out the curve for the masonry at the tail end of a swing bridge. In this case the masonry must be absolutely true to radius all round.

The points set out on the curve should be about 5 ft. apart. A wooden template over 7 ft. 6 in. long should then be made to the exact radius. Lay this over the first two points and mark a third point on the curve about half-way between the first two points, then move the template about 2 ft. 6 in. forward. Bring the template up to agree with the new point just marked out and the third point as originally set out on the curve. If the curve has been correctly set out in the first place, the template and the second point will agree. In this way the curve can be checked all the way round, by always working the template against three points.

A path of cement mortar should then be laid round the curve, and by means of the template the circumference of the curve should be scribed in the mortar. As described when setting out a straight line, the curve set out should be concentric to the required curve and of a smaller radius by something less than 2 ft. If the curve is of short radius and it is possible to set it out direct from the centre point with a wire, as previously described, the use of a template may be dispensed with altogether.

Even after all these precautions, it is better not to set the top ashlar course, which almost butts against the bridge, until the bridge is erected.

Finally, it must be remembered that a curve is, as a rule, easier to set out than a long, truly straight line, because a slight error on a curve will probably not show, and if it does, it can usually be worked out in the building, so as not to show, whereas a very slight error in a straight line shows at once.

Setting Out Walls with Battered Faces on Uneven Foundations. — If the wall has only one face battered, the other face being vertical, the job is quite a simple one, and the method of setting such a wall out can be easily understood by following the description of the setting out of a wall with battered faces on both sides.

In this case the top width A B (Fig. 8) is the only constant dimension. If the wall is straight or curved, the points A and B follow the straight line or the curve. But the toe of the wall—*i.e.*, the points E and F—do not follow any regular line; they depend upon the level of the foundations. E and F, however, are the points the masons want marked off from which to build.

In Figs. 8, 9 and 10, the walls are seen to rise from a natural rock foundation, and they illustrate an actual case. But more usually the natural foundation is not so good as this, and a certain amount of excavation in earth or rock has to be undertaken before a suitable foundation is obtained, and the foundations are stepped up or down, forming even terraces on which to start building. This makes the setting out easier, or, rather, quicker; but the method of doing the setting out is the same in either case. Figs. 8 and 9 show respectively three cross-sections and an elevation of the wall to be set out. The points required on the ground are E F, E F, E F (on the cross-sections).

Choose any axis line A (Fig. 10). It is convenient to choose one of the top arrises for this line. Mark the point A on the foundation. Erect a vertical timber profile of a height at least just above the highest foundation-level on the section. Mark any convenient reduced level (above the highest foundation-level) on the profile.

Calculate the width of the wall *a*, *b* at this level, and nail on a cross-piece *a*, *b* (Fig. 10). Mark off on this cross-piece the calculated width of the wall *a*, *b*

(Fig. 8). At these points on the cross-piece nail profiles to the correct batter of the wall with their ends touching the ground. Nail on small feet, and build the feet in with a little masonry. Nail on struts, check and adjust the profile for batter (it is better to put in only one nail fixing profile to cross-piece in the first instance), and then build a little masonry over the feet of the struts. Mark the level of the top of the wall on these profiles, and the work is done. The above is much the quickest way of doing a rather awkward job.

The level of the cross-piece a, b may conveniently be the same for five or six profiles, and the calculated width a, b will therefore be the same for all these profiles whatever the level of the foundation may be. For the sake of simplicity, it has been stated that the distance a b should be the width of the wall at that level. The profiles should really be set 2½ in., or more, wider (depending upon the projection of rock face on the building stones) on each side.

Taking a definite example for the width a b of a wall with—

Top width	= 3 ft.
Batter	= 1 to 6 and 1 to 8.
Top	= R.L. 60 00.
a b	= R.L. 52.00.

The width a b of the wall will be

1 ft. 4 in. + 3 ft. + 1 ft. = 5 ft. 4 in.,

and allowing 2½ in. on each side for rock face, the width a b between the profiles will be 5 ft. 9 in. The vertical piece A (Fig. 10) should be left in as long as possible, as it helps to support the profile, and as the bottom courses of the wall reach the profiles, the profiles should be spiked into the wall, care being taken not to disturb the batter.

To set and check the batter of the profiles a wooden frame should be made, like a large set-square (Fig. 11), the angle at X being made to the correct batter. The frame is most easily used with an ordinary spirit-level on the horizontal arm, and this level may, conveniently, be permanently screwed on.

If the top of the wall is on a gradient, instead of being horizontal, the distances of the profiles from the start of the wall must be measured, and the reduced level for the top of the wall calculated for each profile, in order to be able to calculate the width of the wall at a, b.

Setting out a wall of this description by this method reduces the instrument work to a minimum, and therefore the carpenter and mason, who are going to set up the profiles, can do most of this work without the help of an engineer.

The engineer first marks the points A on the ground, and then leaves the men to erect the verticals. (In setting the vertical timbers the same edge ought always to be on the mark—*i.e.*, looking one way, either always the left, or always the right-hand edge must represent the vertical line up from A, and all measurements must be taken from this edge.)

The verticals being erected, the engineer puts the level on in pencil, calculates the length from his axis (represented by one edge of the vertical) to a and to b, and writes these distances on the vertical timber. He can then leave the men to do the rest of the work themselves, as the profiles, when erected, can very easily be checked by eye to see they are all at the same batter. These walls are not really so difficult to set out and build as walls with vertical sides, because as the wall approaches the top any slight error in line can be corrected by slightly altering the batter; and this alteration, if small, will not strike the eye in the way an alteration would to a vertical face.

Transferring a Bench-Mark Across a River.—This is often required when work is started from both banks of a river at the same time. Very often this can be done directly by using a theodolite instead of a level, as the telescope of the former is the more powerful of the two.

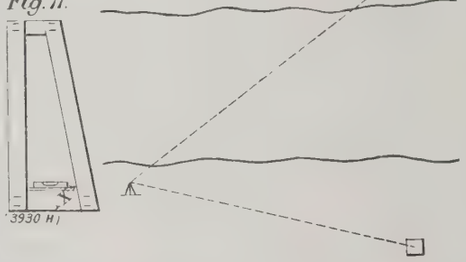
The back-sight and the fore-sight must be equalised as far as possible in regard to distance by making the back-sight as long a sight as possible without making the fore-sight such a long sight that the staff cannot clearly be seen (see Fig. 12). But if the river is too wide to see clearly across, other means must be adopted.

On a very still day, with no wind at all, the water-level may be taken as horizontal, and the level transferred by this means; but this is not a very certain method of doing the job. This method must not be thought of on a windy day, as the wind will back up the water on one side of the river more than on the other; also, a fairly straight reach of the river must be chosen, as a sudden bend will also back up the water against the bank forming the outer circumference. However, on a calm day, across a straight reach of the river and with great care, an accurate result can be obtained. The other method of transferring the bench-mark directly is to anchor a barge in mid-stream, and use this as a change-point for the staff.

A man with a level should be on each bank. The man on whose side the bench-mark is reads the bench-mark and books it as a back-sight, while the man on the other bank reads the point on which it is required to establish the bench-mark, booking it as a fore-sight, they then at a preconcerted signal both read on to the staff held on the barge, the first man books his reading as a fore-sight, and the other man as a back-sight. As a check this last reading should be conjointly repeated, and it forms a better check when doing so if the man on the barge chooses another change-point; then both men have to read different figures on the staff to those they had at the first reading, and so the repetition of an error is avoided. (It is well to remember in this connection that mistakes are more often made in the unit figure or in the first decimal place than elsewhere, as the leveller is so intent on getting the last decimal place correct that he often does not

Fig. 12.

Fig. 11.



pay sufficient attention to the clearer figures, and so sometimes gets them wrong.)

In order that the two levellers may read conjointly two staffs may be tied together back to back, care being taken that the bottoms of both staffs are absolutely flush. A pencil-mark should be made across them at a convenient height to be seen by the staff-holder, and he can then at once detect if either of the staffs has slipped. Of course, one staff only might be used, and first one man read it and then the other, but the method described is better, as even a big barge, when floating, is not always absolutely still even on a calm day.

The staff-holder must have a spirit-level in order to keep the staff vertical. As soon as the constructional works progressing from each bank approach each other sufficiently close to be able to level direct across the gap, this should be done at once, in order to check the work as set out from the transferred bench-mark.

Should the transference of the bench-mark have had to be made under unfavourable conditions, climatic or otherwise, in order to start the constructional work, the bench-mark should be checked at the first favourable opportunity.

If it is found that an error has been made, and that work has been set out from a bench-mark which is valued (for example) at too high a reduced level, the work as built to such setting out will not be too high, but too low. This is an important point, as a misunderstanding might lead to a serious mistake being made. For example, if there should be a bench-mark which has been regarded as 22.00 R.L., when setting out work, but which is really 22.10 R.L., the work set out will be 0.10 *low*, not 0.10 *high*. Because, continuing the example, suppose the work set out is supposed to be 19.00 R.L. Suppose the back-sight on the bench-mark is 1.50. The level of the instrument (H.P.C.) is booked as:—

	22.10 + 1.50 = 23.60
It is desired to set out a point at ...	19.00
The staff is therefore moved up and down on the profile until there is read	4.60

Putting the figures the other way:—

23.60 − 4.60 = 19.00

But it has been subsequently found that the bench-mark is not 22.10 R.L., but 22.00 R.L.

The level of the instrument was therefore:—

	22.00 + 1.50 = 23.50, not 23.60
There was read on the staff ...	4.60
The work is set out therefore at...	18.90, not 19.00

On looking at these figures this all seems very obvious, but in the writer's own experience a man started hacking out his concrete because he said that the bench-mark from which he had been working was 3 in. high. As has been seen, this made his work 3 in. low, not high, as he imagined. The bench-mark was not high; he had given it too high a value.

General Remarks on Setting Out with a Level.—When setting out a long line of levels on profiles, marking the profile with a pencil each time, a man is very apt to get a slightly falling line instead of a horizontal line, because at the change-points the staff has to be moved from the mark in order to turn it round, so as to face the new position of the level. When making the pencil line beneath the staff, the line is often the fraction of an inch below the bottom of the staff, just in the same way as ruling a line on paper, the line and the edge of the ruler seldom absolutely coincide, and when the staff is moved round and replaced, the chain-man is careful to put it right down on to the pencil-mark, so that there is apt to be a slight step down in the level of the line at each change-point. The remedy is to get the chain-man to be careful to see that the pencil-line he makes actually touches the bottom of the staff.

As already stated, the staff-holder should always work with a spirit-level, in order to be able to see that he keeps the staff truly vertical. As in surveying, the fore-sight and the back-sight should be reasonably equi-distant; when this is impossible to manage and real accuracy is important, adopt the following method.

Read your back-sight and fore-sight as usual, the fore-sight will be the mark you are setting out. Then pick the level up and turn it bodily round, level it up, and repeat the two readings, back-sight and fore-sight, again. (The readings on the staff will, of course, both be different, since the level has been moved.) Then go to the point where the chain-man has put in the level marks—*i.e.*, the fore-sight—and if the two levels agree, the mark is certain to be correct. If the level is slightly out of adjustment, the two marks will not agree, in which case take the mean.

If you are using a Y level, the telescope only need be reversed. But Y levels are deservedly not very popular, and the above method forms really a better check, as not only does it compensate for any error in the adjustment of the level, but it also checks any personal error in the reading of the staff, as the staff figures read are not the same since the R.L. of the instrument has been altered.

If you cannot read direct from the bench-mark to the point you wish to set out, but have to change, the levels on the fore-sight and back-sight should be repeated each time as described above. In this case the method described is much better than levelling up from the bench-mark, putting in the mark, and then levelling back to the bench-mark in order to check the work, because it saves so much time.

It may be mentioned here that it also often saves a great deal of time in surveying work, since the leveller has only to walk one way, and can go back by train, perhaps. To save time, two staffs should be used.

Setting Out Submerged Work.—The following methods can be applied to almost any class of construction below water, but in order to make the description as clear as possible the definite example of setting large concrete blocks below water will be taken.

Suppose the work it is required to set out is in the middle of a river, for the piers of a bridge, or in the sea for an island breakwater. The staging is the first thing to set out. The pile-driving barge is first towed out and its position fixed by means of triangulation. It usually saves a lot of time if an engineer goes out on the barge with a box sextant, and so can direct the steersman to the approximate position required, and the barge can then be manœuvred into the exact position by triangulation from the shore. The method of doing this is exactly the same as is employed for the fixing of the position of a boat when taking current observations or soundings, and as it is hoped that it may be possible to give some notes on this subject

at a later date, the method will not be further discussed here.

The position of the barge being fixed, the piles for the staging are driven. The positions of the piles in the first dolphin are carefully watched, as when these piles are driven and braced the dolphin forms an island base, from which the positions for the remaining piles can easily be determined. The staging having been completed and the cranes erected, &c., the setting out for the first blocks has to be undertaken.

A long baulk of timber is first put down by the crane. The timber is weighted to sink, and is set approximately square to the line of the proposed work, and close to the line where the first set of blocks are to be laid.

Wires are then attached to the timber at A and B (see Fig. 13) by dress divers, and the wires are plumbed up from the staging. By means of these wires the amount the timber is out of square is obtained, and also the distance the timber is from

Fig. 13.

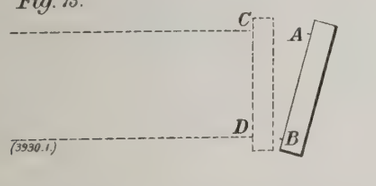


Fig. 14.

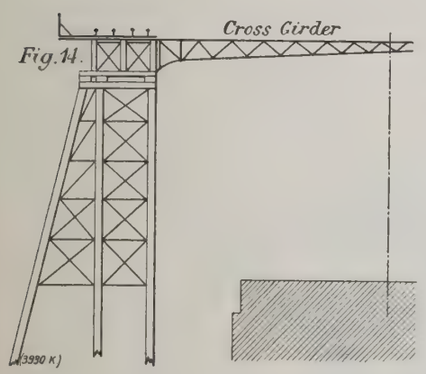


Fig. 15.

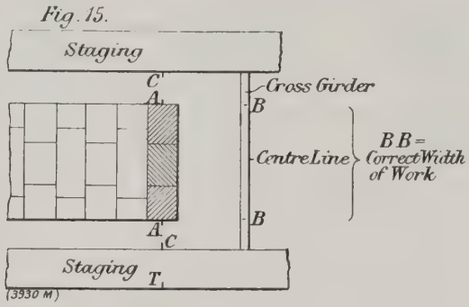
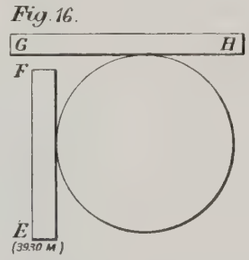


Fig. 16.



the required line for the first set of blocks. The distances A C and B D required to put the timber square and up to the first line of blocks is given to the divers, who drive two pegs into the ground at C and D and move the timber up to them. The timber is then carefully checked by means of wires as before.

The baulk of timber having thus been worked into absolutely the correct position, the distance of the pegs C and D from the edge of the proposed work is given to the divers, and they can then set the blocks against the timber, and they also know how far to extend the work on either side. A cylindrical caisson can be set in exactly the same way by using two baulks of timber E F and G H (see Fig. 16).

To continue the block-setting. Figs. 14 and 15 show a half elevation and plan of staging for the block-setting in a breakwater. It is required to set the blocks shown hatched in Fig. 15. The blocks are lowered into position against the work already set, having previously had two pins A A driven into them about 12 in. from the face. Divers attach wires to the points A A, which are brought up vertically out of the water. The wires are brought up vertical by testing with the theodolite. (This is the reverse operation of testing a theodolite with a plumb-bob and wire; in this case the theodolite is in adjustment, and you plumb the wire thereby.)

Then with the theodolite throw the verticals from A A on to the cross-girder at B B. These points B B on the cross-girder have been set out from the centre line, and are the limits of the work. If, then, the projections of the verticals from A A cut the cross-girder at the points B B, as described, the blocks are right for line; if not, the blocks must be moved and the operation repeated. Then move the theodolite to T and range line A A to C C on the staging.

Marks 100 ft. apart are put on the staging as the work advances. The distances from C C to the nearest 100-ft. marks are constantly measured and compared with the progress plans. By this means the creep of the work is obtained. If the work creeps evenly, it does not matter, as the bond is not affected; but if it creeps unevenly, compensation blocks must be specially made. The compensation blocks correspond to closers in brickwork.

In the foundations, and below water-level, a latitude of 3 in. for face-line and 6 in. for square is not an unreasonable allowance for big work, but above water-line the work should be practically exact.

When planning how to do the setting out of work under water it must be remembered that the divers will be able to see practically nothing, as even if the water is clear to start with, the mud will very soon get stirred up. Also operations should be so arranged that the divers are brought to the surface as seldom as possible, because compression and decompression are the times of trial to a diver; when he is once down it is fairly comfortable.

This last note on the setting out of work under water has been given with the idea only of setting before the reader the general principles of the way in which this work is often done. The methods involved are not nearly so fully described as those adopted for other kinds of work, because these articles are only written for men who have not yet had much experience on works, and it is unlikely that they will be asked to undertake entirely alone such important work as the above. But directly they get out on to works they will probably be asked to do unaided the simpler setting-out operations previously described in these articles, and it is hoped that the present notes may prove of some help to them.

THE ALEXANDRA DOCK EXTENSION AT NEWPORT.

(*Continued from page* 117.)

The construction of the dock extension and the new lock and its equipment having been described in detail in our previous articles, we now propose to deal with some features of the dock equipment. We may begin with the coaling plant. This is situated on the north side of the extension, and consists of four hydraulic hoists built by the East Ferry Road Engineering Works Company, Limited, of Millwall, E. As we have already mentioned, three further hoists are on order, and will be placed two at the west end of the north side, and one on the west side, as indicated in the plan of the dock given in Fig. 1, on page 33 *ante*. These new hoists are being supplied by Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, of Newcastle-on-Tyne, and are designed for a gross load of 23 tons each. Two have a range of 70 ft., and the other of 60 ft. The method employed for handling the wagons to and from all hoists is the same. A series of approach-roads is carried to each hoist. The loaded wagons come up at quay-level, running down a slight gradient to the hoist. After passing over a weigh-bridge, they travel on to a turntable, on which, if they come up wrong way round, they are reversed. They then pass to the cage of the hoist, are lifted and tipped, and then lowered to the level of an overhead viaduct, on which the empties pass over a second weigh-bridge and travel away down a slight gradient.

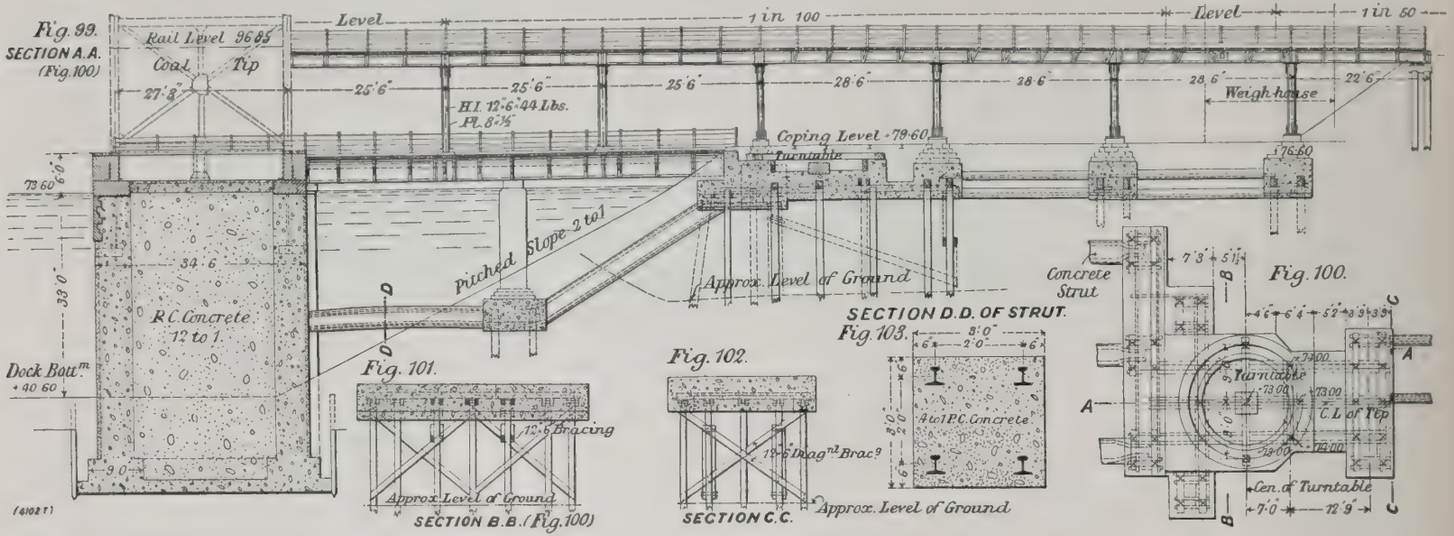
The hoists, supplied by the East Ferry Road Company, are illustrated in Fig. 104, on page 178. They have a lift of 60 ft., and are arranged to deal with loaded wagons of a gross weight of 23 tons. The hoists are, however, strong enough to lift wagons of 30 tons gross, and the cylinders are so designed that they can be bored out to a larger diameter in future, if it is desired to deal with these larger wagons. The cage of the hoist works between vertical guides, and is lifted by two wire ropes which pass to the two lifting-cylinders which are fixed vertically on the side of the framework. There are two cylinders, having rams respectively 18½ in. in diameter and 8 in. in diameter. The smaller cylinder is permanently connected to the mains and balances the weight of the cage. The other cylinder is valve-controlled and lifts the load. The stroke in both cases is 30 ft. The tipping-cylinder has a 14-in. ram, with a 9½-ft. stroke. It is fixed above the lifting cylinders, and can lift the end of the cage through a vertical height of 19 ft. The chute is raised or lowered by locking it to the cradle, and its outer end is controlled by an hydraulic motor fixed on the top of the main framework. Cranes are fixed on either side of the hoist, as is clearly shown in the illustration. One is of 3 tons and one of 5 tons capacity. They are fitted with hydraulic lifting and slewing-cylinders. The 5-ton crane is used for manipulating an anti-breakage box, the method of working being to tip the first few truck-loads into the box which is held below the chute by the crane. These loads are lowered into the hold, and form a cushion on to which subsequent tippings fall. We should add that these coal-hoists were installed under the superintendence of Mr. J. Pattinson, M. I. Mech. E., the chief engineer of the Dock Company. Mr. Pattinson has now retired, and his position is held by Mr. T. W. R. Pearson, M. I. Mech. E.

There is an interesting piece of constructional work in connection with the foundations for these coal-hoists to which we may refer. As will be realised from what has been said in our earlier description, the hoists and the approaches thereto are situated entirely on made ground. The boundary of the dock on the north side is formed by a slope of about 2 to 1, which is faced either with rubble or squared stone, and has a concrete toe. The back of the slope is formed with hard, dry filling. Each hoist is carried on a concrete tower, of which one is shown in section on the left-hand side of Fig. 99, on page 178. The towers have brick copings and facings at the top, and their foundations are carried down to the gravel. As will be seen from Fig. 99, they stand at the bottom of the slope, and their tops are level with the quay. Half-way up the slope there are concrete piers serving as a support for the lower viaduct that connects the towers with the quay. These piers are carried on piles driven down to the gravel. The turntable on the quay and the piers for the upper viaduct are carried on a concrete raft which lies directly on the dry filling, and is supported by a substructure of pile-work, of which some end views are given in Figs. 100 and 101. The concrete raft, the intermediate piers, and the towers are tied together by a series of ferro-concrete members, and the tops of the intermediate piers are similarly tied together, as shown in Figs. 99 and 102. One of the ferro-concrete members is shown in cross-section in Fig. 103. The whole arrangement results in a more or less self-contained structure, and effectively prevents any movement of the raft or intermediate piers which might possibly result owing to instability in the made ground.

The south side of the dock extension, as we have already mentioned, is laid out for the handling of a general goods traffic. A transit-shed has already been erected at the east end, and further sheds will be put up as occasion warrants. The position of the existing shed is shown in Fig. 1, on page 33 *ante*. The whole south quay is further equipped with a series of railway sidings, while hydraulic wharf-cranes have been put in at the east end. The cranes are of 3 tons and 6 tons capacity, and are of the travelling type. We made reference to the tunnel carrying the hydraulic pipes and to the ferro-concrete road on which the cranes work in the first article of this series. We now illustrate the shed in Figs. 107 and 108, on page 179. It stands back some distance from the edge of the quay, sufficient

THE ALEXANDRA DOCK EXTENSION AT NEWPORT.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C. E., WESTMINSTER, ENGINEERS.



to give adequate wharf room and allow a line of rails to be laid on the dock side of the sheds, as shown at the left-hand side of Fig. 107. The floor of the shed is raised above quay-level to allow of easy loading of trains, and, as will be seen, a second line of rails is laid at the other side of the shed, but under cover, to allow of loading being carried out with protection from the weather. The arrangement is well shown in Fig. 108.

The shed is carried largely on made ground, which has been piled for the heavier foundations. The floor is of concrete faced with granolithic paving. It lies directly on dry filling rolled hard. The shed itself does not require a great deal of comment, and the general lines of its construction will be followed from our two illustrations. It is a steel structure, with rolling shutters forming the side towards the quay, and a brick screen the other side. The roof is of glass and slate. An unusual feature in the roof principals is the use of channel-iron bottom members. This arrangement, which can be seen in Fig. 108, has been adopted so that overhead runways may be fitted to transport goods across the shed for entrainment or stacking.

Another feature in connection with the dock extension, which we illustrate this week, is one of the mooring-buoys, of which sixteen are anchored in various positions in the dock. The construction of the buoy will be quite clearly followed from Figs. 109 to 115, on page 180. As will be seen, the buoy is cylindrical, and has two elm fenders, 10 in. by 6 in., fixed all round it. The fenders are secured by angle-iron brackets and through bolts. The buoys are secured to the dock bottom either by mooring-screws or concrete blocks. Both arrangements are illustrated in Fig. 116. The concrete blocks were used for those moorings which could be put in before the admission of water to the dock, while the screw type was adopted for those put in afterwards.

The greater part of the remainder of the illustrations we publish this week refer to the new rolling road and railway bridge which has been constructed at the river end of the old South lock. Drawings of the bridge and various of its details are given in Plate XVIII., while further details and general views will be found on page 190. This bridge handles the whole of the traffic coming to the east and south sides of the extension dock. A rolling bridge had to be adopted, as the exigencies of the site practically dictated some such construction. A swing bridge could not have been accommodated. The lock which the bridge spans is shown in cross-section in Fig. 118, on Plate XVIII. It is 72 ft. wide. The bridge, however, has a horizontal travel of 107 ft., having, of course, an overlap when in position over the lock, and being drawn back well clear of the lock side in its other position. The bridge is controlled hydraulically. Before being drawn back, it is lifted vertically by four cylinders, and is then drawn by ropes attached to the horizontal cylinders. These arrangements we will refer to more in detail in a moment.

As will be seen from Figs. 118 and 119, the whole arrangement is carried by a concrete pier abutting the old lock wall, and carried down to the marl, by six concrete-filled caissons and by four groups of pitch-pine piles. The bridge is carried by two main bogies nearly on the line of the centre of gravity, and by two tail-wheels. Most of the weight comes on the bogies, and the cylinders, which lift the bridge through the bogies, are fixed above the concrete

Fig. 104. Coal-Shipping Hoist.

THE ALEXANDRA DOCK EXTENSION AT NEWPORT; ROLLING BRIDGE OVER THE SOUTH LOCK.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C. E., WESTMINSTER, ENGINEERS.

(For Description, see Page 177.)

Fig. 118.

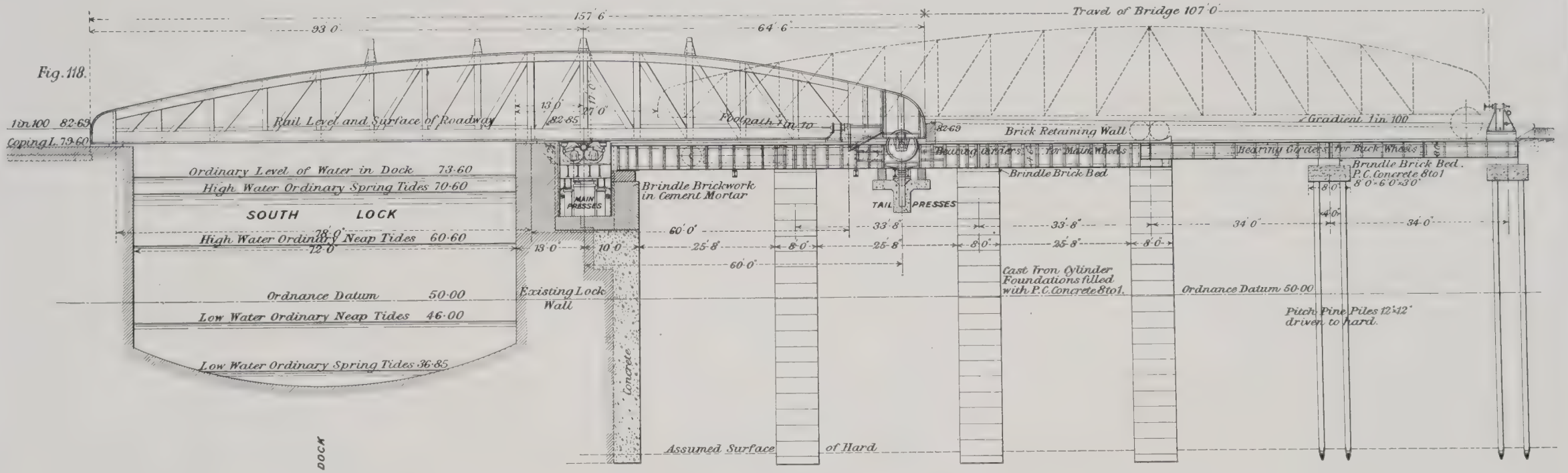

93'0"
157'6"
64'6"
Travel of Bridge 107'0"
Rail Level and Surface of Roadway
Footpath 1 in 10
Brick Retaining Wall
Gradient 1 in 100
Coping L. 79·60
Ordinary Level of Water in Dock 73·60
High Water Ordinary Spring Tides 70·60
SOUTH LOCK
High Water Ordinary Neap Tides 60·60
Ordnance Datum 50·00
Low Water Ordinary Neap Tides 46·00
Low Water Ordinary Spring Tides 36·85
MAIN PRESSES
TAIL PRESSES
Brindle Brickwork in Cement Mortar
Brindle Brick Bed
Brindle Brick Bed. P.C. Concrete 8 to 1
Existing Lock Wall
Concrete
Assumed Surface of Hard
Cast Iron Cylinder Foundations filled with P.C. Concrete 8 to 1.
Pitch Pine Piles 12"×12" driven to Hard.
TO DOCK

Fig. 119.

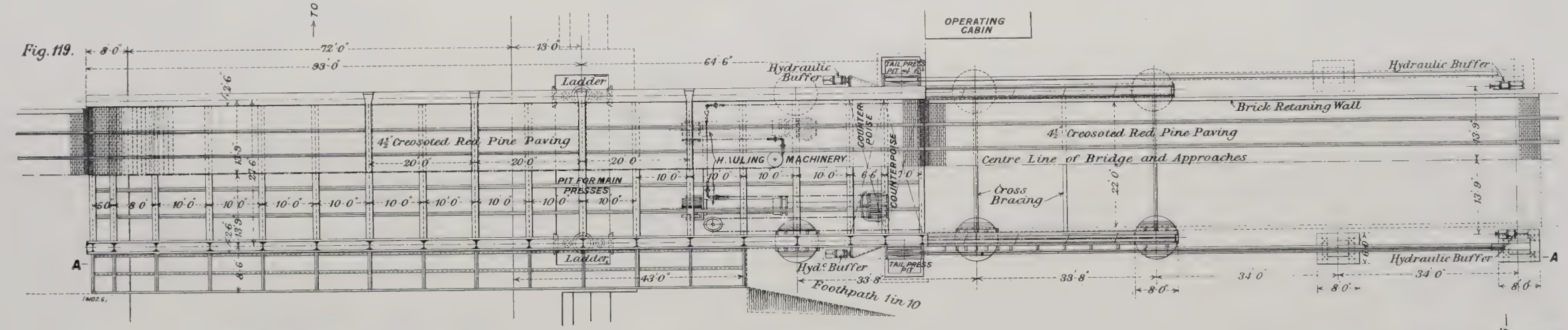
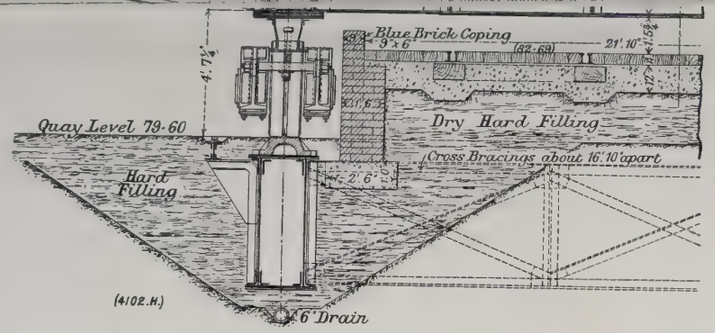


Fig. 120.

Fig. 121. INSIDE ELEVATION

Fig. 122. OUTSIDE ELEVATION



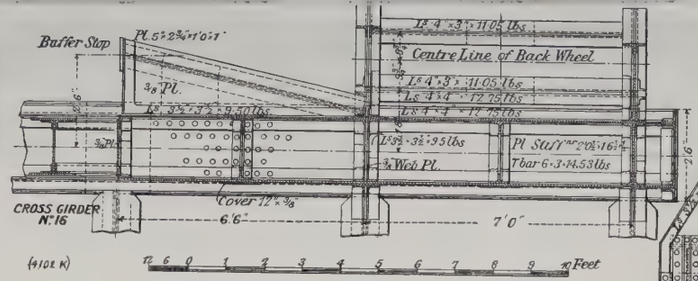


Fig. 124. SECTION N° 18.

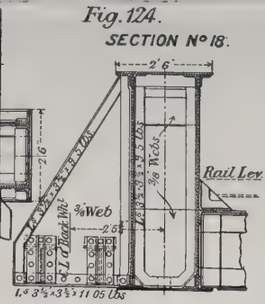


Fig. 125.

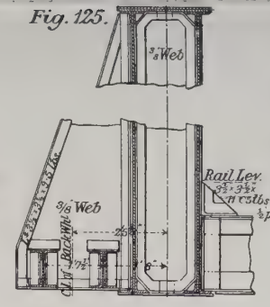


Fig. 126. SECTION N° 16.

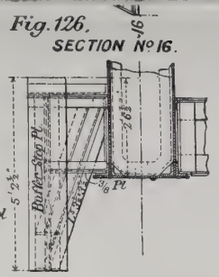


Fig. 127.

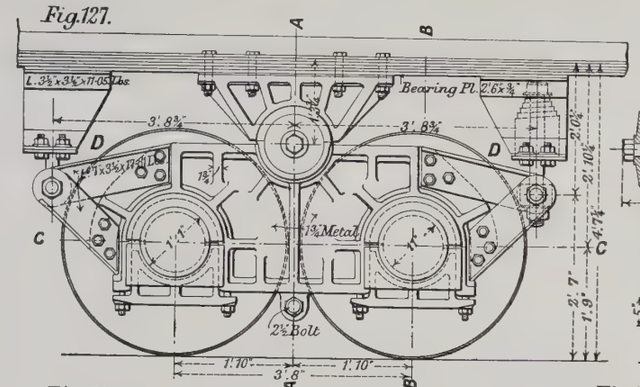


Fig. 129. SECTION A.A

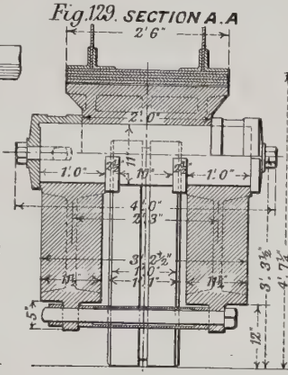
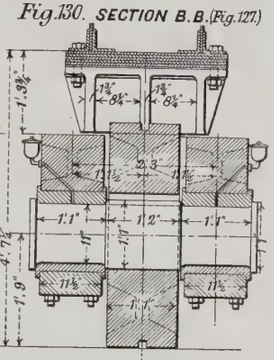


Fig. 130. SECTION B.B. (Fig. 127.)



SECTION X.Y. Coping +79·80 Fig. 135.

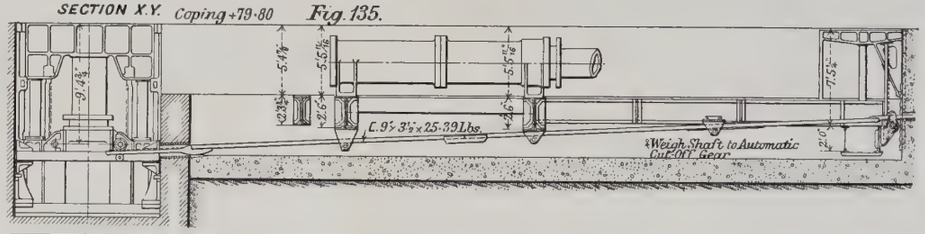


Fig. 128. PLAN AT D.D. & C.C.

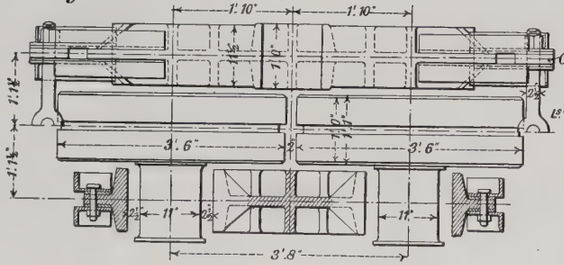


Fig. 131.

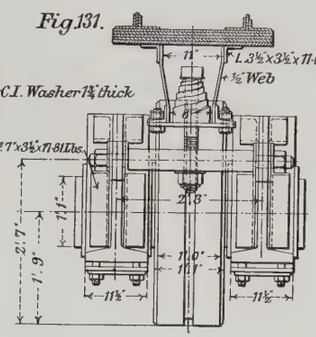
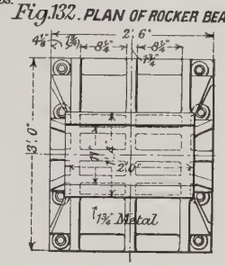


Fig. 132. PLAN OF ROCKER BEARING.



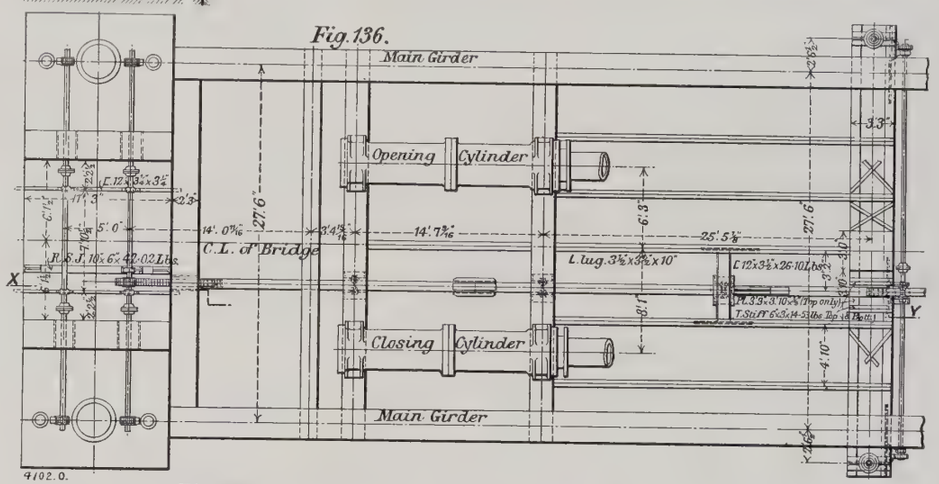


Fig. 133.

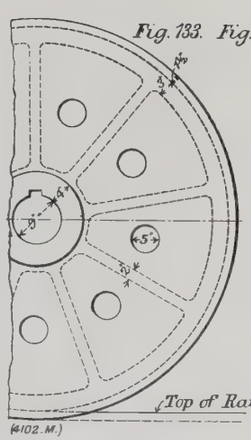


Fig. 134.

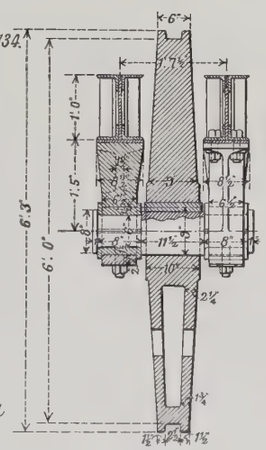


Fig. 137.

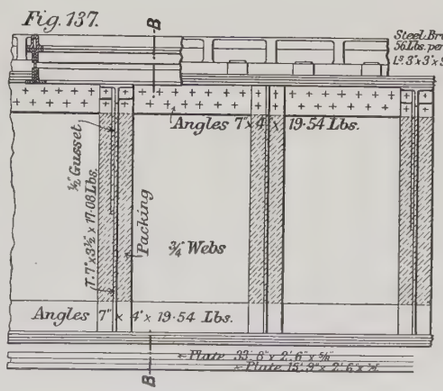


Fig. 138. SECTION B.B. (Fig. 137)

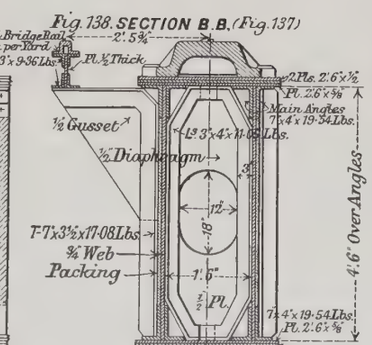


Fig. 139. PLAN.

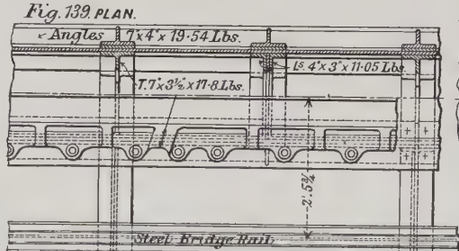


Fig. 140. PLAN OF RAIL.

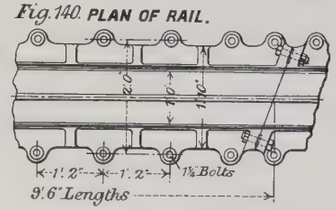
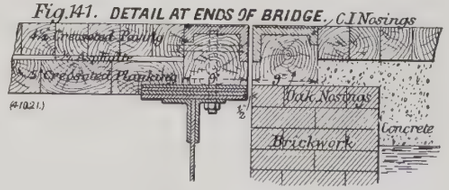
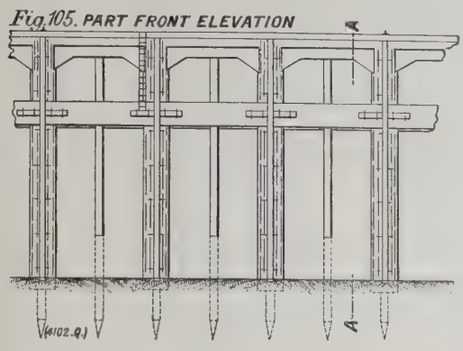


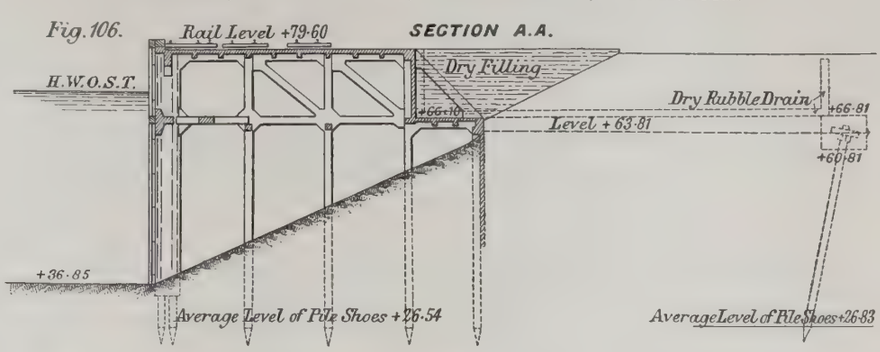
Fig. 141. DETAIL AT ENDS OF BRIDGE, C.I Nosings

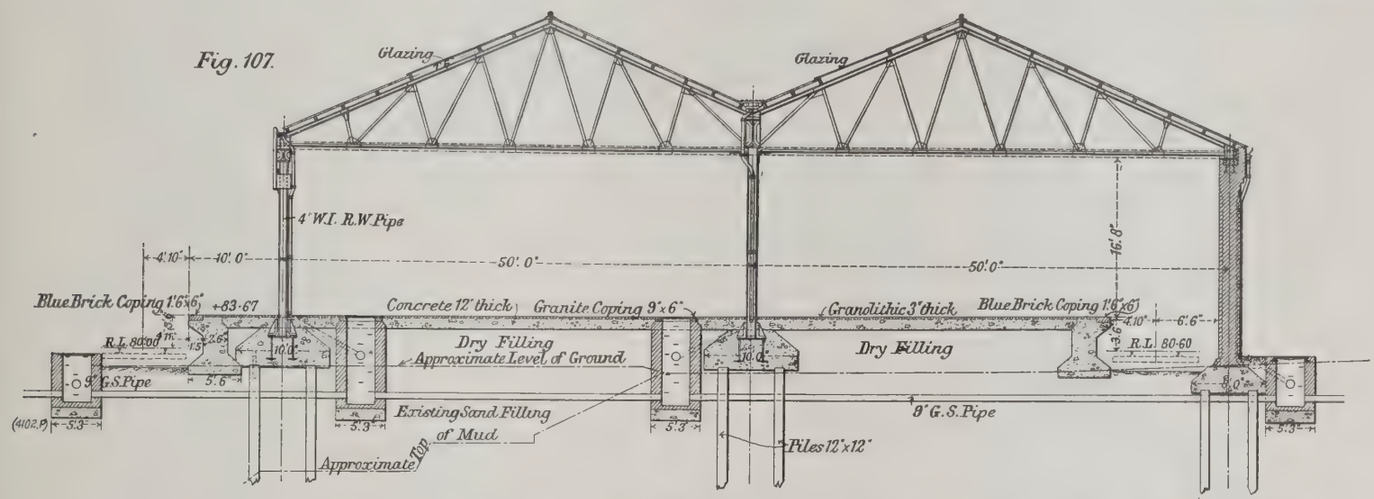


THE ALEXANDRA DOCK EXTENSION AT NEWPORT.

SIR JOHN WOLFE BARRY LYSTER AND PARTNERS, MM. INST. C. E., WESTMINSTER, ENGINEERS.







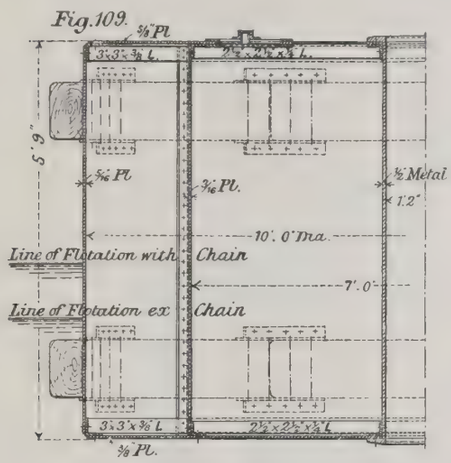
pier to which we have referred. The object of this concrete pier is, of course, in effect to increase the width of the main concrete formation of the lock, and it is on this main formation that the weight of the lifting bridge comes. The concrete-filled caissons carry two heavy girders, on which the track for the main bogies is laid, while the pitch-pine piles carry a pair of lighter girders for the tail wheels. The arrangement of this girder work will be followed from Figs. 118 and 119, while the front ends of the two heavy girders are well shown in Fig. 144, on page 190. Where the track of the tail wheels overlaps that of the bogies the rails for the tail wheels are carried by brackets from the heavy girders, as is shown in Fig. 138, which is a section through one of the heavy girders. Other details of the construction and of the rails are given in Figs. 137 to 141.

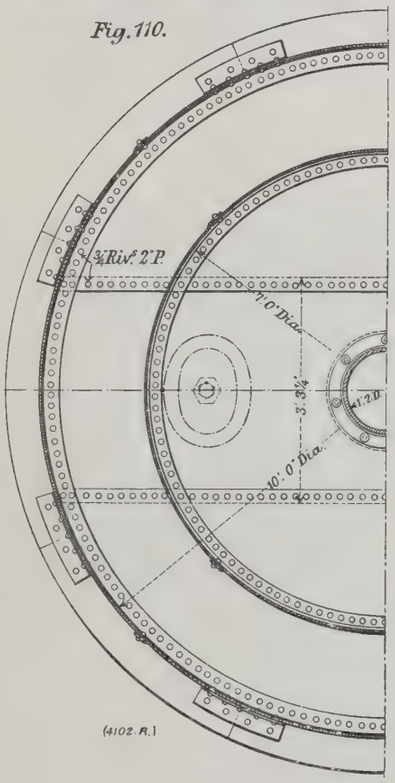
The general construction of the bridge itself will be seen from Fig. 118, while details to a larger scale are given in Figs. 120 to 126. The general lines of the design are also well shown in the views *in situ* given in Figs. 142 and 143, on page 190. The bridge consists of two main girders, with curved upper members connected by verticals and N-bracing to the lower booms. The main girders are connected by straight cross-girders below, and by curved members built up of plates and angles overhead. Cross-joists between the cross-girders carry a wooden flooring, on which wood-block paving is laid. A footway is carried outside the bridge on one side by built-up brackets, as is shown in Fig. 120. Some details of the inner end of the bridge are given in Figs. 121 to 126. As will be seen, the two last panels are furnished with solid web-plates instead of bracing. A certain amount of kentledge is carried here, to ensure a proper and adjustable pressure on the tail wheels. The angle-bracket arrangement just forward of the tail wheels in Fig. 123 is a buffer, which limits the position of the bridge when it is travelling outward over the lock. Details of one of the bogies and one of the tail wheels are given in Figs. 127 to 134, on Plate XVIII.

The lifting and travelling arrangements are shown in Figs. 135 and 136, on Plate XVIII. As has been already mentioned, there are lifting-rams below each of the bogies and each of the tail wheels. When the bridge is to be opened it is lifted from the position shown in full lines in Fig. 118, a height of 4 ft. 3 in., and is then pulled back into the position shown by broken lines. The bridge in its lowered and lifted positions when out over the lock is shown in Figs. 142 and 143, on page 190. The main weight comes on the rams below the bogies. The tail-rams take only about 10 tons, which is adjusted by the kentledge, to which we have already referred. The main rams are controlled by the operating gear, which is situated in a cabin on the quay, which can be seen in Figs. 142 and 143. The tail-rams are constantly in connection with the high-pressure main, and have no valves. These rams exert a lifting force of about 13 tons. When the bridge is to be lifted water is admitted to the main rams, and the lifting commences, the tail-rams following up automatically, the bridge being kept level by the equalising gear. The equalising gear consists of vertical racks carried by the rams at each end of the bridge. These racks gear with pinions on horizontal shafts, so that as the rams rise or fall the pinions are rotated. The pinions at each end of the bridge are connected by a long rod lying more or less horizontally, and carrying a further rack at each end. This rod can be seen in Fig. 135. It gears with the pinions at each end of the bridge, and so ensures that they shall always move in unison. As a consequence it ensures that the main and tail lifting-rams also always move in unison. It will be clear that without this arrangement the bridge would

Fig. 108. Interior of Shed.

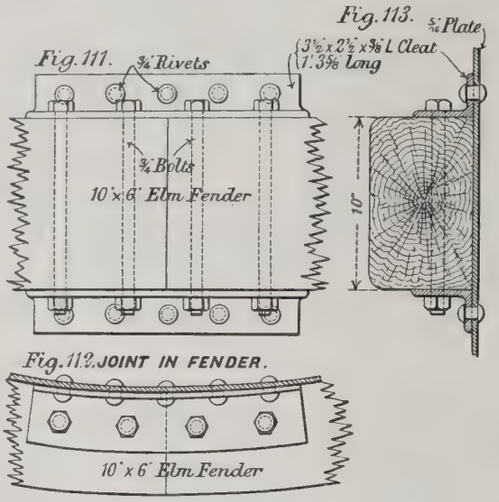
tilt when it began to lower, since when the main rams are put to exhaust and begin to fall, the tail rams, if they were independent from outside control, would stay up, as they lift with a force of 13 tons and have a weight of only about 10 tons to deal with. The rack connection, however, prevents this happening, and the necessary extra weight to cause the tail rams to fall is supplied through the long rod. The arrangement results in a very simple pair of tail rams, which furthermore use no water, since on the down-stroke the water is returned to the mains under full pressure. It should be noted that the long rod connecting the two rack gears is always in tension.

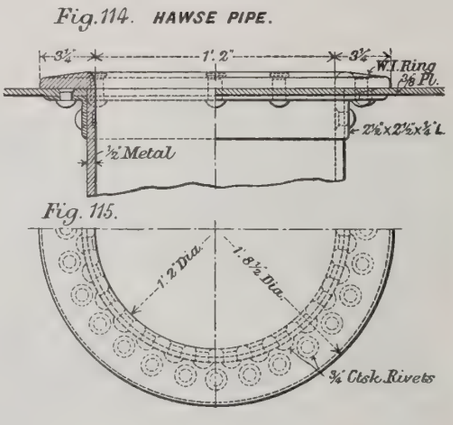




The lifting rams carry cross-heads with rail forms on their upper surfaces. The cross-heads of the tail rams are held against stops at the correct level by the hydraulic pressure when the rams reach the top of their stroke. In the case of the main lifting-rams the cross-heads are first lifted about 1 in. above their correct level. Steel bearing-bolts are then shot beneath the cross-heads by means of a small auxiliary hydraulic cylinder, and the cross-heads are then lowered on to the bolts, thus bringing the rails to the same level as the rails on the box-girders upon which the bridge travels back. The arrangement is illustrated in Fig. 117, annexed, which shows one of the main rams. When the bridge has been lifted, water is supplied to the hauling-rams, which can be seen in Figs. 135 and 136, and are also seen during erection in Fig. 145, page 190. These rams are connected to the ends of the bridge by wire ropes, by means of which the bridge is hauled backwards and forwards. The hauling-ropes can be seen beneath the bridge in Fig. 143. The bridge was built by the Cleveland Bridge Company, of Darlington.

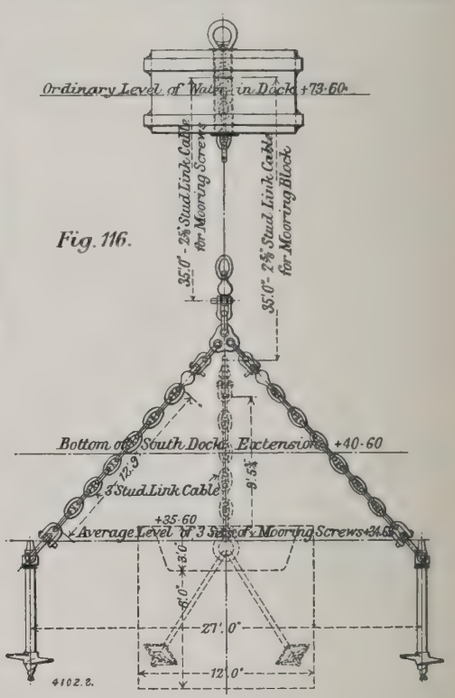
A complete system of interlocking between the various motions of the bridge and the signals and roadway barriers has been installed in the control-cabin, and was supplied by Messrs. McKenzie and Holland, Limited, of 58, Victoria-street, Westminster. Before the bridge is opened, the man in control has to cross from the control-cabin to a ground-frame on the south side of the lock, where he sets the railway signals to danger,





opens the trap-points, and lowers a roadway barrier. He then returns to the control-cabin and performs similar operations to protect the bridge on the north side. The completion of these operations releases the bridge-bolts. These bolts are two in number, one at each end of the bridge, engaging with cast-iron sockets built into the abutments. They act both as detectors to ensure that the bridge is in correct position, both as regards line and level, and also as a connection between the control-cabin and the ground-frame, the levers of which are locked by the withdrawal of the bridge-bolt on the south side. The withdrawal of the bridge-bolts releases the main lifting-valve, by means of which pressure is admitted to the lifting-presses. When the bridge is lifted to its highest position, the cross-head bolts described above are released and are then shot into position. The main cross-heads are then lowered on to the bolts, and when the main lifting-lever has been brought full over to exhaust, the next lever of the frame is released. This lever withdraws the chock which prevents the bridge from travelling, and which can only be inserted when the bridge is in its correct position for lowering. The withdrawal of the chock releases the main hauling lever by which the bridge is drawn back. When the bridge reaches its full open position, it releases a lever alongside the lock which operates a lock-signal indicating that the lock is free for shipping. The lowering of this signal locks the whole of the levers in the bridge-cabin. To prevent the bridge over-running its track, hydraulic buffers are provided at each end of its travel, and the bridge itself operates a cut-off gear by which the supply of water to the hauling-cylinders is reduced, when the bridge nears the end of its travel.

In concluding this article, we may draw attention to Fig. 105 and 106, on page 179. These represent the new ferro concrete wharf on the river above the North Lock, to which we referred in our first article. This wharf, while not actually part of the new dock extension, has been carried through at the same time and forms part of the same scheme of improvement. It is constructed



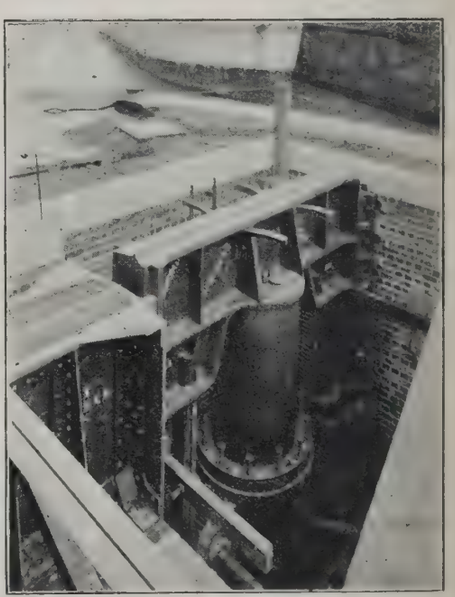


Fig. 117. Lifting-Ram for Bridge.

on the Hennebique system, and is a piled structure throughout, standing directly on the river bank. The whole superstructure is ferro concrete, tied together to form a single rigid decking. It is tied back to the quay with steel rods, which lead to concrete blocks secured by obliquely-driven piles.

(To be continued.)

The Panama Canal.—The Secretary for War of the United States recently announced that the Panama Canal would be opened for use by commercial vessels requiring less than 30 ft. of water on August 15. The official opening is planned for March next year.

OIL-CARRYING STEAMERS.

THE San Isidoro, of which drawings are reproduced on the present page and pages 182, 183, and 184, represents one of ten ships which are the largest of the class so far completed, and one which probably illustrates best the present-day practice in regard to this type of vessel. The builders were Sir W. G. Armstrong, Whitworth and Co., Limited, who, at their Walker Shipyard, have completed more than 100 vessels of the class. The San Isidoro is one of a large new fleet which has been built in the last few years for the Eagle Oil Transport Company, ten of the vessels being of over 15,000 tons capacity, while eleven others are between 9000 and 10,000 tons, and all are primarily intended for the conveyance oversea of Mexican oil.

The first interesting point has reference to the gradual growth in size of oil-tank ships, and particularly the economy resulting from the increase in capacity. We give in Table I. particulars of

TABLE I.—*Particulars of Oil-Tank Steamers.*

Date.	Name.	Dimensions. Length.	Breadth Moulded.	Depth Moulded.	Deadweight.	Average Speed at Sea.	Indicated Horse-Power.	Fuel.	Consumption (Tons per Day).	Ton-Miles (Nautical) per Ton of Fuel.
		ft.	ft. in.	ft. in.	tons	knots				
1890	Bear Creek	294	37 9	27 9	3,250	8.75	1020	Coal	18.0	37,910
1898	Snowflake	294	39 6	27 9	4,200	9.0	1150	,,	20.3	44,800
1901	Kinsman	360	49 9	30 3	6,600	9.6	1540	,,	28.0	54,300
1908	Hermione	385	50 6	31 10	7,500	9.6	1800	,,	33.0	52,370
1912	Cordelia	420	54 6	32 8½	9,700	10.0	2350	Oil	34.0	68,800
1913	San Isidoro	548	66 6	33 6	15,350	10.6	3984	,,	38.3	101,790

successive ships designed by Messrs. Jacobs and Barringer, principally with a view of illustrating these two points. The first vessel, it will be seen, was 294 ft. long, and had a dead-weight capacity of 3250 tons. In her case coal was used as fuel, and a sea speed of 8¾ knots required propelling machinery of 1020 horse-power. The coal consumption for all purposes per day, according to the engineer's log, was 18 tons. These results show that the duty done was 37,910 ton-miles (nautical) per ton of coal. By doubling the size of the ship a very considerable increase was obtained in duty per ton of coal. Thus, in the case of the Kinsman, built in 1901, or eleven years later, the dead-weight was 6600 tons, the sea speed 9.6 knots, while the coal consumption worked out at 1 ton for every 54,300 ton-miles. In recent ships oil has been used, and consequently a direct comparison is not possible. Whereas in the Cordelia, built in 1912, the ton-mileage per ton of oil was 68,800, the result in the case of the San Isidoro, with 15,350 tons dead-weight capacity, is 101,790 ton-miles (nautical) per ton of oil-fuel. In addition to the higher duty for a given expenditure in fuel, there is gain also in the wages cost, and also in the first cost and upkeep of the larger ships per unit of work done.

The San Isidoro, like the other large new ships included in the Eagle Oil Transport fleet, is built on the Isherwood system of longitudinal framing, and is one of the largest ships so far constructed on this system. The dimensions of the vessel are :—

Length over all...	548 ft.
Length between perpendiculars ...	530 ,,
Breadth (extreme)	66 ft. 7 in.
Depth (moulded) to upper deck ...	33 ,, 6 ,,
Height of shelter-deck	8 ft.
Mean draught in service	28 ,,
Dead-weight cargo capacity at this draught	12,350 tons
Bunker, fresh water, and stores capacity	3,000 ,,
Total dead-weight	15,350 ,,
Indicated horse-power on trial ...	4230
Speed on trial	11.956 knots

Fig. 1. SECTION THRO' MIDSHIP CABINS.

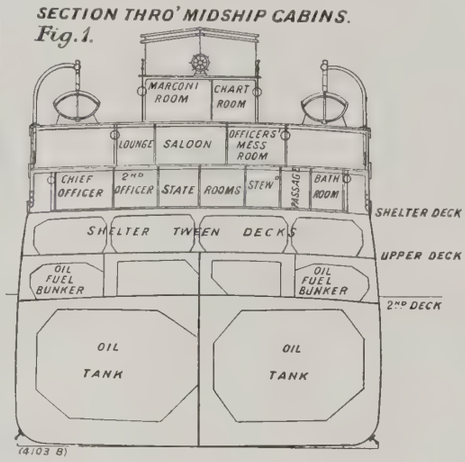
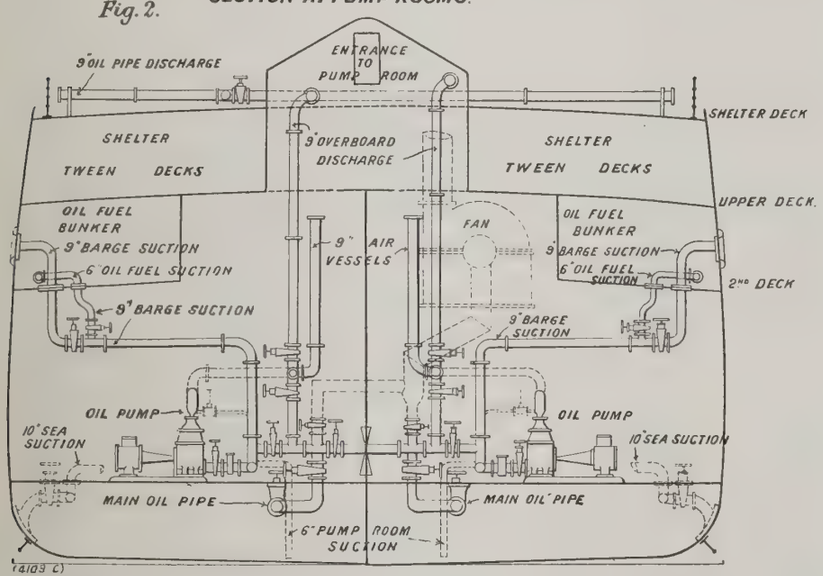


Fig. 2. SECTION AT PUMP ROOMS.



There is given on the next page a longitudinal section, with plans, of the bridge, of the shelter, upper and second decks, and of the hold, while on page 183 are given half midship sections, and on page 184 other details. General sections are given in Figs. 1 and 2, above. These details render unnecessary a full description of the scantlings. There are one or two slight departures from the Isherwood typical designs, principally to suit the requirements of the system of oil-tanks. Moreover, as is the practice with the same designers in the case of iron-ore vessels, all the sheer-strake plating is made a little thicker than is required by Lloyd's Rules. The increase is equal to about $\frac{2}{20}$ in. The strake below is $\frac{1}{20}$ in. thicker for five-eighths of the length of the vessel. The decks, too, are $\frac{2}{20}$ in. thicker than is the general practice. These increases were made in order to augment the stiffness of the vessel, as she is the largest vessel built on this principle. It is worth noting that the total weight of the hull of the San Isidoro is 5760 tons, exclusive of the 840 tons for machinery, and it is computed that a hull of the ordinary frame type would have required about 10 per cent. more steel, other things being equal. The transverse members are clearly shown in the cross-sections, Figs. 10 and 11, the former being intermediate to the bulkheads, while Fig. 12 shows the outer web for the bulkhead, Fig. 13 the middle web, and Fig. 14 the inner web. As we have said, all dimensions are given on the drawings, so that no further description is necessary.

As is shown on the longitudinal section and respective plans, the oil cargo is carried in twelve compartments, which are divided by a central longitudinal bulkhead extending through all the compartments, as well as through the pump-rooms and cofferdams. As there are two pump-rooms, in addition to the cofferdam forward and a cross oil-fuel bunker and cofferdam aft, the cargo space is divided into three main independent units, each of four main compartments, which, because of the longitudinal bulkhead, make eight separate oil-tanks. In the earlier ships the practice was to have only a cofferdam between the machinery space and the after tank, but a change was introduced to conform to the rules issued by the Suez Canal authorities, when permission was granted for the passage of oil-tank ships through this waterway. At that time a cofferdam forward was called for, and this was soon adopted in all ships, even although they were not primarily intended for the Suez Canal route. The practice, too, was for the pump-room to be right aft, and even then it did not extend from the bottom to the upper deck. The increase in the amount of very heavy oil transported called for shorter lengths of pipe, and for this reason, and also because of the great size of the pumps, in the larger ships more than one pump-room is introduced, their position in the length of the ship being determined largely to reduce the length of suction-pipe. At the same time, while the pumps are placed as low in the ship as possible, the pump-room is extended right up to the top of the hold, so as to form an intermediate cofferdam. Thus, in the case of the San Isidoro, there are really four cofferdams, as shown in Figs. 8 and 9, two pump-rooms being introduced among the oil-tanks.

As shown in the plan, Fig. 8, and in the section, Fig. 1, the spaces at the side of the main expansion trunk are used for carrying oil-fuel or cargo, and these are fitted with small expansion trunks extended to the shelter-deck. Oil-fuel is also carried in a large cross-bunker aft, as shown in Figs. 8 and 9, and in a deep tank forward (provided the fuel has not a low flash-point). In order to obtain Lloyd's permission to burn oil below the standard flash-point, it was necessary to enclose the fuel-oil pumps which supply the burners, filters, heaters, &c., in a distinct gas-tight chamber, the only opening to which is on deck. This is a novel feature in these vessels. The pumps dealing with oil for burners are so fitted that the steam ends are in the stokehold, but all the oil ends and glands are in the isolated chamber, cylinder ends being jointed to the bulkhead. There is also a small fan with engine in the stokehold, the shaft passing through a packed gland in the bulkhead, for the ventilation of this chamber. A steam-lift is also fitted for the use of men when proceeding below to deal with the pumps. These pumps can, of course, be regulated from the stokehold without entering the chamber.

The oil-pumping installation is the most complete ever supplied to an oil-carrying steamer, and there is given in Fig. 2 a section through one of the pump-rooms. There are two oil-pumps in each of the two pump-rooms. These are of the Hayward-Tyler duplex type, 22 in. by 14 in. by 18 in., capable of discharging 300 tons of oil per hour against a pressure of 200 lb. per sq. in. Throughout the length of the ship there are, at the bottom of the tanks, two lines of 14-in. main piping, one on each side of the longitudinal bulkhead, as shown in the plan, Fig. 9. From each of these main pipes there is, in each compartment, a branch to the oil-tank on each side of the longitudinal bulkhead, so that oil can be pumped through each main from any of the oil-tanks. There are thus forty-eight suctions for the cargo oil. Normally, with both lines of piping in use, the entire cargo of 12,000 tons can be pumped out in twelve or thirteen hours ; while if there is any breakdown in either of the two main lines of piping the whole cargo can be taken by the one line of piping from all the tanks and discharged in 24 or 26 hours. As shown in the cross-section, Fig. 2, there is a 9-in. suction-valve and an 8-in. air-valve on each suction, and these are actuated by wrought-iron rods, with

THE OIL-CARRYING STEAMER "SAN ISIDORO."

CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, SHIPBUILDERS, WALKER-ON-TYNE.

Fig.3.

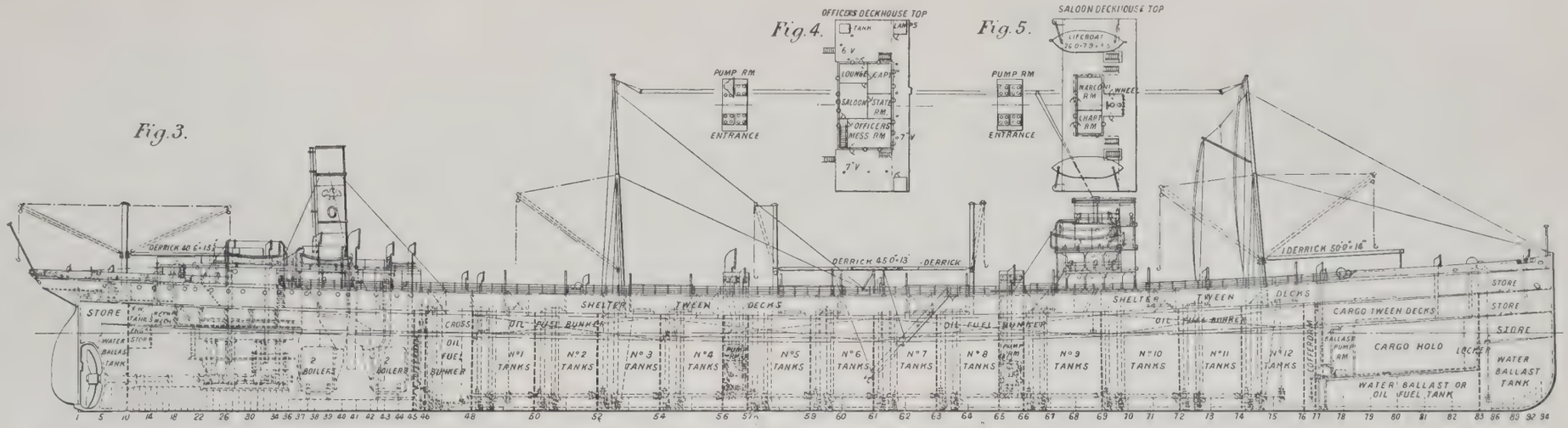


Fig.6. SHELTER DECK.

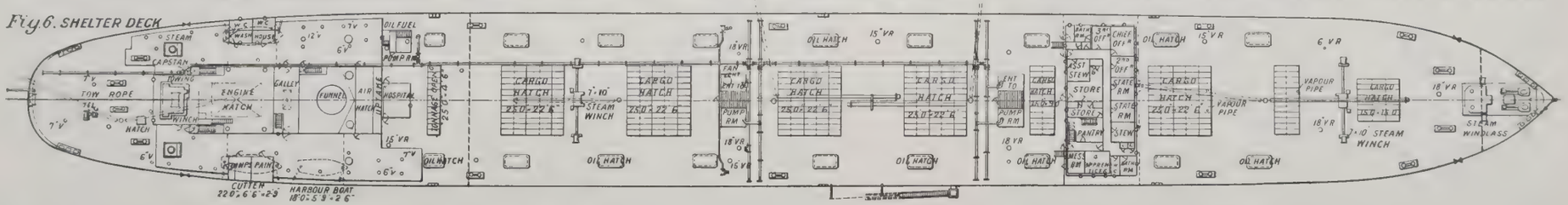


Fig.7. UPPER DECK.

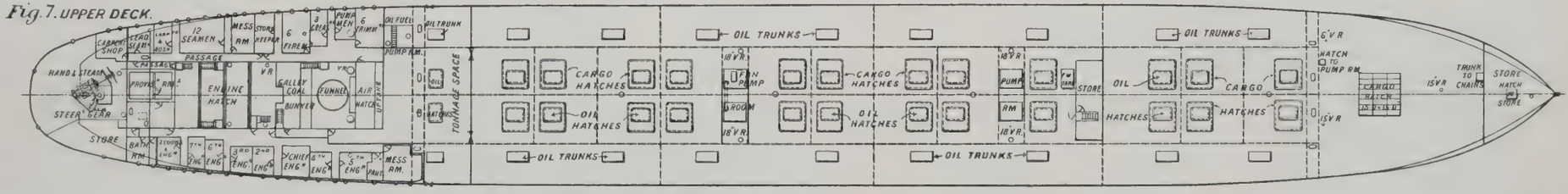


Fig.8. 2ND DECK.

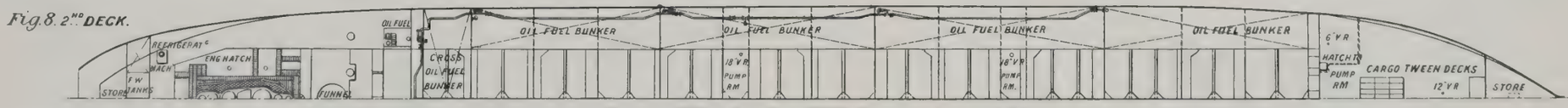
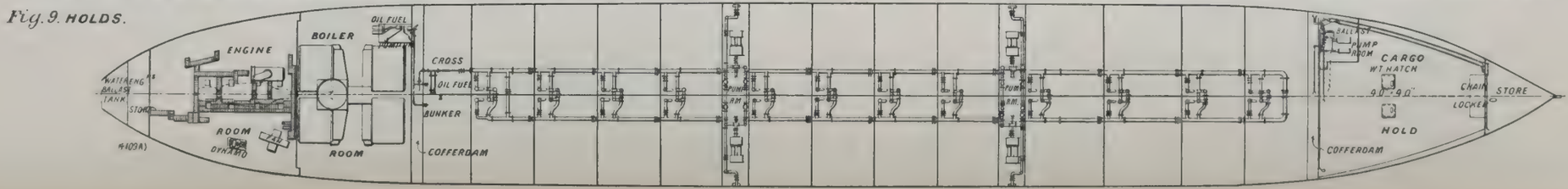


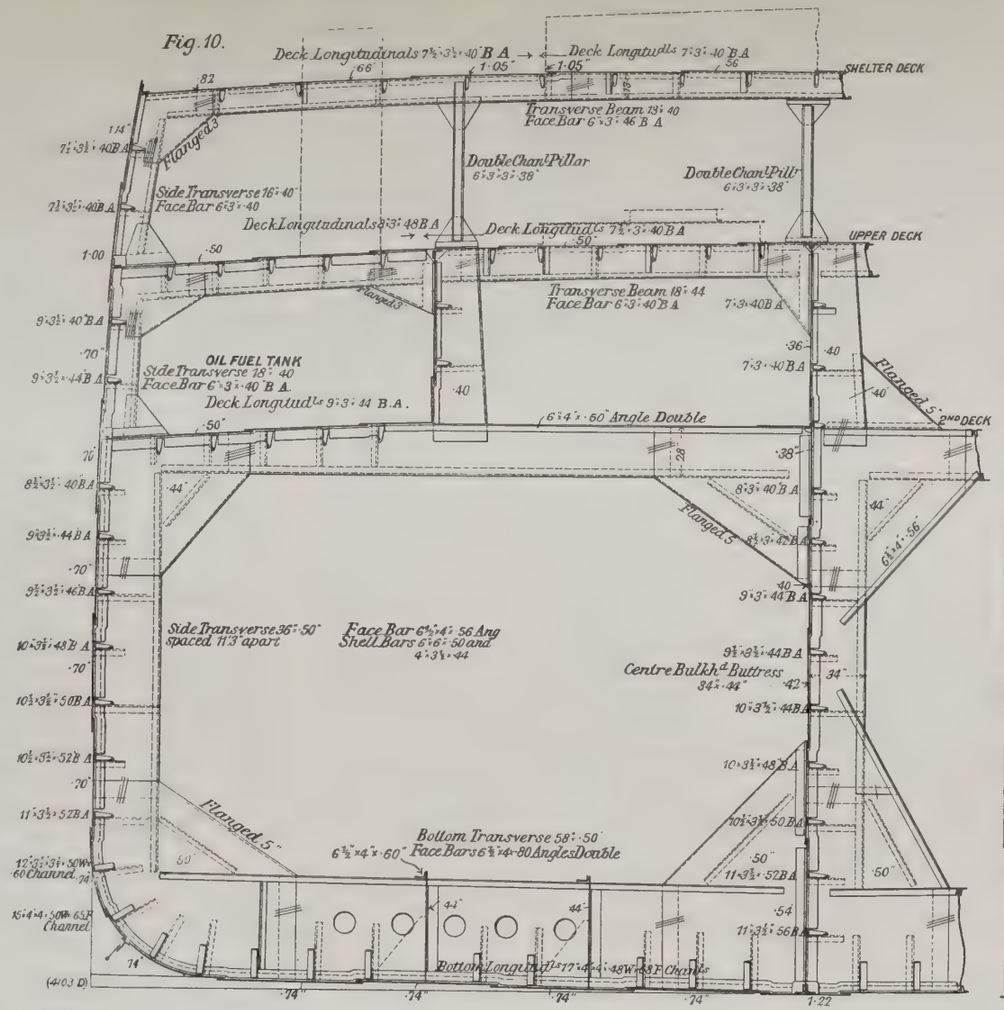
Fig.9. HOLDS.



THE OIL-CARRYING STEAMER "SAN ISIDORO;" DETAILS OF SCANTLINGS.

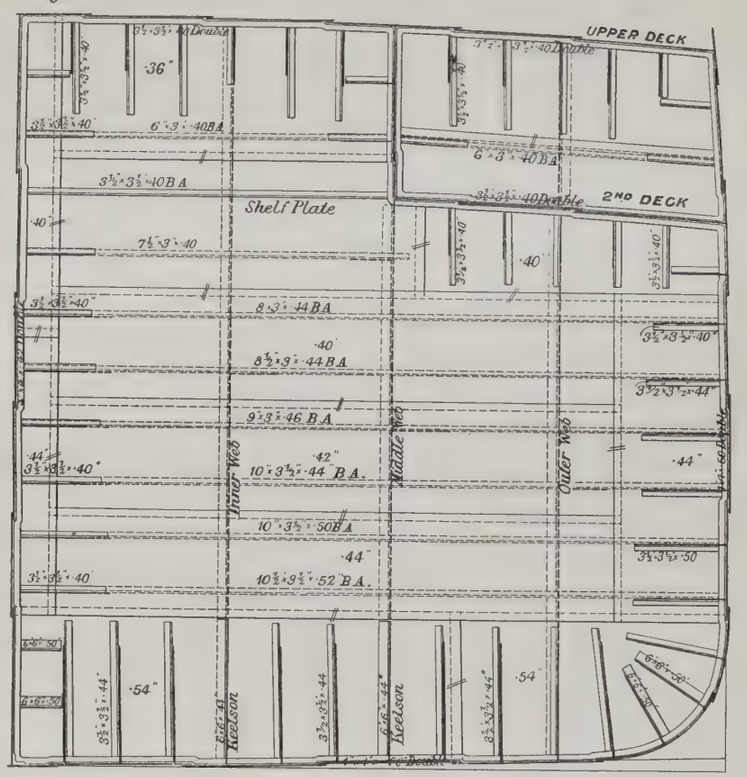
CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, SHIPBUILDERS, WALKER-ON-TYNE.

Fig. 10.



PRINICIPAL DIMENSIONS OF SHIP		PARTICULARS OF MACHINERY	
Length Overall	548' 0"	Quadruple Expansion Engines	
Length between Perp's	530' 0"	Dia of H.P. Cyl	28½"
Breadth Extreme	66' 7"	" " 1st Inter. Cyl	41"
Depth Moulded (to Upper Deck)	33' 6"	" " 2nd " "	58"
Depth of Hold	33' 5"	" " Low Press. Cyl.	54"
Draught of Water	28' 0"	Stroke	54
Total Dead-Weight	15,250 Tons	Boiler Pressure 220 Lbs Sq In	

Fig. 11.



ratchets, and stuffing-boxes from the upper-deck level, but the pumps are controlled solely from the pump-room. The pumps, too, are interchangeable, so that either pump in any of the two pump-rooms can be utilised for pumping through any of the main pipes. The pumps are arranged to discharge overboard through a 9-in. pipe on the shelter-deck level. Alternatively, the pumps discharge through 9-in. pipes through the side of the ship into barges, or they can discharge over the stern. There are also cross-over connections between the main pump-lines in the foremost and aftermost tanks, which are controlled by master-valves. This cross-over connection, which is seen in Fig. 9, can be utilised for pumping the oil from any tank into any other tank. The pumps, if required, can discharge through the bottom of the ship.

All the transferring valves, as we have said, are in the pump-room, and under the charge of the engineer, but the valves directly on the suctions are operated from the deck. These valves open the passage for the oil to the pumps, but the discharge from the pumps is actually in the control of the engineer. This obviates any possibility of confusion as to the disposal of the oil. It is possible—indeed, cases are known—of a tank filled with oil having, by inadvertence, been emptied during the night, when the officer responsible thought he was emptying an adjoining tank of water ballast. In the system adopted in the San Isidoro and sister-ships all the valves are numbered, and a large notice is posted showing what each number represents, and therefore what the function of the valve is. The first and dominant duty inculcated in all cases is that every valve must be closed, so that on ascertainment of the work to be done, the engineer opens such valves as are required for the time being. Thus, although the arrangement seems complicated, there is no possibility of confusion.

With the heavy oils now transported it has been found necessary to fit oil-heating systems, in order to facilitate the pumping operations. Thus, in some cases the oil has to be heated to a temperature of 125 deg., in order to ensure a satisfactory flow. This is required in the case of some of the very heavy oils, where, with an outside temperature of 40 deg., it is almost possible to walk over the oil. Steam is passed through coils of pipes, the piping in the San Isidoro and sister-ships being of 2 in. internal diameter and laid in zigzag lines between the longitudinal bulkhead and outer skin of the ship. The pipes are of ¼-in. metal, with flanged joints, and were water-tested to 300 lb. per sq. in., and steam tested to 220 lb. per sq. in. The steam is passed direct from the boiler or through valves, reducing the pressure to 120 lb. The valves in each compartment are operated from the shelter-deck. Drains are led back into the engine-room to an inspection-chamber, and samples of the water are taken to ascertain if there is any grease, when the water is passed through a filter before being pumped back into the boilers. The oil-fuel bunkers are heated in the same way. For heavier oils the ratio of heating surface in such coils to the contents of the tank is 1 sq. ft. to 2·7 tons of oil, and the cost of the heating installation works out at between 4s. and 5s. per ton of

oil storage capacity, which is assumed at 39 cub. ft. per ton. Each cargo-hold is fitted with a vapour-pipe extending 4 ft. 6 in. above the shelter-deck hatch.

Arrangements are made for taking miscellaneous cargo should the oil in the tanks be of low specific gravity. The tanks at the side of the main expansion-trunk can be utilised for cargo to make up the designed dead-weight. For the trip back to the oil-fields ordinary cargo can be carried, and large hatches are provided, as shown in Figs. 6 and 7. Ventilation is by means of a large steam-fan connected to the main pipe-lines (Fig. 2). There is a complete installation of piping fitted for dealing with water in the deep ballast-tank, forward cofferdam, and fore peak (Fig. 9).

The accommodation is very complete for a vessel of this type, as shown in Figs. 4 to 6. There is a separate cabin for each officer, engineer, and steward, with three large state-rooms for passengers, or directors of the several companies interested in the Mexican oil-fields. The saloon and captain's day-cabin are panelled in oak, and the officers' and engineers' mess-rooms in polished mahogany. Each cabin is fitted with an electric fan, and all doors, side-lights, and scuttles are protected by mosquito-screens. The officers are berthed in the deck-house amidships, and the engineers and crew in the shelter 'tween deck aft, alongside the engine casing (Fig. 7). A refrigerating installation, with chambers for provisions, is fitted in the shelter 'tween deck aft, and a Marconi wireless telegraph installation is fitted in a cabin on the upper bridge (Fig. 5).

The boat outfit includes two extra large lifeboats, two cutters, and one harbour boat A large winch is fitted for towing ocean-going oil-barges if required, and there are two powerful steam-capstans placed aft. The steering-gear is a patent combined hand and steam, on the Wilson-Pirrie principle, and is fitted on the shelter 'tween deck aft.

The propelling machinery is of the quadruple-expansion type, and was supplied by the North-Eastern Marine Engineering Company. The cylinders are 28½ in., 41 in., 58 in. and 84 in. in diameter, with a stroke of 54 in. Steam at 220 lb. is supplied by four boilers, 16 ft. 3 in. in diameter and 12 ft. long, fitted with Howden's forced draught. The well-known and highly successful Wallsend Howden oil-fuel-burning installation was fitted on each boiler by the Wallsend Slipway and Engineering Company, Limited. This system was supplied to all the large vessels of the Eagle Transport Company, and was illustrated in Engineering, vol. xcv., page 131. The pumps for the oil-fuel are fitted in an isolated pump-room (Figs. 6 and 7), thus keeping the boiler-room as clear as possible from any leakage from pipe-joints, &c.

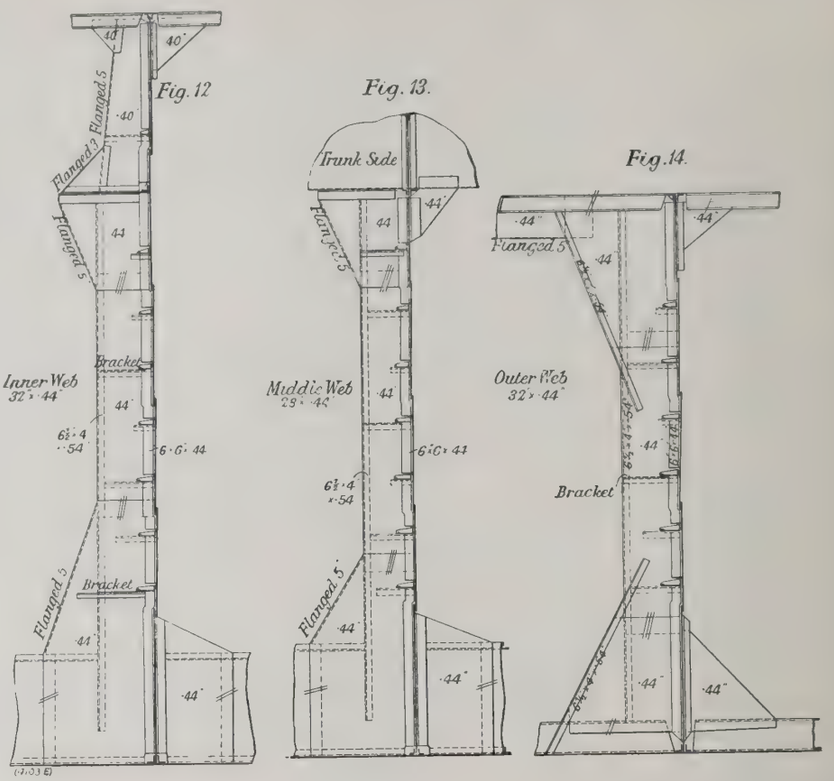
The trial trip of the vessel was run under adverse circumstances, as there was a heavy sea running during the whole time, and the speed—12 knots—which was obtained may therefore be looked upon as extremely satisfactory. The engines and boilers worked very well throughout the trial, and the Mexican oil which was used proved itself to be an excellent and efficient fuel. In view of the large amount of this oil which has now come into the country, this fact is of importance.

That the San Isidoro represents a large amount of experience in design and construction is proved by the facts published. Like all the other vessels for the Eagle Oil Transport Company, she is from the designs of Messrs. Jacobs and Barringer, Limited, who in the last fifteen years have designed fifty-nine ships of the type, with a collective carrying capacity of 516,450 tons, and had at one time in course of construction as many as thirty nine vessels. The work of supervising the construction of these vessels was carried out by the firm's staff of inspectors, with Mr. W. Bradney as chief resident inspector.

Pitman's Governor for Hydraulic Power-Station: Erratum.—Mr. Percy Pitman informs us that there has been a misunderstanding in connection with one detail of his hydraulic governor, illustrated on page 152 of our last issue. The object of the plug-cock shown in Figs. 5 and 6 was accordingly incorrectly stated. It is really intended for use in starting up the turbines by admitting pressure direct to the servo-motor, and thus opening the gate-valves to the turbines. The plug-cock in question also serves as an emergency valve for hand-regulation, and can be operated even when the governor is working. Normally, however, it is closed once the turbine is started up, thus cutting off the direct connection between the pressure water and the servo-motor cylinder.

THE OIL-CARRYING STEAMER "SAN ISIDORO."

SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, WALKER-ON-TYNE.



INDUSTRIAL NOTES.

We are informed that a reduction in iron workers wages will follow upon the ascertainment made by the Midland Iron and Steel Wages Board, concerning the production and the average selling prices of iron during the months of May and June. The puddling rate this month and in September is to be 9s. per ton, corresponding to a reduction of 3d. The increase of 6d. per ton granted to the puddlers by the Wages Board on July 15, 1912, is to continue; this will make the total puddling rate 9s. 6d. per ton. The accountants of the Board have issued the following statement:—

We beg to report that we have examined the returns of the sales of iron made by the seventeen selected firms for the months of May and June, 1914, and have verified the same with their books. We certify the average net selling price to have been 6l. 15s. 9.23d. per ton. Below is a statement of the different classes of iron sold and the average net selling price of each:—

Description.	Weight.	Per-centage of Totals.	Average Net Price.
	tons cwt. qr. lb.		£ s. d.
Bars	19,804 10 2 2	68.69	6 18 80.20
Angles and tees ..	523 0 1 9	1.81	7 2 9.91
Plates and sheets ..	783 18 2 11	2.72	3 0 4.03
Hoops, strips, and miscellaneous	7,720 6 3 21	26.78	6 7 0.37
	28,831 16 1 15	100.00	6 15 9.23

The following table shows the figures for the previous two months:—

Description.	Weight.	Per-centage of Totals.	Average Net Price.
	tons cwt. qr. lb.		£ s. d.
Bars	20,865 3 3 21	74.25	7 2 4.23
Angles and tees ..	848 16 1 5	3.02	7 13 11.13
Plates and sheets ..	681 11 1 2	2.43	8 3 0.45
Hoops, strips, and miscellaneous	5,705 16 0 4	20 30	6 11 1.75
	28,101 7 2 4	100.00	7 0 11.14

A meeting of the Scottish Coal Trade Conciliation Board, at which a deputation of four members from the Miners' Federation of Great Britain assisted, was held in Glasgow on the 30th ult., for the purpose of considering the coalmasters' claim for a reduction of miners' wages by 1s. per day.

At the close of the meeting it was stated that a further one would be held to-day. It is stated that the position of the coal trade in Scotland was fully explained to the English deputation, and that prior to meeting to-day, they will confer with the Executive of the British Miners' Federation. The outlook is considered hopeful.

The National Federation of Building Trade Employers of Great Britain and Ireland held a meeting at Cardiff, on Saturday last, the 29th ult., when the question of a general lock-out was considered. It was announced that the Executive Council had despatched on the preceding day an ultimatum to the executive of all the obdurate operative unions, stating the following:—

"Unless the present dispute in London is brought to an end, so far as your society is concerned, on or before August 15 next, this Federation will issue instructions for an immediate lock-out of the members of your society.

"Whilst the Federation regrets that any such act is necessary, this action has become imperative in consequence of all reasonable suggestions for settlement put forward by the accredited representatives of the employers and operatives having been rejected by the London operatives, although accepted by the London employers.

"The Federation has always recognised and appreciated the general local observance of agreements by your society throughout the provinces, but it is obvious that if a section of your society in London can successfully break agreements that have been entered into after all formal requirements on either side have been complied with, and can receive the support of the provinces, then no agreement throughout the country will any longer be a safeguard to the trade."

It was stated further that a meeting of the employers' executive will take place on the 18th inst., and that in the meantime the Administrative Committee were empowered to deal with any matters that might arise under this issue. The announcement of the decision was received with cheers. After this statement the Press representatives were asked to withdraw, when the meeting proceeded to confer in private.

The report of the executive respecting the lock-out was unanimously approved by the general meeting. Among the unions to which the ultimatum has been sent are:—

The Navvies', Builders' Labourers', and General Labourers' Union.

The United Order of General Labourers of London.

The National Union of Gas Workers and General Labourers.

The National Amalgamated Society of Operative House and Ship-Painters and Decorators.

The National Association of Operative Plasterers.

The Operative Bricklayers' Society (London Order).
The Amalgamated Society of Carpenters and Joiners.
The General Union of Carpenters and Joiners.
The United Kingdom Plumbers' Association.
The London Plumbers' Association.
The National Union of Operative Heating and Domestic Engineers.
The United Builders' Labourers' Union.

A strike of the dining-car staff of the Great Western Railway commenced at mid-day on the 29th ult., when the express trains left Paddington without dining-cars. The strike, which has now been settled, was caused by the reduction in rank of an employee, a dining-car attendant, for an alleged breach of the rules, and it threatened to involve other sections of railway workers. The strikers were members of the National Union of Railwaymen. Shortly after the strike was declared, the Great Western Railway Company issued, from Paddington, a statement to the following effect:—

The trouble arose in connection with a dining-car conductor who was reported by a fellow worker for irregularities, and after investigation was told that he would be made an attendant instead of a conductor, but that he would be given every opportunity of redeeming his character, and might hope to be restored to the position of conductor if he did so. The man resented his punishment, and some of his fellow-workers refused to man the cars in sympathy with him.

Later details showed that Frank Farmer, the dining-car attendant in question, was suspended on the ground that he had supplied food to certain workers on his train. Farmer was reduced in rank. Charles Strange, chef, who admitted having himself given out the food and who accepted all blame, was dismissed.

A mass meeting of all grades of men was held on the same day, the 29th ult., when a resolution was passed demanding the complete reinstatement of Farmer, Strange, and a motor driver who was reduced three weeks ago, and the reinstatement of all men who had withdrawn their labour. A deputation was elected to approach the Great Western Railway Company with the demands.

The men primarily concerned have admitted their wrong, and have apologised to the company. They undertake to act in accordance with the company's regulations in the future.

The Staffordshire china trade is stated to be entering a period of unrest. A two years' wages agreement, which affects over 15,000 operatives, entered into between the English China Manufacturers' Association and the National Union of Pottery Operatives, expires to-day, and notice has been given by the union to the Manufacturers' Association for new minimum prices and conditions, to come into force on August 1. The notice suggests that these minimum prices are already in force in a number of factories, and that firms paying the lower rate should be brought up to the minimum scale. The Manufacturers' Association, we are told, have passed a resolution declining to entertain the operatives' demands.

Mr. J. A. Arrowsmith, secretary of the China Manufacturers' Association, in a letter to the Pottery Workers' Union, states that, taking into account the narrow margin of profit at present existing, and the many expenses and burdens they are called upon to bear, the manufacturers cannot entertain any further increase beyond what was arranged at the settlement of two years ago. They contend that with those prices ruling it is possible for any operative to earn a fair living wage, and they suggest that it is as much to the interest of the operatives as the manufacturers that the china trade should not be diverted to foreign channels.

"If, however," the letter continues, "the operatives are determined to hand in notices to terminate work 28 days from August 1, it is better, in the interests of both manufacturers and operatives, that notice should be given in time (before Wednesday, July 29), so that any arrangements to be made may be conducted before most of the factories are closed for the Wakes. The manufacturers hope, however, that the operatives will not take this extreme course."

The situation was considered at a mass meeting of operatives held at Longton Town Hall on the 28th ult., when the employers' suggestion that notices to cease work should be handed in was strongly criticised.

Mr. S. Clowes, organiser of the Pottery Workers' Union, said the notice on behalf of the operatives had never suggested a stoppage. The demand of the union was for a levelling up of wages at factories which paid low rates to the reasonable minimum standard already allowed by a number of employers. The operatives' leaders were so convinced of the justice of these demands that they were willing to submit them to arbitration.

It is announced that the Wigan Coal and Iron Company, Limited, the owners of works at Wigan, and collieries at various parts of the country, are taking steps to stop a portion of their collieries, coke-ovens, and iron works, owing to the slump in business, the low prices ruling, the high cost of labour, and the expenses connected with Parliament's social laws. The information adds that the stoppage of other portions of the company's establishments is contemplated in the near future.

The special committee appointed to deal with the Leeds municipal strike issued last week a statement which gives the total cost of the strike. According to the report, all the liabilities had been discharged, and the total expenditure was as follows:—Sums expended by the special committee, 12,333*l.*; sums disbursed by the Watch Committee to maintain the peace of the city, 22,771*l.*—total, 35,104*l.*

The strike of men employed by the Mersey Docks and Harbour Board is now stated to be practically ended. So far it had lasted about three weeks, but was never very effective, since the avowed determination of the strikers to "hold up" the dock gates and thereby stop the ingress and egress of ships altogether failed. Sir Helenus Robertson, chairman of the Board, is reported to have stated that he was very sorry for the men. Many of them had been suffering through the strike they had been advised to join. The strikers, he added, would be taken back and reinstated as far as possible. Everything possible had been done to save the positions for the men who went on strike. The Board had been compelled to take on some outside men, but not more than was absolutely necessary, and most of the positions left by the men were waiting to be filled; the Board hoped they would be filled by the men who deserted them to go on strike.

The Committee of the Federation of Master Cotton-Spinners' Associations held their monthly meeting in Manchester last Monday, when the ballot in regard to short time having proved favourable, it was decided to run the mills as stated in the following circular:—

"Proposed stoppage of 166½ hours between July 7 and end of September: American Section.—The ballot on the above question shows that Federation members in the American Section owning more than the necessary percentage of spindles, and non-members owning 1½ million spindles, are willing to curtail production as recommended. If you are users of American cotton, you are requested to notify your local secretary of the manner and details of the stoppage in your mills."

Sir C. W. Macara was appointed president of the Federation for the ensuing twelve months, and Mr. J. B. Tattersall and Mr. Percy Ashworth vice-presidents.

The decision will affect about 35 million spindles, and considerably over a hundred thousand workpeople; it, however, comes largely in the holiday time.

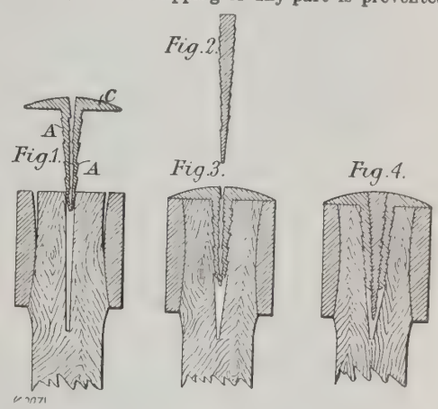
Other news states that, owing to the war, the cotton trade is getting in a most serious situation, and a number, probably a large number, of works will have to close down owing to sales becoming impossible. The situation is further complicated by the fact that a cotton famine is threatening. On Monday last the directors of the Liverpool Cotton Association decided to stop all trading in cotton until further notice, and passed the following resolution, which was notified to the Manchester, New York, and New Orleans markets:—That until further notice all trading in futures and all tenders and all settlements for future contracts be suspended, and that until arrangements to safeguard the interests of all concerned can be made, no trading in spot cotton shall be allowed. In order to carry out the foregoing resolution, the directors shall appoint a special committee to arrange the necessary details. During the afternoon, cables in reply were received from the New York and the New Orleans Exchanges; the three great cotton exchanges of the world are acting in concert.

Contracts.—The water-turbine orders recently booked by Messrs. Boving and Co., Limited, 9½, Union-court, Old Broad-street, E.C., include installations for the Piracicaba Hydro-Electric Company, Brazil; the Kawasugawa Hydro-Electric Company, Japan; the Dominion Portland Cement Company, New Zealand; the Anglo-Japanese Power Company; and for Messrs. F. Street and Co., Oporto. Their pump orders include units for works in this country, the Colonies, and foreign firms. Their contracts also include eighteen Mendheim kilns for the British Aluminium Company, Kinlochleven.—We are informed that the St. Pancras Borough Council have awarded the British Niclausse Boiler Company, Limited, of Caxton House, Westminster, S.W., the contract for four boilers with mechanical stokers, superheaters, economisers, forced and induced-draught installation, and chimneys, of the firm's own design. Each boiler will be capable of producing 40,000 lb. of steam per hour at a pressure of 220 lb. per sq. in. and with 250 deg. of superheat from feed at 120 deg. Fahr. One of the boilers will be delivered before the end of the year, in spite of the international complications.

EXPANDING WEDGE FOR HAMMER-HEADS, &c.

Not the least of the many little annoyances the mechanic meets with in the course of his work is the loosening of hammer-heads from their handles owing to the shrinkage of the wood. This is of frequent occurrence in spite of the rather makeshift methods usually adopted to prevent it, and is often the cause of rather serious accidents. We therefore wish to call attention to an expanding wedge, patented by Mr. G. C. Conner, for the purpose of fixing the heads of hammers, axes, picks, and other similar tools. The inventor claims that the heads are thereby fixed with absolute security, so that the time wasted in tightening them up while work is in progress is saved, and the possibility of accidents arising from the heads flying off and injuring persons or property is eliminated.

The accompanying illustrations, which are more or less self-explanatory, show the design of the wedge and the method of applying it to fix a hammer-head. The device will be seen to consist of a pair of tapered side-plates lettered A in Fig. 1, pinned together at their thin ends for convenience in fixing, and a central wedge, Fig. 2, the object of which is to expand the side plates. The inner and outer faces of the side plates, and the two faces of the wedge, are serrated, as shown, so that slipping of any part is prevented.



To apply the device, a saw cut a little deeper than the thickness of the head is first made in the end of the handle, as shown in Fig. 1. The head having been placed in position on the handle, the side plates are driven into the saw cut so that the projecting flanges are flush with the end of the handle and the head, as shown in Fig. 3. The central wedge is then driven in between the side plates into the position shown in Fig. 4. This operation bursts, or shears, the pin connection between the side plates, and forces them apart, so that the wood is expanded sufficiently to fill the hole in the head completely; the latter is therefore quite immovable. If, after a time, any further shrinkage of the wood should occur, it can be taken up very easily by driving the central wedge down another notch, and this operation can be repeated several times if necessary. In this way the wedge might be driven half-way through the head, though the amount of shrinkage thus taken up would be greater than is ever likely to occur in practice.

These wedges are made by the Patent Expanding Wedge Company, of 114, Great Portland-street, London, W., in fourteen different sizes, of which the smallest measures ⅛ in. by ⅞ in., and is suitable for a head weighing ¼ lb.; the largest size measures 1⅝ in. by 2½ in., and can be used for heads up to 14 lb. in weight. They are very inexpensive, and their use would often save the cost of fitting new handles.

Protection Work on the Mississippi.—We have at one time and another referred briefly to the mattress-protection work carried out on the Mississippi. A recent issue of the *Engineering Record* described an important piece of such work carried out in 1913 by the United States Government at Slough Landing Neck. Here the banks and bottom of the Mississippi have been protected for a length of 5000 ft. and a width of 250 ft. with stone placed on willow mattresses. The mattresses were made in lengths, 1000 ft. long. Each consisted of willow brushwood, bound together to a thickness of 12 in., the upper surface being divided into 8-ft. by 8-ft. pockets for the reception of the stone ballast. They were built up on inclined ways, and the mattress was drawn off into the water, the new bundles of brushwood being added continually at the shore edge. The cost of the work was about 175,000 dols., and it took 28,000 cubic yards of stone and 19,000 cords of brush. The mats were constructed at the rate of about 100 ft. per day. Readers of Engineering will doubtless remember the account we gave recently of the protection work carried out at Rangoon, in which mattresses of a similar character were utilised, Mr. G. C. Buchanan having, in fact, inspected work on the Mississippi before the work at Rangoon was decided upon.

CONTROLLER FOR ELECTRIC HOIST.

CONSTRUCTED BY THE IGRANIC ELECTRIC COMPANY, LIMITED, ENGINEERS, LONDON.

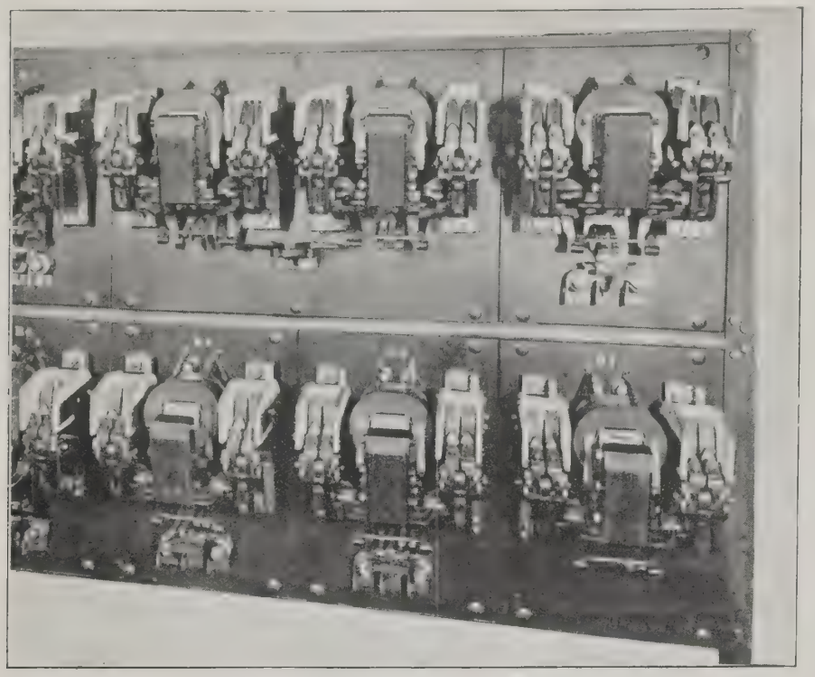


Fig. 1.

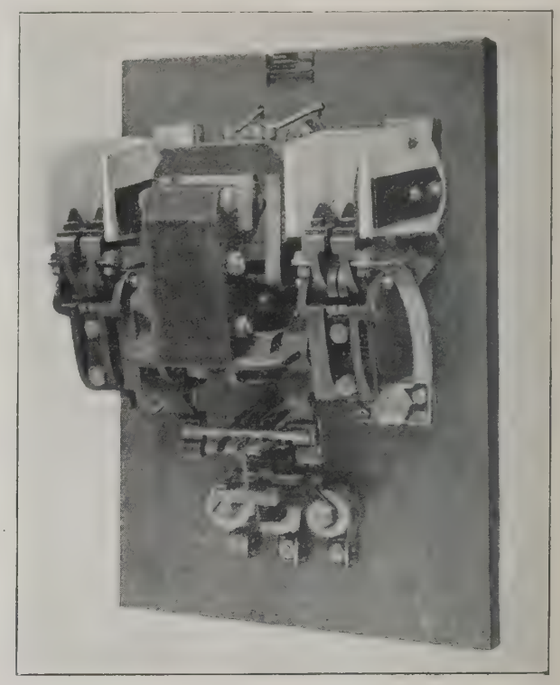


Fig. 3.

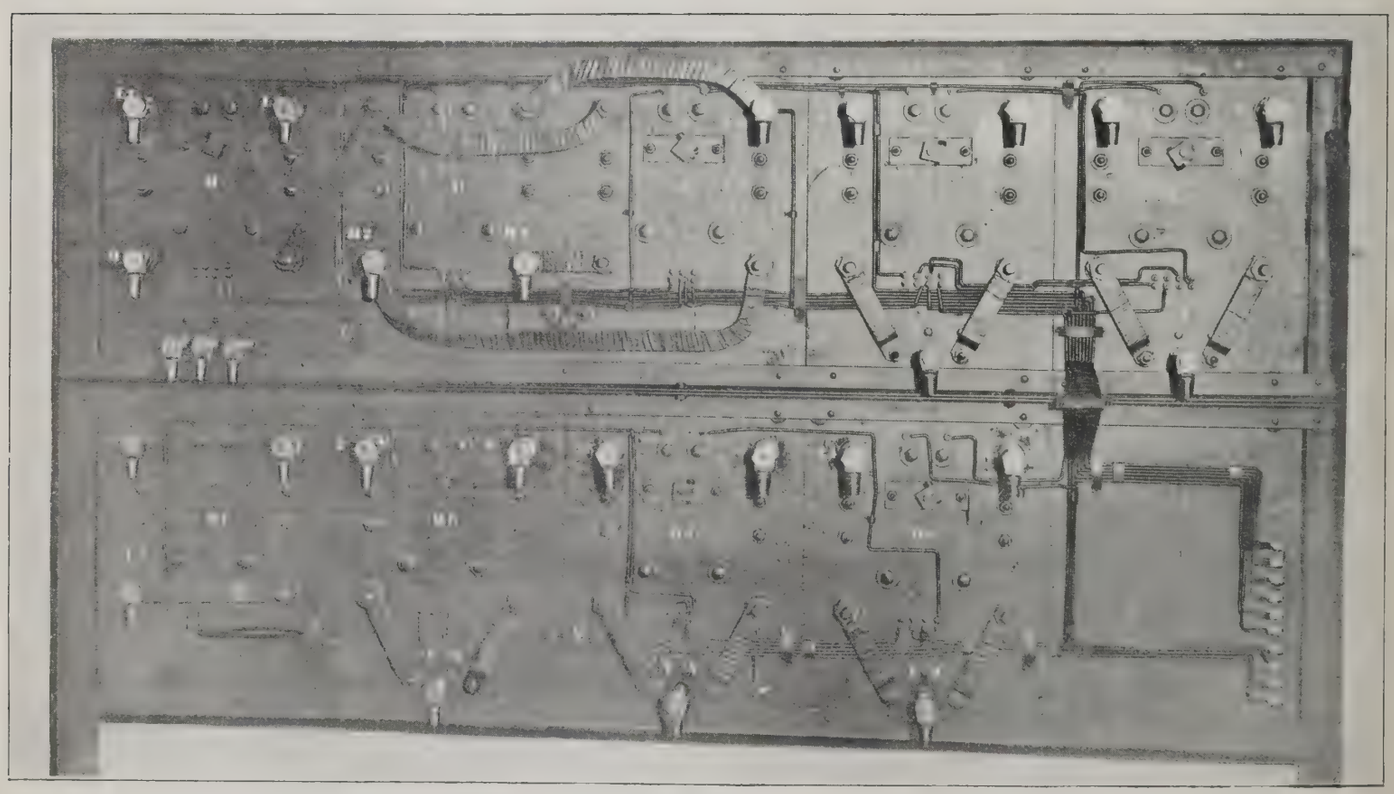


Fig. 2.

On the present and opposite pages we reproduce photographs of a set of control apparatus, made by the Igranic Electric Company, Limited, of 147, Queen Victoria-street, London, E.C., for operating a large electric hoist. The hoist is driven by a three-phase induction motor, capable of developing 260 brake horse-power on peak load; this power is, however, only required for 8 seconds during the period of acceleration. While the hoist is running at constant speed the power required drops to about 60 horse-power, at which it is maintained for 64 seconds. This is followed by a retardation period of 8 seconds, so that the complete cycle takes 80 seconds; the cycle is repeated at intervals of from 95 to 100 seconds. Fig. 1 is a front view of part of the panel, which is mounted on an angle-iron frame, so as to be conveniently fixed as a switchboard. It is provided with nine double-pole alternating-current contactor switches of the type illustrated more clearly in Fig. 3. Two of these switches, which are suitably interlocked, are used for reversing the connections of two of the three phases of the primary winding to alter the direction of rotation of the motor. The other seven are for short-circuiting sections of the resistance in the rotor while starting up. Fig. 4 shows one of the resistance sections, which are of the cast-grid type, mounted in frames separate from the panel. The contactors are operated by a master controller of the drum type, illustrated in Fig. 5, having one "off" position, and eight running notches for each direction of rotation. When the controller handle is moved into the first notch, the primary switches only close, but further movement of the handle closes the accelerating switches in succession until, when the last notch is reached, the rotor is completely short-circuited. Each of the accelerating switches is fitted with a three-phase current-limit relay, which serves to delay the closing of the switches if the controller handle should be moved too rapidly. All the wiring is on the rear of the panel, as is well shown in Fig. 2. The principal circuits are of copper bar, while the control-circuits are of rubber-covered wire secured by cleats. It

CONTROLLER FOR ELECTRIC HOIST.

CONSTRUCTED BY THE IGRANIC ELECTRIC COMPANY, LIMITED, ENGINEERS, LONDON.

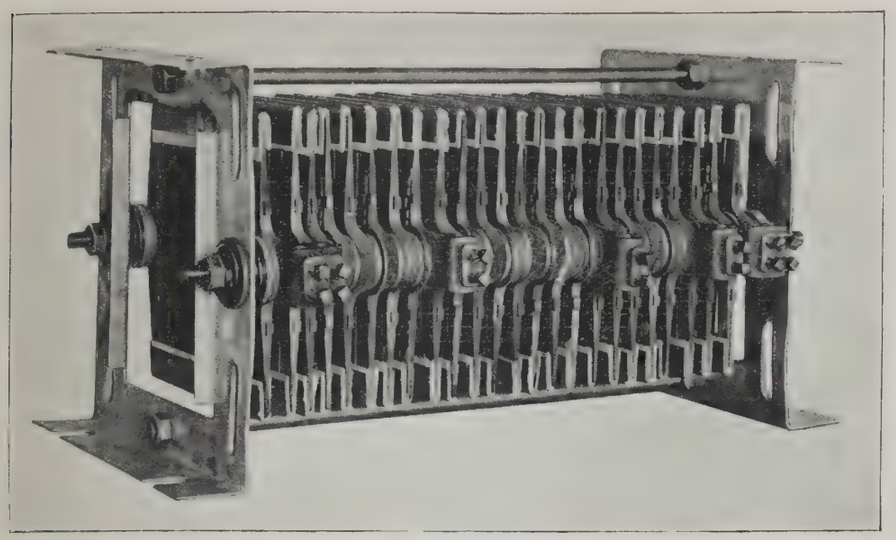


Fig. 4.

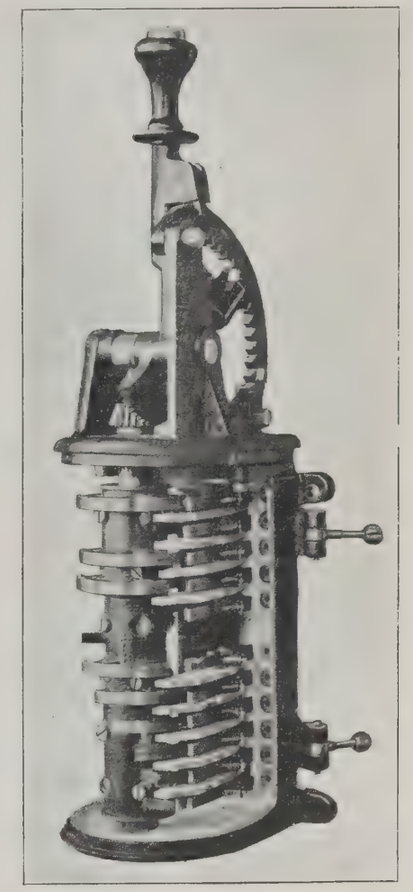
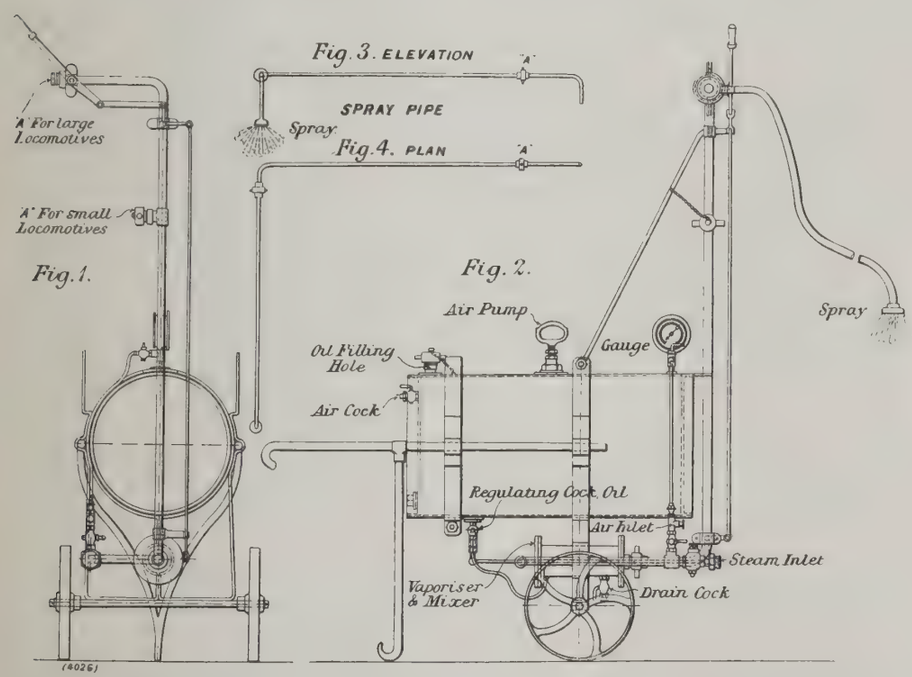


Fig. 5.

will probably have been noticed that there are neither main-line switches nor overload circuit-breakers on the panel; these are, however, provided separately. Also, as the brakes are in this instance pneumatically operated, there is no provision on the panel for handling the brake circuit.

OIL-LIGHTER FOR LOCOMOTIVE FIRES.



The usual method of lighting up locomotives in running-sheds is open to several objections. It necessitates keeping a furnace going from which to draw live coal to start the fires, and involves carrying these coals through the shed on shovels to the engine. The labour and time required are considerable. The superior advantages of a satisfactory portable oil-fuel apparatus for this purpose will be appreciated by railway men, and we therefore illustrate herewith a device used with success at the Old Oak Common sheds of the Great Western Railway. The machine is the invention of Messrs. Armstrong and Rogers, of the locomotive department of the Great Western Railway. It is being made and put on the market by the Westminster Engineering Company, Limited, Victoria-road, Willesden Junction.

The machine is shown in elevation in Figs. 1 and 2, while Figs. 3 and 4 show, to a reduced scale, the nozzle-arm. The appliance consists of a reservoir to hold the crude oil or residue, capable of being put under a pressure of from 5 lb. to 10 lb. per sq. in. by means of a hand-pump. A vaporiser and mixer is arranged under the reservoir, and the oil passes through this on its way to the flexible pipe which terminates in a turbine spraying-head. The latter is placed in the fire-box and the cloud of oil-spray ignited, the flame being directed on to coal already placed on the grate. The effectiveness of the system is evident from the fact that 20 lb. of steam can be raised from a cold boiler in about half the time taken by the ordinary lighting-up method. Where compressed air is available a connection may be made to a branch on the machine, and no hand-pumping or vaporising is then required. Where compressed air is not available steam is used for driving the oil through the turbine-head and for heating the vaporiser. Compressed air is said to be preferable, but the steam method proves quite satisfactory.

It may be mentioned that at the Old Oak Common sheds, where the number of locomotives going out averages 130 per day, three lighting-up machines are in use, and the saving realised 225*l.* in the past twelve months. The oil taken per fire amounts to about 7 pints, which at a cost of about 75s. per ton would mean that the lighting-up costs would be about 2½d. per engine. The whole of the heat developed is put, of course, to useful work, which is far from being the case with the ordinary furnace method; while the saving of time and the elimination of fire and other risks are important.

Universal Directory of Railway Officials, 1914.—We have received a copy of this directory for 1914, the twentieth year of publication. It is compiled under the direction of Mr. S. Richardson Blundstone, editor of the *Railway Engineer*, and is published at the subscription price of 7s. 6d. (after publication, 10s.), by the Directory Publishing Company, Limited, 15, Farringdon-avenue, E.C. It gives information on the railways of the whole world, the information comprising the length of the railway, the gauge, and the names of all members of the Board, engineers, chief clerks, and their address. It contains also a personal index of all the railway officials.

The Copper Market.—In their monthly report, dated the 4th inst., Messrs. James Lewis and Son state that after advancing from 61*l.* on the 1st ult. to 62*l.* 10s. on the 7th, cash standard fell to 60*l.* 3s. 9d. on the 22nd, but recovered next day to 60*l.* 12s. 6d., and declined rapidly to 56*l.* on the 30th, when 1*l.* 10s. per ton additional was paid for three months prompt. On the 31st the committee decided to close the London Metal Exchange until further notice, the settlement price of the 30th holding good until it should be reopened, prompts falling due after the 31st being postponed until further notice. A considerable business—estimated at 35,000 to 45,000 tons for shipment over three months — was transacted in American electrolytic copper during the first week of July at 13⅜ to 13½ cents per pound with home consumers, and at 63*l.* 10s. per ton c.i.f. for export to Europe, up to 13⅝ cents and 64*l.* being subsequently paid. Final quotations were 13 to 13½ cents and 59*l.* 10s. to 60*l.* The copper output of the Tanganyika Company last year was 7000 tons. That for the present year is expected to be 12,000 tons, at a cost of 38*l.* delivered in England; for 1915, 25,000 tons at 30*l.* to 32*l.*, and for 1916, 40,000 tons at about 30*l.* per ton. The copper production of the Otavi Company for the year ended March 31 last was 7088 tons, against 6095 tons for 1913 and 5211 tons for 1912. The Anaconda Company announced the reduction of their output by 2260 tons per month. American exports for July were advised as 34,145 tons.

OXY-ACETYLENE WELDING.

To the Editor of Engineering.

Sir,—With reference to the letter in yesterday's Engineering from the British Acetylene and Welding Association, may I be allowed to inquire through your columns whether welding has ever been suggested or tried in connection with the crown sheeting of a gas-holder?

These sheets in the larger holders would be about $\frac{1}{2}$ in. thick, and are at present lap-jointed and riveted with rivets about $\frac{5}{16}$ in. or $\frac{3}{8}$ in. in diameter.

If the sheets could be satisfactorily welded together *in situ*, a much better job would result, and painting would be easier.

Yours truly,
Hampton Hill, August 1, 1914. W. H. Tozer.

THE ELECTRIC VEHICLE ASSOCIATION OF AMERICA.

To the Editor of Engineering.

Sir,—I have received a letter from the Secretary of the Electric Vehicle Association of America, stating that the Association will be glad to welcome to their annual Convention in Philadelphia, which is being held on Monday, Tuesday, and Wednesday, October 19, 20, and 21, 1914, any electrical engineers in England who are interested in the electric vehicle, and who propose being in the States at that time. I may say that the Electric Vehicle Committee is being represented by its chairman, Mr. R. A. Chattock, the City Electrical Engineer of Birmingham. I should be glad to be advised of any engineers who are proposing to attend, in order that I may notify the secretary of the Association.

Yours faithfully,
F. Ayton, Hon. Secretary.
The Electrical Vehicle Committee of the Incorporated Municipal Electrical Association,
Ipswich, August 4, 1914.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was dead idle, and the prices of Cleveland warrants were easier. Sellers quoted 51s. 2d. cash, and 51s. 3½d. one and three months, while buyers named 50s. 10½d. cash, and 51s. one and three months. In the afternoon there was again nothing doing, and although buyers' quotations for Cleveland warrants were unchanged, sellers quoted a little easier at 51s. 1d. cash, 51s. 2½d. one month, and 51s. 3d. three months. On Friday morning idleness again prevailed, and sellers of Cleveland warrants made no change in their quotations from the previous day. The afternoon session was another blank, but the tone was a shade firmer, with sellers of Cleveland warrants naming 51s. 1½d. cash and 51s. 3d. one month and three months. On Monday—August Bank Holiday—the market was not in session, nor did it open on Tuesday or to-day (Wednesday) on account of the condition of business owing to the present war crisis. As soon as affairs settle down a little the market will be resumed.

Sulphate of Ammonia.—The demand for sulphate of ammonia has fallen off completely, and business is at a standstill. No fixed price can be given, and buyers require to make the best terms possible.

Scotch Steel Trade.—Great tension has prevailed in all business circles during the past few days owing to the possibility of Britain being dragged into the present European trouble, and now that the worst has been realised, and that war has actually broken out with Germany, business has received a staggering blow. The excitement has been very marked on all sides, but in the course of a few days the general trade position will be considerably improved, and manufacturers and merchants will settle down to the new order of things by which they are faced. In the steel trade makers were daily looking for a revival and were anxiously waiting for some improvement, but this now seems as far off as ever. The home trade is poor, while the export trade is almost entirely suspended, as the war insurance risk rates are quite prohibitive; but at present the Government are considering the matter. Of course, the ports to which we can ship material during the present crisis are very limited, and already a number of vessels are hung up—fully and partially loaded. Prices all round have advanced considerably, and no definite quotations can be given, but, roughly speaking, the rise is from 10s. to 20s. per ton, although everything is a matter of negotiation. The supply of raw material has practically stopped, and while arrangements are being made for other sources of supply being tapped, business will be more or less suspended for a day or two.

Malleable-Iron Trade.—The recent quietness in the malleable-iron trade in the West of Scotland had not shown any change for the better this week, and now the business outlook is considerably more gloomy. Producers hope, however, that they will get busier shortly, as there are prospects of our trade routes to oversea ports being thoroughly controlled. Some of the works have not yet been re-opened since the holidays.

Scotch Pig-Iron Trade.—So much of our Scotch pig-iron is shipped abroad that the outbreak of war has caused a cessation in dealings. This is only likely to be temporary, as adequate arrangements will be made to prevent a stoppage in business; but for the present, however, there is little doing either on home or export account. The furnaces in blast number 53, as against 82 for the corresponding week of last year, but even that number will shortly be reduced. Prices are firmer.

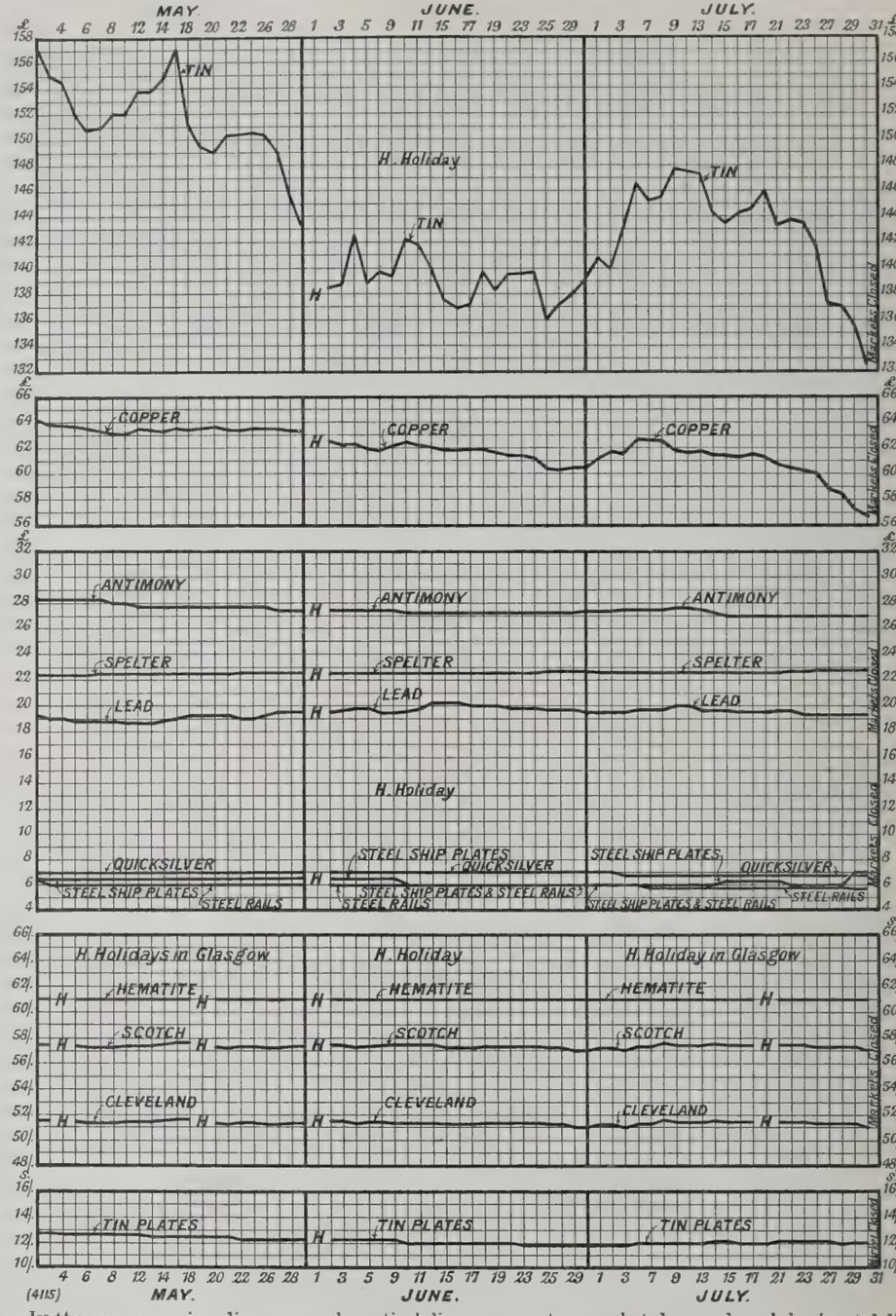
Scotch Shipbuilding.—Like the majority of the industries of the country, the shipbuilding trade is feeling the result of the warlike conditions which have recently prevailed, and now that we, ourselves, are at war with Germany there is the probability that there will be a reduction of employment. The country is in a state of excitement, and the mobilisation of the Crown forces has taken from many of the shipyards large numbers of men belonging to the Royal Naval Reserve, the Army Reserve, and the Territorial Force, but efforts will be made to keep the yards going so long as material can be obtained. During the past month, owing to the holidays, the output was small and only totalled nineteen vessels, with a gross tonnage of 19,533 tons, made up as follows :—

	Vessels.	Tons.
The Clyde	12	16,216
The Forth	2	2,500
The Tay	—	—
The Dee	5	817
Total	19	19,533

The Clyde total is the smallest of any month this year, and the nearest July total to that figure was in 1903, when the output only totalled 15,903 tons. For the year to date there have been launched, on the Clyde, 141 vessels, amounting to 283,893 tons, which compares badly with the 377,270 tons for the same period of last year, the 329,952 tons of 1912, and the 344,218 tons of 1911. When the Aquitania's 50,000 tons is deducted from last year's figures we find that the falling-off for this year is reduced to about 40,000 tons. The seven months' total has only been bettered on five other occasions, so that this year's figures must still be considered quite satisfactory. New work, although not over-plentiful, has been coming in fairly well, and quite a number of contracts are reported, some of which are for good-sized vessels. The outbreak of war, with its consequent tightness of money, will undoubtedly have a telling effect on the shipbuilding trade, on the side of mercantile work, at any rate, but it will bring forward, in the present instance, an improved demand from the Admiralty. The Clyde has quite a lot of Government work on hand just now, as much as or more, perhaps, than at any previous time, as there are no fewer than sixteen vessels under construction. The Dreadnought battleship Benbow at Messrs. William Beardmore and Co.'s yard at Dalmuir, and the Dreadnought cruiser Tiger, at Messrs. John Brown and Co.'s yard at Clydebank, are each nearing completion, and are being speeded on, while some of the other vessels are well under way.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



In the accompanying diagrams each vertical line represents a market day, and each horizontal line represents 1s. in the case of tin-plates, hematite, Scotch and Cleveland iron, and 1*l.* in all other cases. The price of quicksilver is per bottle, the contents of which vary in weight from 70 lb. to 80 lb. The metal prices are per ton. Heavy steel rails are to Middlesbrough quotations. Tin-plates are per box of I.C. cokes.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—Owing to the rapid developments of events on the Continent, the position in the steam-coal market has undergone a marked change. High pressure in shipping has given place to an almost complete cessation of this class of trade. Up to the last available moment orders were expedited for the convenience of Continental consumers, and there was great activity at the ports. The market has been further weakened by a pronounced shrinkage in local industrial buying, the holiday stoppage and war influences having operated together with serious effect. Some of the newer pits in the South Yorkshire area, which have been sending the bulk of their output to the coast, are feeling the pinch acutely. A slight improvement is shown in the buying of household sorts. Much of the weakness at the dépôts has disappeared, although at collieries large stocks are in evidence, and short working is the rule rather than the exception. A slightly larger tonnage is going into the country and to the London dépôts. Values are a little firmer. With the settlement of contracts, gas fuels are a more active medium. Slacks fluctuate. While there has been a good deal of forced selling in the lower qualities, the best sorts are making quite an average figure. There is no improvement in the demand for coke. Quotations:—Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. to 13s.; Derbyshire best brights. 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 10s. 3d. to 11s. 3d.; small nuts, 9s. to 10s.; Yorkshire hards, 11s. to 12s.; Derbyshire hards, 10s. to 11s.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.

Iron and Steel.—Though signs of panic are nowhere to be seen, the position in the South Yorkshire iron and steel trades is one of great seriousness. This is particularly unfortunate, as the majority of the branches in the trade had shown slightly increased activity, and the raw-material markets had felt the benefit of this change for the better. A number of short-dated contracts had been arranged, and there was more buying at better prices in the open market. The complete stoppage of all Continental business which has followed upon the declaration of hostilities, however, has caused something of a slump in the majority of trade departments, whilst those who were solely dependent on Continental buying are in a very precarious position indeed. The first effects of this blow are sufficiently serious, and as war progresses they will become increasingly grave. It is feared that in the more general branches of the trade the Bank Holiday will develop into an indefinite stoppage for some thousands of workmen. The only people to remain unaffected are the armament firms who have cut short the holiday of their employees, and have engaged extra men to enable them to deal promptly with their present enormous rush of orders. Subsidiary trades of the armament industry are also at present fortunately placed, for the emergency demands for steel tools are great, and there is little falling-off in the demand for castings and forgings for English shipbuilding. That promising market for agricultural implements and machinery—Russia—is now closed, and South Yorkshire makers of machine-knives and other agricultural sections are seriously affected. The closing of the Continental market has its effect in two ways, for apart from being a market for finished goods from South Yorkshire, tungsten powder from the German laboratories is a primary factor in the local high-speed steel trade. Many local firms are also very large users of semi-finished products from the Continental foundries, which for some time have been dumped into this country and sold at cheaper rates than those obtainable from local manufacturers of such articles. As a satisfactory set-off against depression in other branches, the home trade has so far been maintained at its recent healthy state. Quite a number of German expert steel analysts employed in the leading Sheffield works have had to leave the city to join their regiments abroad.

MOTOR CRUISING-LAUNCH "CAROLA."—We recently had an opportunity of inspecting the cabin motor cruising-launch "Carola," built by Messrs. J. I. Thornycroft and Co., Limited, of Caxton-House, Westminster, S.W., for Mr. C. B. Warner, of Loughborough. The hull, which is constructed of mahogany, has a length of 35 ft., a beam of 8 ft., a moulded depth of 4 ft., while the draught is 2 ft. 3 in. It is fitted with one of Messrs. Thornycroft's standard two-cylinder marine engines, which develops 15 horse-power and gives a speed of about 8 knots. The fuel used is paraffin, and petrol is used for starting, though we saw the engine started up quite easily on paraffin, after it had been standing for over an hour. The launch is a particularly handy and compact little craft, suitable for sea-cruising purposes, and it can easily be handled by one man. The accommodation, which is very complete, consists of a comfortable and well-lighted saloon, situated amidships, provided with an oval folding-table, and having cushioned seats on either side; the seats can be converted into sleeping-bunks when necessary. Forward of the saloon is a sleeping-cabin, fitted with berth, seats, lockers, and other conveniences, and aft is the engine space, in which the cooking-range, lavatory, w.c., &c., are placed. Still further aft is a cockpit, with cushioned seats to accommodate several persons, and in this space the steering-wheel is fitted on a raised platform, within easy reach of the reversing-lever and the throttle controlling the engine. Throughout the short run we had on the boat the engine ran smoothly and quietly, and the exhaust was hardly visible. The boat is, we understand, exactly similar to one recently supplied to His Grace the Duke of Sutherland, and is one of Messrs. Thornycroft's standard designs.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is no business at all passing in pig-iron, and traders have ceased to quote. Shipments have been discontinued, and deliveries to local consumers have been considerably curtailed, the works not now requiring material. A steady diminution of employment appears certain, and, in fact, in the course of a few days, most works will be closing down. Several vessels that have loaded pig-iron here are to discharge their cargoes again, and it is stated that the S.S. Cronstadt, which left the Tees with a cargo of pig-iron last week for Russia *via* Leith, is returning to Middlesbrough to unload. There are no quotations for coke or foreign ore.

Manufactured Iron and Steel.—There is nothing passing in finished iron and steel, but owing to the withdrawal of German competition, producers here have advanced prices by 10s. per ton, and principal market rates now stand:—Common iron bars, 7*l.* 10s.; best bars, 7*l.* 17s. 6d.; best best bars, 8*l.* 5s.; packing iron, 5*l.* 15s.; iron ship-angles, 7*l.* 10s.; iron ship-plates, 7*l.* 5s.; iron girder-plates, 7*l.* 15s.; iron rivets, 7*l.* 15s.; galvanised corrugated sheets, 11*l.* 10s.; heavy steel rails, 6*l.* 5s.; and steel railway sleepers, 7*l.* 2s. 6d.

Shipments of Iron and Steel.—Last month's shipments of pig-iron from the Tees were only on a moderate scale, averaging 3052 tons per working day, the total loadings being returned at 82,412 tons, 7533 tons of which went from Middlesbrough and 7079 tons from Skinningrove. For the previous month the total despatches of pig were given at 86,907 tons, or a daily average of 3218 tons; and for July last year the clearances reached 105,935 tons, or an average of 3923 tons per working day. Of the pig sent from Skinningrove last month 6540 tons went to Scotland and 539 tons went to Holland; whilst of the iron shipped at Middlesbrough 44,409 tons went abroad, and 30,924 tons coastwise. Scotland, as usual, was the largest buyer, receiving 14,015 tons; Wales taking 8235 tons; Sweden, 6786 tons; France, 5951 tons; Germany, 5916 tons; Italy, 5230 tons; Holland, 4799 tons; and Norway, 3494 tons. Tees loadings of manufactured iron last month amounted to 11,662 tons, of which 3936 tons went foreign and 7726 tons coastwise; and clearances of steel reached 45,196 tons, 38,497 tons of which went abroad, and 6699 tons to home customers. India was the largest buyer of both manufactured iron and steel, importing 2423 tons of the former, and 17,737 tons of the latter. Other principal buyers of steel were:—New South Wales, 6784 tons; West Australia, 4004 tons; the Argentine, 2418 tons; Victoria, 1750 tons; Russia, 1398 tons; and Natal, 1004 tons.

MACHINE-TOOLS FOR THE ANTARCTIC.—The Shackleton expedition to the Antarctic is taking as part of its outfit a 3½-in. S.S.S. Drummond lathe and a sensitive drilling-machine by the same builders, Messrs. Drummond Brothers, Limited, Guildford. It is interesting to note that the Scott Antarctic Expedition also carried a 3½-in. Drummond lathe.

NATIONAL ILLUMINATION COMMITTEE OF GREAT BRITAIN.—We have received a copy of the rules of this committee, which is affiliated to the International Commission on Illumination, and is constituted by co operation of the Illuminating Engineering Society, the Institution of Electrical Engineers, the Institution of Gas Engineers, and the National Physical Laboratory. The secretary and treasurer is Mr. W. J. A. Butterfield, 66, Victoria-street, London, S.W.

THE MANCHESTER MUNICIPAL SCHOOL OF TECHNOLOGY.—The prospectus of university courses in the Municipal School of Technology, Manchester, for the session 1914-15, has just been issued. The courses include mechanical engineering (three years), electrical engineering (three years), municipal and sanitary engineering (three years), general chemical technology (one to three years), chemical technology of textiles (two years), paper manufacture (two years), metallurgy and assaying (three years), chemical technology of brewing (two years), photography (two years), textile industries (three years), photographic technology (two years). The session will open on Tuesday, October 6, and will end on Friday, July 23, 1915. The fees depend upon the courses taken, but are about 20 guineas for the session. The mechanical engineering department has exceptional facilities for steam-engine, hydraulic, and material-testing work, and the present internal-combustion engine laboratory will shortly be greatly extended.

PERSONAL.—Messrs. D. T. Keymer and Co., engineers, Calcutta, have been appointed by Messrs. Musgrave and Co., Limited, of St. Ann's Iron Works, Belfast, as their sole agents for the eastern side of India and for Ceylon.—We are informed that Mr. Daniel Kemp has been appointed as general manager of the engine-works department of Palmer's Shipbuilding and Iron Company, Limited, Jarrow, to succeed Mr. J. W. Reed, who has resigned. Mr. Kemp joined Palmer's Company about three years ago, coming to Jarrow from the engine department of the Clydebank Works of Messrs. John Brown and Co., Limited, where he had occupied the position of assistant manager for some years. Mr. A. MacFarlane has been appointed chief assistant to Mr. Kemp, and Mr. William Brown outside manager. Mr. MacFarlane and Mr. Brown have been connected with the engine-works department of the company for some time. Mr. R. Fullerton, recently of Clydebank, has also been appointed an assistant manager in this department.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The local coal trade has been disorganised by the action of the Admiralty authorities in taking practically the whole of the output of best Admiralty qualities. The uncertainties created by the war crisis made business in other descriptions almost impossible. Continental financial troubles and the possibility of a stoppage in industries, on account of the war, caused both buyers and sellers to adopt a waiting policy to some extent. The requirements of the Admiralty were, however, so urgent that loading operations were continued over Sunday and Bank holiday, as well as at night.

Bristol Tramways.—A Committee of the House of Commons, in dealing with a Bristol Tramways Bill, struck out a clause providing for the compulsory purchase of the tramways by the Bristol City Council. The Bill further enacts that if the Council exercises its statutory right to purchase the tramways, it must, at the same time, acquire the outside portions.

Greater Swansea.—A special meeting of the Swansea Town Council was held on Tuesday, Alderman Coker in the chair, to deal with proposals of the Parliamentary Committee with regard to borough extension and a new drainage system. Mr. D. Matthews, chairman of the committee, moved resolutions, which were adopted unanimously. The resolutions provided that representations be made to the Local Government Board applying for an extension and alteration of the boundaries of the borough, so as to include the urban district of Oystermouth, the whole of the parishes of Brynau, Cockett, Llansamlet Higher, and Llansamlet Lower, and part of the parishes of Penderry and Clase Rural; and that a report of Mr. Midgley Taylor, providing for the comprehensive drainage of the borough, be approved. It is understood that the districts proposed to be included in the borough mean an additional population of about 29,000, which would bring Swansea's population to about 150,000. The drainage scheme differs from one recently thrown out by Parliament, in that the outlet at Mumbles is to be over 100 yards further out to sea, and the storage chamber double the size. The cost will be 344,000*l.*, as against an original proposal of 225,000*l.*

Milford Haven.—Some months since great concern was felt by the shipping interest at Milford Haven when it was discovered that the huge gates at the entrance to the docks had been seriously damaged by the storms of the winter. The dock company's divers found that the keel of one of the gates was broken, and upon this, the docks manager and engineer (Mr. J. C. Ward) consulted some leading London engineers. It was feared that the gates would have to be replaced. Mr. Ward, however, set divers to work on plans of his own, and this week the hazardous undertaking has been successfully accomplished. A keel, 12 ft. 6 in. long by 18 in. wide, with an angle-iron 4 in. by 4 in. bolted on, was taken from the bottom of the gate. The keel was under the centre of the gate, and the men had only 2 ft. 6 in. space to get under to work in to clear the butt-strap. They afterwards fixed on a new keel.

Dowlais.—All departments of the Dowlais Works were well employed until the holiday stoppage. At the Bessemer, the Siemens, and the blast-furnaces a large tonnage of crude steel and pig-iron was turned out, and the Goat Mill had a good production of steel rails, ingots, and tin bars. The Big Mill was employed upon tram rails, gutter iron, angles, curves, and fish-plates.

TURKISH BATTLESHIPS BOUGHT BY BRITISH ADMIRALTY.—We are officially informed that His Majesty's Government have taken over the two battleships, one completed and the other shortly due for completion, which had been ordered in this country by the Turkish Government, and the two destroyer leaders ordered by the Government of Chili. The two battleships will receive the names Agincourt and Erin, and the destroyer leaders will be called Faulkner and Broke, after two famous naval officers.

COAL IN GERMANY.—The production of coal in Germany in June was 15,016,220 tons, as compared with 15,929,858 tons in June, 1913; of lignites, 7,158,655 tons, as compared with 6,858,699 tons; of coke, 2,602,801 tons, as compared with 2,610,818 tons; and of briquettes, 2,438,795 tons, as compared with 2,217,227 tons. The aggregate production of coal in the first half of this year was 94,147,997 tons; of lignites, 44,350,996 tons; of coke, 15,974,254 tons; and of briquettes, 14,514,824 tons. These aggregates, when compared with the corresponding totals for the first half of 1913, showed increases of 570,010 tons in coal, 2,450,838 tons in lignites, 30,017 tons in coke, and 133,254 tons in briquettes. The imports of coal into Germany in the first half of this year were 4,775,981 tons, while the exports were 18,169,595 tons; the corresponding totals for the first half of 1913 were:—Imports, 5,028,462 tons; exports, 16,371,647 tons. The imports of coke into Germany in the first half of this year were 295,142 tons, while the exports were 2,630,139 tons. The corresponding totals for the first half of 1913 were:—Imports, 253,542 tons; exports, 3,430,796 tons. The combined aggregates of production and imports to June 30, this year, were accordingly:—Coal, 98,923,978 tons, as compared with 98,606,449 tons; and coke, 16,269,396 tons, as compared with 16,197,779 tons. When account is taken of the export movement the consumption of coal in Germany in the first half of this year comes out at 80,750,383 tons, as compared with 82,234,802 tons; and of coke, 13,639,257 tons, as compared with 12,766,983 tons.

THE ALEXANDRA DOCK EXTENSION AT NEWPORT; ROLLING BRIDGE OVER THE SOUTH LOCK.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C. E., WESTMINSTER, ENGINEERS.

(*For Description, see Page* 177.)

Fig. 142. Rolling Bridge in Position for Traffic.

Fig. 143 Rolling Bridge Lifted.

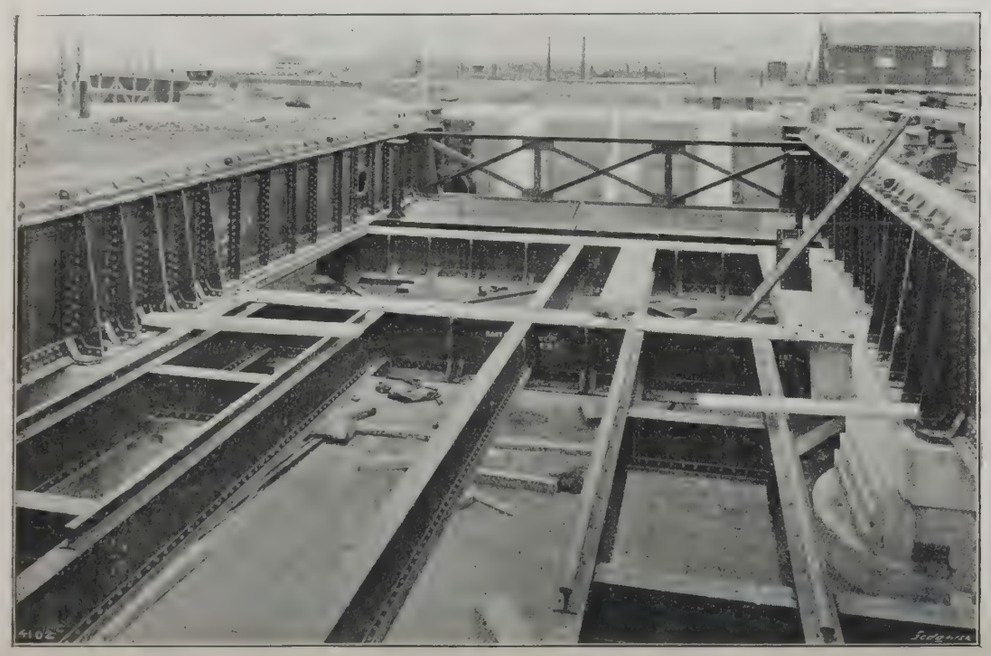


Fig. 144. Main Tracks for Rolling Bridge.

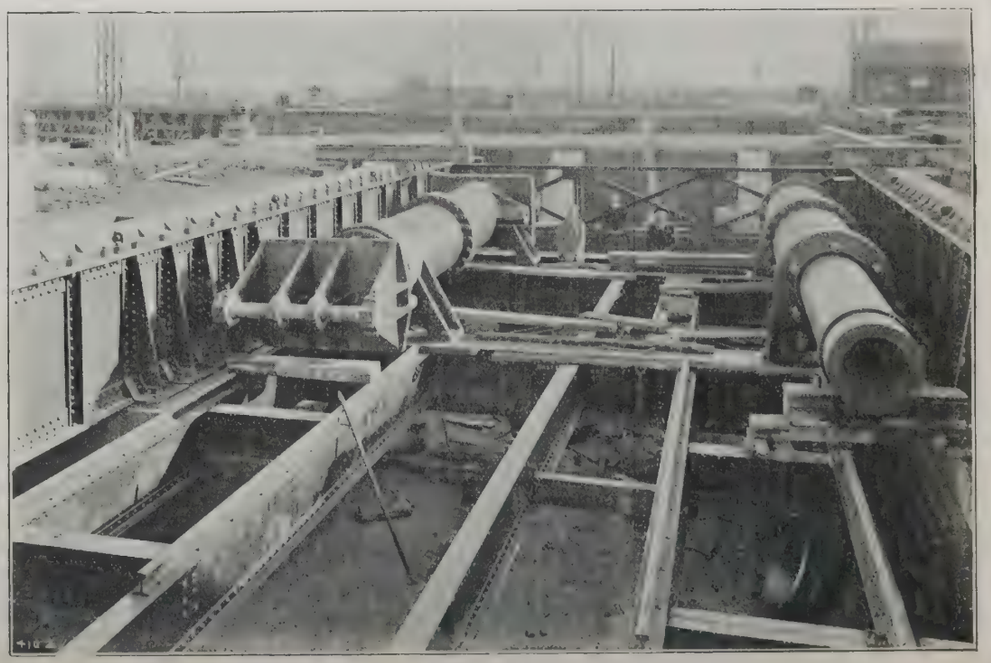


Fig. 145. Hauling Cylinders for Rolling Bridge.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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Thin paper copies	£1	16	0
Thick ,, ...	£2	0	6

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All accounts are payable to **"ENGINEERING," LIMITED.** Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—**3663** and **8598** GERRARD.

READING-CASES.—Reading-cases which will hold twenty-six numbers of "ENGINEERING" may be had of the Publisher or of any newsagent. Price 6s. each.

SPECIAL NOTICE.—With the number of July 24 was published (together with the Index to last Volume) a Classified Directory of Current Advertisements in ENGINEERING, with a List of Telegraphic Addresses and Key to same. This Directory and List, with Telephone Numbers and Telegraph Codes, are also published in compact book form for handy reference, which may be obtained gratis from the Publisher.

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NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, AUGUST 7, 1914.

BEARINGS.

WHERE any mechanical device has been made in very large numbers, and used over a very long period of time, it may generally be taken to have designed itself, being as much the product of evolution as is the organic world. If we may judge from the geological record, Nature has made mistakes in plenty in the past, and eliminated them, though the record of her aberrations remains in the rocks. The engineer is no more infallible than Dame Nature, but, like her, given a sufficiency of time and a sufficiency of material, he may be trusted to "get there" pretty effectively in the end, whatever the blind alleys he may unprofitably explore *en route*. In fact, when any form of mechanism is made in very large quantities under the direction of many independent minds, every possible modification, whether futile or effective, is pretty certain to have been tried at some time or other. These variations, even when successful, are, of course, not necessarily made with knowledge; but where any practice is sanctioned by a very long use and experience it is unlikely to be wholly unreasonable, although its *rationale* is not always easy to discover. The practical man's predilection for locating oil-grooves in his brasses in precisely the regions where theory indicates their undesirability has therefore probably some basis in the experience gained in days when lubricants were supplied to bearings in driblets and at irregular intervals. Mechanics are, however, inclined to extend practice beyond the bounds of experience, and it is at times very difficult to persuade the fitter to omit his traditional oil-grooves, even in the case of an efficiently lubricated bearing. The millwright, on the other hand, may be quite justified in adhering to his customary practice where conditions are the same as those in which that practice developed. Modern bearings of the high-speed type present, however, an entirely different problem in lubrication, the solution of which has for the most part been evolved but gradually, by a cautious step-by-step modification of previous practice. Much, no doubt, still remains to be done, and some exceedingly interesting developments are described in the paper by Mr. Gerald Stoney, F.R.S., read before the North-East Coast Institution of Engineers and Shipbuilders on March 20 last, and reprinted in this issue. The general character of high-speed lubrication is now well known. In a properly-lubricated high-speed bearing the brass and the journal never come into contact, and even a run of many years yields no signs of wear on the so-called rubbing surfaces. In fact, the surfaces do not rub. As is well known, the theory of this type of lubrication was long ago developed by Osborne Reynolds, and in spite of the unavoidable roughness of certain of the assumptions made, a not unsatisfactory agreement has been established between calculation and experiment. Nevertheless, it has not been easy to account on theoretical grounds for the very liberal amount of bearing surface often provided. Even in America, where the absence of keen commercial rivalries leads to risks being more readily run, the area provided appears very ample if judged from the theoretical standpoint. Mr. Balfry, for example, in a paper read before the Rugby Society of Engineers last year, has given the following table as representing the practice of the General Electric Company of America:—

Rubbing Speed. ft. per sec.	Pressure on Projected Area of Brass. lb. per sq. in.
20	167
30	190
40	208
60	229
73.5	235

Even the highest of these figures is very low in comparison with the safe load as indicated by theory. An over long high-speed bearing must, of course, waste power, since the resistance is practically independent of the load carried, being simply proportional to the area of oil under shear. The shearing resistance of this oil varies, of course, with the working conditions, but is generally of the order of $\frac{1}{2}$ lb. per sq. in. A convenient formula for the frictional loss in a bearing of the type under consideration has been given by Mr. Stoney in the form:—

$$\text{B.Th.U. lost in journal friction per hour} = \frac{190\, l \,.\, d \,.\, v}{t - 32},$$

where l = journal length, and d the diameter, both in inches, v the surface velocity in feet per second, and t the temperature in Fahrenheit degrees. A long bearing means, therefore, a relatively high frictional resistance and a large provision of surface in the oil-cooler. There has thus been every inducement to cut down to a minimum the length of high-speed bearings, and the more so in that a long bearing unavoidably implies an increase in the journal diameter necessary to secure adequate strength and stiffness. No wholly satisfactory reason for the long bearings found to be requisite has hitherto been advanced; but Mr. Stoney suggests in his paper that vibration is a factor not provided for in the ordinary theory of lubrication, and that the large areas current in practice form a necessary safeguard against the squeezing out of the oil by the high pressures which will be an inevitable result of the vibration of a heavy rotor. In this connection it is, however, of great interest to note from Mr. Stoney's paper that Sir Charles Parsons is now applying the Michell principle to turbine bearings. Each journal, instead of being supported on a continuous brass, is carried on a few pivoted blocks, these blocks being quite narrow, both circumferentially and in a direction parallel to the axis of the shaft. A great reduction is thus effected in the area of oil under shear, and the total friction of a large turbine can be cut down to an insignificant fraction of what has hitherto been usual. The oil-cooling plant is equally reduced, since less oil has to be pumped into the bearings. The aggregate gain effected under these different heads may be equivalent to a saving of as much as $\frac{1}{4}$ lb. of steam per kilowatt-hour.

Pivoted blocks have, when arranged as thrust-blocks, been run experimentally under loads of over 5 tons per sq. in., the rubbing speed being about 50 ft. per second. There is no obvious reason why such blocks should not work equally well in journals, and though there is no occasion to proceed to the extreme of pressure above noted, it is still quite feasible to cut down the bearing area sufficiently to reduce the over-all length of a large turbine by several feet.

It is of no little interest to compare the remarkable figures realisable with this type of journal with what is found practicable in locomotive practice, and there is no service in which bearings are more severely tried. Here the bearing length is probably not far off the limit of what is possible without a very great increase in the number of damaged brasses. Some highly interesting figures on this head were contributed to the discussion on Mr. Stoney's paper by Mr. J. W. Hobson, who stated that the ratio of length to diameter in locomotive main bearings varied from 0.95 to 1.3, but the lower figure was a matter of necessity, and not of choice. According to Mr. Hobson, the brasses are cut away so that the effective width is 0.4 of the journal diameter, but in new bearings the arc of contact is still further decreased by easing away the brass so that it does not subtend more than 60 deg. to 90 deg. The average load carried, reckoned on the projected area of the effective portion of the brass, is, he says, from 240 lb. to 300 lb. per sq. in., and the maximum rubbing speed at 60 miles an hour is some 8.7 ft. to 10 ft. per second. In the case of the bogie, radial, and tender journals more room is available, and the length varies from 1.5 to 2.1 times the journal diameter, but the angle subtended by the brass is only 0.3 of the journal diameter, whilst the load carried is from 150 lb. to 240 lb. per sq. in. of the effective projected area of the brass in the case of bogie and radial bearings, and nearly double these figures in the case of tender bearings. The rubbing speeds of such journals are about 10 ft. to 12 ft. per second. Mr. Hobson further called attention to the practice, adopted by some builders, of cold rolling or planishing locomotive journals, so as to increase the hardness and toughness of the surface. In this process the journal diameter is reduced,

he says, about $\frac{1}{32}$ in., and the highly polished and hardened surface greatly diminishes the risk of heating. The lubrication is mainly from below, by means of a pad, the most usual lubricant being rape oil. Pad lubrication may, as Professor Goodman showed some years ago, give results not materially worse than bath lubrication, so that it is doubtful whether Mr. Hobson's figures could be much improved on even by the adoption of other methods of lubrication.

One of the greatest difficulties met with in the lubrication of large high-speed bearings is the cooling of the oil. No fluid will readily interchange heat with a solid wall unless it can be got into a condition of turbulent motion. The most usual form of oil-cooler is not unlike a small surface condenser, the oil flowing through the tubes, and the cooling water outside of them. Oil being highly viscous, a velocity of from 70 ft. to 120 ft. per second would be required to secure a turbulent flow in an ordinary standard $\frac{5}{8}$-in. condenser tube, and this speed is, of course, altogether impracticable, as it would involve a very large expenditure of power. Actual practice was well described by Mr. M. G. S. Swallow in his contribution to the discussion on Mr. Stoney's paper. With $\frac{5}{8}$-in. tubes, Mr. Swallow says, the oil velocity is generally about 2 ft. per second, and with the cooling water supplied at 55 deg. to 60 deg. Fahr., the oil can be cooled from 115 deg. down to 100 deg. Fahr., at the rate of about 2 cub. ft. of oil per square foot of cooling surface per hour. With $\frac{1}{2}$-in. tubes about 4$\frac{1}{2}$ cub. ft. per hour can, Mr. Swallow states, be cooled from 140 deg. down to 125 deg. Fahr., but the pressure drop over the tubes is considerably increased thereby. Retarders, he says, are of doubtful value, owing to the great loss of head involved. The cooling water needed is commonly one-third the oil supply, in which case the temperature rise of the water is about equal to the temperature fall of the oil. On the Continent, he states, another type of oil-cooler has been introduced. In this the water passes through the tubes, and the oil outside, baffles being fitted so as to make it flow to and fro at right angles to the tube surface. This causes a very thorough mixing up of the oil, and in consequence 10 cub. ft. can be cooled per square foot per hour. This, it will be seen, is markedly better than when the oil is passed through the tubes, in which case its flow is of a laminar character, there being very little intermixture of adjacent layers, and a correspondingly small rate of heat transfer.

Were it not for certain mechanical difficulties, the proper place to cool the oil would undoubtedly be at the bearing itself. Here the oil lies in a very thin sheet on the surface of the brass, presenting the optimum condition for an interchange of heat. Nevertheless the expense of fitting water-pipes to the brasses, and other incidental drawbacks, have led to this expedient being but very seldom adopted. A notable example is, however, afforded by the main bearings of the Aquitania. Where the bearings are water-cooled care must be taken to avoid any possibility of water leakage becoming mixed with the oil. To avoid this risk, whilst maintaining to some degree the advantages of cooling the oil at the actual bearing, the plan has sometimes been adopted of passing cold oil round passages formed on the exterior of the brass, as is mentioned by Mr. Stoney in his paper.

Some interesting data as to marine turbine practice were contributed by Mr. E. E. Williams. Here it has been usual to limit the bearing pressures to 70 lb. per sq. in., and the surface speed to 30 ft. per second. The oil supply is at the rate of about 27 lb. per sq. in. of the projected area, and the cooling surface is provided at the rate of 1 sq. ft. for each 200 lb. of oil passing the cooler per hour. In these conditions the oil is cooled through about 20 deg. Fahr. The oil used has a flash-point of 406 deg. Fahr., a density of 0.8755, its viscosity being represented by 155 seconds on the viscosity-meter at 140 deg. Fahr., a figure which is increased to 670 seconds at 70 deg. Fahr. With this oil the bearing temperature should not, Mr. Williams states, exceed 150 deg. Fahr., as with long running at 160 deg. Fahr. traces of carbonisation can be detected.

As was only natural, the thrust-bearing received much consideration during the discussion. Such bearings afford a remarkable exception to the general law, quoted at the beginning of this article, that, when the practical man has made anything for many years, but little improvement has resulted from a further knowledge of theory. The Michell bearing may, indeed, fairly be claimed as a triumph for theory, and to their own discredit it has, so far, found little favour with superintending engineers. It is now, however, being applied to some extent, and it should be noted that it is by no means essential to the success of the system that the rubbing speeds shall be high. To a very considerable degree a low rubbing speed can be compensated for by an increase in the viscosity of the lubricant. The system has, in fact, been successfully applied to the pivot-bearings of brick-making machines, running at but 24 revolutions per minute.

An interesting modification of the Michell principle has been introduced by Sir C. A. Parsons, who finds that centrally-pivoted blocks work quite satisfactorily, and have the advantage that they are equally effective whatever the direction of rotation. It would seem, however, from Mr. H. T. Newbigin's remarks that the friction is greater with such centrally-pivoted blocks. He quoted experiments made at the works of Messrs. Belliss and Morcom, in which the position of the pivot was varied as follows :—

Position of Pivoting Point.	Temperature of Bearing. deg. Fahr.
$\frac{1}{16}$ in. in front of centre ...	135
Central	132
$\frac{1}{16}$ in. behind centre	126
$\frac{1}{8}$ in. behind centre	124

The rise of temperature is a fair indication of the greater friction, the centrally-pivoted block being materially worse than with the pivot at the Michell point. The coefficient of friction ranged in different experiments from about 0.001 to 0.002 ; but, as Mr. Newbigin points out, this term is out of place when applied to a properly-lubricated journal, the resistance of which is, within wide limits, practically independent of the load carried. In this connection some interesting conclusions have been deduced by Mr. S. S. Cook. In Michell's calculations the assumption made has been that the oil film is only half as thick at the trailing end of the block as at the leading edge, and in this case the centre of pressure is nearest the trailing edge. If, however, the oil thickness at the trailing edge is a larger fraction of that at the leading edge, the centre of pressure approaches this leading edge and may become central.

It may be added that bearings constructed with blocks pivoted on the Michell system, work perfectly well if alternate blocks are made "right and left handed." The layer of oil dragged in between the opposing surfaces is then thicker in the case of the blocks properly presented to the direction of motion, so that the alternate blocks, in a way, fall out of action.

Mr. Stoney, in his reply to the discussion, stated that the pivoted thrust-blocks, now being fitted in certain cases, were generally designed for working pressures of 500 lb. to 600 lb. per sq. in. ; but even if this figure were reduced to 185 lb. per sq. in., the whole 30,000-lb. thrust of a cargo-steamer developing 22,000 indicated horse-power could, he said, be easily taken on a single collar instead of the usual six, and the consequent reduction in the friction would be equivalent to a gain of half of 1 per cent. on the horse-power.

In this connection it may be added that Mr. Ferranti has succeeded in operating fixed collars at loads comparable with those taken by the Michell type. This he effects by slotting away the collar so that its whole surface is broken up into a number of narrow radial elements, each of which is slightly bevelled off at the edges. In these conditions a continuous film of oil is, he finds, maintained between the surface even under heavy loads.

RESULTS OF FRENCH STATE RAILWAY WORKING.

The Western of France Railway, which was nationalised in 1908, was not the first railway system to come under State ownership, since in 1878 the State established a small system in the south-west of France, when it redeemed a series of companies which had failed, and at the same time constructed certain new lines. The small extent of this system, which we shall style in this article "the old system," which was connected with Paris solely by the joint use of a line belonging to the Western of France Railway, was urged as an explanation of its indifferent success. Indeed, so little business was done that this system was incapable of paying the interest and providing the redemption fund on the capital employed for its purchase.

It was contended in Parliament that the possibilities of State management could not be demonstrated satisfactorily, and that the engineers were unable to prove the excellence of their methods, on so small a system, and that was one reason why, in pursuance of a plan of campaign that has been followed for twenty years or so, Parliament decided on the purchase of the Western of France Railway. In order to justify the transaction, it was also urged that the system, when privately worked, had not shown very fortunate financial results. The company had been compelled, down to 1908, to take advantage of the "guarantee of interest," by which the State, by way of advance only, had to supplement the receipts in order that the guaranteed dividend might be paid on the shares.

There is no doubt that the Western Railway Company, from the moment that it agreed to work such additional lines as Parliament demanded, had been compelled to have recourse to this guarantee in all to the extent of several hundreds of million francs. But at the time when nationalisation was decided upon the company was annually making less and less demand upon this guarantee. The extremely unproductive lines were built to satisfy electors ; they had been forced upon the system. The situation was not improved by the fact that the longest line of the system—from Paris to Havre—had to meet the formidable competition of the Seine, which the State, at the expense of the taxpayer, had canalised and improved, without requiring any return on the expense incurred from the users.

In Parliamentary and Governmental quarters the endeavour was made, in order to justify the purchase of the railway by the State, to consider it in the light of an advantageous transaction, which would lead to very economical working, and much more favourable financial results. It was claimed that the Western Railway, a private company, sought only one thing—namely, to make profits at the expense of the State, by drawing on the guarantee fund. The advocates of nationalisation asserted that the superiority of State working over private working would be clearly demonstrated. At the commencement of 1909 the State engineers took over the Western system. Sufficient time has therefore elapsed to enable some estimate to be formed of the venture.

To comprehend properly the present enormous deficit of the Western Railway, omitting reference to the earlier State system, which is still operated independently of the new, it is necessary to remember that the Western Railway Company had never applied for more than 27 million francs in any one year from the interest-guarantee fund. For the years 1904 to 1909 the average payments advanced to it by the State amounted to slightly less than 11 million francs per annum. The 27 million francs deficit was reached in 1908, the last year of working by the company, when its very existence had become impossible. The *personnel*, seeing that the purchase was imminent, worked as little as possible, increasing operating costs of all sorts. In 1907, the insufficiency of the net receipts had been only 16 million francs; it was 6 million francs in 1906. It should be noted that the calls on the guarantee fund of 6 million francs in 1906, and of less than 7$\frac{1}{2}$ million francs in 1905, tend to show that the company would probably soon have ceased to ask the Treasury to supplement its receipts, and would have commenced to reimburse the loans granted to it previously.

In the hope of rendering less apparent the deficit in working occasioned by the State taking the system over, the attempt has been made to convey the impression that the call for guaranteed interest on the part of the private company was much greater than was actually necessary ; moreover, it has been pretended, quite wrongly, that the company, during the later part of its existence, had not carried out its obligations in regard to maintenance and renewals. It was maladroit to pretend that the system was not in good condition when nationalised, since it was closely supervised by officials of the State. In consequence the company was compelled to make adequate provision in the way of maintenance. A former director of the company, M. Colson, who is a very com-

petent authority in these matters, has shown that the system was excellently maintained to the end. If the endeavour has been made to spread the contrary belief, it is because the State administration, in order ostensibly to reduce its own working expenses, carried to the first cost account 11 million francs spent on maintenance and repairs of the track, which, the Government officials alleged, had been left in an unsatisfactory state by the company.

In order to arrive at the real deficit due to State management, account should, of course, be taken of the charges on the original capital. Although these are not fully taken into account, the deficit increases annually. Ingenious but scarcely straightforward methods have hitherto been adopted of masking a considerable portion of these charges on capital. The State has adopted accounting methods of an unusual character. The present deficit would be far more considerable if the State railways had to pay interest and redemption on capital.

No doubt the Western system when worked by the private company did not show very brilliant financial results, but the time certainly seemed to be approaching when the balance between receipts and expenditure (including capital charges) would have been established, in spite of the very unsatisfactory lines upon which the company had been compelled to develop. The fact that after purchase by the State the deficit has increased in such large proportions in the space of five years cannot be attributed to a diminution in the receipts. Up to the present year the French railways have, speaking generally, shown a fairly regular increase of traffic. From 1909 to 1911, for instance, the gross receipts of the large private companies increased by 103 million francs, and from 1911 to 1912 by 88 million francs. So far as the State systems are concerned—that is, both the old and the nationalised Western—the increase in receipts was 22 million francs between 1909 and 1911, while from 1911 to 1912 it amounted to 11 million francs. In 1908 the Western Company had a revenue of 219½ million francs. Since 1910 the receipts have exceeded 229½ million francs, and were over 236 million francs in 1911. The figure for 1912 was about 224½ million francs, and for 1913 about 252 million francs. The increase in the receipts averaged 3½ per cent. annually, which might be regarded as satisfactory. Even on the old State system the average growth of receipts was approximately 2.64 per cent. Much satisfaction was derived in 1913 from this rise. Parliamentarians who were favourable to State working regarded it as the best reply to their opponents. In fact, however, this increase of working receipts was due more to the industrial and commercial development of the country than to the efforts of the Administration. However satisfactory it may have been, the deficits have also grown at a formidable rate, in consequence of the members of the *personnel* being State officials and of the desire of the State to gratify them by increasing their wages as much as possible.

In 1908, when the operations of the company ceased, the net proceeds were nearly 71½ million francs; the charges amounted to slightly over 98½ million francs, the deficit (covered by the guarantee) being 27 million francs, as above stated. This was the maximum figure attained. In 1909, when the State took over the working, the net revenue fell to less than 70 million francs, and, as the charges had increased to nearly 109 million francs, without taking into account the charges on original capital, the deficit was about 39 million francs. From 1909 to 1911 the expenditure of the State system increased altogether by 55 million francs, in which the special increase imposed by the parliamentary requirements in regard to pensions to employees, placed upon all railway administrations, did not even amount to 4 million francs. During the period 1909-11, while on the concessionary lines worked by companies expenditure only increased by about 1 per cent., the increase for the two State systems exceeded 26 per cent. Between 1911 and 1912 their working costs again increased by 22 million francs. From 1909 to 1911 the annual expenses (booked to capital account) of the two systems had grown by 102 million francs, and by 42 million francs from 1911 to 1912. For the Western line the working expenses, which were less than 148 million francs in 1908—the last year of private operation—rose to 172½ million francs in 1910, and to 222½ million francs in 1912.

During the year 1913 the position of the French railways was generally not so satisfactory as in previous years, but that does not seem to have hindered the gross receipts of the State Railways from increasing by 14 million francs. Expenditure has actually been slightly diminished, but a great part of the comparatively trifling reduction has been due to the suppression of trains. The working ratio has been brought down, but is still a very high figure. For the moment concessions to the staff have ceased. Interest, redemption, and charges on capital account—provided the latter could be estimated at the present time — would more than counterbalance the small economies in working expenses, and even the unexpected surplus in the receipts. The net receipts, without counting the charges on first cost, fell from close upon 72 million francs in 1908 to some 32 million francs in 1911, and to less than 28 million francs in 1912, a figure which a year so fortunate as 1913 has not raised more than 36 million francs. In 1911 the net proceeds per train-kilometre varied from 1.75 francs to 2.11 francs in the case of the privately-owned lines; it was only 0.53 franc on the Western State, and 0.44 franc on the old State line.

In the case of the latter, the results have not been much more fortunate, especially since 1908. On this system, perhaps, even more than in the case of the Western system, there have been numerous sacrifices in favour of a staff whose zeal leaves much to be desired. Between 1908 and 1911 the gross receipts increased from about 59 million to about 65½ million francs, but expenditure rose from 47½ million to nearly 58 million francs. Consequently, net revenue diminished. With regard to this older railway system, it has not been possible, ever since 1878, the year of its constitution, to arrive even approximately at the real figure for capital invested. The fact that the system combined a number of bankrupt lines is one of the reasons put forward in support of the contention that the difference between receipts and expenditure constitutes a true profit from the system. The charges on capital account of this line, had it been established as a private company's line, with subventions from the State and a large part of the expense of construction borne by the State itself, would have exceeded 16 million francs for the period down to December 31, 1910. For the year 1912 the corresponding charge would be about 18 million francs. These charges are never taken into account, and the system is in reality a debtor to the extent of these accumulated amounts. The net proceeds of the old system in 1909 did not reach even 13½ million francs. In 1910 they fell to 10½ million francs or thereabouts, and in 1911 to rather over 8½ million francs, while in 1912 the figure was less than 6 million francs.

We have referred to the working ratio. It must not be concluded that this figure represents exactly the extent of good or bad operation. It is, however, interesting to compare the ratios for the old and the new State railways with those of private companies, because the conditions are very similar. For the French State lines the working ratio in 1911 was 87 per cent., while for the great private companies of France the corresponding average figure was only 58 per cent. It is fair to say, however, that the Western Railway system, at the time of private operation, in consequence of unfavourable conditions and the competition of the Seine, had a working ratio of 67 per cent.; but in the first year of State operation it exceeded 69.60 per cent., reaching 75 per cent. in 1910, and nearly 89 per cent. in 1912. On the old State line, in 1909, it was rather more than 78 per cent., 83 per cent. in 1910, nearly 87 per cent. in 1911, and 91.5 per cent. in 1912. The ratios for 1913 were appreciably lower; nevertheless they are materially higher than the average ratio for the private railway companies of France. We confess that we have no great confidence in this reduction; it is probable that it is only transitory. On the old State line, even as far back as 1878, the working ratio has always been very high.

We may now refer to the repeated concessions to the staff of the old and new lines. It is clear that these form the principal, but not the only, reason for the growing deficits and the enormous advance in the working costs. For the moment, as regards regularity of trains, the services are working comparatively well. But it was not always so, and for at least a year before the general strike of the staff to obtain increased pay, delays were constant and out of all reason. The employees have been granted practically what they demanded, and the general manager, who is responsible for the administration of State railways, has received instructions to spend freely and do all that is possible to secure punctuality, so as to stop open complaints on the part of the public.

To group these large outlays in favour of the staff, it may be recalled that in 1908, before the Western Railway was taken over, the expenses for the staff on the old French State Railway did not exceed 24,240,000 francs, and almost exactly 79 million francs for the Western system. Since then these expenses have mounted up, until for the year 1913 the figure was 36½ million francs for the old State Railway, and nearly 137½ million francs in the case of the Western Railway. Since 1909, therefore, there has been an increase of nearly 70 million francs in wages. It has now been stated that this continual growth must cease. There is, however, no guarantee that such will be the case. If the men on the railways again either strike or threaten to strike, it is probable that increased pay will be granted. Many parliamentarians are proud of the peace-offerings thus made. They assert that the State does not neglect the interests of the railway workers, but it is a matter for regret that these expenses are at the cost of the mass of the taxpayers. Moreover, these increases have not resulted solely from advances in rates of pay, shorter hours, or more favourable regulations for promotion; but also from the increase in the number of railway servants. It is recognised that the men's syndicates are not satisfied with the concessions so far made. The journals of the syndicates openly declare they want more.

We can say without prejudice that the staff in favour of whom these millions have not been spared frequently shows itself incapable and appears normally idle. To it, in great measure, are due the serious and costly accidents which have occurred on several occasions on the State railways. To the staff also may be attributed the damage and loss suffered by the shippers and traders, leading to an increase of indemnities. The idleness of the staff is clearly proved by the frequent absences for illness. The State administration is very generous in this respect, and grants full pay for illness over a period which may extend to 60 days in the year. In 1909 the proportion of workers in the railway service that was ill was 41 per cent.; since 1911 it has reached 50 per cent. In the case of the permanent-way department the figure has grown from 27 per cent. to 42 per cent., and in the case of the management staff from 25 per cent. to 44 per cent. Upon the new lines, in which the staff seems to be even more indolent, the figures have been from 17 per cent. to 55 per cent. The large proportion of servants ill has therefore involved a great increase in expenses.

We have alluded to the importance among working expenses of the indemnities for losses, damage, and accidents. Upon the old State Railway, between 1908 and 1912 alone, these expenses rose from 370,000 francs to 1,900,000 francs, as a consequence, principally, of two very grave accidents. On the system more recently taken over the corresponding expense was a little more than a million in 1909; it reached 1.608,000 francs in 1910, and 2,953,000 francs in 1911, while provision was made for 2,570,000 francs in 1912, without regard to judicial expenses, and anticipating a somewhat unlikely reduction. On the nationalised Western Railway the payments amounted to 2.82 francs per 100,000 francs of gross receipts, and to 10.24 francs per 100,000 train-kilometres. Taking the five large private companies, the corresponding annual averages are only 1.17 francs and 5.76 francs respectively.

We have referred to the importance which should be attached to the charges for capital in any rational examination of the State systems. It is not only on the old system that no account has been taken of those charges up to recent times, but on the newer system all kinds of methods have been practised to delay the moment at which such charges on capital account will affect the results of working, and increase the deficit. In the space of only five years an expenditure of 718 million francs on capital account was made on the Western system. The private companies are compelled to take into account the debt which they contract with the public Treasury on account of the guarantees of interest of which they avail themselves. For the five years' working of the new State system the deficit has exceeded 327 million francs; this

shows the magnitude of the supplementary charges arising from these deficits of the State railways. It should be noted, moreover, that of the 718 million francs expenses on capital account, and sums borrowed since the commencement of 1909 by the State for its railways, the share of the Western system involves only 581 millions, and that of the old State Railway 137 millions. Means have been found for relieving the working of the State railways of a good part of these expenses. In fact, bonds issued on account of the administration of the State railways represent 400 million francs. The remainder of the sum actually expended —namely, 318 millions—since the end of 1913, has been furnished by advances from the Treasury to the railway administration. The Treasury is contented with an interest of 2.50 per cent., while the bonds placed with the public cost, including redemption, 4.75 per cent. That there is some manipulation of the charges for which the State system should be responsible is shown by the fact that according to the accounts of 1912, for instance, only 4,390,000 francs are put down to meet the interest on bonds, though the Minister of Public Works admits that the system had borrowed, either by issuing bonds or in the form of advances received from the Treasury, some 518 millions.

It is clear that the figures given, representing the real deficits of working, enormous though they are, are still much below the actual amounts. According to the budget figures, the deficit was estimated at a little less than 39 millions in 1909, over 71 millions in 1911, 84½ millions in 1912, and at 85 millions in 1913, which latter figure has been exceeded, for it must not be forgotten that, at the end of the year, the State Railways administration demanded supplementary credits for 19 million francs, which reflects unsatisfactorily on the manner in which the estimates are prepared. To be quite fair, account should be taken of the fact that if the Western Company had continued it would have had to meet certain new burdens which have affected the other lines, particularly an increase of pensions. It would have had to borrow the needed capital at higher rates, and it would certainly have had to resort to the issue of bonds to meet certain indispensable capital charges. These facts offset to a slight extent the deficit which has resulted from State working. Nevertheless, the present deficit in the neighbourhood of 75 million francs must be certainly 40 millions more than it would have been had the operation by a private company continued, even in unfavourable conditions.

Such results were foreseen by those acquainted with the working of the older system. The time was when both the Minister of Public Works and the Minister of Finances asserted that the nationalisation of the Western of France Railway system would not involve any increase in expenses for the Treasury. Even if the 40 million francs per annum had not been exceeded the sum is somewhat high, especially for a budget so heavily charged as that of France. It is not surprising therefore that Ministers who are responsible for drawing up the budget, though they are favourably inclined towards State working, do not hesitate to recommend a policy of economy; they point to numerous useless expenses and to extravagance, and find that the work could be carried out by a much smaller clerical staff. Others, also favourable to State working, declare that the expenses are increasing at such a rate that a time will come when the system will find it impossible to realise any profit at all. Politics, both local or national, have much to answer for. The experience is fairly conclusive. It certainly does not seem that it can be taken as an argument in favour of the nationalisation of railways, whether in France or in other countries.

"CORRECTORS" FOR THE SIGHTING-GEAR OF HEAVY ORDNANCE.

Since the present form of dial-sights replaced the tangent bar-sight on all mountings of 6-in. guns and over, there have been rapid developments in the design, and a great increase in the number of appliances fitted to the sights to correct automatically for changes occurring to the conditions under which the guns are fired. The amount of wear which takes place in the bore of a gun with the firing of each round, and the consequent fall in muzzle-velocity, necessitated a continual changing of range-dials. For example, a new gun of a certain calibre has a muzzle-velocity of 2650 ft. per second, which falls to 2500 ft. per second before the inner tube is worn out. To compensate for this gradual loss of muzzle-velocity seven dials would be required, graduated for 2650 ft., 2625 ft., 2600 ft., 2575 ft., 2550 ft., 2525 ft., and 2500 ft. per second respectively. A corresponding number would be required for the reduced practice charge, which falls from 2200 ft. to 2050 ft. per second.

In some designs the dials were graduated upon both sides, which made a saving in the number, but not in the work required to graduate them, or in the time required to change them from a high to a low muzzle velocity.

Before describing the patents that have been fitted to compensate for changing muzzle velocity without having to fit a fresh dial, it will be as well to show the simple principle which underlies the setting of a sight, especially as it is difficult to follow what is taking place on a modern sight when it is set to a given range, owing to the multiplicity of correctors fitted. In Fig. 1 the gun and sighting-telescope are shown horizontal at a, and it is required to give the gun an elevation e corresponding in the range and elevation tables to the required range. By means of gear, which will be described later, the sight-setter depresses the telescope to the angle e, the gun meanwhile remaining horizontal, as at b. The gun-layer has no control over the handles which operate the sight, and he can only bring the telescope to bear on the target by elevating the gun itself, which carries on the cradle the complete sight. When the telescope is again horizontal, the gun will be elevated through the angle e, as shown at c, and the gun-layer then fires. When the axis of the telescope is arranged above the axis of the gun, the telescope is depressed through an additional angle, increasing as the range decreases, and this additional angle must be allowed for in spacing the graduations on the dial. The reason for this is apparent from Fig. 2.

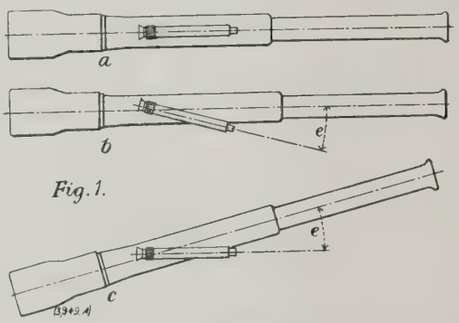


Fig. 1.

Fig. 2.

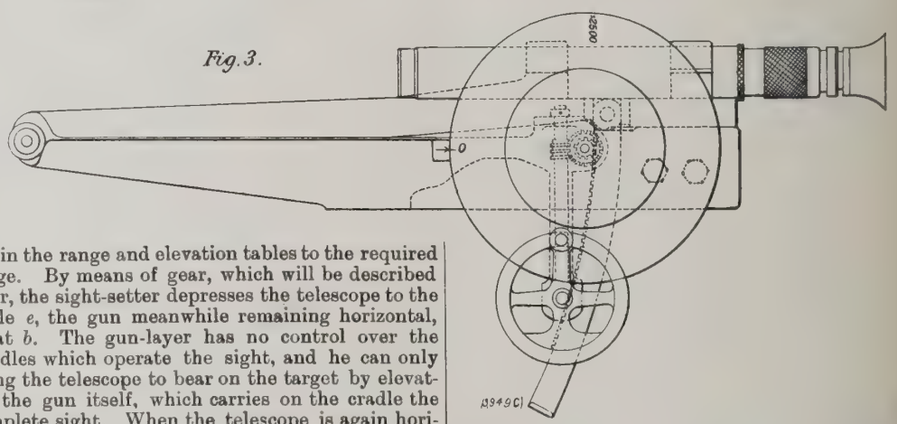


Fig. 3.

To come now to the means employed to enable the sight-setter to depress the telescope to an angle e, which is to be exact to within 0.5 min. to the elevation given in the range table. Referring to Fig. 3, the rack is raised and the telescope depressed by means of the spur-wheel, worm and worm-wheel, and hand-wheel shown, and it was upon this rack, or its equivalent, that the tangents of angles of elevation were marked in the old type of sights. When it is remembered that about three hundred 50-yard divisions would have to be engraved upon an arc subtended by less than 14 deg., extreme accuracy in setting could not be expected.

In the form of sight shown in Fig. 3 the graduations are arranged upon a dial, and it will be seen that for every 10 deg. the rack revolves the dial will revolve 550 deg., the rack radius being 27½ in. and the spur-wheel radius being ½ in. Supposing that from the range tables it is known that the elevation for a particular gun is 1 deg. 42.6 min. for a range of 2500 yards, and that the axis of the telescope is 26.2 in. above the axis of the gun. Referring to Fig. 2, it will be seen that the correction for height of telescope above axis will be

$$\text{Tan } \alpha = \left(\frac{26.2}{36} \times \frac{1}{2500}\right) = 0.00029$$
$$\alpha = 1 \text{ min.}$$

The total angle which the telescope will have to be depressed will be 1 deg. 42.6 min. + 1 min., and the amount which the dial will have to revolve through will be (1 deg. 42.6 min. + 1 min.) × 55 gear ratio = 95 deg. The range 2500 yards will be engraved against a mark 95 deg. from zero on the dial, and the same process is gone through for every range given in the range and elevation table. It is usual to add 50-yard division marks, which are placed midway between the 100-yard marks without calculation. Where the dial makes more than one complete turn the graduations are arranged around a spiral line.

Range and elevation tables show that a change of muzzle velocity causes a change in elevation which is small at the lower ranges but rapidly increases at higher ranges, as the following example shows:—

Range.	Elevation for High Muzzle Velocity.	Elevation for Low Muzzle Velocity.	Difference in Elevation.	Difference Measured on Dial with a Gear Ratio of 55.
yards	deg. min.	deg. min.	deg. min.	deg. min.
1000	0 48	0 58	0 10	9 10
2000	1 46	2 7	0 21	19 15
3000	2 50	3 22	0 32	29 20
4000	4 0	4 46	0 46	42 10
5000	5 18	6 18	1 0	55 0
6000	6 41	7 58	1 17	70 35
7000	8 15	9 50	1 35	87 5
8000	9 56	11 48	1 52	102 40

Fig. 4 shows column 5 plotted for a particular gun, and shows the differences in elevation upon the dial for each of six muzzle velocities, three being in 25 ft. per second steps above the velocity for which the dial is graduated, and three below. The divisions on the abscissa of these curves are the divisions on the graduated dial to any predetermined scale. It is found that for the same gun the curves plotted in this way are of similar shape, though lying at different angles.

Fig. 5 shows a form of muzzle-velocity corrector in which cams are cut to the plotted curves, and the range-reader, by means of a roller, is constrained to move over the face of the dial, giving automatically the new range for the alteration in muzzle velocity. The dotted lines indicate the shape of cams for other changes in muzzle velocity. This arrangement saved the multiplicity of dials, but a considerable amount of time was required to change from one cam to another.

In Fig. 6 advantage is taken of the fact of the curves being all of similar shape, and a double cam, fitted with a central switch, is moved into the positions of the various cams used in the arrangement shown in Fig. 5.

In Fig. 6 the cam is set for the same muzzle velocity as that for which the dial is graduated; the roller on the range-reader therefore moves along the straight part of the cam, which is set horizontal, and therefore gives no correction to the reader; but

in Fig. 7 the cam has been moved to correct for a new muzzle velocity, and the reader is constrained to move to an angle which is the angle given in column 5 of the table for any range. The great importance of this design is in the fact that minute adjustments can be made, and it is no longer necessary to put on the adjustments in jumps of 25 ft. per second; in fact, the cam can be moved towards the lower muzzle-velocity position after the firing of each charge if desired, with practically no loss of time. Equally important is the fact that other corrections can be made with the same apparatus; for instance, a change of temperature in the magazine makes a change in the muzzle velocity depending upon the size of the charge and the calibre of the gun. A rise or fall of only 10 deg. Fahr. in the temperature of the charge will cause a rise or fall of as much as 25 ft. per second in the muzzle velocity.

If this ratio is found exactly for each type of gun, a scale can be graduated for degrees of temperature and used as a vernier to the muzzle-velocity scale, and one method of doing this is shown in Fig. 6, in which a ratio of 10 deg. Fahr. equals 25 ft. per second muzzle velocity is shown. Attempts have also been made with more or less success to apply correctors for air-density, shape of shot, barometer readings, &c., by moving the reader relatively to the dial by means of various shaped cams.

Another form of corrector depends upon a large cam-groove cut in the back of the range-dial itself (see Fig. 8), the throw of the cam at each range being based upon the difference in elevation required by the maximum and minimum muzzle velocity. A roller attached to one arm of a bell-crank lever runs in the cam-groove, and so oscillates the bell-crank when the dial is rotated. The other arm of a bell-crank is in the form of a quadrant, upon which a slider may be clamped at various distances from the pivot. This slider is connected by a link to the range-reader pivoted coaxially behind the range-dial.

When the slider is fixed with the end of the link directly over the pivot of the bell-crank, as in Fig. 8, it is obvious that the oscillation of the latter has no effect on the range-reader. If, however, the slider is moved away from the dead centre in either direction, as in Figs. 9 or 10, one effect of rotating the range-dial will be to move the range-reader either with or against the direction of movement of the dial, so that the sight has to be elevated more or less, so correcting the elevation for the new muzzle velocity. The quadrant is suitably graduated with scales for muzzle velocity and temperature to guide the setting of the slider. The great advantage of this type of corrector is the large cam that can be cut in the back of the range-dial, giving greater accuracy in working, whilst the results of wear are proportionately reduced.

Correctors which govern the lateral movement of the shot have not been improved upon to any great extent, except that it is now common practice to put the deflection-dial and actuating-worm upon the fixed part of the sight, and connect them to the telescope by means of a flexible arm; this became necessary as the total angle of elevation increased, for on a modern sight any gear on the moving part of the sight to be in reach of the sight-setter would swing through an arc of quite 2 ft. The substitution of periscopes for telescopes has brought the eye-piece very much nearer to the trunnion centre, with a resultant decrease in the movement of the eye-piece, and has also reduced the size of the protective hood, the gun-layer being able to keep wholly below the roof of the gun-house. The application of a central fire-control station does not affect in any way the methods described for applying muzzle-velocity and air-density correctors, and it will be found the principles described apply to the various link motions and differential gears which are from time to time invented to take the place of the cam-gearing described.

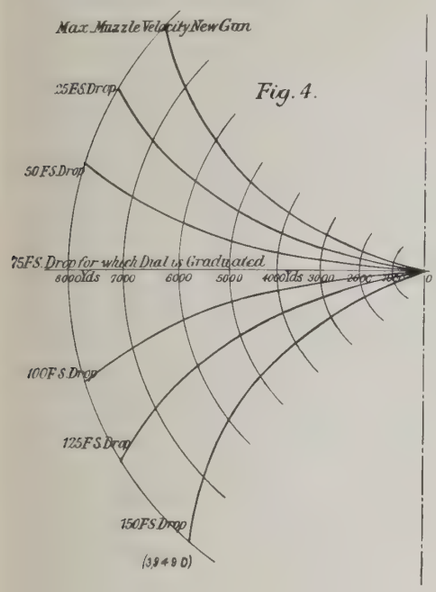

Max. Muzzle Velocity New Gun
25 F.S. Drop
50 F.S. Drop
75 F.S. Drop for which Dial is Graduated.
8000 ds 7000 6000 5000 4000 ds 3000 2000 1000 0
100 F.S. Drop
125 F.S. Drop
150 F.S. Drop
(3948 D)

Fig. 4.

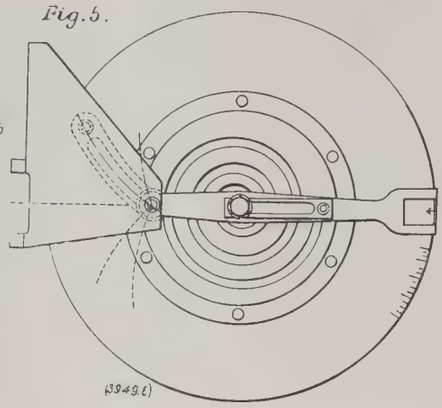


Fig. 5.

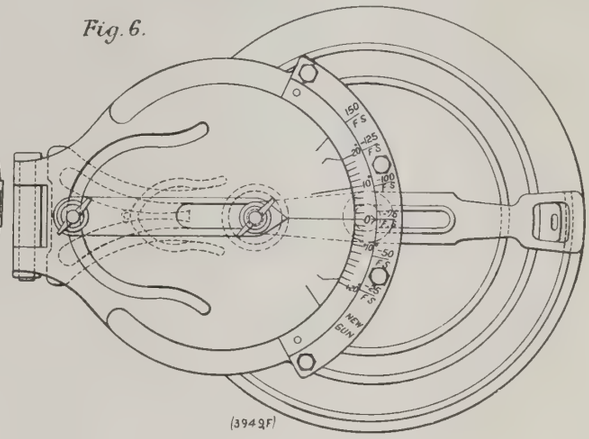


Fig. 6.

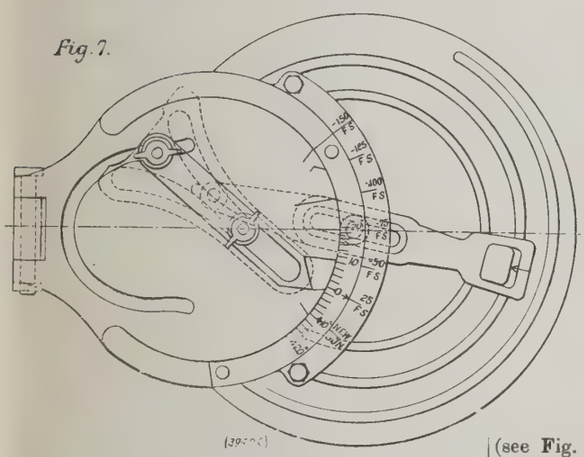


Fig. 7.

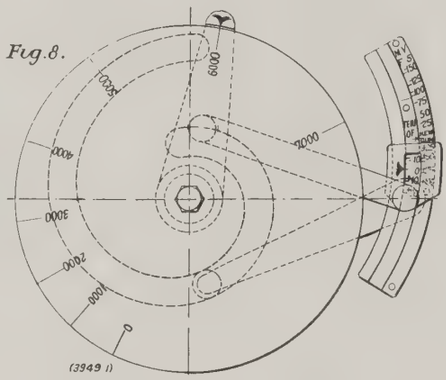


Fig. 8.

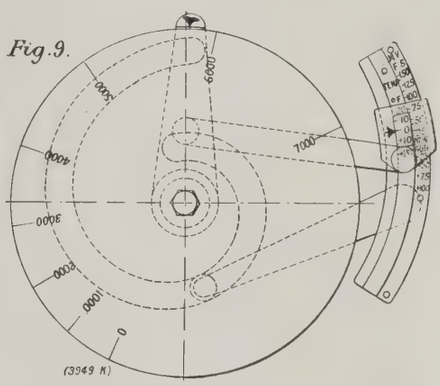


Fig. 9.

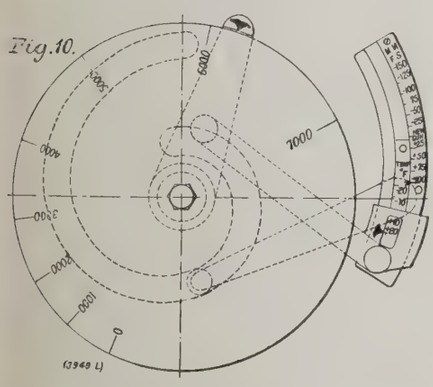


Fig. 10.

"SUCTION" BETWEEN PASSING SHIPS.

By Sidney A. Reeve, M.E., New York.

I. History and General Theory.

Definitions and Data.—"Suction" is a term commonly applied by pilots to at least three distinct hydraulic phenomena associated with moving vessels, between which phenomena they distinguish most vaguely, if at all. These three quite independent actions are:—

1. The direct impulse embodied in the streams of water projected astern by screw or paddle, independently of any motion of the ship itself.

2. The direct effect of the mass of water which follows a ship bodily when it is moved slowly through restricted waters.

3. The indirect, or lateral pressure, effect of the fore-and-aft acceleration of the water displaced from bow to stern during normal motion through the water at full speed.

Of these, the first two are most simple and obvious, hydraulically speaking, because there the force exerted is aligned with the water's motion. In the case of the last, the force developed hydraulically acts at right angles to the line of the water's motion. The first two need no explanation, and have nothing in common (speaking scientifically) with the third. They play an insignificant part, if any at all, in the majority of "suction" collisions, and are mentioned here chiefly for the purpose of eliminating them from further discussion. They are of frequent occurrence in the daily handling of shipping about crowded wharves, and for want of other name, or in lack of official definition, they are frequently called "suction"

by the (American) Admiralty Courts; but because they are seldom of sufficient violence to be of importance, and because they are more of the nature of a "puff" than a "suck," the term "suction" will be used here as excluding them.

Historically speaking, while the science of hydrodynamics has been developed chiefly by British—or, at most, European—students, yet the recognition of suction as a feature of importance in navigation has arisen virtually exclusively in American experience. The sources of information are the books and the Admiralty Court records. Previous to the Olympic-Hawke collision of 1911 there was no literature on the subject known to the writer, excepting Taylor's paper of 1909, describing his Washington experiments. Search of the British Admiralty records by deputy discloses not a single reference to the subject. Marsden's "Collisions at Sea" (London, 1910) makes only a single reference to "suction," saying:—

> A vessel will be held in fault if, without necessity, she navigates so close that . . . . she is affected by the wash or suction of the ship ahead and will not answer her helm,

referring by footnote to the American cases of the McCandless, Mariel, Brockton, and Chicago. No search of French or German court records has been made, but the principal German work devoted to ship collisions ("Der Zusammenstoss von Schiffen," Dr. Richard Prien, Berlin, 1899) makes no mention of the subject, which could hardly have happened had it ever been discussed by the German, or even by any European, courts.

In American waters the earliest instances of ship-action which were probably suction, although not given that name, occurred in 1846 and 1847, in the Naugatuck-Rhode Island and Governor-Worcester collisions. By 1869 the phenomenon had found official name, as "suction," in the Narragansett-Providence collision. From that time forward the appearance of the thing was frequent, albeit at irregular intervals. In 1871 are recorded two cases, in 1877 two, in 1880 five, in 1883 one, &c. All of these occurred in restricted inland waters. In 1885 occurred the first case involving Atlantic liners, when the Aurania and the Republic came together by suction outside Sandy Hook (but not in deep water).

Excepting possibly the records of Naval Courts of Inquiry, which are inaccessible, the sole source of data as to actual cases of suction collision is the testimony before the Admiralty Courts. This testimony, it must be understood at the outset, is almost universally incompetent and contradictory. England's sole experience, the Olympic-Hawke case, was merely typical in this respect. The trouble is not that the witnesses are incompetent as navigators. The trouble is that navigation normally makes no demand for the estimate of distances in feet or yards. The pilot is accustomed to gauging his distance from outlying buoys or other ships in terms of his vessel's speed or rate of swing, but not in feet. Again, when called upon afterwards for the data essential for an analysis of the collision, he can give, instead of sytematic observations or estimates, only his subconscious guess as to what must have been the conditions in order that the known results should have followed, which he does in perfect sincerity. Or even if estimates were actually made, they must have been made at times of great excitement and responsibility, when positions were altering rapidly, and when the pilot's mind was properly occupied with other things.

In one case the witness was the captain of a prominent trans-Atlantic liner, a man of dignity and experience. As he testified, the writer plotted the ship's position on a large-scale chart. Had the statements been correct, the ship must have been aground all the way down the harbour. Yet so obvious was the skill, experience, and sincerity of the witness that even opposing counsel made no attempt to impeach his statements. Both sides accepted the testimony as competent to prove that his ship was well over to that side of the channel on which he (virtually) testified that she was aground. In another case the Court found, from the combined testimony of competent witnesses, that it was a physical impossibility for a collision to have occurred; but since both vessels were injured, the hypothesis as to the facts is necessarily a compromise which includes a collision.

For all these reasons the formation of any accurate deductions as to the distance or angle at which suction becomes an overwhelming force is an impossibility, even for any one case. When the influence of such widely-varying factors as ship-model, speed, sea-bottom, &c., is included, it becomes obvious that any hope of securing from experience or theory a *quantitative* law of suction must be abandoned at the start. But even without this, a *qualitative* understanding of the forces at work in "suction" can be of the greatest value in warning pilots as to the general conditions under which it is liable to occur, and as to where a larger margin of caution than usual is needed. For such a qualitative understanding of "suction" a brief incursion into theoretical hydraulics is necessary.

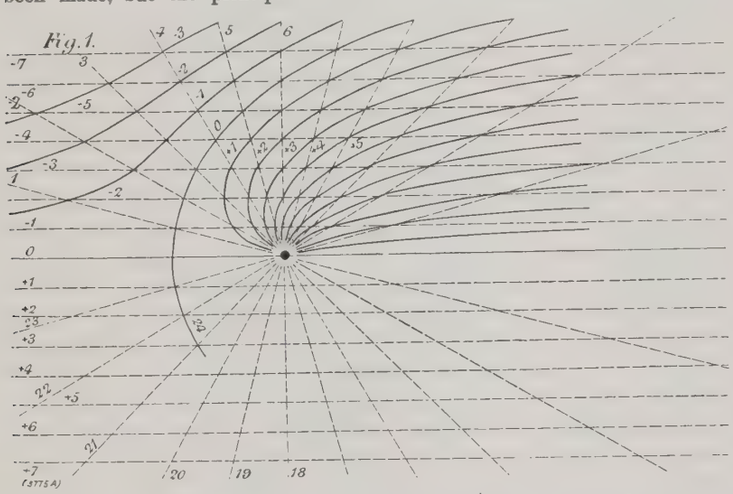
Stream-Lines: "Sources" and "Sinks."—Imagine a body of water of uniform depth and unlimited lateral extent, in which is placed vertically, and extending from bottom to surface, a straight pipe of small diameter. Imagine the sides of this pipe everywhere perforated with many small holes, so that it can discharge or take in water on every side throughout its entire length. Let it be connected at the foot with some unlimited reservoir of water below the sea-bottom, so that it can draw water from this reservoir or discharge into it to unlimited extent, just as a "grounded" wire can draw electricity from the earth, or discharge into it, without limit. Disregard all question of friction of flow within the pipe, so that the capacity of the pipe for handling water is independent of its diameter, the speed of flow being anything imaginable. Therefore, for convenience, let the pipe be represented, in plan, by a geometric point.

Such a point as this, when drawing water from below and discharging it into the sea, is called a "source." When the flow is in the opposite direction it is called a "sink." Thus a source would radiate water horizontally in the sea, away from it as a centre, in all directions equally. Conversely, a sink would draw water to it horizontally in all directions.

"Stream-lines" are mathematical functions of the volume of flow of water which can be represented conveniently and accurately on fields of co-ordinates, and which can be added, subtracted, &c., like other mathematical quantities. They may be of any imaginable form, and may be either of two or of three dimensions. For present purposes, no presentation of the mathematics of stream-lines is needed; nor do we need the three-dimension functions, which are much more intricate to handle than the two-dimension. Only those particular forms of two-dimension lines which pertain to the analysis of "suction" will be mentioned, and for an understanding of their mathematics the reader is referred to the bibliography listed later herein.

From a "source," or toward a "sink," radiate straight stream-lines, like the spokes of a wheel. Physically speaking, each stream-line represents a sector of flow of water, measured from some radius taken arbitrarily as a zero axis around to the radius or stream-line in question. Therefore the angle between zero axis and stream-line is the mathematical measure of its quantity, and this quantity of flow is the same at all distances from the centre. Any convenient angle may be taken as the unit angle, or an arbitrary quantity of flow may be taken as the unit. According to the number of such unit stream-lines radiating from a "source" or "sink," the latter is said to have different "strengths."

In a canal of uniform, rectangular cross-section, in all portions of which the rate of flow was the same, the stream-lines would be straight lines parallel with the banks. The distance from the bank would be the mathematical quantity of the stream-line.



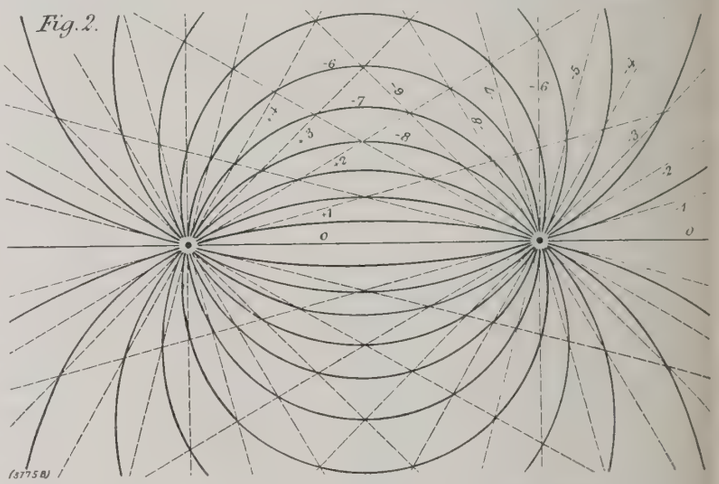


Fig. 1 shows the addition of two such sets of stream-lines, resulting in a third set. The radial stream-lines are given numerical values, from "zero," at the axis of the figure, around to "24" for an angle of 360 deg. The parallel lines are given similar values—positive below the axis, and negative above. Selecting any desired value for a resultant stream-line, the line can be located as passing through the intersection of each pair of original lines the sum of whose values equals the desired value. Resultant lines are thus found having values ranging from "zero" for the stream-line crossing the axis at right angles and rising above it, increasing around to the right until the same line below the axis has the value "24." From the "zero" resultant line above and to the left are lines having negative values. Below and to the left are those having values above "24." Both positive and negative series extend indefinitely away from the centre of the figure.

Such a set of resultant stream-lines would give the effect of placing a "source" or a "sink" in a uniform current, the current flowing to the right if the point be a source, or to the left if it be a sink. Fig. 2 gives the stream-lines resultant from compounding a source with a neighbouring sink in still water. Fig. 3 gives the lines resultant from compounding a source and a sink in a uniform current, or from moving a source and sink together through still water. (The resultant lines are restricted, for clarity, to one out of the four quadrants of the figure, but they obviously exist alike in all four quadrants.) The latter condition gives us our first mathematical approximation to the displacement of water from bow to stern of a moving ship.

In Fig. 3 the stream-line A, when completed, gives the first suggestion of the water-line of a ship. If we imagine the water encompassed by this

stream-line, in a sea of uniform depth equal to the draught of a ship, to be solidified without change in volume, this solid would form a ship-body having vertical sides and a rectangular cross-section ; and the motion of this ship-body through the sea at the speed represented by the parallel lines of current would develop stream-lines in the surrounding sea which would be mathematically equal to those developed by the combination of moving source and sink. The source represents the water thrown off by the bow to open passage-way for the ship, while the sink represents the regathering of this water under the stern, to fill in the trough cut by the ship's passage.

The "source-and-sink" method thus opens a door to the exact analysis of the displacement of the sea by a passing vessel. It is a method to which much time has been given by many able men. Originally it was cultivated as a means for designing ships of perfect form, which should be capable of waveless progress through the water with minimum resistance, but its very limited value for this purpose was realised long ago. Now the problem of "suction" offers it a new application.

Historical.—Rankine (Brit. Inst. Naval Arch., 1870, page 175) credits the composition of stream-lines to Clerk Maxwell, but refers, for original algebraic investigations, to the work of Stokes, published in the Cambridge Transactions for 1842 and 1850. The problem of stream-lines past a sphere was solved by Dr. Hoppe (*Quarterly Journal of Mathematics*, 1856). Rankine also refers to his own previous work in a paper read to the Royal Society in 1863 and printed in the *Philosophical Transactions*, entitled "On Plane Water-Lines in Two Dimensions," and to his book entitled "Shipbuilding, Theoretical and Practical," published in 1866-7. In the *Philosophical Magazine* for 1864 he extended similar methods to stream-line surfaces of revolution, in three dimensions.

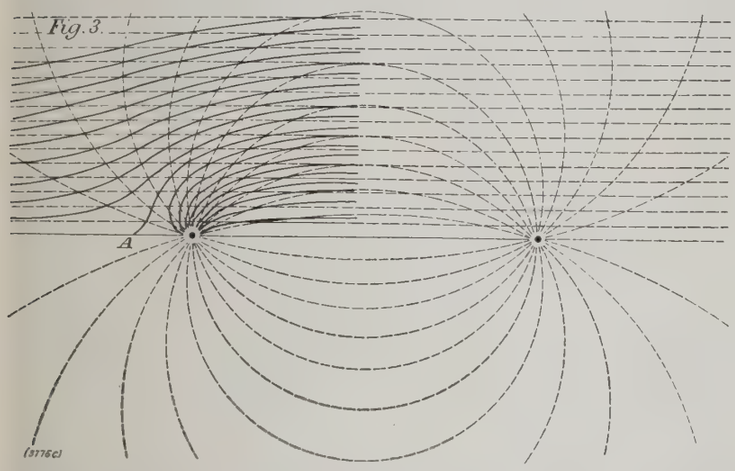
The stream-line oval A of Fig. 3 was developed by Rankine, in his paper of 1870, into the form shown in Fig. 4, by the use of two sources near the bow and two sinks near the stern (A and A'), to give some approach to concavity of bow and run. But this is still far from a truly typical ship model.

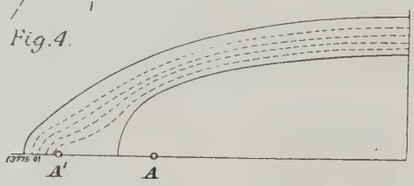
Other milestones in the progress of knowledge concerning ship motion are noted below, all references being to the Proceedings of the Institution of Naval Architects (British):—

"On a Vessel in Motion," by Henry Ransford, 1871; "On Waves in Liquids," by W. J. M. Rankine, 1873; "Wave-Making Resistance of Ships," by William Froude, 1877; "Theory of Deep-Sea Waves," by Joseph Woolley, 1878; Wave Principle in Ship Design," by Colin Archer, 1878; "Wave of Translation," by J. Scott Russell, 1879: "Wave-Line Form of Mid-ship Section," by J. Scott Russell, 1880; "On Wave Periods," by Emile Bertin, 1880; "On Ship Waves," by Lord Kelvin (Institution of Mechanical Engineers (British), 1887); "Diverging Waves," by Professor G. W. Hovgaard, 1909.

After the general authorities noted above, by far the most ingenious and the clearest development of the stream-line theory for actual ship-models has been contributed by United States Naval Constructor Taylor. He read two papers before the Institution of Naval Architects (British), one, in 1894, on "Two-Dimension Stream-Lines," and the other, on "Three-Dimension Lines," in 1895. Taylor conceived the idea that if it be permissible to compound the stream-lines from two finite sources and sinks, as Rankine did, or from several finite sources, as other computers did afterwards, it is equally permissible to increase the number of sources and sinks indefinitely, each source becoming correspondingly reduced in strength, until an infinite number of infinitesimal points form the basis for integration into stream-lines. In other words, the fore half of the ship is represented by one (graphical) function of sources of varying strength, while the after half has a similar function of sinks. By a very ingenious method of graphical integration, without which the computation of even a few finite sources becomes intolerably burdensome, the stream-lines are deduced from these assumed functions. For the details of Taylor's method the reader is referred to his papers.*

Mr. Taylor made tests of the force of suction between two ship-models towed in fixed parallel position in the testing-tank at Washington, in 1909, and these were reported to the (American) Society of Naval Architects and Marine Engineers. He repeated similar tests before the British Admiralty Court sitting on the case of the Olympic-Hawke collision during the winter of 1911-12.

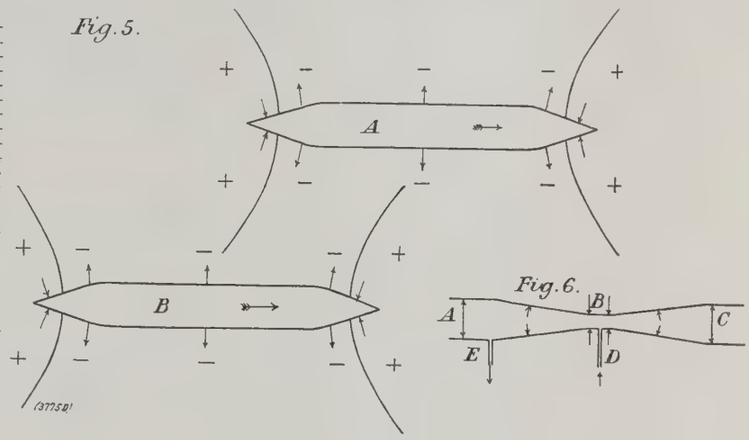




The author's connection with the development of the theory of suction began in 1908, when he was called upon to explain the suction collision between the United States and the Monterey, coastwise liners, in New York Bay. The trial being already under way when he was first approached, there was time only for the preparation of crude diagrams. But in connection with the Denver-Lehigh case later that same year, and in the case of the Parima and the Prinzessin Irene still later, these diagrams were got up more carefully. They discussed merely the general outline of the constrained wave, that for one ship being drawn on transparent cloth, so that it could be slid over that for the other ship, to show how suction forces were developed by these two outlines getting into and out of phase. This, so far as the author is aware, was the first publication of any general theory of suction. There were then no tests even of the forces developed when the ships are held in relatively fixed position. Of all the scientific material then lying ready, none had ever been directed towards the problem of suction.

Yet, it is proper to state, no further developments to which the writer has been able to carry this general theory, toward exactness in terms of particular ship-lines, have appreciably altered this first explanation, which was based upon hydraulic facts which are familiar to every pilot and ship-owner. In April, 1911, the writer had the honour of delivering a lecture upon "suction" before the adult naval officers of the graduate school at Annapolis. The following September two of his auditors happened to be passengers upon the promenade deck of the Olympic at the time of the Hawke's approach. In the report to his superior officers one of these young men states that, while he and his brother officers were sceptical at the time of the lecture, yet the approach of the Hawke developed what he recognised as "an ideal case" for suction, as defined in the lecture; from which basis the collision with the Olympic was predicted while the Hawke still held her virtually parallel course several hundred feet distant, from which she swerved suddenly an instant later, "as on a pivot," to plunge into the Olympic's quarter.

Since prediction is the prime test of any science, it is proper to recount this incident to show that the equipment of a navigator with even the most general, if clear, ideas of the conditions under which a ship's constrained wave becomes a menace to herself or her neighbours, is sufficient to permit foresight and prevention of such danger, when without it the ordinary pilot is helpless, even if vaguely apprehensive of danger. For such clearness it is first requisite that the constrained wave



be clearly recognised as independent of bow waves, propeller-wash, &c., as the cause of suction. From such simple premises the following argument arises inevitably.

II. Ship-Waves and Sea-Contours.

In all the earlier writers, and persisting in some text-books to the present day, there is a confusion as to classification of the several sorts of ship resistance, which must be cleared before the navigator taught in those years can understand "suction" clearly. These resistances are now distinguished as (1) skin-friction, (2) wave-making, with sometimes a third, "eddy-making," which is really a part of (1). At present these resistances are mentioned only for the purpose of excluding them from the argument. Suction depends solely upon the existence, about every moving ship, of (3) the "constrained wave," which is quite distinct from the bow, stern, and échelon waves of the usual analysis of the wave-making resistance. But it was not until 1898 that there appears in the papers of the Institution of Naval Architects (British) any realisation (by B. Schieldrop, of Bergen) that the "constrained wave" is distinct from these other resistances, in cause as well as in character.

The "constrained wave" of a ship is not a true wave at all. The true waves are classified as (*a*) bow waves, (*b*) stern waves, and (*c*) échelon waves. All of these are visible disturbances of the sea surface which travel away from the ship by their own inertia, when once started, and with which all seafaring people are familiar. The "constrained wave," on the other hand, is often invisible and usually needs to be looked for, even when visible. It consists of a wide, low mound of water which the ship piles up ahead of herself, and which accumulates until enough surplus pressure is gathered to start the water into motion aft, beneath or around the hull. Its height is very low, like a ground swell, but its bulk is tremendous. Its trough may be seen on either beam amidships, and at the stern rises a second low crest. Although it is relatively to this that the

* "On Ship-Shape Stream Forms," by D. W. Taylor. Transactions of the Institution of Naval Architects, 1894, vol. xxxv., page 385; ENGINEERING, vol. lvii., page 410. "On Solid Stream Forms, and the Depth of Water Necessary to Avoid Abnormal Resistance of Ships," by D. W. Taylor. Transactions of the Institution of Naval Architects, 1895, vol. xxxvi., page 234; ENGINEERING, vol. lix., pages 489 and 497.

true waves rise visibly, yet the "constrained wave" itself is visible about every fast vessel, and in tugs it often rises a fair fraction of the freeboard, the hull "squatting" visibly into its trough.

This "constrained wave" may be explained in terms of the stream-line analysis. The two-dimension stream-line presupposes that the sea is of uniform depth, that the ship's sides are everywhere vertical, reaching to the sea bottom, and that the sea is covered with a thin sheet of rigid ice, strong enough to prevent any vertical alteration of sea surface. This ice may be supposed not to interfere with the motion of the ship, or the ship may be a submarine just reaching from bottom to surface. Under such conditions alone would the motion of the water displaced by the ship's motion be purely horizontal. Under such conditions the increase in pressure necessary for accelerating the water away from the bows, and that engendered by its arrest at the stern again, would remain purely *pressure*, confined by the rigid ice against rising in surface-waves.

But in actuality there is no ice. The increase in pressure ahead of and astern of the ship actually occurs, but is partially relieved at the sea-surface. A readier means for the release of the water than *horizontal* acceleration is *vertical* acceleration. The water gets out of the ship's way by rising vertically from either bow, in waves. The most striking instance of this is the tiny jet of water often appearing right at the stem of river steamers. This water is displaced by a hull of rectangular outline, but small dimensions (the stem), which is propelled at disproportionate speed by a relatively enormous power; hence the vertical acceleration of the water is exaggerated.

But a more common form of vertical acceleration is seen in the "bow waves," which rise on either bow, and repeat themselves in a series extending obliquely aft along lines making angles of about 23 deg. with the ship's course, ultimately merging themselves with the échelon waves. From the stern trail away two similar series of "stern waves," but much smaller than the bow waves. On either beam, and all across the wake, spreads the procession of broad, low échelon waves. All of these are due to *vertical* acceleration of the water due to the lack of constraining ice, and all of them constitute deductions of energy from the "constrained wave," which is normally due to purely horizontal acceleration of the water.

In actuality, too, there is always room for some water to escape beneath the ship's bottom, instead of spreading out laterally. In deep water this is the path for most of the displaced water. But in shallow water this path is cut off. Even when there is a foot or so of water between hull and sea-floor this space is useless for passage of water, because of the turmoil of eddies. And since the force of suction is developed only by an acceleration of water, which finds its pure and best expression only when the ship extends to the bottom, while the sea-surface is constrained by imaginary ice, these are the conditions which will be assumed throughout the discussion. All question of bow waves, échelon waves, &c., is thus eliminated.

In such a sea let there be held a vertical pole, extending to the bottom, which is then moved horizontally. This is like a vertical pipe having perforations in its sides, the side looking toward the course ahead being a "source," while the after side is a "sink." Imagine two lines drawn on the chart through the point representing such a pole, at angles of 45 deg. with its course, forming four quadrants—one ahead, one astern, and one on either beam. The theory of stream-lines shows that in the quadrants ahead and astern the sea-pressure is greater than normal, so that, if there were no ice present, the sea-surface would be elevated above normal. In the quadrants on either beam, conversely, the sea-pressure is less than normal, so that, in the absence of ice, the sea-surface would be depressed. The 45-deg. lines are the loci, or contourlines, of mean sea-level.

Such a four-phased distortion of the sea-surface actually accompanies every ship. Its exact form is influenced by the ship's model and by the energy leaking away in vertical wave-forming acceleration. But, in essence, it is always there, approximating the 45-deg. lines in mean sea-level contour. It is due solely to horizontal motion of the water, and it constitutes virtually the sole force causing suction.

This "constrained wave" is not properly a wave at all. It does not proceed by its own inertia, but is held constrained, as to form and magnitude, by the environing solid ship and sea-bottom. It is stationary relatively to the ship. Its inertia plays no part so long as the depth remains constant. When that varies, however, the inertia of the constrained wave becomes the most powerful force controlling the ship. For while its head is low—so low as usually to be invisible—yet the mass of water involved is enormous. It extends away from the ship indefinitely, decreasing with distance, but still perceptible at several ship-lengths away.

The form of this constrained wave is markedly distorted near the ship, away from the simple 45-deg. lines of mean sea-level developed by the pole, by the lines of the ship. It will be necessary to trace further in detail these influences before the constrained waves of actual ships can be studied for suction purposes.

Every moving ship acts approximately like the vertical pole just imagined as moved horizontally through the water—viz., to distort the sea surface about it in four quadrants, demarked by oblique 45-deg. lines through its centre of displacement. The quadrants ahead and astern exhibit surplus pressures, or elevations, of the surface above mean sea-level. The quadrants on either beam show deficits below mean sea-level; but in the case of the actual ship its elongated form distorts the 45-deg. lines near the ship into curves of a hyperbolic form, asymptotic to the 45-deg. lines, meeting the hull on either bow or either quarter.

In Fig. 5 are shown two ships in water-line plan, A and B, overlapping each other on parallel courses. The hyperbolic contours of mean sea-level are shown extending from either bow and quarter; the plus and minus signs indicate the surplus and deficit of sea pressure in the neighbourhood of each ship, while the net horizontal pressure upon the hull is shown by arrows—an arrow heading toward the hull indicating surplus, and one heading outwardly a deficit, of pressure. The ships will be assumed to be moving toward the right, although the curves would be the same (in this particular case) for motion in either direction.

Without attempting now to indicate the exact form of these curves, which will be discussed later, it is plain at a glance that the two sets of plus and minus signs must cancel each other, to some degree at least. Thus ship A will have its lateral pressures along its starboard bow *increased* by the influence of B's forward quadrant of surplus pressure, while the pressures along A's starboard quarter will be *decreased* by the influence of B's port lateral deficit of pressure. Since the normal sea pressures along A's port side are virtually unchanged by B's presence, A will feel a tendency to swing to port.

Following the same reasoning as to the effect upon B of A's starboard and astern quadrants, it appears that B must feel a tendency to swing to port also. But whereas A's swing in response to these forces carries her away from their origin and decreases the danger of collision, except with objects on A's port hand, any slight response of B to these forces will very rapidly exaggerate them and accelerate her approach to A's quarter.

To the engineer, the situation may be clearer if explained in terms of the familiar Venturi meter, a diagram of which is given in Fig. 6. In the Venturi any surplus pressure existing within the conduit at either end, as indicated by the arrows, is altered more or less into a deficit at the "throat" B by the restricted diameter, and the consequent acceleration of the water at this point. If a branch pipe D be connected at this point, the deficit may be enough to draw fluid in through this pipe, although water might flow outwardly with force at E. Or, if the Venturi be made of flexible material, when the flow has reached a certain velocity the deficit of pressure at B will cause the walls to collapse; and this collapse will be sudden and violent, in unstable equilibrium.

Now the space between the two ships of Fig. 5 offers the most direct pathway for the water which, displaced by both vessels, must get from ahead to astern by some way or another. But it forms a *restricted* pathway, with gradual convergence and divergence of solid walls on either side of the "throat." In all this it is quite like a Venturi. But if ship B swings a bit to port, it creates a situation quite like the first "give" of the throat of the flexible Venturi—the forces engender their own acceleration, in unstable equilibrium, and the motion, once started, accelerates rapidly to a sudden and violent end.

Since the situation of Fig. 5 is usually created by a larger, faster vessel overtaking a smaller, slower one, the latter finds itself first in the A position; but this is the position of less danger and is often passed without mishap. But when the smaller vessel has dropped back into the B position, it is in the greatest danger. The majority of suction collisions occur in this position, the overtaken vessel suddenly swerving uncontrollably—usually in defiance of a hard-over helm, and often against reversed engines—into the quarter of the other vessel.

Usually, of course, the larger vessel is unaffected by the forces engendered mutually between the two; but sometimes it is the larger vessel which is the slower one. Indeed, the recorded instances of suction seem to include every conceivable combination of circumstance which could set these forces at work, with various results. Frequently the ship in the A position is driven off her course enough to collide with other vessels, or with a bank. In one instance, a large freighter going down New York Bay, when overtaken by a liner, was swung eight points off her course by this repellant component of the "suction" forces—fortunately having sea room enough to check her way before running aground—but was left in that position helpless until the liner was well by.

For it is obvious that the forces created by these "constrained" waves following and preceding the ships can easily be far greater than any of those ordinarily relied upon for manœuvring. While the altitude of the constrained wave is slight, its extent covers an area of ship-side which is enormous when compared with the rudder-surface. Indeed, the difficulty in connection with suction is not to explain it, but to explain how it is that so many ships pass closely without its becoming an overwhelming factor. The most frequent answer is, *depth of water*. It requires no mathematics to show that this Venturi-like restriction of waterway between the two ships is much worse in shallow water than in deep. But suction collisions sometimes occur in water which, while not very deep, provides enough space beneath the hulls to pass a good deal of water; while in quite shallow water vessels often pass very close in safety. To answer these questions, the exact form of the constrained wave needs further consideration.

(To be continued.)

Engineering Exhibition, Manchester.—The Northern Engineering Industries Exhibitors' Committee have sent us a prospectus of the Second Northern International Engineering Exhibition, which is to be held under their auspices, in Manchester, from October 29 to November 20. It is being organised by the committee in the same manner as the recent Colliery and Mining Exhibition, held under the auspices of a similar committee representing the colliery machinists of this country.

Regulations for Technical Schools, Schools of Art, &c., in England and Wales.—The Board of Education have now consolidated into a single volume the separate sets of regulations which have been issued previously for different types of technical schools and classes, uniting in a single volume the regulations for evening schools, for day courses (other than university courses) in technical institutes, and for schools of art, the regulations for junior technical schools, and the regulations for university tutorial classes. Copies, price 2d., can be obtained through any bookseller.

Peat in the Falkland Islands.—No less than one-sixth of the total area of the Falkland Islands, which embrace territory amounting to about 6500 square miles, is entirely composed of peat, having a calorific value and richness which compare favourably with the best peat that is produced in Canada, Newfoundland, Ireland, Germany, or elsewhere. The Government of the Falkland Islands is prepared to grant concessions to any firm that will undertake the exploitation of the peat situated on Crown lands for briquetting or other purposes, and every facility will be given to such firm or firms for carrying out the work. Full particulars may be obtained from the Crown Agents for the Colonies, Whitehall-gardens, London, S.W.

United States Steel Corporation.—The profits realised by the United States Steel Corporation in the first quarter of the year were 17,994,381 dols., and for the second quarter 22,896,300 dols., making an aggregate for the six months of 40,890,681 dols., as compared with 75,644,614 dols. in the first half of 1913, and 42,929,238 dols. in the corresponding period of 1912. The orders on hand at the close of June represented an aggregate of 4,032,857 tons, as compared with 5,807,317 tons at the close of June, 1913, 5,807,346 tons at the close of June, 1912, and 3,361,058 tons at the close of June, 1911. The monthly aggregates this year of orders on hand and in course of execution have been as follow:—January, 4,613,680 tons; February, 5,026,440 tons; March, 4,853,825 tons; April, 4,277,668 tons; May, 3,988,160 tons; and June, 4,032,857 tons.

THE "UNION" FLEXIBLE COUPLING.

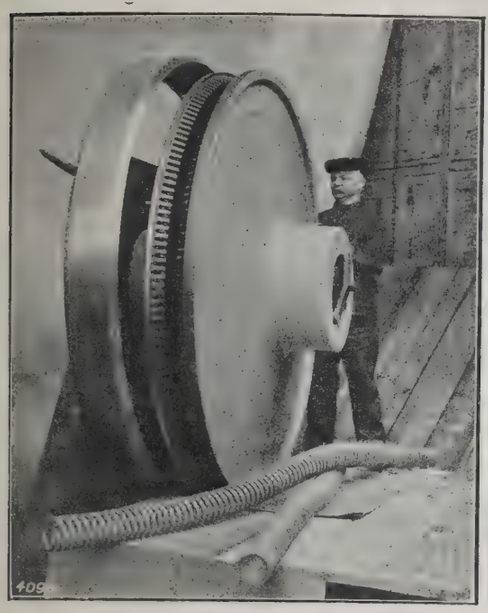


Fig. 1.

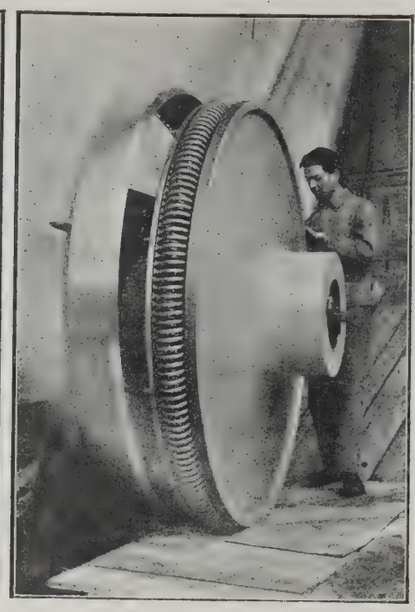


Fig. 2.

We illustrate above an interesting type of flexible shaft-coupling, known as the "Union" coupling, and being introduced by Messrs. Boving and Co., Limited, of 9½, Union-court, Old Broad-street, London, E.C., who own the British patent.

The most essential parts of the coupling are a pair of bossed discs, one of which is keyed to each of the adjoining ends of the shafts to be connected. On the opposing faces of the discs, and near their peripheries, are formed a large number of small projections or teeth, clearly shown in Fig. 1, and into the spaces between these teeth are placed the coils of two helical steel springs, which can be seen in the foreground of Fig. 1, and are shown in position in Fig. 2. They are afterwards covered by the flanged ring, shown in both figures, the ring being attached to one of the discs by means of screws. The two springs have right-handed and left-handed coils respectively when the coupling is to run in either direction, and their object is, of course, to transmit the torque from one part of the coupling to the other. At the same time they permit a certain amount of angular, radial, and axial movement to take place between the two halves of the coupling, thus allowing two shafts to work satisfactorily when somewhat out of alignment. They also, to a great extent, prevent the transmission of shocks from the machinery to the driving-motor, and almost entirely damp out small cyclic variations of torque.

The actual coupling illustrated above is one of the largest of this pattern yet constructed. It is designed to transmit 3000 horse-power at 88 revolutions per minute. The discs are of cast steel, machined all over, the teeth being milled out in much the same way as are the teeth of a worm-wheel. In the case of small couplings for low-speed work the discs can be made of cast iron, but high-speed couplings are always constructed with cast-steel discs.

It will be seen that no perishable materials are employed in the construction of these couplings; they thus have a long life, and can withstand very rough usage. They require no attention in use except the addition of a small quantity of heavy lubricating oil about once a month. It should also be mentioned that, before placing the springs in position, the spaces between the teeth are filled with grease, so that wear is reduced to a negligible quantity. Another advantage is that, owing to the large number of torque-transmitting elements, one of which is formed by each coil of the spring, a comparatively small and light coupling can be made to transmit a large torque; the individual weakness of each torque-transmitting element also leads to a very flexible drive. These couplings will run equally well in either direction, and are especially suitable for heavy intermittent work of all kinds. We understand that they have been successfully employed for upwards of three years in connection with the electric driving of rolling-mills, mine-hoists, lifts, air-compressors, and other machinery, and that they have been adopted for general use in several large rolling-mills in Germany and Austria.

As stated above, the coupling illustrated is one of the largest sizes made, but the standard sizes available cover practically all requirements. One of the smallest sizes, for instance, has been used to transmit 10 horse-power at 10,000 revolutions per minute.

The Alberta (Canada) Oil Boom.—The *Saskatoon Board of Trade Weekly News* letter states that there are hopeful indications of oil deposits much more adjacent than Calgary—in fact, a hundred miles or so west of Saskatoon. Certain local capitalists have been for some time quietly filing large parts of the area in question, which, according to the map issued by the Geological Department of the Dominion Government, in addition to the evidence of more than one prominent expert, may be hopefully prospected. A somewhat disquieting feature of the Alberta oil boom is that over 400 companies have already been incorporated, with a total capital of 400,000,000 dols. It is said that the most valuable oil district in the world could not pay a dividend on such an immense capital. The general hope is that the Calgary field will prove fully up to expectations, but the fact remains that the people there have gone oil crazy, and that discretion has been thrown to the winds.

The Royal Mail Steam-Packet Company's Steamer "Devon."—This steamer, built by Messrs. Cammell Laird at Birkenhead, successfully completed her official speed trials on the 28th ult. She is very similar to the Dart and Doon, recently built for the same company by Messrs. Cammell Laird, and is specially designed for the service of conveying chilled and frozen meat from the upper reaches of the River Plate to the ocean-going steamers engaged in the chilled-meat trade. Her dimensions are 220 ft. by 42 ft. by 12 ft. 7 in. The refrigerating plant has been provided by the Liverpool Refrigerating Company. The main propelling machinery consists of two sets of direct-acting triple-expansion engines, with cylinders 13½ in., 21 in., and 34 in. in diameter, and a stroke of 19 in., designed for running at about 175 revolutions per minute. The main condenser is of the "Contraflo" design, the shell being of galvanised mild steel, and the doors and water-ends of cast iron. The boiler installation consists of two single-ended boilers, 12 ft. in diameter by 10 ft. 3 in. long, fitted with Howden's system of forced draught.

"Anuario de Mineria Metalurgia, Electricidad, é Industrias Quimicas de Espana," 1914.—This annual directory, for 1914, of mines, metallurgy, electricity, and commercial chemistry in Spain, published by the Revista Minera, Metalurgica y de Ingenieria, under the direction of Mr. Adriano Contreras, mining engineer, ex-professor of the School of Mines in Madrid, and Mr. Román Oriol, mining engineer, is the fourteenth volume. It covers 850 pages, and its price, bound in cloth, is 7 pesetas. It can be obtained from the Revista Minera, Villalar 3, Madrid. It contains a list of all the mines classified according to metal and province; a list of the mining, metallurgical, electrical, and chemical societies established in Spain, with their capital, address, and administrative boards, &c.; and a list of metallurgical and chemical factories, and of the Spanish and foreign mining engineers. It also gives data on the railway companies, and information on carriage rates for ores, metallurgical and chemical products, on the fees of the School of Mines Laboratory for examining and analysing ore, and on the Custom House duties and commercial treaties. The laws referring to the metallurgical and mining industry are also dealt with.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

South Africa: With reference to the proposed extension of the works of the Rand Water Board, H.M. Trade Commissioner for South Africa reports the publication, in the *Union Gazette (Extraordinary)*, of an Act authorising the Rand Water Board to borrow a sum not exceeding 1,250,000*l.* for carrying out the proposed works. A dam is to be built across the Vaal River capable of storing 2,181,280,000 cub. ft. of water, of which not more than 3,200,000 cub. ft. may be used daily, whilst 238,000,000 cub. ft. are to be reserved for the benefit of the riparian land-owners in the vicinity of the storage area who may be awarded permits to impound and store water in the reservoir. H.M. Trade Commissioner for South Africa also reports that the Municipality of Mossel Bay, Cape Province, proposes to borrow a sum of 11,593*l.* for carrying out an electric-lighting scheme. H.M. Trade Commissioner further reports that the Municipality of Queenstown, Cape Province, is endeavouring to borrow a sum of 70,000*l.*, of which 59,000*l.* will be allocated to sewerage works, and 4187*l.* to a water-works redistribution scheme.

France (Society Islands): With reference to previous notices relative to proposed harbour improvements at Papeete, it appears from the report by H.M. Consul at Tahiti on the trade of the Society Islands in 1913, which will shortly be issued, that the positions for the erection of the four lighthouses, on the Islands of Fatuhiva, Matahiva, Tetiaroa, and Moorea respectively, have been surveyed, and tenders for the erection of the buildings have been invited and will be received up to September next.

Spain: The *Gaceta de Madrid* notifies that a law has now been passed authorising the Ministerio de Fomento to expend the sum of 70,500,000 pesetas (about 2,611,000*l.*) on the repairing of State roads, and a further sum of 1,500,000 pesetas (about 55,000*l.*) on the purchase of stone to be stored for use for future repairs.

Italy: The *Gazzetta Ufficiale*, Rome, announces that tenders will be received up to August 20, at the Ministero dei Lavori Pubblici (Sezione Contratti), Rome, for the carrying out of work involved in the repair of the breakwater on the left bank of the Tagliamento, at a curve of the river in the Commune of Latisana. The upset price is put at 145,130 lire (about 5800*l.*). Although the contract will doubtless be awarded to an Italian firm, nevertheless the carrying out of the works may involve the purchase of materials and accessories outside Italy.

Mexico: H.M. Minister at Mexico City reports that a contract has recently been entered into between the Ministry of Communications and Public Works and the representative of Messrs. Hersent, contractors for public works, and Messrs. Schneider and Co., of Creusot, France, for the construction of port works at Acapulco, Tuxpam, and other Mexican ports, at a cost not exceeding 100,000,000 pesos (about 7,000,000*l.* at the present rate of exchange). All materials required in connection with the carrying out of the works which it may be necessary to import from abroad will be admitted free of duty.

City and Guilds of London Institute.—The programme of the Department of Technology of the City and Guilds of London Institute for the 1914-15 session has just been issued. It contains the regulations for the registration, conduct, and inspection of classes and examination of candidates in technological subjects, and for the award of teachers' certificates in manual training and domestic subjects. The programme is published by Mr. John Murray, of Albemarle-street, London, W., at the price of 9d. net.

New York Harbour Improvements.—On the North River, New York, a new pier is to be constructed, 1050 ft. long and 150 ft. wide, and a corresponding half pier, giving slips 360 ft. wide, and having a depth of water of 44 ft. The accommodation thus provided will allow of the simultaneous berthing of three of the largest ocean steamers. Preliminary work has already made considerable headway, a large cofferdam having been constructed so as to allow excavation of rock on the site to proceed in the dry. The basin enclosed by the cofferdam is 800 ft. by 300 ft., and sheet-steel piles of a maximum length of 73 ft. were used. The piles were arranged in pockets, the inner faces of which were from 16 ft. to 22 ft. apart, the ends being 24 ft. apart. These pockets were subsequently filled and supported on the inside of the dam by a bank of stone.

A High Surge-Tank.—A surge-tank on the differential principle has been constructed at the hydro-electric plant of the Salmon River Power Company, Altmar, N.Y. The structure is 180 ft. high to the top edge of the tank, which has a height of 80 ft. and a diameter of 50 ft., and stands on a base built up of ten lattice columns. The tank has to take care of surges from a column of water 9625 ft. long and 12 ft. in diameter. A 12-ft. riser connects the bowl-shaped bottom of the tank with the pipe-line. Inside the tank is a 10-ft. vertical pipe tapered from 10 ft. 8 in. diameter at the bottom end to 15 ft. at the upper end. The annular space between the mouth of the 12-ft. riser and that of the 10-ft. 8-in. pipe allows part of the water to flow straight out into the tank, while the rest passes up the 10-ft. pipe. The effect is to throttle the surges very considerably.

WARSHIPS DESIGNED AND BUILT AT ELSWICK.*

Some Notes on Warships Designed and Constructed by Sir W. G. Armstrong, Whitworth and Co., Limited.

By J. R. Perbett, Member of Council.

The inauguration of the new Armstrong yard at Walker marks an epoch in local and national warship-building enterprise of an importance that cannot be seriously exaggerated. The present occasion, therefore, affords the first, and perhaps the most fitting, opportunity for reviewing the history of the firm with which I have had the honour to be connected, especially with reference to its work as producers of warships and armaments during a period approaching nearly half a century.

So with your permission I propose to deal as briefly as possible with some of the events associated with the origin and development of the warship and armament departments of the firm, with, as I have already suggested, particular reference to the warship-building section, in which I have been engaged for the past twenty-eight years, and over which it has been my privilege to preside as chief naval architect and general manager during the past twelve years.

Previous to 1867 the Elswick company was occupied almost entirely in the construction of guns and their appurtenances, including explosives, but about that date it was decided to embark upon the building of war vessels, and arrangements were made with the late Mr. Charles Mitchell to build such vessels at his Walker shipyard, where several warships of various types had already been constructed.

The Elswick company was fortunate in having as a managing partner Mr. George Rendel, under whose direction the new shipbuilding department of the firm was initiated and managed for about fourteen years. Mr. Rendel, as an engineer, was responsible for many important improvements, both in warship design and the manufacture of ordnance. Several warships from his design were constructed at Walker. Amongst those may be mentioned the Tsukuchi Kan, Yung Wei, and Chao Yung (1881)—vessels of 1480 tons. In these vessels Mr. Rendel introduced the steel protective deck, a new feature in design, which he developed in the Esmeralda (1884), a swift cruiser of 3000 tons, constructed for the Chilian Government. The development in this instance was brought about by extending the protective deck from bow to stern, and increasing its thickness over the machinery and magazine spaces. The protective deck feature of design, as is well known, has been retained, and in some respects improved upon, in many warships since constructed for both our own and foreign navies.

During the few years succeeding 1868 several war vessels were built at Walker, including cruisers, gun-boats, and troopships for the British and foreign navies. Eight of these gun-boats were built for the Chinese Navy, and each was armed with one 12½-in. 38-ton muzzle-loading gun and others of smaller calibre.

In 1882 the Walker shipyard was taken over by the Armstrong Company, and in the following year the Chilian cruiser Esmeralda, already referred to, was laid down. This vessel had a displacement of 3000 tons and a speed of 18¼ knots. She mounted two 10-in. breech-loading guns, six 6-in. guns, and others of smaller calibre. The Esmeralda was the pioneer of the fast protected cruiser class. She was heavily armed for a vessel of her displacement; she had a considerable radius of action, and her achievements on trial attracted widespread attention in naval circles, and greatly enhanced the rapidly growing reputation of the firm as designers and builders of vessels of the type.

From 1883 to 1885 the shipbuilding department of the firm was under the direction of the late Sir William H. (then Mr.) White, whose recent death came as a great shock to all those who had the honour to know and be associated with him. During the period of Sir W. White's tenure, the firm acquired, and he organised, the Elswick shipyard solely for the construction of warships, the Walker yard being left to deal with the construction of vessels other than warships. It was then that the designing and building of warships by the firm was really earnestly and vigorously entered upon. Up to this period the presence of a warship in the Tyne was a somewhat rare occurrence, but since then my firm has never been without an order for one or more of such vessels.

The Elswick Shipyard was inaugurated in October, 1884, by the laying down of the protected cruiser Panther for the Austro-Hungarian Government, and before her construction had progressed very far a sister vessel (the Leopard) for the same navy was ordered and laid down. These vessels were each of 1530 tons, with a speed of 18½ knots. Two-inch steel protection was given to the machinery, and the armament comprised two 12-cm. guns, two 4.7-mm. guns, and four torpedo-tubes. The vessels were from the design of Sir William White.

In 1885 was commenced the protected cruiser Dogali, which found her home in the Italian navy. She also was designed by Sir William White. Her displacement was 2070 tons, speed 19½ knots, the armament ten 6-in. quick-firing guns, nine 6-pounders, a large number of smaller guns, and four torpedo-tubes.

In the same year the Victoria, the first battleship built at Elswick, was commenced for the British Navy. Her length was 340 ft., beam 70 ft., and displacement 10,810 tons. She carried two 110-ton 16½-in. breech-loading guns, one 10-in., and twelve 6-in. guns. She and her sister vessel, the Sans Pariel, were the only ships built at that time to carry the 110-ton guns. The Victoria was considered a huge vessel in those days, and it will be remembered the task of navigating her through the bridges at Newcastle aroused considerable interest and discussion in the district. In this connection it is interesting to observe that we have at present building five vessels, each of a displacement nearly three times that of the Victoria, and each of a beam exceeding 89 ft. It is worthy of note also that whereas in 1886 we were allowed a period of three-and-a-half years in which to build the Victoria, the period allowed for the Monarch, a vessel 125 per cent. greater displacement than the Victoria, was only two years. Notwithstanding a strike of sixteen weeks' duration, we succeeded in building and handing over the Monarch within the contract time.

In 1886 we were building war vessels both at Elswick and Walker, and in that year the Naniwa Kan and Takachiho Kan, protected cruisers, each of 3700 tons, were completed at Walker for the Japanese Government. They carried two 10-in. breach-loading guns, six 6-in. and other smaller guns, and four torpedo-tubes. In their case the thickness of the protective deck was increased, varying from 2 in. on the flat to 3 in. on the slopes. These vessels steamed at 18¾ knots on trial with an indicated horse-power of 7100.

Towards the end of 1885, Sir William White was invited by the Admiralty to accept the position of Director of Naval Construction and Assistant Controller of the Navy, and he was succeeded at Elswick by Mr. (now Sir Philip) Watts.

Two vessels were laid down in the latter part of this year—namely, the Chih Yuan and Ching Yuan—for the Chinese Navy. These were protected cruisers, of 2300 tons, and a speed of 18½ knots. They carried three 8-in. and two 6-in. guns and four torpedo-tubes, and were also designed by Sir William White.

At the beginning of 1887 two smaller cruisers for Spain were laid down at Elswick, each of 1050 tons displacement, and carrying six 4.7-in. guns.

In the same year the Piemonte, the first vessel designed by Sir Philip Watts after he joined Elswick, was commenced for the Italian Navy. The vessel was of 2500 tons, and in her the designer adopted, for the first time, engines of the triple-expansion four-cylinder vertical type. These engines developed 12,700 indicated horse-power, and gave the vessel a speed of 22.4 knots, which was very much in excess of that of any similar vessel designed up to that date. The performance of the Piemonte attracted considerable attention, and evoked a great deal of discussion in naval circles.

During the following few years, warships of almost every type were constructed at Elswick for the British and foreign navies, including Japan and China in the East, the United States in the West, the South American Republics Brazil, Argentine, and Chili, as well as Norway, Portugal, Italy, Roumania, and Spain. Among these vessels were included many cruisers of the high-speed, heavily-armed type, introduced by the Elswick firm.

In 1894 we received from the Japanese Government an order to construct the battleship Yashima, designed by Sir Philip Watts, this being the first large battleship built on the Tyne for that country. Her length was 372 ft.; beam, 73½ ft.; and displacement, 12,330 tons. She carried four 12-in. breech-loading guns, twin-mounted in barbettes, ten 6-in. guns, and numerous smaller guns. Her main belt was 18 in. in thickness over the machinery spaces. With 14,000 indicated horse-power she steamed at 19.27 knots. She was regarded as a battleship with the speed of a cruiser.

Between 1894 and 1897 we built at Elswick the armoured cruisers Esmeralda (this was the second Esmeralda built for Chili by our firm) and the O'Higgins. Both these vessels were sheathed. The Esmeralda was of 7030 tons, and in addition to a protective deck throughout the whole of the length, we saw in this vessel the introduction of the armoured belt in cruiser design, and this armoured belt was adopted in nearly all the Elswick-designed cruisers after that date. Later its adoption became universal, and now it is regarded as an essential feature of all cruiser designs. In the Esmeralda the armoured belt was 6 in. thick and 7 ft. deep. The vessel carried two 8-in. guns, sixteen 6-in. guns, and eighteen smaller guns, in addition to three torpedo-tubes. Her speed was 23 knots.

The O'Higgins, built about the same time, had a belt of a maximum thickness of 7 in. She carried four 8-in. guns, ten 6-in. guns, twenty-four smaller guns, and three torpedo-tubes. Her displacement was 8500 tons; speed, 21½ knots.

About this time, also, we were constructing a protected cruiser of 4500 tons—the Takasago—and a second battleship—the Hatsuse—of 14,967 tons, both for Japan. In the former we find the protective deck increased in thickness to 4½ in. Her speed was 22½ knots. In the battleship, the main armour belt was 406 ft. long, with a maximum thickness of 9 in. The thickness of the barbettes for the 12-in. guns, of which she carried four, was 14 in. This vessel was 440 ft. long, 76½ ft. beam, and she steamed at over 19 knots with 16,000 indicated horse-power.

Elswick now became particularly busy with naval work for the Japanese Government. Amongst a number of armoured cruisers built for that navy were the Idzumo and Iwate, each of 9750 tons, carrying four 8-in. guns and a secondary armament of fourteen 6-in. and smaller guns. The main armour belt had a thickness of 7 in., and there was an upper belt of 5 in. These vessels steamed at 22 knots. Two similar vessels, the Asama and Tokiwa, with a knot higher speed, were also constructed for the Japanese Navy.

It may be mentioned here that we have designed and built for the Japanese Navy 13 warships—3 battleships and 10 cruisers—armoured and unarmoured. Nearly all of these vessels were engaged in the war against Russia, and the whole of the Japanese fleet taking part in that war was armed with guns furnished by the Elswick firm.

These vessels were followed by two sheathed-protected cruisers, each of 3430 tons and 20½ knots speed, designed for Brazil, and purchased by the United States Navy, and a pair of coast-defence armour-clads of 3850 tons for the Norwegian Government.

In 1902 Sir Philip Watts left Elswick to become Director of Naval Construction at the Admiralty in succession to Sir William White. I was chosen as his successor.

In March of that year the Constitucion, one of two battleships designed at Elswick for the Chilian Navy, was laid down. These were heavily-armoured fast vessels, and were afterwards acquired by the British Government, when they were re-named the Swifture and Triumph. They were 436 ft. long, 71 ft. beam, with a displacement of 11,800 tons. They steamed at over 20 knots, and carried four 10-in. guns, fourteen 7.5-in. guns and twenty smaller guns. The maximum thickness of the belt armour was 7 in. In the case of the Elswick-built vessel it is worthy of note that during a considerable period of her construction the weight of steel worked into the hull weekly amounted to 250 tons, the contract time for building the vessel being 18 months, but towards the end of this period the rate of progress was permitted to ease off in consequence of the change of ownership.

Another vessel that may be mentioned here is the Turkish cruiser Hamidieh (ex Abdul Hamid), of 3800 tons, commenced in 1902. This vessel was very actively engaged in the recent war. Some of you may have seen a picture of the ship steaming, very greatly down at the bow, towards Malta for repairs after being pierced by shot in her forward compartments, a tribute to the quality of her water-tight work, which probably accounts for the vessel being afloat to-day.

I now come to the British cruiser Amethyst, laid down in 1902. This was the first vessel larger than the destroyer in which turbine machinery was fitted. This machinery was manufactured by the Parsons Company from designs by Sir Charles Parsons. The speed of the Amethyst was a mile per hour greater than that of sister vessels fitted with reciprocating machinery, and although at the outset difficulties were experienced in connection with the ventilation of the engine-rooms, which were eventually satisfactorily overcome, this first turbine cruiser proved an unqualified success, and paved the way for the fuller application of the turbine type of machinery which has since taken place in connection with large cruisers and battleships.

Since the Amethyst (1904), or during the past ten years, the aggregate horse-power of the turbine machinery fitted in war vessels built or building by my firm amounts to over 465,000; in the same period the aggregate or corresponding horse-power of the machinery of reciprocating type fitted in war vessels built or building by us is over 110,000, or approximately one-fifth of the power of the turbine machinery. All of this turbine machinery has been of the type introduced and developed by our distinguished friend Sir Charles Parsons, and the figures furnish a significant proof of the growing application of the turbine principle in the propulsion of war vessels and the gradual abandonment of the old type.

In 1903 a pair of scouts named the Adventure and Attentive were designed at Elswick and laid down for our own Navy. In these vessels six-cylinder reciprocating engines were fitted as desired by the Admiralty, although I should have preferred, and asked that we might be allowed to provide, machinery of the turbine type. The Attentive attained a speed of 25.88 knots, which established her as the fastest vessel of the class, and, I believe, the fastest vessel in the world at that time, excluding destroyers. Excellent as were the results of the trials of this vessel, I am of opinion that with turbine machinery a speed of about 27 knots would have been easily attained.

In the following year another battleship, the Kashima, was commenced for the Japanese Government. She was 425 ft. long and of 78 ft. beam, with a displacement of 16,400 tons. She carried four 12-in. guns, four 10-in. guns, twelve 6-in. guns, a number of smaller guns, and five submerged torpedo-tubes. The main armour belt had a thickness of 9 in., and there was an upper belt of 6 in.; the citadel armour was also 6 in. thick. She attained a speed of 19.24 knots. In 1905 we were entrusted by the British Admiralty with the construction of the Invincible. This was an interesting vessel from the fact that she was one of the first of the type known as the "cruiser-battleship." She was also the first to have all the big-gun machinery worked by electric power. She was most successful in her speed trials, and proved to be the fastest ship of the class.

During the succeeding year the Brazilian battleships Minas Geraes and Sao Paulo were designed at Elswick, and the first-named was laid down there. In these vessels was adopted for the first time, in this country, a new system of emplacement of the primary armament, the two forward pairs of guns being in separate turrets, that to the rear carrying the guns at a higher level, the two after pairs having a similar disposition, thus affording a very large arc of training to all of the main guns. I may be permitted to observe here that we had for a considerable time advocated the adoption of the superimposed turret, but it was not until the latter end of 1906 that we were able to induce our clients to adopt this arrangement. The Minas Geraes and Sao Paulo each had a displacement of 19,281 tons; they were 500 ft. long, with a beam of 83 ft. They each carried twelve 12-in. guns, twenty-two 4.7-in. guns, and a number of smaller guns. Their main armour was 9 in. in thickness. The Minas Geraes was the first vessel with which it was ever

* Paper read at the joint meeting of the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, and the North-East Coast Institution of Engineers and Shipbuilders, at Newcastle-on-Tyne, July 8, 1914.

attempted to test the effect of firing the whole of the broadside armament simultaneously, and, as is now well known, this operation was carried out most successfully, and without any but the most minor damages to a few unimportant fittings of the vessel.

Included in the Brazilian programme covering the two vessels of which I have just spoken, were two scouts, the Bahia and Rio Grande Do Sul, each of 3100 tons displacement, designed and built at Elswick. They each carried ten 4·7-in. guns as main armament, and with 22,000 horse-power they attained a speed of 27½ knots.

These vessels were followed by a couple of armour-clad gunboats, of 1000 tons each, for the Argentine Navy, the battleship Superb for the British Navy, and the cruisers Newcastle and Weymouth, also for the British Navy. The Newcastle was, I believe, the first war vessel of her size to take the water with her main machinery and boilers on board and funnels erected.

The next important vessel we had the honour of building was the Monarch, for our own Navy. The period allowed for her completion and delivery was two years, and notwithstanding, as I have already stated, a strike of 16 weeks' duration, she was handed over within the contract period, which may be regarded as a very fine performance, and was, in a great measure, due to the energy displayed by Mr. G. J. Carter, who was then my colleague at Elswick, and who had charge of the building of the ship.

Another interesting vessel which we recently completed and delivered to the Chinese Government was the Chao Ho, a training cruiser of 2750 tons, specially designed and constructed to afford the fullest possible instruction in naval seamanship and gunnery. She had a length of 330 ft., a beam of 42 ft., and carried quite a museum of guns, including two 6-in., four 4-in., two 3-in., six 3-pounders, and two machine-guns. Her machinery was of the Parsons compound marine steam-turbine type, and on the official speed trials she achieved remarkable results, which might prove valuable for future guidance in designing vessels of her class.

The speed trials were commenced on January 23, 1912, when a series of progressive runs were taken on the Hartley mile. The morning being somewhat hazy, it was necessary to run closer to the shore than desirable, with the result that the effects of the shallow water soon manifested themselves. Comparison with results obtained at a later date in deep water showed that reduction in speed due to insufficient depth of water began at about 17 knots, and, increasing rapidly, amounted to about half-a-knot when a speed of 20 knots was attained. Later in the day, when high-power runs were taken, the haze had lifted, and the vessel was run as far from the shore as possible without rendering the measured-mile post invisible to the naked eye. The increased depth of water thus obtained had a marked effect upon the speed, but even at this distance from the shore the speed in the neighbourhood of 22 knots was one-fifth of a knot less than that subsequently obtained in deep water with the same power. These trials provided another example of the unsuitability of our Hartley measured mile for high-speed vessels.

On January 30, 1912, a twelve hours' trial at four-fifths full power was carried out, in the course of which six runs were taken upon the deep-water mile at St. Abb's Head. The mean speed during the six runs was 20.75 knots, the turbine revolutions per minute being 492, and the shaft horse-power 5366. Over the whole of the twelve hours the mean speed was 20.7 knots, the corresponding revolutions being 491 and the shaft horse-power, 5394. The mean coal consumption during this trial was 1.71 lb. per shaft horse-power per hour.

The full-speed trial was taken on February 15, 1912, and was of four hours' duration. During six runs upon the St. Abb's mile, a mean speed of 22.257 knots was obtained, the revolutions per minute being 558.75 and the shaft horse-power, 8797. The results for the four hours' trial were: mean speed, 22.123 knots; revolutions, 555.4; shaft horse-power, 8626; mean coal, per shaft horse-power per hour, 1.51 lb. The displacement upon the runs was 2424 tons. At a speed of 20 knots (the speed at which the vessel was designed to run), the shaft horse-power recorded was 4500, and the revolutions per minute, 468.

The form of the vessel was based on that of a model which gave exceedingly fine results in some experiments made at the Admiralty tank at Torquay when I was an assistant in the works, and I make out that the propulsive coefficient at top speed, the effective horse-power being based upon the resistance of the naked model, is 55 per cent., whilst at 20 knots the value is 56½ per cent.

This latter figure is the highest we have yet reached with turbine-driven vessels, and has been but rarely attained in vessels fitted with reciprocating engines running at a much smaller number of revolutions per minute.

At the present time we are building the battleship Sultan Osman I. (ex Rio de Janeiro) for the Imperial Ottoman Government. This vessel is 632 ft. long, with a beam of 89 ft. and a displacement of 27,500 tons. She will carry fourteen 12-in. guns, twenty 6-in. guns, and a number of small guns. Her main armour belt is 9 in. and the upper belt 6 in. She has various armoured decks and extensive magazine protection. She is designed for a speed of 22 knots, and will shortly go on trial.*

We are also at present engaged in the construction of two battleships of 28,000 tons each, for the Chilian Navy. These vessels are 625 ft. long with a beam of 92 ft. They have ten 14-in. guns, sixteen 6-in. guns and smaller guns. Their armour is of 9 in. and 7 in. in thickness. We have also in hand two coast-defence battleships for the Norwegian Navy, and an armoured river gunboat from our own design for the Siamese Government, an order which I am glad to have received in competition with other builders, by way of introduction to the Siamese naval authorities. These vessels and a number of submarines are in course of construction at our Elswick Shipyard. At our new Armstrong yard we have commenced the building of the Dreadnought Malaya; and an armourclad of over 30,000 tons for a foreign navy.

The new Armstrong yard has already been described through various channels,* and I will not weary you with a detailed description of this huge establishment, but merely content myself by stating that it contains nine building-berths, the largest of which will take any class of vessel up to 1000 ft. in length and almost any beam. The smallest berth will take a vessel up to 500 ft. in length. Three of these berths have been specially constructed and strengthened by ferro-concrete piling and foundations for the building of the largest and heaviest war or mercantile vessels yet contemplated. There is a river frontage nearly a mile in length. The yard is, or, rather, will be, equipped with all the latest and most improved machinery, and has been brought as thoroughly up-to-date as money and mechanical appliances will allow. Provided the supply of labour and material were available, we could undertake to construct simultaneously at the Armstrong Yard over 200,000 tons of shipbuilding work.

The following table shows at a glance how battleships have increased in size, weight, and power since the days of the Victoria—28 years ago:—

——	Length.	Breadth.	Displacement.	Main Armament.
	ft.	ft. in.		
Victoria (1886) ..	340	70 0	10,810	2 16½-in., 1 10-in., 12 6-in., 8 T.T.
Yashima	372	73 6	12,330	4 12-in., 10 6-in., 5 T.T.
Hatsuse	440	76 6	14,967	4 12-in., 14 6-in., 4 T.T.
Superb	490	82 5¼	18,668	10 12-in., 16 4-in., 3 T.T.
Minas Geraes ..	500	83 0	19,281	12 12-in., 22 4.7 in.
Sultan Osman I. (now H.M.S. Agincourt)	632	89 0	27,500	14 12-in., 20 6-in., 10 3-in., 3 T.T.
Almirante Latorre	625	92 0	28,000	10 14-in., 16 6-in., 4 3-in., 4 T.T.
Battleship (1914)	620	94 0	30,500	8 15-in., 14 6-in., 10 4-in., 2 T.T.

The last-named vessel will have 13½-in. armour on the main belt, barbettes, and gun shields.

Since 1884 we have constructed, or have in hand, from our own designs, 64 warships, 59 being on foreign account, whilst five were built for or acquired by our own Government. These 64 vessels included 15 battleships, 33 cruisers, five torpedo-boat destroyers, three armoured gunboats, six scouts, and two training-ships. The Turkish Royal yacht and State barge were also designed and constructed at Elswick. Their total displacement amounts to 365,463 tons, and the total horse-power of the machinery fitted in them to 756,706. Added to the remainder of our warship output, these figures become respectively 619,979 tons and 1,221,687 horse-power.

In the foregoing I have attempted to convey to you some idea of the warship-building work carried out by the Elswick firm. I have not specially mentioned all of the vessels constructed by the firm, but only some of the more interesting, with a view of illustrating the developments that have taken place in warship design and construction, especially during the past twenty years; and at the same time I have endeavoured to indicate the tremendous advance that has been brought about during that period in the rate of production. You will have noted from the figures I have quoted the gradual increase in dimensions, weight, fighting power, and speed of the various classes of vessels.

When the Elswick Shipyard began, 30 years ago, orders for warships were not booked in great numbers by private firms; nevertheless, our firm has never been without an order for one or more vessels of one class or another during that period. Indeed, on one or two occasions our resources have been rather severely taxed, as, for instance, in 1896, when we had in various stages of completion no fewer than 20 warships of different classes, 15 being under construction at Elswick, and 5 at Walker. This list included a 12,300-ton battleship, two first-class armoured cruisers, each of 9700 tons, one armoured cruiser 8500 tons, one armoured cruiser, 7000 tons, two coast-defence armour clads, each of 3400 tons, eleven second and third-class cruisers, and two torpedo-boat destroyers. The aggregate displacement of these vessels amounted to 98,000 tons, and six of them were launched from Elswick during the year mentioned—namely, one first-class battleship, one first class armoured cruiser, and four second-class cruisers. At the present moment, as I have already indicated, we have in hand ten war-vessels of a total displacement of 158,670 tons, comprising five dreadnoughts, two coast-defence armourclads, two scouts, and one armoured gunboat. In addition to these we are constructing a number of submarines.

We have also extensive interests in a huge programme of warship building which is being carried out at Ferrol and Cartagena for the Spanish Navy, and in the Turkish war-vessels under construction at Barrow, as well as in the reorganisation of the Ottoman arsenals and dockyards in Turkey.

During the period under review we have broken old and established new records, and the acquisition of the Armstrong Yard at Walker places the firm in a position that will enable it to achieve still more in that direction; whilst the fact that so much has been accomplished by one firm on this little River Tyne must afford considerable satisfaction to all concerned or interested in the welfare and progress of our local shipbuilding industry.

The attached statement furnishes a summary of the firm's total warship output, and I need say no more to demonstrate the extent of our past and present undertakings as designers and builders of war vessels and manufacturers of armour and armaments. I will, therefore, conclude by thanking you for the kind attention you have accorded me, and by expressing the hope that the facts and figures I have quoted may not be without interest to the present assembly.

Summary of the Firm's Warship Output.

Flag.	Number of Ships.	Displacement.	Horse-Power.
		tons.	
Argentine	5	13,619	48,537
Austria	2	3,082	11,880
British	46	203,283	444,521
Brazilian	11	84,610	141,893
Chilian	10	59,670	158,479
Chinese	22	25,765	67,193
Dutch	2	340	220
Italian	5	8,969	26,982
Japanese	13	100,587	169,244
Norwegian	6	24,554	26,000
Portuguese	1	4,253	12,500
Roumanian	1	1,331	4,714
Russia	8	(say) 14,000	7,270
Siam	1	1,070	850
Spanish	2	2,108	5,254
Turkish	5	39,301	89,000
United States	1	3,437	7,150
Grand totals ..	141	619,979	1,221,687

HIGH-SPEED BEARINGS.*

By GERALD STONEY, F.R.S.

THERE are three principal types of friction in all bearings:—

1. Contact friction, where both surfaces are dry, and this type was investigated as early as 1781 by Coulomb, who found for pressures from ¾ lb. to 100 lb. per sq. in., and speeds up to 10 ft. per second, that the friction was independent of the pressure per square inch and the velocity, but was proportional to the total force pressing the surfaces together, and was dependent also on the nature and material of the surfaces.

2. Greasy friction, where there is more or less complete lubrication and a more or less complete film of oil between the surfaces. This has been investigated by many experimenters, but concordant results have not been obtained, as so much depends on the degree of lubrication. Generally speaking, however, friction of this kind is proportional to the load, and is independent of the speed—*i.e.*, the coefficient of friction is constant.

3. Complete lubrication where there is a complete oil film between the surfaces and there is no metallic contact. This usually occurs in high-speed journal-bearings where bath or forced lubrication in some form is provided. Many experimenters have investigated this form of friction, including Towers (Proceedings of the Institution of Mechanical Engineers, 1883, 1885, 1888); Goodman (Manchester Association of Engineers, 1890); O. Lasche, of Berlin (*Traction and Transmission*, vol. vi., No. 22, January, 1903). Tests have also been made by Thurston, 1873 (ENGINEERING, vol. xvi., page 92); Woodbury, 1884 (ENGINEERING, vol. xxxviii., page 532); Wellington (Transactions of the American Society of Civil Engineers, 1884); Kimball (American Journal of Science, 1878); Stribeck, Westinghouse (Journal of the American Society of Naval Engineers, November, 1912); and many others.

The theory of complete lubrication may be said to have originated in 1884 at the British Association meeting at Montreal.

In Lord Rayleigh's address (page 13 of British Association Report, 1884), he mentions Towers' experiments, and shows that the incoming layer of oil is thicker than the outgoing. He mentions, moreover, that some additional elucidation of the phenomena might be expected from Professor Stokes, afterwards Sir George Stokes, but there is no further record of this in the British Association Report. There was also a paper read by Professor Osborne Reynolds before Section A "On the action of Lubricants," but no more than the title of this is given.

Lord Rayleigh pointed out the value of Towers' experiments with complete lubrication, and how they upset ideas previously widely admitted, and that the results showed the friction to be nearly independent of the load and much smaller than generally supposed, giving a value of μ as low as $\frac{1}{1000}$. He also directed attention to the fact that the weight on the bearing was really borne by the oil film, which was thicker at the ingoing than at the outgoing edge, and that the oil must have a certain viscosity proportional to the pressure.

It is evident that both Lord Rayleigh and Professor Stokes saw that the problem could be attacked mathematically, but until Professor Reynolds in 1886 (*Philosophical Transactions*, 1886) effected the integrations in certain cases nothing further was done. Even the integrations then effected are in most cases approximate only. Professor Reynolds, in fact, worked out two cases, first that of a flat surface (of finite length in the direction of motion, but of infinite length at right angles to it), moving over another flat surface; and, secondly, the case of a shaft running in a bearing of infinite length. The bearing assumed in his calculations was semicircular and of slightly larger radius than the shaft. He showed that the theory thus established gave results in very close agreement with Towers' experiments. A further exten-

* See page 155 *ante*. This vessel has just been purchased by the British Admiralty, and is re-named the Agincourt.

* See page 1 *ante*.

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders.

HIGH-SPEED BEARINGS.

Fig. 1.

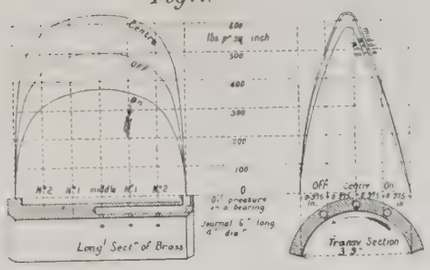
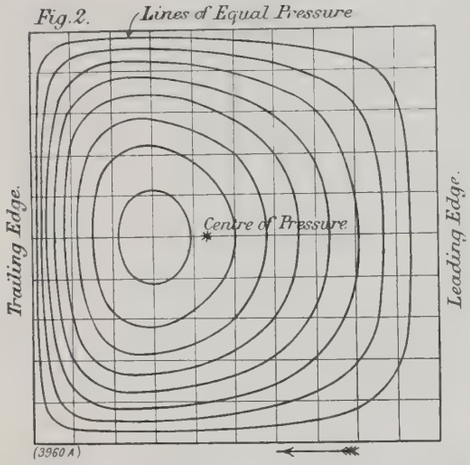


Fig. 2. Lines of Equal Pressure



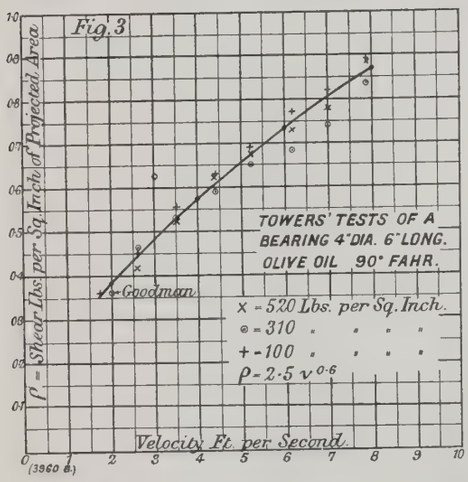
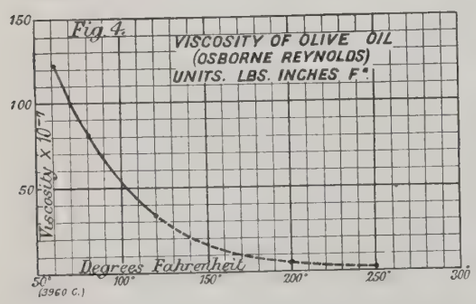


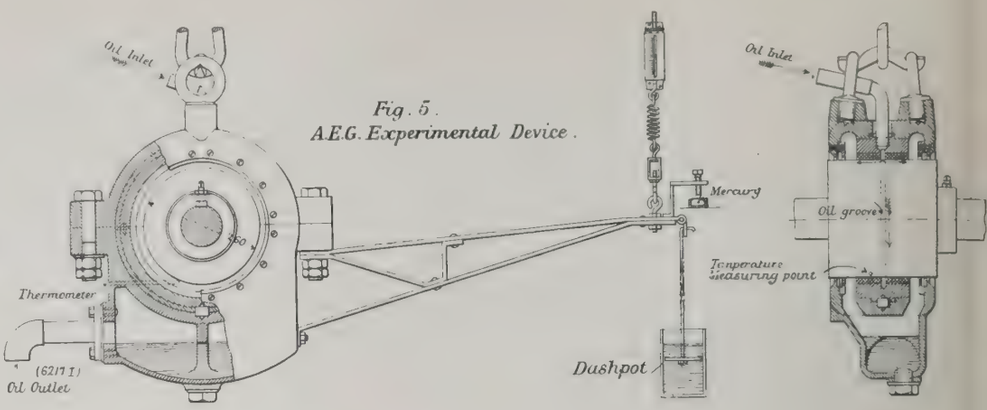
Fig. 3
F = Shear Lbs. per Sq. Inch of Projected Area.
TOWERS' TESTS OF A BEARING 4" DIA. 6" LONG.
OLIVE OIL 90° FAHR.
Dr. Goodman
× = 520 Lbs. per Sq. Inch.
⊙ = 310 " " " "
+ = 100 " " " "
P = 2·5 v 0·6
Velocity Ft. per Second.
(3960 B)



sion was made by Sommerfield (*Zeitschrift für Mathematisch und Physic*, Band 50), and Michell (*Ibid.*, Band 52). The latter worked out the distribution of pressure, the coefficient of friction, and the angle of the surfaces for the cases of a square plane, a plane with the length three times the width, a plane of infinite length, and a plane of infinite width, and it was on this investigation that he based his well-known pivoted thrust-bearing. The case usually occurring in practice of a journal of finite length bearing on only, say, one-third of the completed circumference has not, so far as can be traced, had the necessary integrations made, and so we have to fall back on experimental results.

Towers experimented with a bearing 4 in. in diameter and 6 in. long, the brass embracing the full half circle, and being accurately scraped to an easy fit to the shaft. The brass was on top, and the shaft dipped into an oil-bath so as to ensure complete lubrication. He found that the oil-film was under very considerable pressure, and that the distribution of pressure was as shown in

Fig. 5.
A.E.G. Experimental Device.



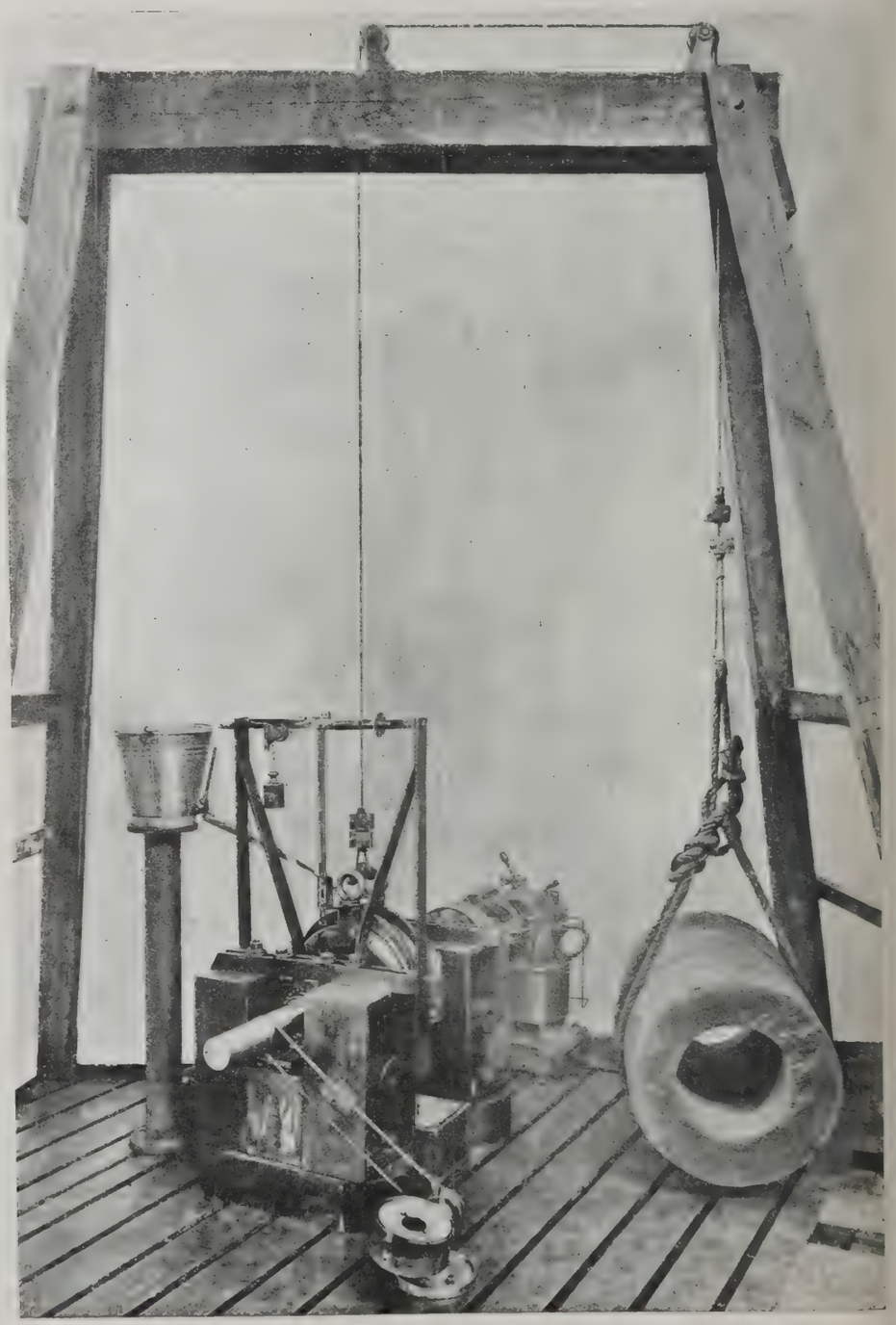


Fig. 6. Lasche's Apparatus for Experiments on High-Speed Bearings.

Figs. 1 and 2, with a nominal load of 333 lb. per sq. in. The general result was that with olive oil at 90 deg. Fahr. the friction was nearly independent of the pressure, and increased approximately as the velocity $V^{0.6}$.

Fig. 3 shows the average of his results, V being in feet per second, ρ being the shear resistance per square inch taken on the projected area of 24 sq. in. In the range of his experiments, with pressures from 100 lb. to 500 lb. per sq. in. of projected area, there was little change in the value of ρ.

Fig. 4 shows the relative viscosity of the oil at various temperatures, from Osborne Reynolds's experiments. The dotted part is extrapolated by his formula.

Goodman (Manchester Association of Engineers, 1899) experimented with a bearing 2 in. in diameter and 4 in. long, running at 233 revolutions per minute, equivalent to a surface speed of 2.04 ft. per second, with an oil-bath maintained at a temperature of 40 deg. Cent., and found little difference with loads varying from 50 lb. to 550 lb. He also found that the total friction was proportional to the arc of content, which he varied from the full width of 2 in. down to $\frac{1}{2}$ in., the shear resistance being constant at 0.36 lb. per sq. in. taken on the chord of the arc of contact. This reduction of the arc of contact has been used in railway journals to reduce the friction.

The chief published experiments on high-speed bearings are those of O. Lasche (*Traction and Transmission*, vol. vi., No. 22, 1903), and the author may be excused quoting fully from them, as the number of *Traction and Transmission* in which they are published is completely out of print, and it is only by the courtesy of ENGINEERING that a copy has been obtained. They have also been kind enough to lend the blocks for illustrating this paper. The results are given on the metric system, and as the English system of units is used throughout this paper, an apology is due for the admixture of the two systems.

The experimental apparatus is shown in Figs. 5, 6, and 7, and the following bearings were tested :—

No. 1 bearing, 26 cm. in diameter, 11 cm. long, 230 sq. cm. projected area of bearing surface. Usually pressures are calculated on the full projected area of 26×11 cm. = 286 sq. cm., and if this is done Lasche's pressures will have to be reduced by about 20 per cent.

No. 2 bearing, 11 cm. in diameter, 24 cm. long.

The following journals were used :—

1. Nickel steel, 26 cm. in diameter, 11 cm. long, in bearings of gun-metal.
2. In bearings of white metal.
3. In bearings of mercury amalgam.
4. Mild-steel journal of same size in a white-metal bush.
5. Carbon-steel journal, 11 cm. in diameter, 24 cm. long, in white metal.

The lubricants used were :—Imperial oil No. 0 (Russian), rape seed oil, and sperm oil, and during the whole of the experiments oil at the rate of 0.8 litre = 1.4 pints per minute was run through the bearings.

The bearing temperature (t) was always taken at the lowest point about one-third of the way along the bearing.

Figs. 8 to 17 show the relations between pressure (p) kgs. per sq. cm. ; temperature (t) Centigrade; velocity (v) metres per second ; coefficient of friction (μ); the limits of the tests being : p, 1 to 15 kg. per sq. cm. ; t, 25 deg. to 100 deg. Cent. ; v, 1 to 20 metres per second.

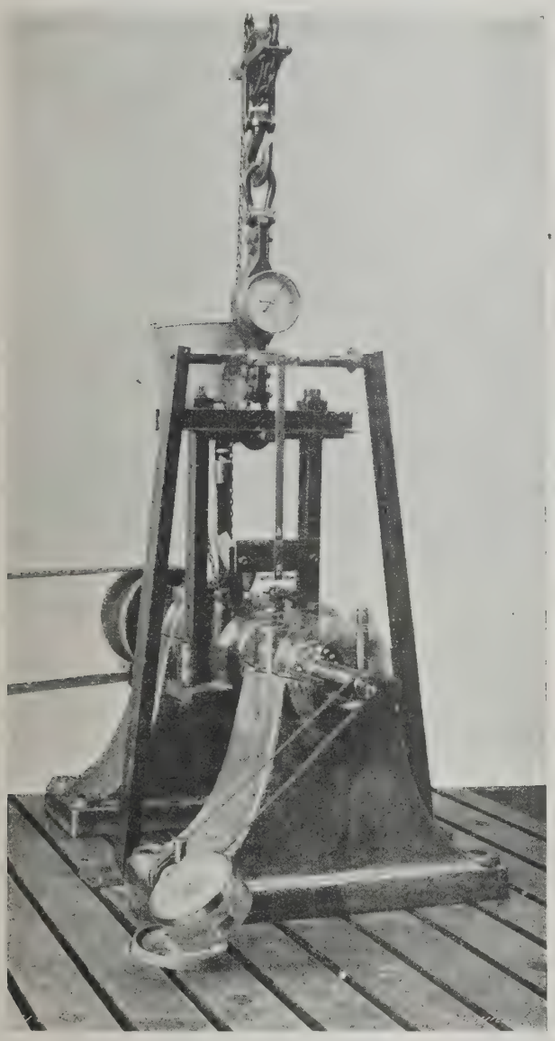


FIG. 7. LASCHE'S APPARATUS FOR EXPERIMENTS ON HIGH-SPEED BEARINGS.

It is seen from Fig. 11 that the shear $\rho = p\mu$ is practically constant and independent of p, and for 50 deg. Cent., or 122 deg. Fahr., $\rho = 0.04$ kg. per sq. cm., or 0.57 lb. per sq. in. This is equal to 0.46 lb. per sq. in. on the projected area. From Figs. 14 and 15 it is evident that the material of the journals and bearings makes little difference, as would naturally be expected when the journal is entirely supported by an oil film. In practice, for small shafts, gun-metal is generally used for the bearings, but for large bearings white metal is better on account of the danger of gun-metal seizing and damaging the shaft. From Fig. 17 it will be seen that at the higher temperatures all the oils used seemed to yield about the same results, and Fig. 13 shows that the friction is roughly inversely proportional to the temperature reckoned from freezing-point. Figs. 9 and 11 show that ρ increases up to a velocity of 10 to 15 metres per second, and is then nearly constant.

The general result of the experiments is that approximately up to $v = 2.5$ metres per second the friction varies as $\sqrt{V}$, from 2.4 to 4 metres per second and as about $v^{\frac{1}{5}}$, and above 10 metres per second is nearly constant. It is unfortunate that the clearance used in these bearings does not seem to be given, but Fig. 18 shows the effect of clearance given by putting a liner between the two halves of a bearing 26 cm. in diameter and 11 cm. long, and a common clearance in turbine bearings is about $\frac{1}{1000}$th of the diameter for bearings up to about 6 in. or 8 in. in diameter, and rather less above that. These tests show that so far as friction is concerned it is not well to use a large shaft and a long bearing, but experience shows that for high speeds and heavy loads long bearings are necessary, and they have also to be large to avoid vibration and critical speeds, and also the risk of fracture due to vibration. To avoid this latter danger the bending stresses have to be kept to a figure which would be considered very low in ordinary practice, as there have been several cases of fracture of shaft ends. If the pressure is too high, or the oil is too thin, a bearing may run all right so long as there is no vibration; but if vibration occurs, the oil film may be driven out and seizing take place. This is especially liable to happen with the shafts of electrical machinery, such as the armatures of dynamos and rotors of alternators, where there is always a liability to vibration due to their going out of balance, and it is probable that much lower pressures are advisable in such cases than in those of turbine rotors, which from their construction are not, as a rule, so liable to go out of balance. This effect is reduced in very high-speed shafts, above, say, 2000 revolutions per minute, by the use of the well-known Parsons flexible bearing, where there are two or more tubes outside the bearing-bush with a small clearance between them in which the viscosity of the oil tends to damp out vibrations. In turbine work a rule much used for deciding the size of bearings has been that the product of the speed by the pressure should not exceed a certain figure, but it is doubtful whether this rule is of much value, as it really assumes greasy friction and not perfect

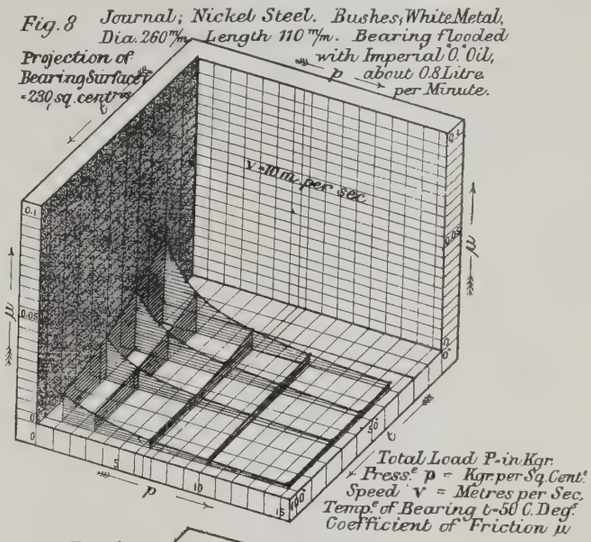
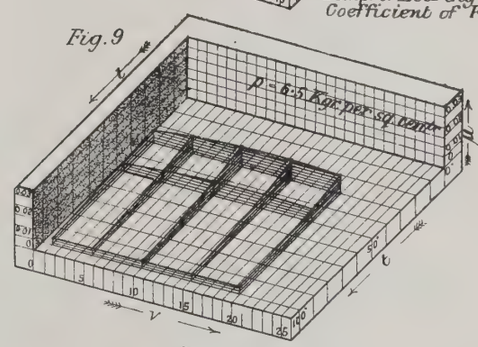
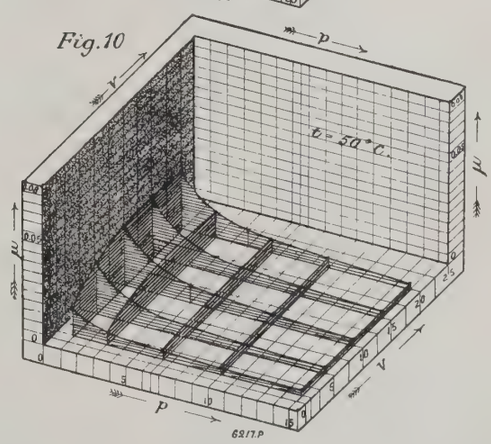


Fig. 8 Journal, Nickel Steel. Bushes, White Metal.
Dia. 260 m/m. Length 110 m/m. Bearing flooded with Imperial 0. Oil.
Projection of Bearing Surface = 230 sq. cent.
p about 0.8 Litre per Minute.
V = 10 m. per sec.
Total Load P in Kgr.
Press.e p = Kgr. per Sq. Cent.
Speed V = Metres per Sec.
Temp.e of Bearing t-50 C. Deg.
Coefficient of Friction μ





lubrication. In land work a product of 5600 has rarely been exceeded, or 75 lb. per sq. in. at 75 ft. per second. At lower speeds higher pressures are used satisfactorily, as, for example, at about 35 ft. per second a pressure of 130 lb. to 150 lb. per sq. in. is admissible.

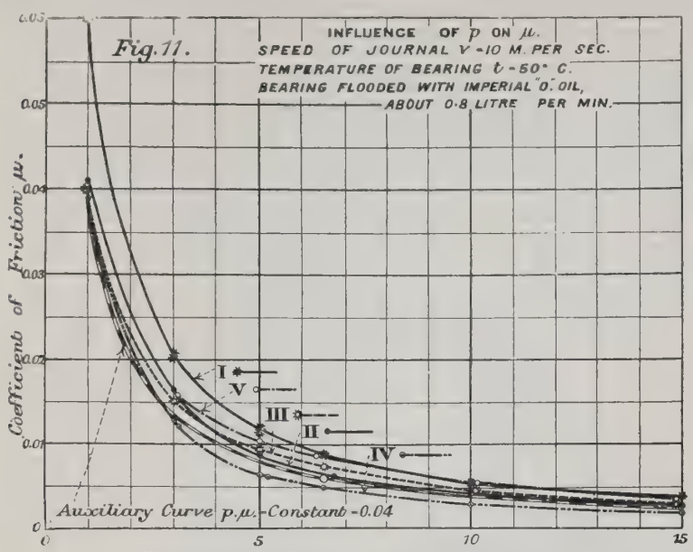


Fig. 11.
INFLUENCE OF p ON μ.
SPEED OF JOURNAL V = 10 M. PER SEC.
TEMPERATURE OF BEARING t = 50° C.
BEARING FLOODED WITH IMPERIAL O. OIL,
ABOUT 0·8 LITRE PER MIN.
Coefficient of Friction μ.
Auxiliary Curve p.μ. = Constant = 0.04
I
V
III
II
IV
Pressure p in Kgr. per Sq. Centimetre.

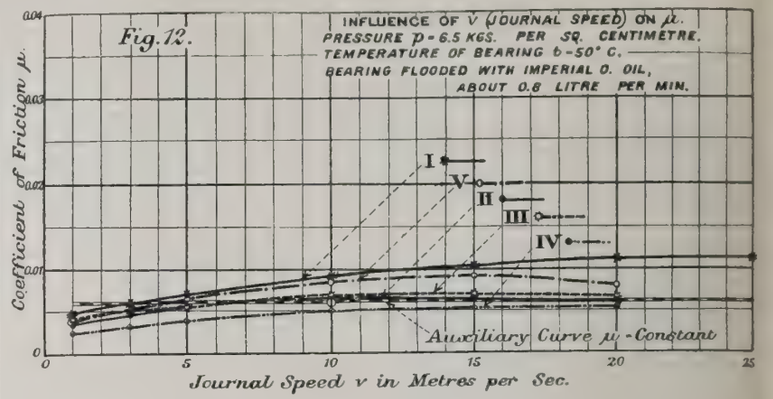


Fig. 12.
INFLUENCE OF V (JOURNAL SPEED) ON μ.
PRESSURE p = 6.5 KGS. PER SQ. CENTIMETRE.
TEMPERATURE OF BEARING t = 50° C.
BEARING FLOODED WITH IMPERIAL O. OIL,
ABOUT 0.8 LITRE PER MIN.
Coefficient of Friction μ.
I
V
II
III
IV
Auxiliary Curve μ = Constant
Journal Speed v in Metres per Sec.

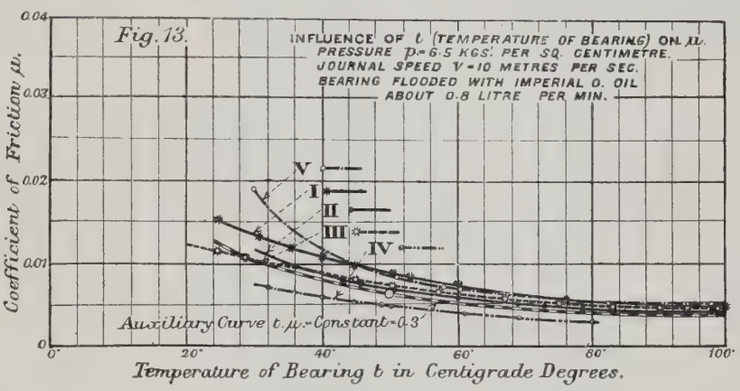
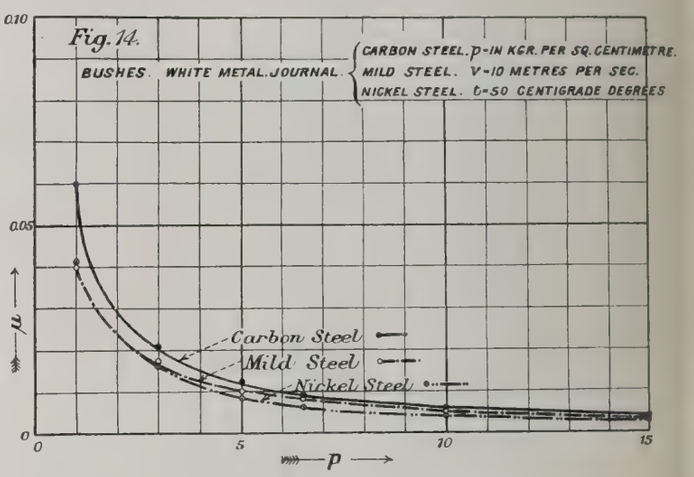
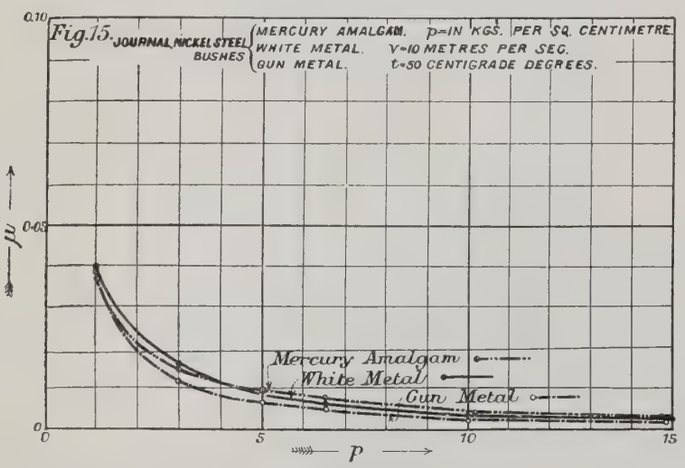


Fig. 13.
INFLUENCE OF t (TEMPERATURE OF BEARING) ON μ.
PRESSURE p = 6·5 KGS. PER SQ. CENTIMETRE.
JOURNAL SPEED V = 10 METRES PER SEC.
BEARING FLOODED WITH IMPERIAL O. OIL
ABOUT 0·8 LITRE PER MIN.
Coefficient of Friction μ.
V
I
II
III
IV
Auxiliary Curve t.μ. = Constant = 0.3
Temperature of Bearing t in Centigrade Degrees.





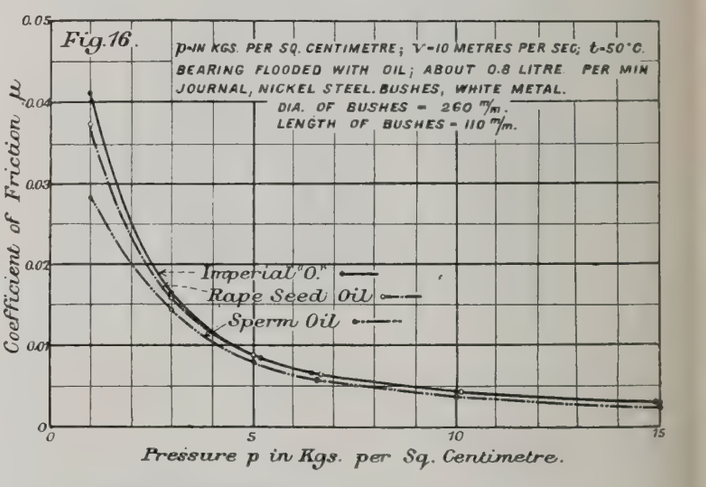
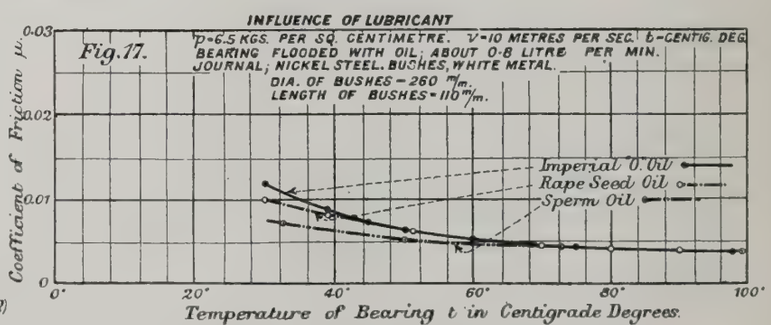


Fig. 16.
p = IN KGS. PER SQ. CENTIMETRE; V = 10 METRES PER SEC; t = 50° C.
BEARING FLOODED WITH OIL; ABOUT 0.8 LITRE PER MIN
JOURNAL, NICKEL STEEL. BUSHES, WHITE METAL.
DIA. OF BUSHES = 260 m/m.
LENGTH OF BUSHES = 110 m/m.
Coefficient of Friction μ
Imperial "O."
Rape Seed Oil
Sperm Oil
Pressure p in Kgs. per Sq. Centimetre.

In a discussion on Professor Christie's paper before the American Society of Mechanical Engineers in 1912, Hodgkinson stated that speeds of 80 ft. per second and 100 lb. per sq. in. were commonly employed in America, and where there is no risk of heavy vibration there does not seem any reason why higher pressures should not be used. It has to be remembered that the heat to be carried off does not increase with the pressure, and that the real danger lies in the possible breaking down of the oil film by excessive pressure or vibration.

In marine turbines the journal speeds are much lower than on land, and rarely exceed 30 ft. per second, and the pressures are usually 80 lb. to 100 lb. per sq. in.; but there is a strong tendency to increase this latter figure, and it is probable that pressures of 150 lb., or even possibly 200 lb. per sq. in., could be used, especially if the oil temperature does not exceed 100 deg. to 110 deg. Fahr., as is usual in marine work. The temperature of the oil is limited by its loss of viscosity at high temperature (see Fig. 4), and by its liability to carbonise and oxidise, and thus cause deposit in the pipes, oilways, &c. In land practice temperatures of 120 deg. to 140 deg. Fahr. are common, but it is not well to go above 150 deg. or 160 deg. Fahr., as most oils seem liable to oxidise and cause deposit above this temperature. At about 250 deg. Fahr. most oils cease to lubricate, as their viscosity becomes too low.

From Lasche's Fig. 13 it is seen that the friction is approximately inversely proportional to the temperature measured from freezing-point; but after a certain temperature the friction rapidly increases and seizing takes place, due to the loss of viscosity. In all high-speed bearings artificial means have to be used to carry off the heat, radiation from the bearings not being sufficient. The general plan is to have such a flow of oil through the bearing as to cause the heat generated to be carried away without an undue rise of temperature. Water-jacketing the bearings has been used in some cases, but it is not as satisfactory in general as the plan of supplying sufficient oil to carry off the heat. Oil-coolers have therefore generally to be provided to cool the oil. In some cases also the oil is circulated round the outside of the bearing in suitable passages so as to assist in cooling it, and this is probably necessary in the case of very large bearings running at high surface speeds. The heat to be removed is not only that caused by friction, but also that caused


INFLUENCE OF LUBRICANT
Fig. 17.
p = 6.5 KGS. PER SQ. CENTIMETRE. V = 10 METRES PER SEC. t = CENTIG. DEG.
BEARING FLOODED WITH OIL; ABOUT 0·8 LITRE PER MIN.
JOURNAL; NICKEL STEEL. BUSHES, WHITE METAL.
DIA. OF BUSHES = 260 m/m.
LENGTH OF BUSHES = 110 m/m.
Coefficient of Friction μ.
Imperial "O" Oil
Rape Seed Oil
Sperm Oil
(6217.9)
Temperature of Bearing t in Centigrade Degrees.

by conduction from the steam; on the other hand, the bearings near the condenser are cooled by the exhaust steam and heated by the gland steam. From Lasche's tests the heat produced in bearings running at a temperature of about 122 deg. Fahr. is that due to a shear of the oil-film of about 0.46 lb. per sq. in. of the projected area, and this gives as the B.T.U. per hour:—

marine work, and an oil temperature of about 100 deg. Fahr.

It may be taken that this is approximately the heat that has to be carried off by the oil. Taking the specific heat of oil to be 0.31, and allowing a rise of 10 deg. Fahr. in the oil, we require 20 lb., or about one-third of a cubic foot, of oil per hour per square inch of projected bearing

the results were found to be very variable, and in general he says that the tests show ring lubrication to be very uncertain, and that it should not be used in cases where external cooling of the oil is necessary. Figs. 19 to 21 show the apparatus and some tests made on a 9-cm. diameter bearing, and it is seen that much more oil came out of one side than at the other.

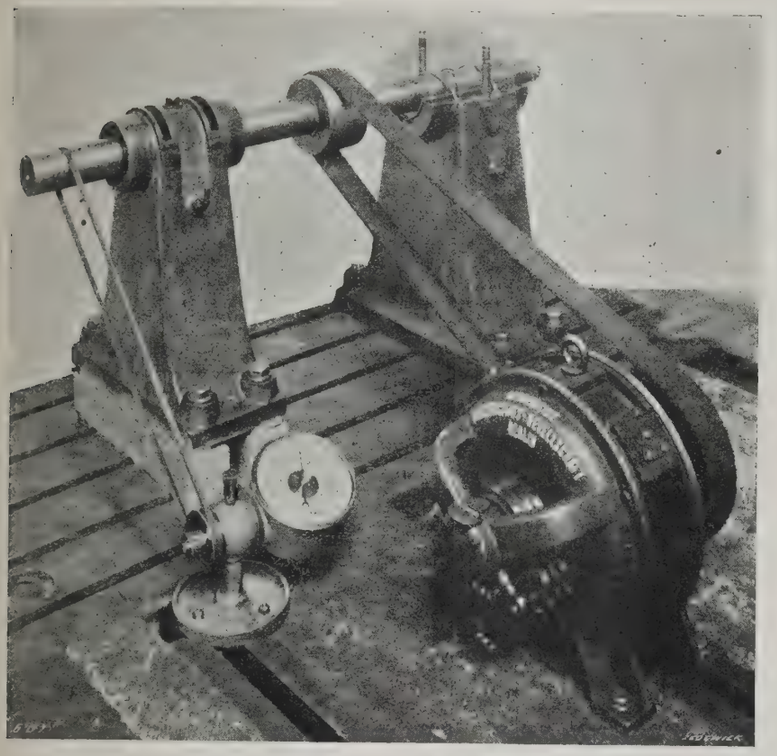


FIG. 19. LASCHE'S APPARATUS FOR TESTS OF HIGH-SPEED BEARINGS.

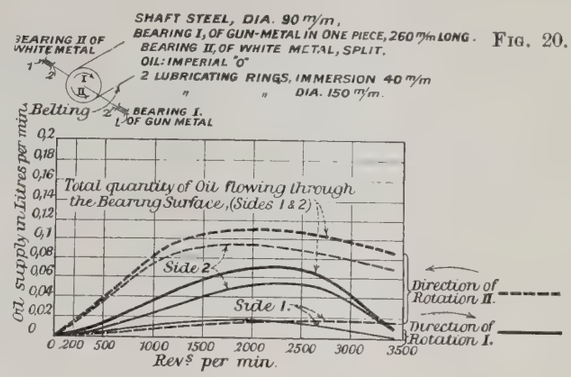

SHAFT STEEL, DIA. 90 m/m,
BEARING I, OF GUN-METAL IN ONE PIECE, 260 m/m LONG.
BEARING II, OF WHITE METAL, SPLIT.
OIL: IMPERIAL "O"
2 LUBRICATING RINGS, IMMERSION 40 m/m
" " DIA. 150 m/m.
BEARING II OF WHITE METAL
BEARING I. OF GUN METAL
Belting
Oil supply in Litres per min.
Total quantity of Oil flowing through the Bearing Surface, (Sides 1 & 2)
Side 2.
Side 1.
Direction of Rotation II.
Direction of Rotation I.
Revs per min.

FIG. 20.

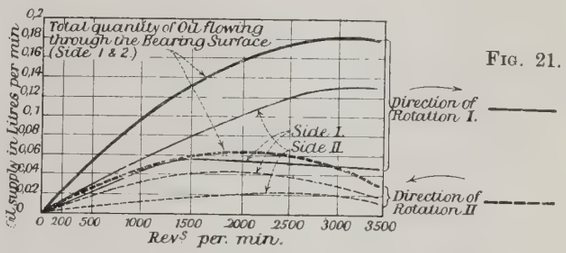
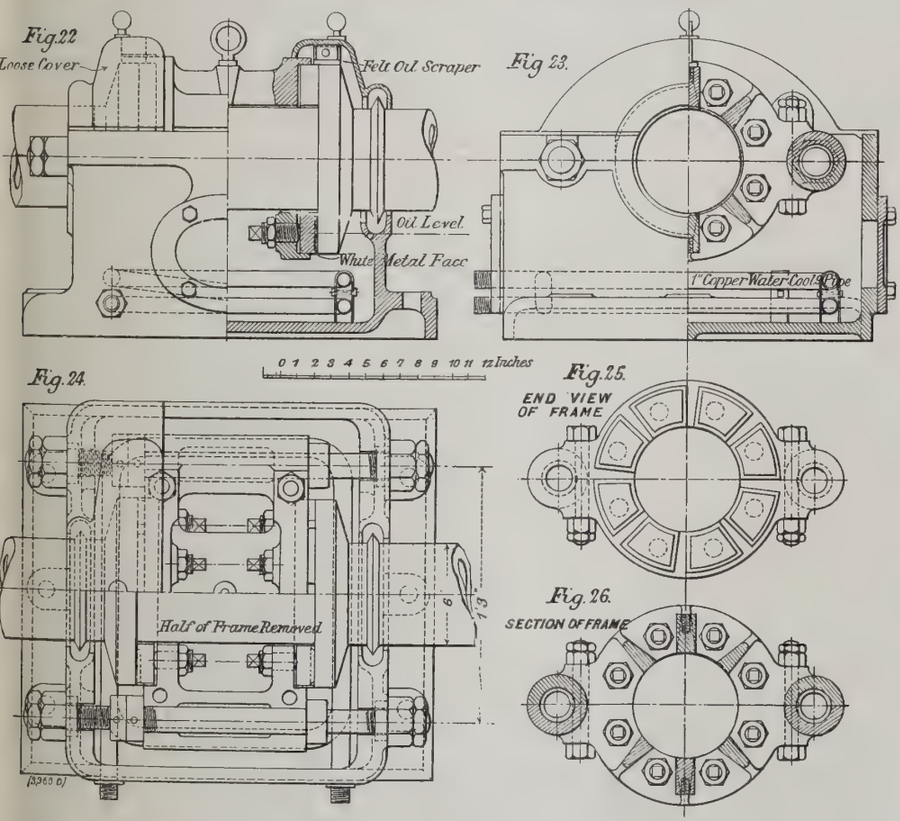

Oil supply in Litres per min.
Total quantity of Oil flowing through the Bearing Surface, (Side 1 & 2)
Side I.
Side II.
Direction of Rotation I.
Direction of Rotation II
Revs per min.

FIG. 21.

Influence of Clearances between Bearing & Shaft.
Journal; Nickel Steel. Bushes; White Metal.
Dia. 260 m/m. Length 110 m/m
Bearing Flooded with Sperm Oil, about 0.8 Litre per Min. Projection of Bearing Surface f = 230 Sq. Centimetres.



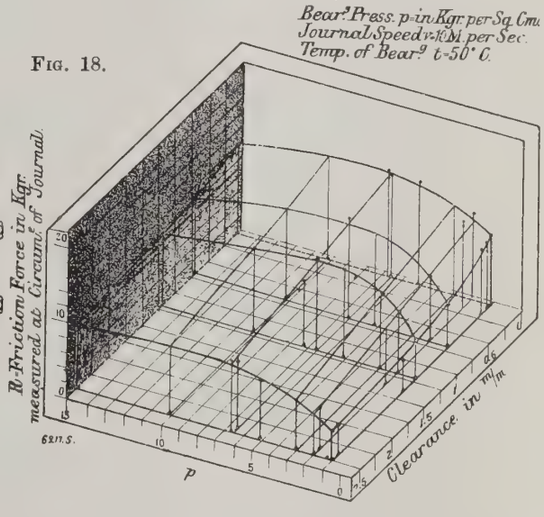

Bear.s Press. p in Kgr. per Sq. Cm.
Journal Speed v K.M. per Sec.
Temp. of Bear.s t-50° C.
R Friction Force in Kgr. measured at Circum.e of Journal.
Clearance in m/m
p

FIG. 18.

$$B.T.U. = 2.1\, d.l.v,$$

where d is diameter of bearing in inches,
l is length of bearing in inches,
v is surface velocity in feet per second.

The constant varies inversely as the temperature above freezing-point. A formula which has been often used in marine practice is: $B.T.U. = d.l.v.^{1\cdot38}$, which gives slightly greater results for the usual speeds in surface when the surface speed is 30 ft. per second, and 40 lb., or two-thirds of a cubic foot, of oil per hour with a surface speed of 60 ft. per second. In practice these quantities are often increased by from 30 to 50 per cent., to allow of the unequal distribution of oil between the bearings, and to ensure that there is no undue heating, also in some cases to allow for the flow of heat from the steam.

Ring lubrication was experimented on by Lasche, but

Thrust-bearings are generally of the usual collar type, with the bottom and top halves separately adjustable to take up end play; and in land turbines, which are practically balanced, the pressures are very low, never exceeding 20 lb. per sq. in., and even in marine turbines 50 lb. per sq. in. is never exceeded.

There are no tests available as to the friction of such bearings, but it is probable that it is fairly high, as perfect lubrication is difficult to attain, and, as an approximation, the total area—that is, the area of the top and bottom halves together—might be added to that of the main bearings in estimating the quantity of oil required and the surface of the oil-cooler. Such bearings have generally a high coefficient of friction, owing to the low pressures employed, since, as it is impossible for a wedging action to take place and thus admit the oil, such as has been described as occurring in the case of journal-bearings, the lubrication is rarely perfect. Towers found at moderate speeds that the pressure which could be safely carried was about 60 lb. per sq. in., as against 600 lb. in a journal-bearing, and that the shear resistance of the oil film was greater, being 1.5 lb. per sq. in., this giving about sixteen times the coefficient of friction for a thrust-bearing as for a journal one.

The theoretical consideration of the conditions necessary for perfect lubrication, as set out in Osborne Reynolds's Royal Society paper in 1886, referred to above, and also his own investigations, led Michell, in 1905, to

devise a thrust-bearing which would admit of perfect lubrication (see patents 875 of 1905, and 8885 of 1912). In this thrust-bearing there are segmental blocks pivoted at the theoretical centre of pressure, which is about 0.6 of the length from the leading edge. By this device perfect lubrication is attained, and pressures up to 1500 lb. per sq. in. can be safely carried at high velocities, with a consequent reduction of the coefficient of friction to about $\frac{1}{10}$th of what it is in an ordinary thrust-bearing. Another advantage is that the end play in the thrust-bearing can be greatly reduced.

The same idea has been further developed by Sir Charles Parsons, K.C.B., F.R.S., in patent 8266 of 1912, where the blocks are centrally pivoted, and it has been found that in cases where the pressure comes on gradually this works equally well in practice, and has the advantage that the shaft may run in either direction without the complication of shifting the point of support. These principles have also been applied to journal-bearings by Michell (patent 23,496 of 1911) and Sir Charles Parsons (patents 8266 of 1912, 29,810 of 1912, 953 of 1913, and 5619 of 1913), enabling greatly increased pressures to be used, with a resultant reduction of the coefficient of friction, and also a large reduction in the length of the bearings, and thus of the whole plant. The reduction of friction may in some cases reduce the consumption of steam between 1 per cent. and 2 per cent. in a turbine plant.

Ferranti (patent 5035 of 1910) has also worked on the same lines, as well as Kingsbury in America (American Patent 947,242 of 1910), and there are full details of the latter's thrust-bearing in the Journal of the American Society of Naval Engineers, November, 1912.

Figs. 22 to 26 show a thrust-bearing of the Michell type, designed by Mr. H. T. Newbigin for 23,000 lb. thrust at 550 to 570 revolutions per minute.

In the U.S.S. Neptune a single collar, 13½ in. in diameter, carries 45,000 lb. thrust at 72 ft. per second mean speed surface, or a pressure of 500 lb. per sq. in., and, in general, such turbine thrust-bearings are designed for about 500 lb per sq. in. at 60 ft. to 75 ft. per second. Much higher pressures can be safely carried, as is shown by some tests carried out by the Westinghouse Company, where pressures up to about 7000 lb per sq. in. at 54 ft. per second were carried without heating. The coefficient of friction of such a bearing may be from 0.0008 to 0.003, and for such a pressure as 500 lb. per sq. in. may be safely taken as about 0.002, or, say, one-tenth to one-fifteenth of that of an ordinary thrust-bearing.

The Westinghouse Company, of Pittsburg, made an interesting set of tests on such a thrust-bearing for a steam turbine, the pressure being varied by throttling the balancing-pipe to the dummy piston. The following are the particulars of this bearing:—

Outside diameter of collar	...	4⅜ in.
Inside diameter of collar	...	2⅜ ,,
Number of pivoted blocks	...	10
Total area of pivoted blocks	...	10.4 sq. in.
Revolutions per minute	...	3470
Mean surface speed	...	54 ft. per second.

The blocks were steel-faced with white metal $\frac{1}{16}$ in. thick, and were pivoted behind their centre of area, and with all the blocks in use, 1010 lb. per sq. in. was carried without heating. As this was the limit of force which could be applied, the number was first reduced to four blocks, and then to two, the corresponding pressures per sq. in. being respectively 2620 lb. and 5420 lb. per sq. in., which were carried without difficulty. The surface was then reduced to 1.9 sq. in., and the pressure rose to 5910 lb. per sq. in. It was further reduced to 1.2 sq. in., with a pressure of 10,000 lb. per sq. in., but here the white metal flowed in all directions until the area was increased so that the pressure was reduced to 7000 lb. per sq. in., but no heating occurred. It is worth noting that the white metal flowed equally in all directions irrespective of the direction of rotation. It is thus seen that the limit of pressure with such a bearing is the flowing of the white metal and not the failure of the lubrication, and that with pressures of 500 lb. per sq. in. there is an enormous margin of safety; it is probable that three times this pressure will be found quite safe in practice.

In conclusion, I would wish to express my thanks to various friends who have helped me in compiling this paper, especially Mr. H. T. Newbigin, of Newcastle-on-Tyne, and Mr. H. M. Martin, of ENGINEERING.

CATALOGUES.

Electrical Cooking and Heating Appliances.—A binder containing copies of their latest illustrated price-lists of electric fires, boiling-plates, grills, ovens, and other cooking and heating appliances, has come to hand from Messrs. Ferranti, Limited, Central House, Kingsway, London, W.C.

Steam-Shovels.—Messrs. Ruston, Proctor and Co., Limited, Sheaf Iron Works, Lincoln, have sent us a copy of an illustrated catalogue, giving full particulars of their new 70-ton steam-shovels. These shovels were illustrated and fully described in our issue of June 5 last, on page 775.

Gas-Engines and Suction-Gas Producers.—From the Dudbridge Iron Works, Limited, Stroud, Gloucestershire, a catalogue of gas-engines and suction-gas plants has reached us. The engines, which are governed on the variable-admission principle, are made in sizes giving from 15 to 225 brake horse-power with producer-gas. Two types, for ordinary industrial work and for electric lighting respectively, are built by the firm. The catalogue gives a detailed illustrated description of the engines, with full particulars of the different sizes made. It also illustrates and describes the firm's suction-gas producers which are made in sizes suitable for supplying any of the engines in the list.

Oil and Petrol-Engines.—We have received from the Parsons Motor Company, Limited, Town Quay Works, Southampton, a copy of their latest catalogue of oil and petrol-engines for marine and stationary work. Full particulars are given of marine engines ranging from 7 to 180 horse-power, and prices are stated for the engines alone, or complete with reversing gear, clutch, propeller, shafting, stern-tube, &c. Illustrations and particulars of similar engines for stationary work, such as electric lighting, pumping, air-compressing, &c., are also included. The firm have also sent us an album of illustrations of yachts, launches, pinnaces, fishing-vessels, and other craft on which Parsons engines are used for main or auxiliary power.

Electrical Machinery and Apparatus.—We have to acknowledge the receipt from the Adnil Electric Company, Limited, Adnil Building, Artillery-lane, E.C., of a number of pamphlets giving prices and full particulars of electric motors, generators, and fittings manufactured by this firm. Included among them is a price-list of direct-current motors and generators of the interpole type, dealing with motors of from 4 to 125 horse-power, and with generators having capacities up to 90 kw. This list also includes particulars of starters and of flexible and insulating couplings. Other lists deal with fittings for indirect lighting, fittings for use with half-watt lamps, and with small motors. The latter are made in sizes ranging from $\frac{1}{10}$ to $\frac{1}{8}$ horse-power, for either direct or alternating current.

Commercial Motor-Vehicles.—We have to acknowledge the receipt from Messrs De Dion Bouton (1907), Limited, of 10, Great Marlborough-street, W., of a copy of a pamphlet giving full particulars of their half-ton motor delivery vans, which are fitted with 8-horse-power single-cylinder engines. The pamphlet contains a general specification for the chassis, and illustrates several of them complete with bodies of different types. A number of testimonials from users, giving some interesting and useful figures as to the results obtained with these vans in service, are also reproduced. In a Royal Automobile Club trial run, from London to Edinburgh and back, the distance covered per gallon of petrol was 24.5 miles, although the road condition was exceptionally unfavourable, and in spite of the fact that a leakage in the petrol-pipe union was not discovered until the run had been almost completed.

Steam-Turbines.—We have received from Messrs. Willans and Robinson, Limited, of Rugby, a pamphlet relating to their disc-and-drum type steam-turbines. As we have already dealt very fully with these turbines (see ENGINEERING, vol. xcvi., page 643), our readers will be familiar with their details, so that we need say nothing further about them now. The pamphlet illustrates and describes the construction of the turbines, and also illustrates a number of turbo-generators constructed by the firm. It also deals with back-pressure and "pass-out" turbines, for use where a supply of low-pressure steam is required for heating or other purposes. Exhaust-steam and mixed-pressure turbines and turbo-blowers are also illustrated, and a complete list of the installations supplied by the firm is given. The list includes high-pressure turbines of the pure reaction type, disc-and-drum turbines, exhaust-steam turbines, and mixed-pressure turbines, with capacities ranging from 200 kw. to 8500 kw.; many of the turbines made were repeat orders.

Anti-Friction Metal.—We have received from the Magnolia Anti-Friction Metal Company of Great Britain, Limited, 49, Queen Victoria-street, E.C., a number of circulars pointing out the advantages of their well-known brand of anti-friction metal for all kinds of bearings. Among them is an interesting diagram of some comparative tests, made by Professor J. Goodman, on genuine "Magnolia" metal and three imitations of this alloy. The tests were made with a 6-in. shaft, running at 200 revolutions per minute, the total load on the bearing being increased from 2000 lb. to 14,000 lb. With two of the imitation alloys, the load could not be raised above 10,000 lb. (1111 lb. per sq. in.), at which load the friction was 117 lb., 65 lb., 41 lb., and 29 lb., the latter figure being that obtained with "Magnolia" metal. At a load of 14,000 lb. (1555 lb. per sq. in.), the friction with "Magnolia" metal was 50 lb., while that of the one other alloy that sustained this load was just twice as much. Instructions for using "Magnolia" metal are given in some of the circulars.

Brushes.—A catalogue of Gerhold's patent brushes has reached us from the Fearless Brush Company, Limited, of 26, Hart-street, W.C. The chief feature of these brushes is that no cementing material of any kind is used to hold the bristles in place. Another advantage is that they have iron handles, which can be made of any shape or bent to any angle, so that the brushes are more convenient to use for many purposes than ordinary brushes with straight wooden handles. "Fearless" brushes are constructed on an iron rod, which is flattened and bent to form a hook at one end. A bundle of hair or bristle, of a suitable length, is placed in the hook, which is afterwards pinched up so as to hold the bristle firmly. The two ends of the bundle of bristle are then doubled together and bound round with wire at the bend, the wire being closely coiled to form a sort of cup, from which the ends of the bristles project. The wire is next soldered all over; it is also soldered to the handle, and after this operation the brush is completed. The catalogue illustrates and states prices for a great variety of engine-cleaning brushes, motor-car and carriage-washing brushes, and brushes for applying glue, whitewash, tar, paint, &c. It also deals with combination wheel-cleaning brushes, in which a brush constructed as above described is combined with a spiral brush of ordinary construction. Many other useful brushes for special purposes are included in the catalogue.

Neon Lamps.—The Westinghouse Cooper-Hewitt Company, Limited, of 80, York-road, King's Cross, N., have issued a circular relating to neon lamps, which they now manufacture under Claude and other patents. These lamps consist of large Geissler tubes containing neon gas under very low pressure; when supplied with high-tension alternating current, the tubes emit the characteristic reddish light of the gas. The high-tension current is supplied by means of a small transformer having a regulating inductance in series with the primary. The voltage at the electrodes, and the current in the tube, vary according to the length and form of the tube. In the case of a straight tube, 6 metres long and 5 cm. in diameter, the current flowing is about 1 ampere with 1000 volts at the electrodes; for each additional metre in length the pressure must be increased by 100 volts. When used on direct-current circuits, the high-tension currents can be supplied either by an induction coil or rotary converter. The tubes, which are especially suitable for advertising purposes owing to the distinctive character of the light, can be supplied in straight lengths (usually 6 metres long) or bent into the form of letters or designs. The luminous intensity of the tubes is approximately 200 spherical candle-power per metre length, and the efficiency is given as 0.5 watt per spherical candle-power. The lamps light up immediately the switch is closed, and they require no attention in use beyond an occasional cleaning of the tubes.

Water-Coolers and Air-Filters.—Two pamphlets, dealing respectively with Heenan water-coolers and air-filters, have been received from Messrs. Heenan and Froude, Limited, of Worcester. It will be remembered that in these coolers the water, or other liquid to be cooled, is contained in a tank in which a large number of cooling cylinders slowly revolve about a horizontal axis. The cylinders are composed of galvanised-steel sheeting wound in the form of a spiral, of which the lower part dips into the liquid in the tank. Air blown in an axial direction through the upper part of the cylinders by means of a fan, cools the liquid adhering to the sheet-steel surfaces, the cooling being effected partly by direct contact with the air and partly by evaporation. The pamphlet illustrates some of the many applications of these coolers, showing them in use in connection with internal-combustion engines, condensing plants, refrigerating plants, air-compressors, &c.; it also contains a long list of users. The air-filters are similar in principle and construction to the coolers, but are usually shorter. The particles of dust in the air adhere to the wet plates of which the revolving cylinders are constructed, and are washed off by the water into which the cylinders dip as they revolve. The water is maintained at a constant level by means of a small ball-cock, and about once a week the dirty water is run off and replaced with clean. It is claimed that the air treated in this way is completely cleaned and cooled, and that there is no possibility of drops of water being carried along with the air, as may happen with filters of the water-spray type. These air-filters are intended principally for treating the air supplied for cooling large electric generators, but they can obviously be used for many other purposes.

Machine-Tools and Accessories.—We have to acknowledge the receipt from Messrs. Schuchardt and Schutte, 34, Victoria-street, Westminster, S.W., of copies of their latest list of machine-tools and accessories. These lists are devoted respectively to sliding, surfacing, and screw-cutting lathes, precision engine-lathes, plain milling-machines and accessories, and bending-machines. The latter, which are known as the "Initiandum" bending-machines, are suitable for bending, at a white heat, all sections of bar-iron to practically any shape. The machines consist of a horizontal circular table, on which a pair of sector-shaped blocks are mounted so that their sides lie on radii of the circle. One of these blocks is stationary, and the other can be turned about the centre of the table by means of a powerful worm-gear. The blocks are first set so that their sides lie on a diameter of the circular table, thus forming a straight vertical wall, against which the heated bar is clamped. The bar is then bent by turning the movable block through the necessary angle. It is claimed that flat, round, and square bars, and also angle and T sections, can be bent in this way to any angle without using special jaws, but as the hot iron tends to rise during the bending, it must be kept down by hammering, and when bending channels and beam-sections, suitably-shaped blocks must be employed to prevent distortion. The corners are said to come out quite sharp, and the strength of the bend is considerably increased by the swaging process. By means of specially-shaped jaws the machine can produce an almost endless variety of work, numerous examples of which are illustrated in the list before us. Dimensions and prices are stated for machines, in three sizes, capable of bending round bars up to 2½ in., 3⅛ in., and 4⅜ in. in diameter, respectively. The smallest machine is operated by hand power, while the others can be driven either by belt or by an electric motor. Another list received from this firm relates to worm-milling machines, and gives particulars of three sizes capable of cutting worms up to 9 in., 11⅜ in., and 17⅜ in. in diameter respectively. The machines, which are fully automatic in action, will cut either right-handed or left-handed worms of any pitch, as well as spiral-gears. They are claimed to give a very much greater output than screw-cutting lathes on this class of work, especially when cutting multiple-thread and steep-lead worms. An automatic grinding-machine for the milling-cutters used in these machines is also illustrated and described in the list.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

11,106/13. Marconi's Wireless Telegraph Company, Limited, and C. P. Ryan, London. Wireless Telegraphy. [3 *Figs.*] May 10, 1913.—This invention relates to improved apparatus for giving alarms by means of wireless telegraphy when a series of signals which have been transmitted at regular intervals of time, preferably by means of a pendulum or metronome, falls upon a detector. The invention relates to apparatus of the known type in which a relay actuated by these signals causes an electromagnet to attract a balance-wheel whose period of oscillation is equal to the intervals between the signals and to start it swinging. The successive signals increase the amplitude of oscillation of the balance-wheel, and when this is sufficiently great it makes or trips a contact which gives an alarm and preferably also starts an electric motor which resets the trip-contact and may do other work. According to this invention, a balance-wheel, which carries a strip of iron in proximity to an electro-magnet, is so mounted that when the magnet is energised the wheel tends to rotate and wind up a spiral spring, by which it is connected to an adjustable support. The arbor of the wheel carries a contact-finger adapted, when the wheel oscillates through

Fig.1.

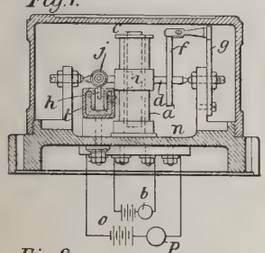
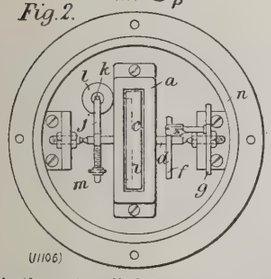
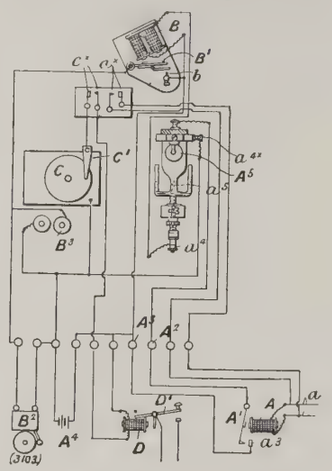


Fig.2.



an angle sufficiently great, to dip into mercury contained in a cup, and so to complete a local circuit. *a* is an electro-magnet, which is energised when the relay *b* is actuated by the incoming signals. *c* is a balance-wheel on an arbor *d*, connected by a spiral spring *f* to a plate *g*, which can be clamped in any desired position. Let into the wheel *c* is a strip of iron *i*. The arbor also carries an arm *j*, on one end of which is a contact-finger *k* adapted, when the wheel comes into the position shown, to dip into mercury contained in a cup *l*, while the other end carries a counterbalancing nut *m*. The arbor-brackets and bed-plate *n* are connected to a battery *o* and relay *p*, the other side of which is connected to the mercury in the cup *l*. Ordinary signals do not affect the balance-wheel sufficiently to cause the finger *k* to dip into the mercury, and the relay *p* is therefore not actuated; but when a number of signals arrive at intervals equal to the period of oscillation of the balance-wheel, this wheel is set swinging, and eventually the finger dips into the mercury, and the circuit through the battery *o* is closed, and the relay *p* is actuated. This relay may consist of a trip-contact, which gives an alarm, and preferably also starts an electric motor, which resets the contact, and may do other work. (*Accepted May* 13, 1914).

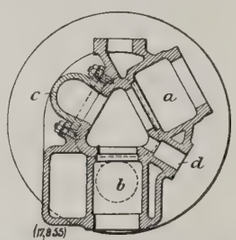
3103/13. The Radio Signal Company, Limited, W. H. Shephard and A. E McKechnie, London. Wireless Telegraphy. [2 *Figs.*] February 6, 1913.—This invention relates to wireless telegraph, telephone or submarine sound-signalling systems. According to this invention, the applicants provide, in combination, an alarm device which is adapted to be brought into operation by a displaceable member when the receiving apparatus is rendered operative and to be cut out from the receiving circuit when the telephone receiver is removed from its switch-arm, so that the reception of the message is not interrupted by the said alarm, an automatic transmitter which is also brought into operation by the above-mentioned displaceable member and is so arranged that a signal will be automatically transmitted, and a movable switch which renders the alarm device circuit operative only after more or less continuous calls have been received. The lines *a*, *a* represent part of the wireless receiving circuit, and A an electro-magnet in this circuit. A^1 is a switch-arm under the control of this magnet, the arm being electrically connected to a terminal A^2, and being adapted to make contact with a contact-piece a^3 in circuit with another terminal A^3. These two terminals are arranged in circuit with a battery A^4, with an electric lamp A^5 forming part of the movable switch. Thus, when the arm A^1 is caused to bear against the contact a^3 the lamp A^5 is lighted. The heat from the lamp, when kept alight or flashed at frequent intervals for some time, causes a column of mercury a^5 to move downwards, owing to the expansion of air in the bulb containing the lamp, as set forth in the Specification of Application No. 22,036, of 1912. A wire in connection with a binding-screw a^4 is normally covered by the mercury, and current from the battery A^4 is therefore passing through an electro-magnet or solenoid B, the mercury being in electrical connection with another binding-screw a^{4*}. As soon as the mercury a^5 uncovers the wire connected to the binding-screw a^4, the current through the magnet or solenoid B ceases, and a pivoted weighted member B^1, normally held by the magnet, then drops into contact with a screw *b*. The screw *b* is in a circuit containing an alarm-bell B^2 and an electro-magnet or solenoid B^3 having an armature that engages with a pin *c* on a disc C, constituting the automatic transmitter, this disc being driven by a clock movement. Consequently, when the member B^1 drops into contact with the screw *b*, the bell B^2 rings and the armature of the electro-magnet B^3 is released from the pin, thereby allowing the disc C to rotate. This disc is provided with contacts which bear against a brush C^1 arranged in circuit with an electro-magnet or solenoid D, the armature of which is connected to a key D^1 in the transmitting circuit. When the disc C rotates, the current through the magnet D is intermittently made and broken in accordance with the spacing of the contacts on the disc C, and the key D^1 accordingly automatically transmits a message—such, for example, as the code word representing the name of the ship carrying the apparatus. The circuit through the brush C^1 and the magnet D is broken at the



contact points c^*, c^* when the telephone receiver is removed from its pivoted hook, this being effected by providing the hook with an arm, which normally closes the contacts c^*, c^*, but which, when the receiver is removed from the hook, moves into a position to enable the contacts c^*, c^*, one of which is resilient, to break the circuit through the brush C^1 and the magnet D. This movement of the hook causes its arm to close the normally unclosed contacts a^*, a^*, thereby short-circuiting the electro-magnet A and preventing the alarm device from coming into operation when the message is being received. This movement of the hook also moves the member B^1 into contact with the electro-magnet B. The pivoted hook is connected by means of a slip-pawl with a chain or with a slotted rod. The slot of this rod is adapted to receive a pin connected to an arm that is adapted to wind a spring that affects the movement of the disc C. This arm moves with the clockwork that actuates the disc C, so that when the latter has completed its automatic movement the pin is at or near the bottom of the slot in the rod. The replacement of the receiver consequently causes the arm to be lifted until the rod is released by the pawl, whereupon the rod falls, so that the upper wall of the slot rests upon, or is contiguous to, the pin, which can thus move downwards in the slot during the movement of the arm as the disc C rotates. (*Accepted May* 13, 1914.)

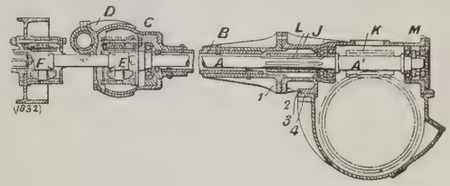
GAS-ENGINES, PRODUCERS, HOLDERS, &c.

17,855/13. E. Gardner, Patricroft. Oil-Engines. [4 *Figs.*] August 5, 1913.—This invention comprises improvements in and relating to the combustion-chambers of oil-engines, particularly of the four-stroke-cycle type, with which the fuel is sprayed into the combustion-chamber at about maximum compression, and instantly consumed. With engines of this type, the degree of compression adopted is comparatively high, frequently of the order of about 300 lb. per sq. in., and it is essential for obtaining maximum power from an engine of given dimensions that the area of the combustion-chamber should be kept smaller than is found possible with the existing forms and arrangements of such chambers, and the admission and exhaust-valves and other fittings or attachments employed therewith. The invention consists in an oil-engine combustion-chamber of a triangular form, arranged in direct connection with the engine cylinder, and having extensions formed with or secured to its sides or faces, serving respectively for the reception of the admission and exhaust-valves, and as the vaporising and igniting space or area for the oil admitted through a sprayer or the like fitted opposite the said space or area. In carrying the invention into effect in the manner illustrated by the drawings, the combustion-chamber is adapted for bolting to the end of the engine cylinder with which it is to be employed, and for serving as the end cover of such cylinder. The chamber is made to a triangular form, and on the three sides or faces of the triangle there are provided extensions *a*, *b*, and *c*, of which *a* serves for the reception of the air-admission valve and *b* for the exhaust-valve, whilst *c* constitutes the vaporising and igniting space or area. The body of the combustion-chamber and also the two radial extensions *a* and *b* for the reception of the valves are water-jacketed; the third extension, for the vaporising and igniting area, is unjacketed, and its surface is thus adapted for external heating as required. The admission of the oil-spray, under compression, is arranged at *d*, opposite to the aforesaid vaporising and igniting space or area *c*. For starting the engine, a compressed-air admission-inlet may be provided, preferably in alignment with the centre of the cylinder. Provision may also be made upon the combustion-chamber for an indicator and other attachments. (*Accepted May* 13, 1914.)



MOTOR ROAD VEHICLES.

1832/14. H. Spurrier, Leyland. Motor Road Vehicles. [1 *Fig.*] January 23, 1914.—This invention relates to improvements in motor-vehicle driving-gear of that type in which the torque-tube has the lid of the gear-casing connected to it, so that such lid and the torque-tube with the propeller-shaft can be lifted together from the gear-casing, to expose or to give access to the gearing in the casing, and which lid can also be disconnected from the torque-tube, so as to give greater facilities for dealing with the gearing. In carrying this invention into effect, the end or part of the end of the lid which is opposite to the end of the propeller-shaft is removable, so that through the opening made by removing such part the propeller-shaft or the end of such shaft may be axially withdrawn. A represents the propeller-shaft and B its torque-tube, one end of which is mounted in a ball-and socket joint C in a bracket D attached to the vehicle framing. The shaft has two universal joints E, F. G is the casing containing a differential gear, and J is the lid of the casing. This lid and the end of the torque-tube B are connected



together by bolts through the flanges 1, 2. The propeller-shaft, in the construction illustrated, has a removable end part A^1, which carries a worm K driving the differential gear, and is connected to the shaft A by a splined or sliding joint in the muff L. One end of the end-part or shaft A^1 bears through suitable bearings against the removable thrust-plate M attached to the gear-casing lid. When the plate M is removed, the shaft A^1 and its worm can be withdrawn axially through the hole thus uncovered. The lid is removable from the casing when bolts passing through the flanges 3, 4 are removed. By disconnecting the lid from its casing, the torque-tube and lid can be raised together, turning angularly around the socket-joint C, D so as to lift and expose the gearing which is attached to the underside of the lid, or to expose gearing which remains in position in the casing. If the differential-gear is to be withdrawn from the casing with the lid, its wheels are disconnected from the live axles in the manner already known. By disconnecting the lid from the torque-tube it can be removed bodily with its contained worm-shaft A^1. (*Accepted May* 13, 1914.)

10,797/13. L. E Cowey, Kew Gardens. Motor Road Vehicles. [4 *Figs.*] May 7, 1913.—This invention relates to the suspension of motor road vehicles of the kind in which special resilient devices are used for giving lateral support to the body of the vehicle. According to this invention, the springs which give lateral support to the body (at the front or rear, or both front and rear) are adapted to form compression-rods or members which are each at one end pivotally connected at or about the centre of the vehicle body or underframe or upon the rear axle, whilst at the other end they are pivotally attached to arms or pillars on the vehicle front axle or to pivots fitted, say, to pneumatic suspension cylinders used in conjunction with the back axle, the result being that when the body or frame is in a mean position in relation to the wheel axles the compression members of each axle are in alignment and act in opposition to each other and therefore have no tendency either to raise or lower the body or frame relatively to the axles. Should, however, the body be upwardly displaced, the effect of the compression members, directly they are caused to move out of alignment, is to amplify the upward displacement; likewise should the body be downwardly displaced, the effect is to amplify the downward displacement, thus acting in an entirely opposite manner to the ordinary and known suspension arrangements, which, in conjunction with the weight of the body, tend to resist either an upward or downward displacement of the said body. *a* indicates the axle connected to the front or steering-wheels *b* by the vertical pins *c*, which extend or project upwardly to form the supports or pillars for the outer ends or extremities of the resilient devices. *d*, *e* are the telescopic tubes with the springs *f* mounted therein to form the compression-rods or cross-tie members. The tubes *d* are connected or pivoted to the axle-pins *c* by means of lugs preferably formed integral with tubular dust-proof sheaths or covers d^2 fitted over the outer end of each tube *d*, whilst the tubes *e* are each provided with an eye or ring e^1 capable of encircling or fitting over the bearing of the starting-handle *h*. According to the example shown, the tube *d* of each cross-tie member is made capable of sliding within the tube *e*, and for the purpose of centralising the spring *f*, which is made an easy fit in the inner tube *d*, each tube *e* is provided with an internal plug or distance-piece e^2. Whilst showing the cross-tie members connected at their inner ends to the bracket *i* of the frame *j*, which supports the starting-handle, they may be pivoted at any other convenient point in the body or frame of the vehicle. It will thus be understood that with these resilient cross-tie members pivotally attached respectively to the pillars or pins on the axle and to an approximately central pivot on the frame or body, and the springs being in compression, lateral support will be afforded to the body of the vehicle, whilst the bending stresses to which the axle is subjected will be also counterbalanced. (*Sealed July* 23, 1914.)

Fig.1.

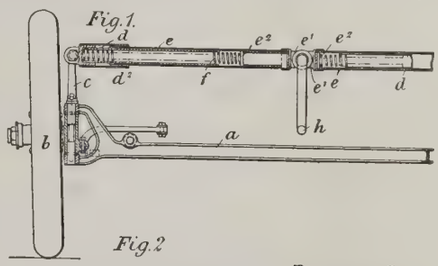
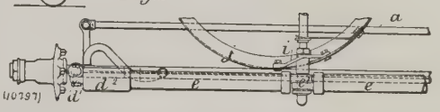
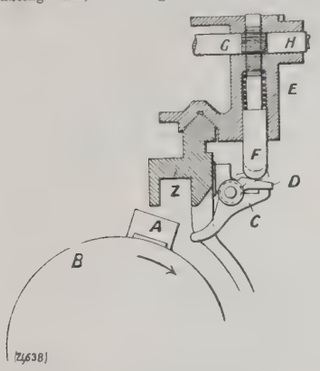


Fig.2



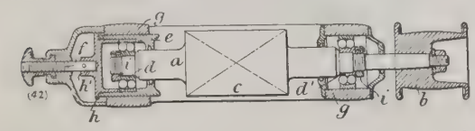
MACHINE AND OTHER TOOLS, SHAFTING, &c.

21,638/13. A. Herbert, Burford, and P. V. Vernon, Coventry. Turret Lathes. [3 *Figs.*] September 25, 1913.—On turret lathes the operations of the turret are often controlled from cams or the like carried on the bed of the lathes. These cams in most cases do not move with the turret-slide, and in such cases adjustment of some part of the connecting mechanism between the cam and the turret has to be made to suit different positions of withdrawal of the turret and the slide. It is the object of the present invention to provide a simple method of overcoming this difficulty. In the mechanism between the cam and the turret lies a plunger and a lever, carried respectively by the turret-slide and bed of the lathe, or *vice versâ*, and, according to this invention, a long surface is provided on one of these parts so as to ensure engagement by the other part in spite of the fact that the withdrawal position of the slide may vary. The clutch (which is not shown) may be operated from a cam A fixed to the turret-actuating cam B, or to its shaft. This cam A may, in other cases, be mounted upon a shaft geared with a turret-actuating cam, and to give the required frequency of



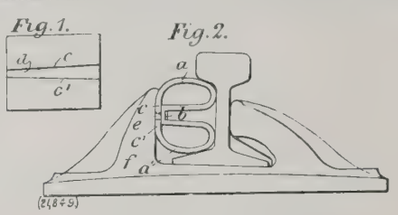
operation to suit the cycle or the gearing between this shaft and the turret-actuating cam, a plurality of clutch-control cams may be employed. The cam A is adapted to strike a bell-crank lever C pivoted to the bed Z of the lathe, the axis of which lever is longitudinal with regard to the bed of the machine. The end of the lever engaging the cam may be of comparatively narrow width, but the other end D is formed with a long face which extends along the bed of the lathe for a suitable distance. Free to move vertically on the turret-slide E is a vertically-moving plunger F, and the length of the face D referred to is such that at all withdrawal positions of the turret-slide the plunger F is sure to be over part of the face D, and is therefore capable of being actuated by movement of the other end of the rocking-lever. The plunger may, through rack-and-pinion mechanism at G, rotate a shaft H which directly or indirectly moves a lever engaging and disengaging the clutch in any well-known manner. It will therefore be seen that the actuation of the clutch is independent of the movement of the turret, and that no adjustment of any part of the mechanism between the lever and the actuating cam is necessary in spite of the fact that the turret-slide may withdraw to varying distances. (*Sealed July* 23, 1914.)

42/14. Thomas Robinson and Son, Limited, and P. S. Robinson, Rochdale. Wood-Working Machines. [4 *Figs.*] January 1, 1914.—This invention relates to the cutter and circular-saw spindles and similar spindles of wood-working machines, and consists in a method of, and means for, longitudinally adjusting such spindles, whether vertical or horizontal, without the necessity of moving the complete housing or frame carrying the ball-bearings, and also to minimise the number of joints that would be likely to cause vibration in the spindles. This result is attained by carrying the ball-bearing (or bearings), which locates or holds the spindle against end thrust and longitudinal movement, in a bush or sleeve which can be adjusted to and from the housing or frame of the machine in which it is supported by means of a screw or other mechanical means. This bush or sleeve has suitable projections or stops provided on it to limit the amount of the adjustment in each direction. *a* designates the cutter-spindle or circular-saw spindle; *b* the pulley by which it is driven; *c* the cutter-block (or it might be a circular saw); *d* a ball-bearing for one end of the spindle *a*; *d*¹ the other ball-bearing; *e* a sliding bush or sleeve made up of two or more parts screwed together and carrying the ball-bearing *d*; *f* a screw or screw-threaded sleeve for moving and adjusting the sliding bush *e* with the ball-bearing *d*; *g* the housing or frame in which the sliding bush *e* is fitted and capable of being adjusted; *h*, *h*¹ suitable stops or projections on the sliding bush *e* to limit the amount of the adjustment in each direction; *i* screwed lock-nuts used to secure the inner races of the ball-bearings to the spindle *a*. The outer races of the ball-bearing *d*¹ are free to move or float in the housing *g* to allow for possible expansion or contraction of the spindle or for mechanical adjustment of the spindle when setting the position of the circular saw or cutter-block on the machine. (*Accepted May* 13, 1914.)



RAILWAYS AND TRAMWAYS.

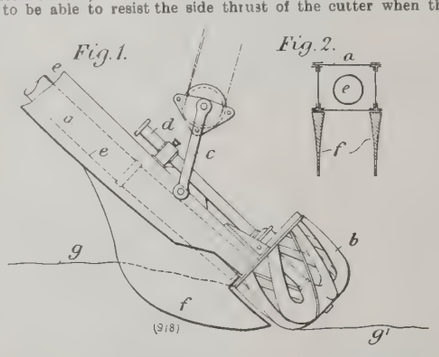
21,849/13. George Turton Platts and Co., Limited, Sheffield, and A. R. Stuart, Bangalore, South India. Permanent Way. [14 *Figs.*] September 27, 1913.—This invention relates to steel spring-keys, with expanding wedges, for securing railway rails in their supporting chairs, and is an improvement in the metal key-and-wedge fastening described in Specification No. 14,410, of 1908. The object of the present invention is to ensure the proper tightening of the wedge and key in position, notwithstanding slight variations in the distance between the jaws of the chairs or the jaws of sleeper-bowls and the web of the rail. For this purpose, the wedge, which is employed to expand, the key is tapered both in width and thickness, and those portions of the key against which the wedge bears with three of its sides are inclined to correspond to the taper of the wedge, the intermediate bend in the key against which the inner surface of the wedge reacts being proportioned according to the thickness of the wedge, so that the thin edge of the wedge can be readily inserted between the bend and the chair-jaw. In one form of the invention, the steel spring-key is constructed by pressing or rolling a steel plate of suitable dimensions to form upper and lower inwardly-directed loops or bends *a*, *a*¹ engaging respectively in the angles between the head and the foot and web of the rail, and separated by an outward bend *b* of the plate approaching the opposed edges *c*, *c*¹ of the plate at a suitable distance apart and suitably inclined to form a taper groove *d* for the reception of two sides of the fixing wedge *e*. The outward bend *b* is inclined in a longitudinal direction towards a vertical plane through the longitudinal axis of the key for the reception of one side of the fixing wedge *e*. When the key for the reception of one side of the chair and rail, as shown, the spring key is in position between the chair and rail, as shown, the edges *c*, *c*¹ are adjacent the jaw *f* of the chair and the wedge *e*, tapered in width and thickness, is driven into the groove *d*, which is closed on the outer side by the inner face of the chair-jaw *f*. The steel wedge *e*, driven in a horizontal direction, produces initially a simultaneous expansion of the upper and lower loops *a*, *a*¹ of the key in a direction parallel to the vertical axis of the section of the rail. The reaction of the upper loop *a* of the steel spring-key on the head of the rail, and the reaction of the lower loop *a*¹ of the steel spring-key on the foot of the rail, together produce a contraction of the intermediate bend *b* of the key in a direction



parallel to the vertical axis of the section of the rail and at the same time an expansion of the same intermediate portion *b* of the key in a direction at right angles to the vertical axis of the section of the rail, the expansion of the intermediate portion *b* of the steel spring-key in a direction at right angles to the vertical axis of the section of the rail producing the following pressures:—A pressure of the upper and lower loops *a*, *a*¹ of the steel spring key against the web of the rail and a pressure of the summit of the outward bend or curve *b* of the key against the inner wedging surface of the steel wedge *e*; a pressure of the outward surfaces of the steel spring-key adjacent to the extremities *c* and *c*¹ of the steel spring-key against the inner surface of the outer jaw *f* of the chair; also a pressure of the outer surface of the steel wedge *e* against the inner surface of the outer jaw *f* of the chair. Finally, the pressure of the steel spring-key and wedge against the inner surface of the jaw *f* of the chair, and the pressure of the steel spring key against the head, the web, and the foot of the rail, as described in the foregoing, force the rail against the inner surface of the inner jaw of the chair and secure the rail in position in the chair. (*Sealed July* 23, 1914.)

SHIPS AND NAUTICAL APPLIANCES.

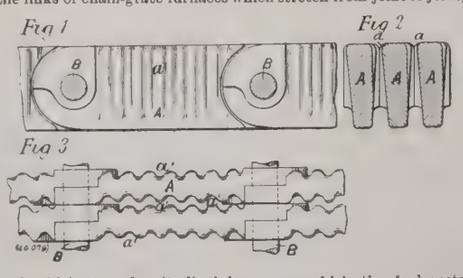
918/14. F. Lobnitz, Crookston. Suction-Dredgers. [2 *Figs.*] January 13, 1914.—This invention relates to what are known as suction-dredgers. The object of this invention is to provide means whereby a rotary-cutter suction-dredger can be utilised to effectively perform the work without being moored, the vessel being navigated slowly over the bottom and the suction-ladder, with its cutter, being trailed over the soil in the same manner as with a trailing suction-dredger. The invention consists in providing, on or in conjunction with the ladder, an arrangement which, when the ladder is dragged over a fairly hard bottom surface, will sink or cut into the surface to such an extent as to be able to resist the side thrust of the cutter when the



cutter is rotated. The arrangement may take the form of one or more fins, keels, blades or spurs, or equivalent, which are so shaped and arranged as to cut or sink into the soil as the dredger moves through the water. On the drawings, *a* is the ladder, *b* the rotary cutter, *c* part of the usual raising and lowering gear for the ladder, *d* the lower part of the shaft of the cutter, and *e* the suction-pipe. The lines *g*, *g*¹ represent the soil. According to the arrangement shown, one or more fins or keels *f* are rigidly secured to the under side of the ladder *a*. The two fins *f*, *f* are arranged side by side, and parallel to one another, and, as will be seen from the lines *g*, *g*¹, they cut into the soil as the dredger moves forward over the bottom. (*Accepted May* 13, 1914.)

STEAM-ENGINES, BOILERS, EVAPORATORS &c

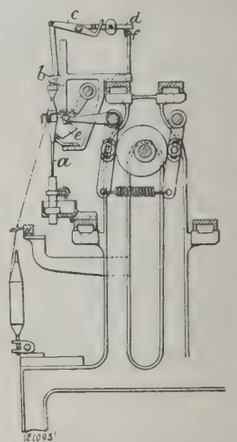
20,079/13. E. Bennis, Bolton. Chain-Grate Furnaces. [8 *Figs.*] September 5, 1913.—This invention relates to the links of chain-grate furnaces which stretch from joint to joint,



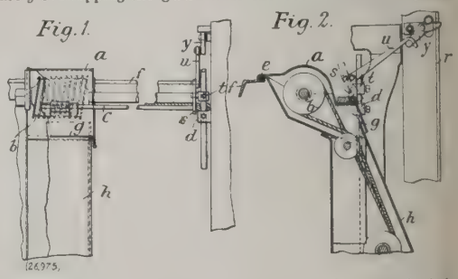
and which form longitudinal bars upon which the fuel rests. Hitherto the top surfaces of these longitudinal links have been made flat, forming a flat surface to the grate for the fuel to lie upon, with air spaces or slits between the links, the sides being formed with ribs or corrugations. This invention consists in making the top surface of each longitudinal link rounded, curved or bevelled, whether flat or corrugated, at the sides, to provide an air space beneath the layer of fuel, and secure a better circulation or diffusion of the air through the fuel. The grate is built up of a number of longitudinal links A, mounted on transverse rods B in the usual way. According to the present invention, the top of each link A is made round or curved or flat on top with curved or bevelled edges *a*. The links A are, in addition to the curved, rounded or bevelled top, also preferably corrugated or fluted at *a*¹ at both sides, and in the direction of their length the links may be straight on top or corrugated. By thus constructing the longitudinal links A so that the edge *a*, where the air passes up to the fire, is of rounded or curved shape or bevelled, it will not burn away so quickly as in the usual form of link. Moreover, the coal will be supported on a less area of the link, and will offer less obstruction to the passage of the air to the fire and as a depression is formed between two links through which the air can pass, it will consequently reach a larger area of fuel. The corrugations serve a similar purpose. (*Accepted May* 20, 1914.)

TEXTILE MACHINERY.

21,095/13. J. Higginson and H. Arundel, Stockport. Cop-Winding Machines. [4 *Figs.*] September 18, 1913.—This invention relates to cop or pirn-winding machines, and comprises the provision of means for ensuring the production of a good cop bottom by assisting the initial traversing movement of the cop-spindle as winding takes place between the cop and cone-builder. The cop-spindle *a* with its slide *b* are balanced in the usual manner by the ordinary weighted lever *c*. For the purpose of assisting the initial traversing or upward movement of the spindle *a* and its slide *b* in the early part of the winding or building of a cop there is employed a supplementary balancing-lever *d*. The supplementary balancing-lever *d* is arranged with respect to the ordinary lever *c* so that only during the first or initial portion of the winding of the cop does it act or have any balancing or lifting effect on the cop-spindle *a* and its slide *b*, whereby the pressure between the cop and the usual cone-builder *e* is relieved. As the winding or building of the cop proceeds, the spindle *a* and slide *b* gradually ascend. Early in such ascent, the supplementary balancing-lever *d* is brought to rest on the stop *f* and so put out of action. (*Sealed July* 16, 1914.)



26,975/13. J. Pickford, Oldham. Self-Acting Mules. [5 *Figs.*] August 5, 1913.—This invention relates to improvements in guards for self-acting mules or twiners, and has for its object to provide a guard for, or so arranging the existing guard of the drawing-out scrolls that it can be readily slid sideways out of or into its operative position, as may be required, and which guard may be also so arranged under the control of the headstock-guard of the machine, say such as described in Application for Letters Patent No. 2960, of 1913, that it cannot be removed from its operative position until the machine has been stopped, and the machine cannot be permanently started again until the guard has been slid back into its operative position. In carrying out this invention according to one embodiment, the guard *a* of the middle drawing-out scroll *b* is formed to surround the latter, and closed at its inner and open at its outer end. To the outer side of the guard *a* rod *c* is secured adapted to rest upon the creel brackets *d*, while the inner side has a flange *e* resting upon the roller-beam *f*, and the outer side has a downwardly extending part *g* overlapping the guard *h* of the bottom scroll or pulley.



When employing the scroll guard *a* under the control of the headstock-guard *r* in the operative position of the middle taking-in scroll-guard *a* on the left side of the headstock, the end of the rod *c* on the right thereof abuts against one end of a lever *s* fulcrumed to the creel-frame bracket *t*, the other end of which has pivoted thereto the headstock-guard hook *u*. In order to permit of removing the scroll-guard *a* from its operative or inoperative position, it is necessary to first remove the headstock-guard *r* by lifting the hook *u* off the swivel *y*, which causes the lower end of the lever *s* to move from behind the rod *c*, and the end of the rod *c* of the guard *a* of the middle scroll drawing-out scroll to be released, and thus the guard to be unlocked so as to permit of being slid sideways from the operative into the inoperative position. When it is desired to start the machine again, owing to the right end of the rod *c* of the guard *a* on the left-hand side of the headstock having taken up a position in front of the lower end of the lever *s*, the machine cannot be started again permanently until the scroll-guards have been slid back into their operative position, as only then the headstock-guard can be placed back again in position. (*Accepted May* 20, 1914.)

SOME EXPERIMENTS ON DUST EXPLOSIONS IN TUBES.

By J. D. Morgan, A.M. Inst. C.E., A.M.I.E.E.

The object of these experiments was to ascertain the character of the pressure variations which occur during combustible-dust explosions in a tube which is closed at one end and open at the other, the explosions being initiated at the closed end. In all the experiments here recorded lycopodium dust was employed. The graphs obtained were produced by means of a specially-designed oscillograph, full particulars of which are given in a paper read by the author before the London Physical Society.* Briefly, the instrument consists of a light rectangular steel vane *a* (Fig. 1), hinged by means of a torsion wire along the upper edge, and mounted parallel to the axis of the tube *b* in a cell *c*. Along the two ends and bottom edge the vane is free. To one end of the vane is attached a light style *d*, which describes a line on a smoked-paper strip carried by the drum *e*. Time is marked on the same strip by an electromagnetically-driven tuning-fork of known frequency. The instrument is rendered dead-beat by a dash-pot *f*.

Fig. 1.

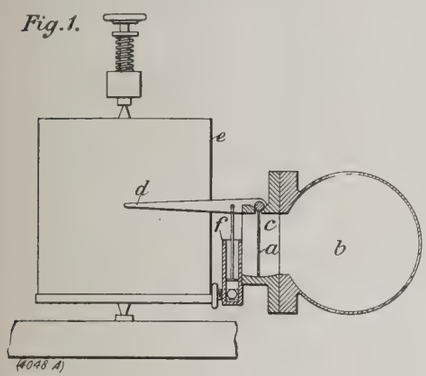
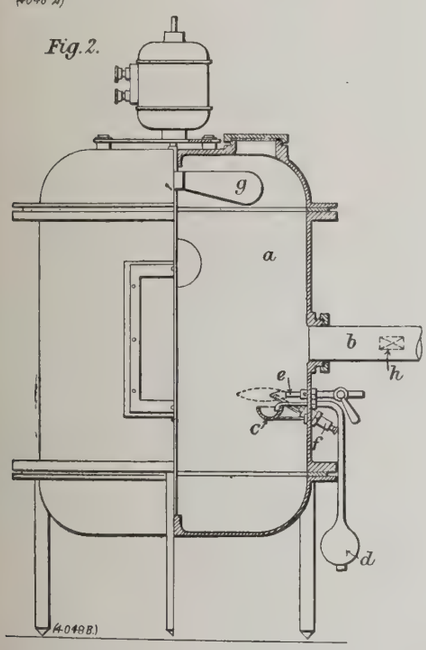


Fig. 2.



It is apparent that different initial conditions will be followed by different effects. The three undermentioned conditions were selected: (*a*) flame accompanied by a large current of air projected into a dusty tube; (*b*) same as (*a*) but with a small current of air; (*c*) disturbance produced in the tube by concussion and ignition effected by a glowing platinum coil.

Before discussing the experiments in detail, a digression on a certain rudimentary feature of the subject may be useful to those not familiar with laboratory work on dust explosions. One of the principal difficulties encountered by the experimenter is to control the density of the dust-clouds. For explosions in a small closed chamber the difficulty is not insuperable. By properly designing the chamber and the means for producing the cloud a fairly uniform distribution of the dust throughout the air space can be obtained. But when the experiments are performed in a long tube anything like the same uniformity is almost, if not quite, impossible to attain, and in consequence each experiment needs to be repeated a larger number of times with the same and different charges before deductions can safely be made. With much elaboration of apparatus the distribution difficulty could doubtless be minimised largely, but simple apparatus is always to be preferred.

As in gas explosions, a certain proportion of dust and air gives the maximum explosion effect. Excess of dust stifles combustion, and retards propagation of the flame. Deficiency of dust prevents the formation of flame. Repeated trials are necessary to find the approximate quantity of dust required to give the best result; but even when this quantity is determined, the state of distribution in the tube or a variation in the state of motion of the air, or in the source of ignition, may nullify the experiment.

Fig. 3.

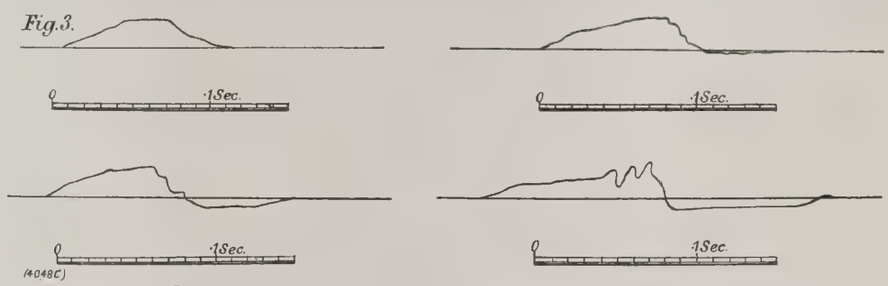


Fig. 4.

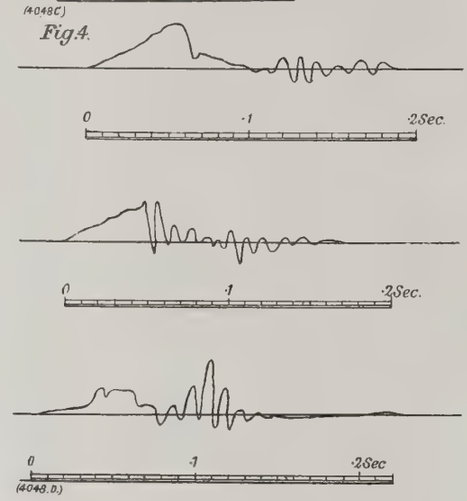
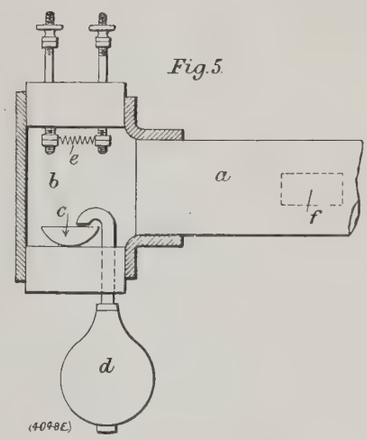


Fig. 5.



Regarding experiments under the first condition above mentioned—namely, flame accompanied by a large current of air projected into a dusty tube—the apparatus shown in Fig. 2 was employed. A chamber *a*, of about 1 cub. ft. capacity, was fitted to a tube *b*, of $1\frac{1}{2}$ in. diameter and 10 in. in length. A small quantity of dust was placed in a dish *c*, and blown up into a cloud by a puff of air from a rubber bulb *d*. Ignition of the cloud was effected by the flame of a gas-burner *e*, and ignition of the gas was effected by a sparking-plug *f*. The expansion of air in the chamber by the combustion of the dust-cloud produced a strong rush of air in the tube, which served to raise the dust-cloud, and the flame swept into the tube served to ignite the cloud. To obtain the required distribution of the dust along the tube prior to the explosion, a small heap of dust was placed at the inner end of the tube, and the electrically-driven fan *g* was rotated for a few seconds. A loose coating of dust was thus deposited over the whole of the tube interior. After the explosion the chamber was opened, and the foul gases cleared out of the apparatus by means of the fan.

In the first series of experiments the oscillograph was placed within a few inches of the inner end of the tube, as indicated by the dotted rectangle *h*. All the successful experiments were accompanied by a large outburst of flame, with some smoke at the outer end of the tube, and a strong puff which could hardly be called a noise, but might be called a dull report. On one occasion, when the laboratory windows were closed, the effect of the explosion on the air of the room was such as to cause the half-open door to be slammed vigorously. The magnitude of the pressures obtained in the tube was not investigated. If the dust was in excess, little or no flame and much smoke appeared. When the dust was deficient, there was little or no smoke and no flame.

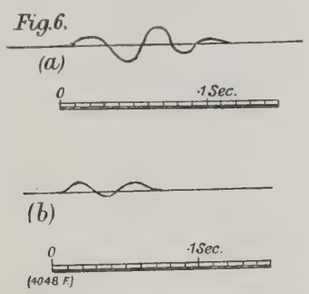
A large number of graphs were taken, and, as might be expected, they differed largely from each other, but the same predominant characteristic was found in all. Fig. 3 shows four representative graphs. In each case it will be noticed that the pressure rises comparatively slowly, and the line of increasing pressure is fairly regular. When the pressure falls the rate of change is rapid and rather irregular, indications of a slight vibrational condition in the tube becoming apparent, and in some cases the pressure becomes negative before it returns to the normal value.

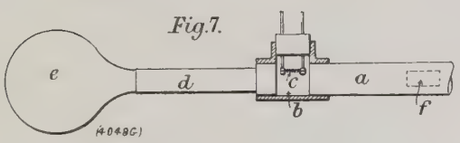
Subsequently the oscillograph was moved to a position in the tube 5 ft. from the open end, and the experiments repeated. A striking difference is at once apparent in the graphs. Fig. 4 illustrates three typical curves. It will be noticed that the pressure rises more suddenly, and rapidly passes into a strong vibrational condition. This phenomenon is extremely interesting. Two questions at once arise concerning it. The first is as to the cause of the vibration, and the second as to the probable effect on the propagation of the explosion. Regarding the first, the answer appears to be that the vibration is due to the sudden expansion at the open end of the tube; and, regarding the effect on propagation, the answer is probably that the vibration contributes more than the direct motion of the air current. In a paper shortly to be published by the Institution of Civil Engineers, the author describes a simple experiment illustrative of the relative dust-raising properties of vibrational and unidirectional motion of the air within a dusty tube. If a pneumatic motor-horn be sounded at one end of a long glass tube, along the bottom of which a layer of fine dust has been strewn, a cloud which fills the greater part of the tube immediately rises; whereas if the reed be removed from the horn and the bulb compressed so as to discharge into the tube a stream of air similar to the former one, only a slight disturbance of the dust occurs. From the graphs shown in Fig. 4 it is evident that a vibrational condition is automatically set up in the tube, and it is highly probable that this causes a greater agitation of the dust in advance of the flame than the unidirectional air-current. The possibility of propagation of the flame in the absence of vibration is, of course, not excluded by these considerations. On the contrary,

* "An Instrument for Recording Pressure Variations Due to Explosions in Tubes," Proceedings of the Physical Society of London, Vol. xxvi., Part III., April 15, 1914.

as is shown by the next experiments, a sufficient rush of air is necessary to carry on the explosion. If the initial motion of the air and flame is small, the explosion quickly dies out, excepting when there is present another condition, which will be described later.

Referring to Fig. 5, the apparatus there shown comprises a tube a, of $1\frac{1}{2}$ in. diameter and 10 ft. in length, fitted at one end with a small chamber b. At the base of the latter is arranged a dish c for containing a small quantity of dust and a tube for directing into the dish a puff of air from the bulb d. The cloud raised by this device is ignited by the glowing platinum coil e, and the resulting flame passes with the expanding air into the dusty tube. The oscillograph was first placed near the chamber, as indicated by the dotted rectangle f. This apparatus enables the second of the conditions above mentioned to be obtained—namely, the projection into the tube of a flame with a small rush of air. As in the previous experiments, a large number of tests were made. In all cases, the puffs

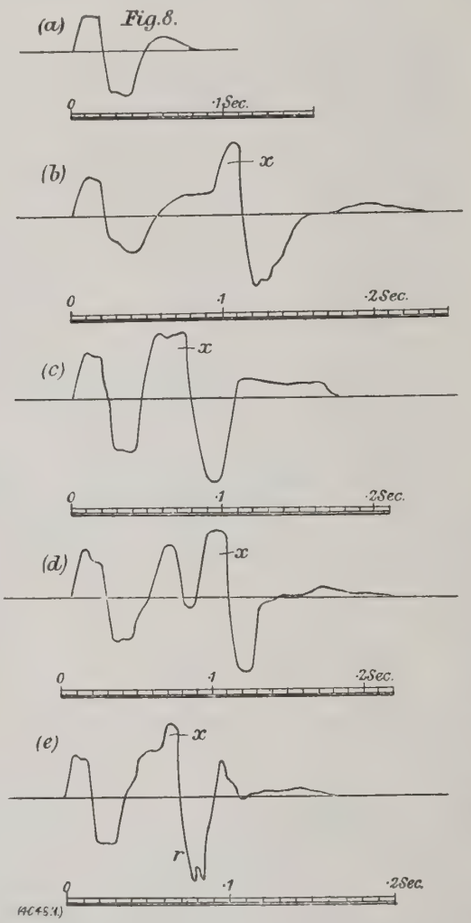




at the end of the tube were slight, and in no case was the flame propagated so far as to reach the outer end of the tube, the maximum travel of the flame being about 6 ft. The graphs obtained were all of the character shown at (a), Fig. 6. It will be observed that the pressure variations were entirely vibrational and not very energetic. With the oscillograph placed at 5 ft. from the end of the tube, graphs of the kind shown at (b), Fig. 6, were obtained. The variations were of the same character as the first, but feebler. It is apparent that, notwithstanding the fact that an explosion tends to gather force as it travels along a dusty tube, the explosion rapidly dies down if not initiated with sufficient movement of air along the tube.

Concerning experiments under the third condition—viz., disturbance of dust by concussion—the apparatus shown in Fig. 7 was employed. A tube a, of $1\frac{1}{2}$ in. diameter and 10 ft. in length, was fitted with an ignition-chamber b, containing a glowing platinum coil c, and communicating with this chamber was a tube d, of 1 in. diameter and 1 ft. in length. To the outer end of the latter was attached a rubber bulb e of about 4 in. diameter. The oscillograph was placed at f, a few inches from the ignition-chamber. The method of the experiment was to coat the large tube with a fine layer of loose dust and place a very small quantity of dust in the bulb. On striking the bulb with a sharp, strong blow, a fine cloud was projected from the bulb across the coil, and a disturbance produced in the main tube. Explosions obtained in this way are more rapid and energetic than any other tube explosions, and they closely approximate in character to gas explosions. Fig. 8 illustrates at b to e four typical graphs, and at a the effect of striking the bulb only. The first rise and fall of pressure (or complete oscillation) in each of the graphs b to e is due to the bulb concussion. Graphs obtained at a point 5 ft. from the end of the tube a are of the same type. As regards the visible and audible effects of the explosion, flame with but little smoke was projected from the end of the tube, and the character of the flame was quite different from that obtained in the experiments under the first condition, being in the form of a sharp tongue instead of an expanding cloud, indicating a more complete and rapid combustion. The report was also of a higher note than in the former experiments, although only in exceptional cases was the report loud, as in gas explosions.

As is evident, the graphs possess certain peculiar characteristics. The vibrations are few, and there is one principal peak x in each case which represents the explosion proper. In d there are two peaks indicating two explosions. Subsequent to the principal peak there are evidences of more or less irregular pressure variations, which are probably due to the lingering of flame in the tube. Prior to the peak there is an interval between it and the original disturbance which varies considerably. An explosion of this class appears to be in the nature of a single impulse. In coal-gas explosions the same characteristic peak is found. When the gas mixture is of the right proportion, a single irregular wave, distinguished by a rapid transition from the positive to the negative side of the zero line, and followed by a half-wave of positive pressure, is obtained. If the mixture is poor or rich in gas, the principal peak is either followed or preceded by a long train of waves.*

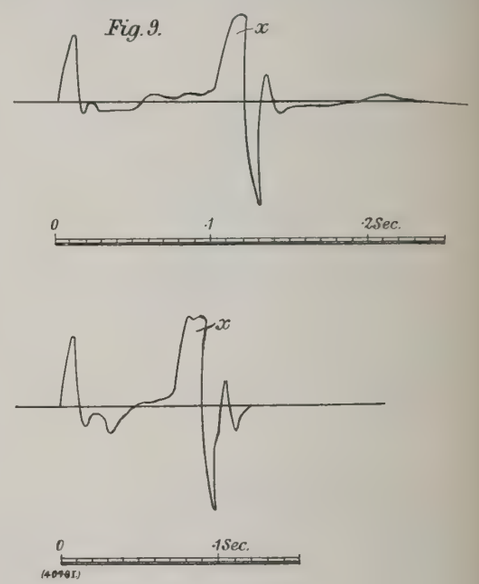


If the $1\frac{1}{2}$-in. tube shown in Fig. 7 is replaced by a tube of 1 in. diameter, a closer approximation to gas-explosion effects is secured. The tube employed was 6 ft. long. Fig. 9 illustrates two typical graphs. The explosions were attended by the projection of a short, sharp flame from the end of the tube, and a report as loud as any obtained in a coal-gas explosion. As in Fig. 8, the initial peak is due to the bulb disturbance, while the explosion is represented by the peak x. Also the interval between the two peaks varies considerably. The full significance of these curves, and especially of the aforesaid interval, remains to be discovered. A great deal of time has been spent by the author on explosions of the last-mentioned kind, and one of the conclusions reached is that they require a great deal more investigation before their mystery is revealed. A comparison of the curves at Fig. 9 with those shown, *e.g.*, at b or e in Fig. 8, suggests that the explosions were very similar in character; but judging from the noise produced they were distinguished by a much more rapid combustion in the latter case than in the former. And in explosions in the same tube it was noticed that explosions which were differentiated very markedly

* See Appendix to Physical Society paper above cited.

by their reports produced graphs which were very similar. It would appear, therefore, that there is some quality of the explosion which is not shown by an oscillographic investigation. A curious result noticed was that for the production of loud explosions with flame at the tube end in the 1-in. tube no other dust than that placed in the bulb was required, and the graphs had the same general appearance as those in Fig. 9.

A fact impressed upon the author by the results of his work is that the initial state of motion of the dust has an important effect upon the rapidity of the explosion. In the experiments recorded the most rapid motion was apparently obtained by concussion, and it was when concussion was employed that the most violent explosions were produced. Dr. Dugald Clerk has shown* that turbulence increases the rate of explosion in gas mixtures, and it is the author's belief that turbulence plays a greater part in determining the rate of explosion in a dust and air mixture than has hitherto been fully realised. Various experi-



menters in this country and abroad have observed that the explosibility of a dust-cloud depends to some extent on the velocity of the air, but, judging from published records, the explanation usually adopted has been that a certain velocity of air is necessary to keep the dust in a state of suspension. In the author's opinion the true explanation is to be found in Dr. Clerk's theory of turbulence. On this point, however, a final conclusion cannot be reached from the results here recorded, and in consequence further work is being carried on for the purpose of investigating specifically the effect of turbulence on explosions in tubes. As regards explosions in closed chambers, sufficient evidence has been gathered to prove that the rate of explosion does depend on the state of commotion of the dust and air.

Through the kindness of Mr. E. C. R. Marks, the experiments above described were conducted in the laboratory of Messrs. Marks and Clerk at Birmingham.

ICE-BREAKING RAILWAY-TRAIN FERRY "LEONARD."

Messrs. Cammell Laird and Co. recently completed, at their naval works at Birkenhead, an ice-breaking steam railway-train ferry for the Commissioners of the Transcontinental Railway of Canada, and a longitudinal section and deck plans are reproduced on page 211. As the port and starboard halves of the plans are practically symmetrical, we have given in each case only a half plan. The cross-section on page 213 shows the noteworthy features of the ferry—an elevating-deck with double railway track, whose height can be varied to suit the tidal range of the St. Lawrence River, in which the vessel operates. The vessel is designed for the special service of transporting passenger railway trains or freight trains across the River St. Lawrence, at all seasons of the year, between Quebec

* Gustave Canet Lecture, 1913; Dr. Dugald Clerk, F.R.S.

ICE-BREAKING RAILWAY-TRAIN FERRY FOR CANADA.

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, SHIPBUILDERS AND ENGINEERS, BIRKENHEAD.

Fig. 1.

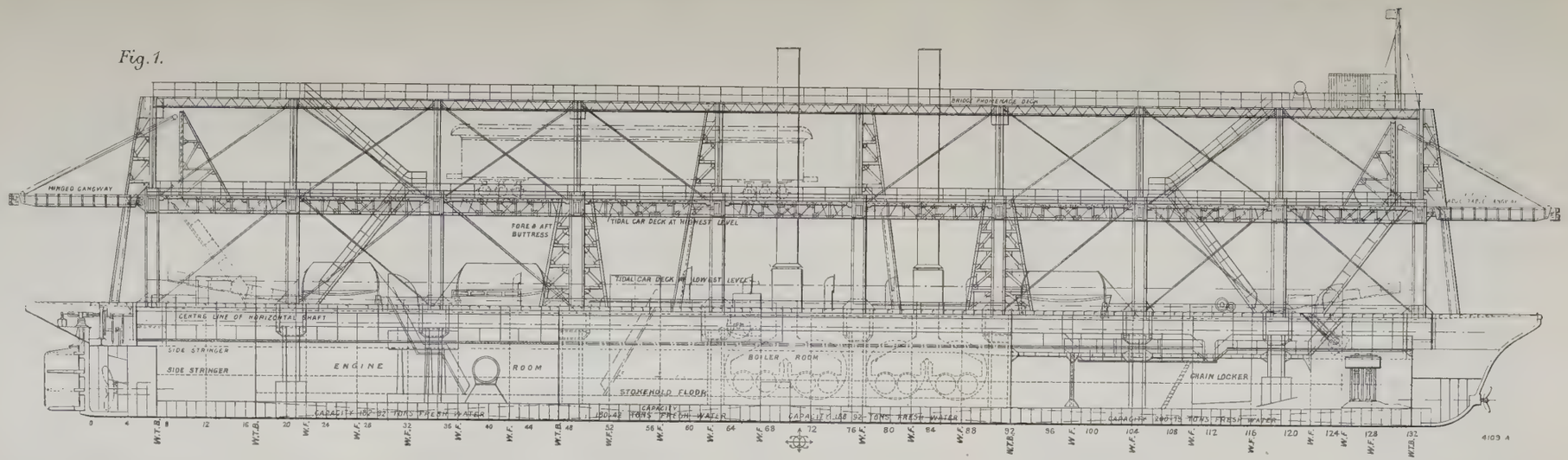


Fig. 2. BRIDGE PROMENADE

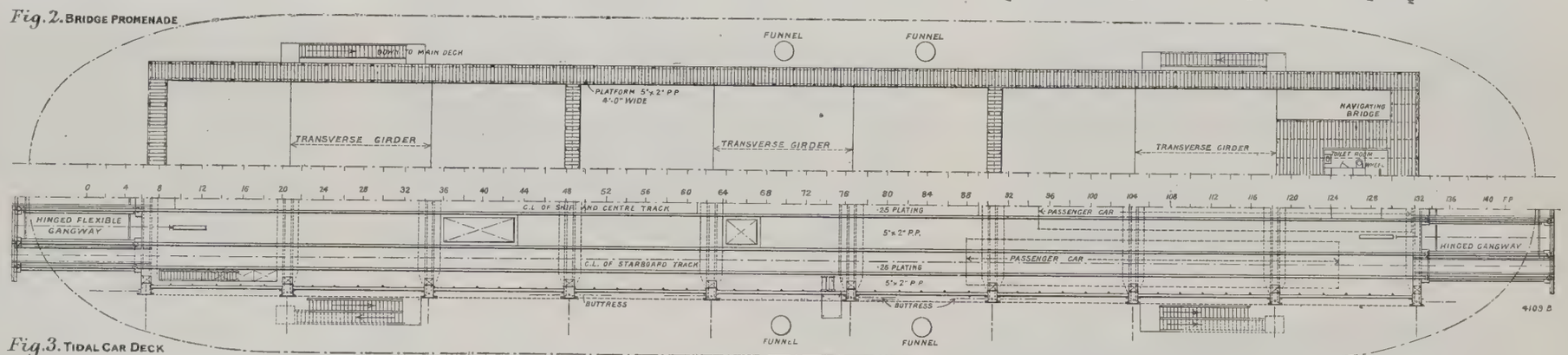


Fig. 3. TIDAL CAR DECK

Fig. 4. MAIN DECK

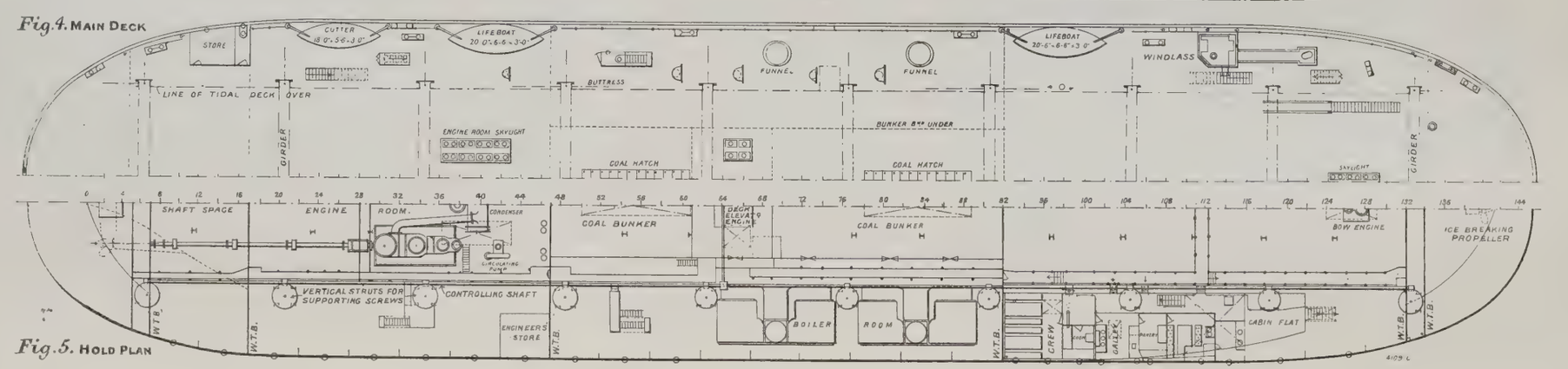


Fig. 5. HOLD PLAN

ICE-BREAKING RAILWAY-TRAIN FERRY FOR CANADA.

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Fig. 6. Screw for Elevating Train-Deck.

Fig. 7. Elevating Train-Deck Raised.

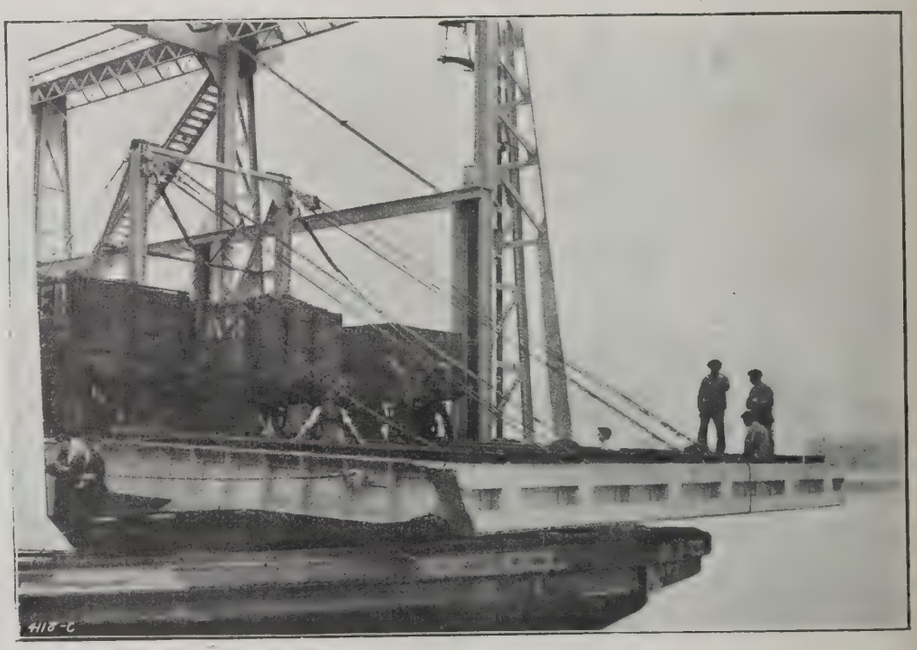


Fig. 8. Adjustable Hinged Gangway.

and Levis. The weight of the train to be carried is 1285 tons. The ferry has been designed so that the time taken in running the train on to the ferry, crossing the river (a distance of 2½ miles), and landing and coupling up the train, will not occupy more than three-quarters of an hour. The perspective views of the steamer on the present page and page 216 further illustrate this interesting craft. The principal dimensions are as follow :—

Length over all	326 ft.
Breadth, moulded	65 ,,
,, over fenders	66 ft. 9½ in.
Depth, moulded	23 ft.
Mean draught	15 ,,
Speed...	15 statute miles per hour.
Indicated horse-power of main engines	3200
Indicated horse-power of engines for ice-breaking propeller	420

The vessel is of the twin-screw type, with a third ice-breaking propeller at the forward end. She is designed in accordance with the requirements of Lloyd's Register, and is specially strengthened for navigating through ice.

As already stated, the special feature of the design is the elevating car-deck. The railway tracks on the landing-berths at Quebec and Levis are, of course, at a fixed level, and the tidal deck can be brought to a level exactly corresponding to that of the land railway terminals, and thus take coaches and locomotive from the fixed tracks at any state of tide, the range being 18 ft. The tidal deck, which is shown at its highest level in the longitudinal section (Fig. 1), is arranged above the main deck of the vessel, and is carried on ten transverse girders, the ends of which each rests on a large nut, and the revolving of a vertical screw causes the nuts to raise or lower the deck through the necessary range to suit the various conditions of the tide.

The tidal-deck vertical lifting-screws are hung from ball-bearings supported on strong columns (Fig. 6). These columns are stayed by lattice buttresses and bracing against fore and aft movement, as shown in Fig. 1, and in the perspective view, Fig. 12, page 216, while transverse thrusts are provided for, as shown in the transverse section, Fig. 9, and in the perspective view, Fig. 11. Below the main deck again a specially strong-braced strut is built in way of each column, which distributes the load to the keel of the ship (Fig. 9). The main deck and hull are also specially strengthened by additional intercostals, &c., to ensure sufficient strength to resist the stresses induced by the heavy loads on the tidal deck. The braced columns below the main deck also serve to carry the worm-gearing for lifting the tidal deck (Fig. 7).

Three lengths of track are fitted on the tidal deck, each supported on lattice girders (Figs. 3 and 9). The length of each track is about 272 ft. These are well shown in Figs. 11 and 12. At each end of the tidal deck an adjustable hinged gangway is suspended by means of triple purchases from struts fixed on the deck, as shown in Figs. 1 and 3, and in perspective in Fig. 8. These gangways are arranged with ball-and-socket joints at the ends of each of the girders carrying the rails, in order to allow for any heel of the ship, or any change of trim, which may take place while the train is passing on or off the ferry. A special motor is arranged in conjunction with each gangway for raising or lowering it. An electric winch with two winding-drums is fitted between girders of the tidal deck for hauling the carriages on or off the ship.

The machinery for raising and lowering the train-deck, which is placed amidships, as shown in Fig. 5, is of special construction throughout. The engine is of the four-cylinder high-pressure type, of massive design, driving through double helical spur-wheels, a second motion-shaft running athwartship. At each end of this shaft mitre-wheels are arranged for driving the fore and aft line shafting arranged on both port and starboard sides of the vessel, Fig. 5. At equal distances along this shafting worm and wheel gearing is fitted for turning the vertical lifting-screws, which are driven through a loose forged-steel sleeve and sliding-key arrangement, fitted into the boss of the wheel. Heavy gun-metal nuts, into which the screws work, are fitted into the structure of the train-deck, as already explained, the load coming upon the screws being taken up by special ball-bearings supported by the upper structure of the vessel.

Above the highest position of the carriages on the

TRAIN-FERRY FOR CANADA.

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, BIRKENHEAD.

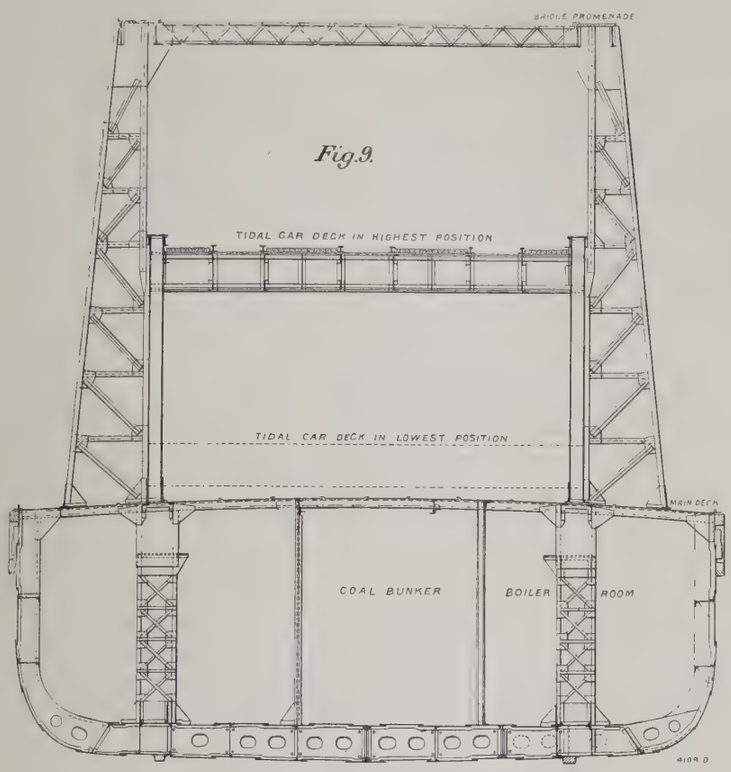


Fig. 9.

tidal deck a promenade is arranged all round the vessel, with a bridge platform at the forward end, carrying a pilot-house and chart-room, Fig. 2. This promenade and bridge are carried, as shown in Figs. 1, 10, 11, and 12, on lattice girders supported by the buttresses. Special arrangements are made to prevent any stress which would result from the bending moment on the hull being taken by the girders supporting the promenade.

The main deck, Fig. 4, so far as the part between the vertical screws is concerned, is only a covering for the coal-bunkers, machinery spaces below, and is fitted with skylights and hatches; but when the elevating-deck is at its lowest position it is close down to the main deck level, as shown in the perspective views, Figs. 10 and 12. On each side of the main deck, where space is found for the lattice buttresses, there are lifeboats forward and aft, as shown on the plan, Fig. 4, with companion-ways to the officers' and crew's quarters below and to the engine and boiler-rooms.

Accommodation is arranged for officers and crew on a flat below the main deck forward, on both sides of the ship, everything necessary for full day and night crews being provided (Fig. 5).

The boiler-rooms are arranged in the wing compartments on the port and starboard sides amidships, with the coal-bunkers and tidal-deck engine-room between them (Fig. 5). The main propelling engines are situated centrally abaft the bunkers, and the engines for the ice-propeller in the hold just abaft the fore-peak bulkhead (Fig. 5). A special feed-water tank is built in the double bottom, extending from bilge to bilge for a length of three frame-spaces. Ample local stiffening is arranged to allow of the bottom being perforated, to ensure a sufficient supply of water when working in ice.

The propelling machinery is of a design which Messrs. Cammell Laird and Co. fit to the large number of merchant ships built at Birkenhead, and which has proved of great economy and reliability. The two sets are of triple-expansion surface-condensing type, with cylinders 23 in., 35 in., and 55 in. in diameter and a 33-in. stroke, and designed to run at 120 revolutions per minute. A special feature of the machinery is the shafting, which is made throughout much stronger than usual, to stand the "shock" should the propellers strike solid ice. The propellers themselves have also been made especially strong for this reason, and are of nickel steel. At the forward end of the vessel a set of compound surface-condensing engines is fitted, having cylinders 15 in. and 32 in. in diameter by 21-in. stroke, driving a nickel-steel propeller at the bow for clearing ice from the landing-stage. This propeller is arranged to run idly when there is no ice. Steam is supplied to all the machinery by eight single-ended boilers working under natural draught, and constructed for a working pressure of 165 lb. per sq. in.

A complete installation of auxiliary machinery has been fitted. The pumping and heating arrangements are exceptionally complete, special arrangements being made for heating the railway carriages during transit. The vessel is fitted with electric light throughout. Two powerful steam windlasses are fitted, one on each side of the ship, with slip-drums for mooring.

The hull and machinery, which were made to comply with Lloyd's requirements, were constructed under the supervision of Mr. J. E. Hamilton.

LITERATURE.

Screw-Propellers and Estimation of Power for the Propulsion of Ships. By Captain Charles W. Dyson, U.S. Navy. Vol. I., Text; Vol. II., Atlas. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 31s. 6d. net.]

In 1901, while serving as an assistant in the Bureau of Steam Engineering, United States Navy Department, Captain Dyson was requested by the Engineer-in-Chief to prepare a paper on the performances of the screw-propellers of naval vessels.

The preparation of this paper so interested him in the subject that he has continued its study ever since, and has from time to time communicated papers on the design of propellers which have been published in the Journal of the American Society of Naval Engineers. These papers have been widely read, and have justly caused Captain Dyson to be regarded as one of the leading writers on screw-propulsion. The book under review, which is published in two well-got-up volumes, one devoted to letterpress and the other to charts and diagrams, is a *résumé* of these various papers, from which all statements and deductions which later study has shown to be erroneous have been eliminated.

The author states that the theory of design set forth in this book is based on the tank trial curves of model hulls supplied by Mr. D. W. Taylor, and upon Froude's theory of the propeller, as developed by Mr. S. W. Barnaby in his work on "Marine Propellers," as well as upon the data of trials of actual vessels of the United States Navy. The book opens with a prologue giving a short history of the development of screw propulsion. Chapter I. is devoted to the subject of appendages, block coefficients, thrust deduction, and appendage resistance. The author is of opinion that curves of effective horse-power obtained from model trials of the proposed hull give the only satisfactory basis for estimating the power required for its propulsion; but as model trials are almost always made on a naked hull, without any appendages, the increase of effective horse-power due to the resistance of these has to be estimated independently, and there always must remain considerable uncertainty as to their combined effect. The resistance of bilge-keels and shafts is taken as due to the friction of their wetted surface only. The other appendages enter into the residual resistance due to wave and eddy making and are estimated as varying according to Froude's law of comparison, although the correctness of this law as applied to such forms is not certain. Captain Dyson gives a chart showing the percentage of increase of resistance above the naked-hull resistance for each form of appendage, such as rudder and post, bilge-keels, shafts and shaft struts, and docking-keels. These resistances are supposed to vary directly as the ratio of beam to length of vessel for standard forms of forward and after body lines, and the appendage resistance curves on the chart are based on a block coefficient of about 0.6. Another chart is given showing how much the appendage resistance is increased by diminished wake when the block coefficient is finer than the standard, and how much it is reduced by increased wake when it is fuller. A chart is also given to enable designers to estimate the correction to be made for variation in thrust deduction due to the fullness of after-body lines. Were it not for the two elements of wake and thrust deduction propeller problems would be much simplified. The effect of the wake is to increase propeller efficiency, the effect of thrust deduction is to reduce hull efficiency. The object of a designer should be to so place his screws as to take the greatest advantage of the wake to reduce slip without increasing thrust deduction, and with it the effective horse-power. The recent paper by Mr. Luke, read at the spring meetings of the Institution of Naval Architects, upon the efficiency of screws placed one behind the other, and revolving in opposite directions, as in torpedoes, illustrates the very large effect of wake and thrust deduction on total efficiency.

These combination screws in open water are shown to have only 86 per cent. of the efficiency of twin-screws, yet when placed behind a full-bodied vessel, where they each get the fullest advantage from the frictional wake, and have the least effect upon thrust deduction, the gain is not only sufficient to make up for the bad efficiency of the propellers themselves, but to show a net gain of 15 per cent. in total efficiency as compared with twin-screws. This advantage rapidly disappears as the fineness of after-body is increased and the effect of wake diminished, until in very fine forms of hull the efficiency is only equal to that of twin-screws.

The two charts of Captain Dyson, to which we have referred, are, so far as we know, the first attempt to give a graphical guide to the correction needed for varying conditions of wake and thrust deduction, and are consequently of special interest and value. Chapter II. is devoted to a description of the different methods in use for estimating power, and a very concise and lucid explanation is given of the method of deducing power from model experiments, illustrated by a concrete example.

Chapter III. is upon theories and methods of design of screws. Any idea of designing propellers from purely theoretical formulæ has long since been discarded as impractical, and the only methods in use are: (1) By direct comparison when all the conditions for a vessel of similar form to the one under consideration are known. (2) By methods based on trials of model propellers in tanks. (3) By methods based on trials of full-size propellers in service. The author's plan consists of a combination of all three. Representing Barnaby's constants obtained from model trials graphically as a chart, he has plotted the performances of a

large number of actual ships' propellers upon the chart, and from these results a number of factors directly affecting efficiency have been so co-ordinated graphically as to render it possible to take from those charts the necessary factors for use in determining the diameter, pitch, projected area, and probable propulsive coefficient for any desired case when the resistance and form of hull are known.

Chapter IV. discusses forms of blade and blade sections, and the effect of variation of width of blade.

A very large number of diagrams showing the propellers of actual ships in the United States Navy are given, together with the form of the blade sections; and there seems to be hardly a conceivable form of section which has not been tried upon one ship or another, but the author's conclusion is that the ordinary form, in which the back of the blade is an arc of a circle, and both edges are made as thin and sharp as possible, gives the best results. Towards the root of the blade, where, due to the thickness of metal, the angle of the back is steep, he thinks it advisable to slightly fine the entrance of the blade by throwing back the leading edge. This is a common practice in this country. Succeeding chapters deal with the effect on pitch of twisting blades in the boss, with material for construction, with the effect of change of blade form, of blade surface, of pitch ratio, of number of shafts, and of location of propeller, on propeller efficiency. A number of problems are worked out in detail, showing how to use the various charts in designing propellers for different conditions, and this will assist those wishing to make use of them.

In a chapter on "Cavitation," after describing the trials of the destroyer Daring, when the phenomenon of cavitation was first recognised and defined, the author quotes the opinion of Mr. D. W. Taylor that the tip speed and the shape of the blade section are the prime factors involved, and states that, in his own opinion, the thrust that can safely be used on any particular propeller depends on the form of the after body of the hull, and he gives a chart derived from performances of numerous vessels showing the safe thrust to be used with different values of block coefficient.

As regards the influence of blade section in producing cavitation, Captain Dyson considers that "of two sections of different form, offering approximately the same resistance to motion through the water, that section which produces the greater increase of actual over nominal pitch will produce the earlier cavitation." The meaning of this statement is, however, not quite clear, as it would seem to lead to the conclusion that a section in which the metal of the blade was divided evenly on each side of the nominal pitch surface—the real pitch being then equal to the nominal pitch—should give the best results, at least as regards cavitation; yet, as Captain Dyson states elsewhere that with blades of this section the resultant thrust per revolution is much lower, and the apparent slip much higher, than with blades of the same nominal pitch but of different section, it would not seem to be a form to be recommended.

Very remarkable blade sections have recently been proposed by distinguished experimenters with the object of avoiding cavitation, but none of them, so far as we know, has as yet advanced beyond the theoretical stage. Is there some truth in the words of an eminent engineer quoted by the author? "Any man can design a good propeller, but it takes an exceptionally fine engineer to design a bad one."

Le Moteur Humain et les Bases Scientifiques du Travail Professionel. Par Jules Amar, Directeur du Laboratoire de Recherches sur le Travail Professionel. Avec une Préface de Henri Le Chatelier. Paris: H. Dunod and E. Pinat. [Price 12.50 francs.]

Economic psychology has of late had many exponents. The prospect of attaining increased efficiency in production, and at the same time diminishing fatigue, is very attractive. In this work the author does not attack the more abstruse problems of psychology, which in some aspects are apt to grow a little whimsical, and the treatment to be more curious than practical. He is content to lean rather to the physiological side, to consider the mechanism of the human machine, how it is to be handled to produce the best results, the causes that make for and against its effectiveness, and the devices employed in measuring the results obtained under given conditions. Even thus limited there is ample scope for inquiry, and we believe success will be more marked if the older methods of experiment and measurement are adopted for tools of research, rather than by directing analysis to the resolution of intellectual processes. There is also a grave necessity for inquiry, since it may be admitted that the average individual, as the result of a definite amount of fatigue and exhaustion, effects far less than his maximum possible. He would gain in health and usefulness if his efficiency were judiciously developed, while the gain to the community through improved economy would be enormous.

M. Amar divides his treatise into six sections, and by aiming at complete treatment makes the subject rather tedious and forbidding. The first book, devoted to the consideration of the principles of mechanics, is of that elementary character that would of necessity be familiar to students interested in, or capable of furthering, the object of this work. The second book deals with the human frame, its muscles and nerves, its method of nourishment and its expenditure of energy by various means. The same subject is continued into the third division, which deals almost entirely with energy, and the physiological effects of work and fatigue. Next is considered how the human frame is affected by the medium in which it finds itself, and how its capacity for work is modified by such external conditions as temperature, humidity, light, deleterious vapours, &c. Having submitted the human machine to a great variety of conditions, the author is in a position to describe the instruments for measuring the amount of work performed in various directions, or the signs and amount of fatigue exhibited. This section is very interesting, because a great amount of ingenuity has been expended in devising suitable apparatus for measuring effects, and in arranging experiments that should be typical and decisive. In the last section we approach the main purpose of the treatise to describe the conditions, mechanical and physiological, that are most favourable to the better production of work.

In an appreciative preface M. Le Chatelier would persuade us that this work ought to serve as a guide and encouragement to inspectors and foremen in manufactories. He thinks that, on the one hand, the suggestions and experiments would prove useful to the employer, and that, on the other, they would ensure the hearty co-operation of the workman, since the object is to obtain the maximum output of work with the minimum expenditure of energy, or the reduction of personal fatigue. He contends that it is to the interest of employers and employed alike to reduce to a minimum the wear of the human machine. "If," he says, "the economical working of a steam-engine has been the object of so much care and thought, *a fortiori*, more attention should be bestowed on the living mechanism." This is undoubtedly true, but unfortunately masters and men are likely to differ as to the proper means of sustaining the efficiency and of getting the most economical return from the living machine, the human factor. Moreover, the workman is apt to object to being made the subject of experiment. Not only does he resist being treated like a machine, but, not comprehending the object of the inquiry, he fears being duped and made to suffer for the seemingly harmless wiles of science. M. Amar himself has experienced some of the recalcitrant ways of the workman, who recoiled from the monotony of carrying weights a definite distance, receiving in return "une ration alimentaire d'entretien approprié à son travail." In despair, M. Amar betook himself to Algiers, and in a less sophisticated society found suitable subjects, who did not object to the monotony of existence imposed by devotion to scientific ends.

But, admitting the experiments to have been carried out successfully, and scientific selection made of certain workers peculiarly qualified for certain tasks, the case does not appear so simple as M. le Chatelier puts it. We have not only to consider the human apparatus as a tool adapted for the performance of certain movements, but we have to consider the sociological aspect. More work is accomplished by what the employer calls "scientific management," but to which the employee gives a very different name, embittering the relation between the two parties to the contract. The advantages of following exact method are more on the side of the capitalist than on that of the labourer. The eternal friction and struggle between capital and labour are made more bitter and virulent, for though wages may be increased, the margin of improvement will lie with the employer. Except markets were very largely increased, of which there is no sign, the output of work would remain little altered, and therefore the competition of workmen, all able to effect more in the same time, would become so keen that wages would tend to a lower level, and the discrepancy of reward to the possessors of capital and of labour respectively would be more marked than ever. We shall not rid ourselves of many of the social problems that make life so difficult by the scientific training of human nerves and muscles to perform particular tasks with automatic and regular rhythm. The whole of this question is not to be solved in the psychological or physiological laboratory. Statesmen and sociologists, trained in a different school, would alike acknowledge that the application of a science that tended to increase the tension in our industrial system was to be deprecated, and would view with alarm any considerable disturbance of existing methods.

For it must not be supposed that the outcome of those who are studying new and economical methods affects only a small issue, something of the nature of a fad wherewith to tickle the imaginations of *dilettante* employers. In its entirety it involves something akin to an industrial revolution. After making every allowance for the ardour of pioneers and enthusiasts, it has been amply demonstrated by Taylor and others, whom M. Amar quotes with admiration, that it is possible in certain cases, by the scientific study of the physiology of movement, to double or treble the effective work without increasing the exertion of the worker. It is difficult to realise what this means or what it could avail under the stress of keen competition. In the Bethlehem Steel Works, under Taylor's supervision, it was found possible to quadruple the amount of cinders and slag shovelled per man by slight improvement in method and tools. The author quotes a case of the building of a wall 0.30 metre thick, in which, by the old method of bricklaying, stereotyped by long usage, it was possible to lay 120 bricks per hour per man. Under new methods, which Mr. Galbreth determined after a rigorous analysis of the various movements, it was found possible to place 350 bricks per hour per man—practically a triple output. The author and writers on this subject have to overcome the difficulty of persuading us that some simple operation, that we have watched every day, representing the accumulated experience of centuries, can be improved. But it is the peculiar merit of psychological and physiological economy, a science of which M. Amar is an able exponent, to teach us that success is not attained by blind repetition, nor efficiency promoted by following our conservative instincts.

Elementary Practical Mathematics, with Numerous Exercises for the Use of Students, and especially of Mechanical and Electrical Engineering Students. By John Perry, M.E., D.Sc., LL.D., F.R.S. London: Macmillan and Co., Limited. [Price 6s.]

"Some friends of mine assert that no man or boy ought to be allowed to use logarithms until he knows how to calculate them. They say this, knowing that the calculation is a branch of higher mathematics, and that the average schoolboy, after six years at mathematics, finds it hopeless to even begin the study of the exponential theorem. It is a hard saying; . . . it is the sort of unfeeling statement which so well illustrates the attitude of the superior person." This extract from Professor Perry's book strikes the keynote of his attitude towards the antiquated method of teaching mathematics; and if there is any answer to it, we do not know it, for the plea that has been raised by members of the old school, that the advocates of a more advanced scheme would sacrifice thoroughness to a desire to cover the ground quickly, leaves us unconvinced. Professor Perry was early in the field demanding for his students and for the engineering profession generally the tools that were best adapted for progress. He saw more clearly than most the necessity of separating the education of the mathematician, properly so-called, from the educational training of the man who was to use his mathematical knowledge, however acquired, in the pursuit of applied science. The one should be engaged in devising new tools, in advancing the frontiers of pure science; the other, in using the tools ready to his hand. Dexterity in application is not to be despised. To get from the average man a result, a correct result, with speed and certainty, is no mean achievement, though he may not be able to

differentiate and integrate more than a few of the simplest functions that are met with in applied science. By the directness of Professor Perry's iconoclastic attack, many a student of nimble brain and fingers, whose road was blocked by the artfully-constructed conundrums of a mistaken ingenuity, sees a useful career opening before him. Now that the victory has been won all along the line, there is no necessity to labour the point over which the struggle was keen a few years ago. The attack was first delivered against the hallowed worship of Euclid, and the fall of the idol has been complete. If any testimony were needed to the value of the reforms introduced, it might be found in the attitude assumed by Germany, whose mathematicians, justly credited with the desire of creating a sure and sufficient foundation for superstructure, now recommend the teaching of geometry much as Professor Perry would teach it, by rule and compass, by drawing and by work, which familiarises geometrical concepts.

One might go a step further and ask, as he sees the uses to which the author turns the squared paper, the slide rule, and other time-saving and educative devices, whether our pedagogic methods have not all erred by leaning too much to the literary side. In Professor Perry's words, "we still teach as if all average boys were proceeding to classical studies at the University, and preparing to be clergymen or schoolmasters." It is to be regretted that the prospect of future vocation is excluded from the school of to-day. Educational theory condemns the utilitarian as contemptible. We do not think that this is the author's view. An industrial nation can only hold its own in these strenuous days, if it recognises the necessity of cultivating at an early age the industrial ideas and powers of those who are to fill responsible positions. Where much has to be learned, economy of time cannot be overlooked. To keep our workers unproductive in order to satisfy the philosophical cravings of the pure mathematician is a policy of doubtful value. It would seem to be a worthier aim of the educationist to see the teacher inspiring in his pupil ambitions and ideals concerning his future work, and training in him the beginnings of the skill and power to engage in it.

Though Professor Perry has been a protagonist in the strife for improved mathematical teaching, this volume contains, we believe, his first serious attempt to cover the whole of the ground needed by the practical engineer, under the ordinary conditions of the profession. He has given courses of lectures demonstrating his method, and has encouraged teachers in various ways to break from the old trammels. A summary of specimen lectures given to working men was published under Government auspices, but he complains that the teachers do not to any extent consult the text, and fail to profit by the exercises and criticisms offered. Apparently he has met with more success in the case of provincial teachers, who come to London for a three weeks' course in the summer. These teachers are earnest and qualified mathematicians, who themselves select the subject of the lectures, and by their suggestions have influenced the form and direction in which some of the advanced exercises appear in the volume. In 1912, this class chose the subject of harmonic functions, and the chapters given towards the end of the book concerning vibrating bodies, alternating currents of electricity, submarine telegraph and telephone circuits, heat conduction, &c., are the consequences of these lectures. The exercises attached to these chapters are addressed to a wider audience than appears on the surface. They could be adopted to problems more immediately connected with mechanical engineering or general physical problems by substituting other technology than that of the electrician. Herein is perhaps suggested the merit, as well as the difficulty, of constructing problems that shall appeal to students of various branches of technology, test their capacity and intelligence, and avoid quibbling complications. In many cases, Professor Perry tells us, several hours' work was necessary before he satisfied himself, and in some instances even days.

But though the treatment of the more advanced branches of mathematics is inspiring and illuminating, the peculiar features on which Professor Perry insists are best illustrated in the more elementary chapters. Only a few students can become interested in periodic functions or problems in the calculus, whereas thousands of boys might be benefited by what the author has to say concerning arithmetical processes, mensuration, the solution of plane triangles, &c., and would express their satisfaction, no doubt, at learning there is "some hope of Euclid, and of all the recent pretences of a reform of Euclid, disappearing from our school-teaching in time." Also hundreds of teachers might be enabled to make their work more entertaining and purposeful by grasping the general principles underlying the scheme, and lighten the lot of the coming generation. They should be induced to follow the less arid paths by remembering the melancholy fact that classes in pure mathematics conducted on the exploded methods of past centuries are seen to grow gradually less in numbers as the course advances, whereas a class in practical mathematics keeps up its attendance almost intact to the end of the session. Looking at the book as a whole, as the outline of a matured scheme, we have not dwelt upon any one chapter showing its merits or its supposed deficiencies. We might have asked, for instance, why "Vectors" are banished to the end of the book, thus preventing a powerful machinery being put into the hands of the inquirer, or suggested some further ingenious applications for the use of the slide-rule or of ruled paper; but in a book of this character details are of little importance. It is the entire scheme which has to be considered, its capacity to fulfil a distinct purpose, its suggestiveness in the hands of a competent teacher, its flexibility, and its comprehensiveness. The object of this valuable treatise is to teach how to teach, and its merit must be judged by the influence it exerts.

A Text-Book on Trade-Waste Waters, their Nature and Disposal. By H. MacLean Wilson, M.D., B.Sc., and H. T. Calvert, M.Sc., Ph.D., F.I.C. London: Charles Griffin and Co. [Price 18s. net, bound.]

The authors of this volume, Dr. H. MacLean Wilson, Chief Inspector to the West Riding of Yorkshire Rivers Board, and Dr. H. T. Calvert, Chief Chemical Assistant to the same Board, have compiled a most useful and instructive book, which will be appreciated by members of local authorities who are frequently called upon to vote on technical matters which they hardly understand, as well as by manufacturers who are troubled to know what to do with their waste waters. A county councillor of our days should be something of a universal expert on legal and technical problems properly to discharge his duties when deciding upon concessions to be granted and regulations to be laid down, and he will be grateful when he can obtain general independent advice, instead of, or in addition to, the special expert opinions which the contending parties place before him. Such general disinterested advice, legal as well as technical, he will find in the book before us. The term "text-book," used in the title, is not well chosen, perhaps, though not inappropriate; the term might suggest the lecture-room and young students, whilst the authors offer an account of their own experience of the working of the Rivers Pollution Prevention Acts to men who have to make up their minds as to how to face practical difficulties. The authors had the good fortune of securing assistance from manufacturers and engineers who readily gave information on particulars of their trade processes and purification works, and the 340 pages of this volume are all the more valuable, as Continental and American practices receive due consideration.

Up till the middle of the past century industrial waste waters, frequently together with crude sewage, were simply discharged into the nearest streams in this country. The law hardly interfered. By 1865 matters had become intolerable, and a Royal Commission was appointed to inquire into river pollution. The first report of that Commission spoke out clearly enough; but the Rivers Pollution Prevention Act of 1876 remained a dead letter, because "its administration was entrusted to the care of a multitude of sanitary authorities, nearly all of whom were themselves gross offenders." The Local Government Act of 1888 placed the power of enforcing the Act of 1876 into the hands of the County Councils and their joint committees, which had jurisdiction over large areas, so that one joint committee could be formed to deal with the whole course of a river. Such joint committees are the Irwell and Mersey and the Ribble Committees of 1892, and the West Riding Rivers Board of 1893; the Middlesex County Council obtained extended powers in 1906. The Lea Conservancy Board, an ancient body, reconstituted in 1868, and the Thames Conservancy Board, incorporated in 1857, are likewise competent to deal with pollution. Another Royal Commission was appointed in 1898 to report on the disposal of sewage, including liquids from factories. This Commission, which is still sitting, has already issued seven reports.

It is noteworthy that several authorities have adopted the principle of receiving the crude refuse into the sewers and accepting a payment from the manufacturers in lieu of insisting upon a preliminary treatment. As the law stands at present, however, the authors point out, any legal proceedings against manufacturers for river pollution are hampered by restriction and saving clauses in the Acts of Parliament. When Mr. Milnes Gaskell, in discussing these matters with Mr. Gladstone, used the phrase that "Parliament had been very lenient to manufacturers," Mr. Gladstone replied: "Say far too cowardly." That such statement would still be justified is proved by chapters I. and XII. of this volume; the latter chapter deals in particular with the legal aspect of sewage disposal.

The book covers a very wide range of problems. The different sections are headed: The coal trade; coal-gas manufacture; grain-washing, malting, brewing, and distilling; the leather trades; the paper trade; the textile trades (three chapters); miscellaneous trades; pumps, screens, tanks, filters, and other apparatus; a thirteenth and last chapter describes methods of analysis and limits of impurity. An alphabetical index—carefully compiled to all appearance, though we cannot find zeolites, but find due reference to the permutit process—concludes the volume. The authors describe the respective processes briefly, explain the nature of the waste waters produced, and tell us how these waters are dealt with in various localities, illustrating the respective plants and apparatus by 74 figures, including 22 plates. At the end of each chapter a list of the literature on the subject is given. Most of these lists are excellent, up-to-date, and by no means confined to British authors; German books are, in fact, conspicuous, as one would expect. The literature list on textiles is rather short though, particularly when we consider that the three very good chapters on textiles comprise bleaching and dyeing. Grease extraction and distillation and sheep-washing, as well as galvanising, alkali manufacture, oil-refining, tar-spraying of roads, glue, size, bone-boiling, creamery refuse, sugar and starch, ore and china-clay washing, &c., are dealt with in the chapter on miscellaneous trade, in rather odd order.

Though the names of the publishers are stated in the lists of books, the initials of the authors and readers of papers, mentioned in the subject matter, should also have been given; it would further facilitate hunting up references. Messrs. Wilson and Calvert have done so much for the reader that we may allude to this point. The field is wide; it would be inadvisable to enter into details. But the authors cover large ground. They do not bore us with generalities and repetitions; they come at once to the point, describe many useful contrivances of practical merit in clear, concise language, and they fully justify the title of their book.

BOOKS RECEIVED.

British Shipping: Its History, Organisation, and Importance. By Adam W. Kirkaldy. London: Kegan Paul, Trench, Trübner and Co., Limited. [Price 6s. net].

Swindon Engineering Society: Transactions, 1912-13. Edited by H. Holcraft, Honorary Secretary. Swindon: Published by the Society. [Price 5s.]

Marine Engineering. By Engineer-Captain A. E. Tompkins, R.N. (Ret.) Fourth edition, revised and partly re-written. London: Macmillan and Co., Limited.

The Motorists' Workshop: A Hand-Book for Amateur Mechanics. Second Edition. London: Temple Press, Limited. [Price 1s.]

Guide to Patents, Trade Marks, and Designs. Seventh Edition. London: J. S. Withers and Spooner, Staple House, Chancery-lane, E.C.

The Railway Library, 1913, *Fifth Series. A Collection of Noteworthy Addresses and Papers mostly Delivered or Published during the Year Named.* Compiled and edited by Slason Thompson, Director of Bureau of Railway News and Statistics, Chicago. Chicago: R. R. Donnelley and Sons Company. [Price 50 cents.]

Annual Report of the Minister of Mines for the Year Ended December 31, 1913, *being an Account of Mining Operations for Gold, Coal, &c., in the Province of British Columbia.* Victoria, B.C.: The Government of British Columbia.

Ships and Shipping. Two volumes. London and Edinburgh: Thomas Nelson and Sons. [Price 1s. net, each volume.]

ICE-BREAKING RAILWAY-TRAIN FERRY FOR CANADA.

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO, LIMITED, SHIPBUILDERS AND ENGINEERS, BIRKENHEAD.

(*For Description, see Page* 210.)

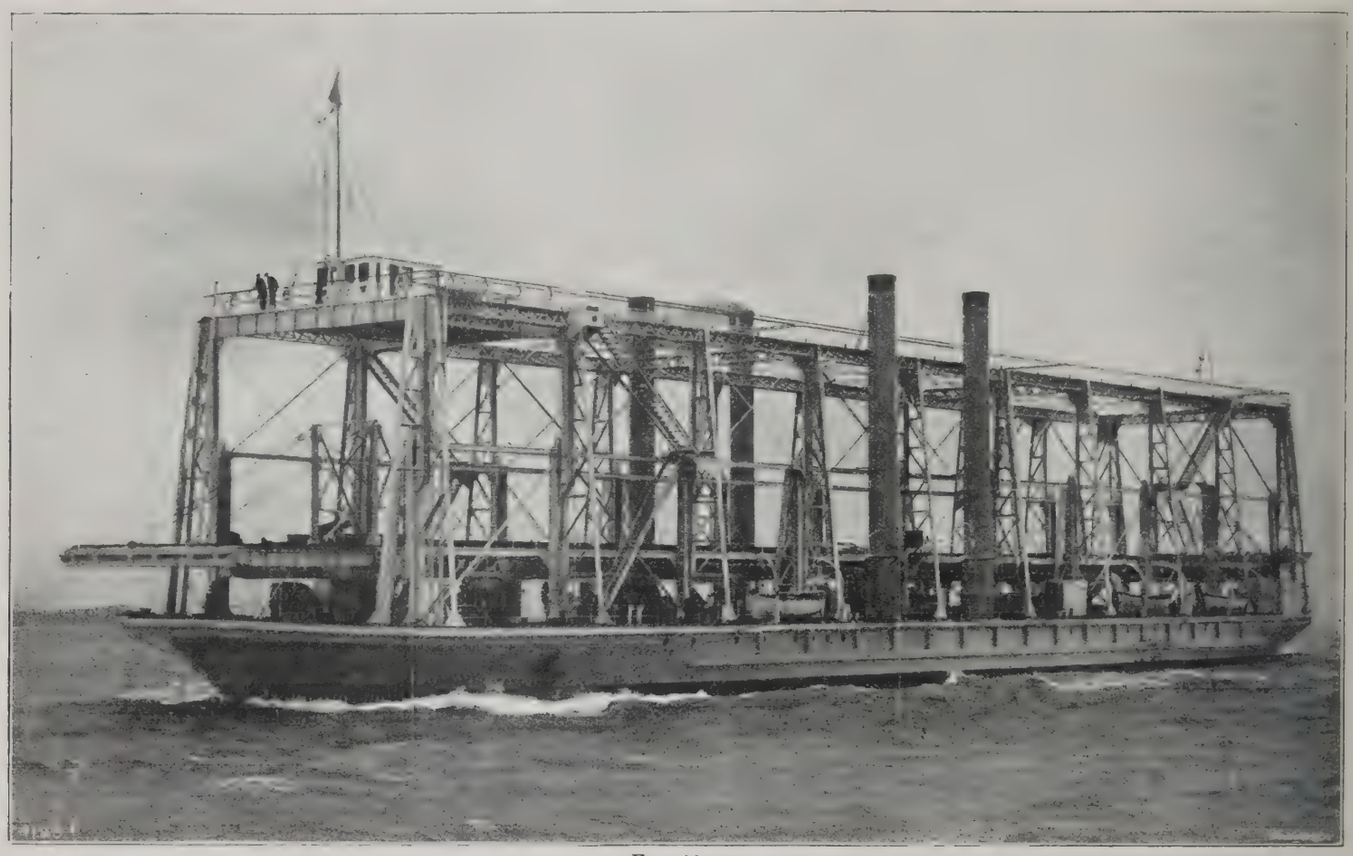


Fig 10.

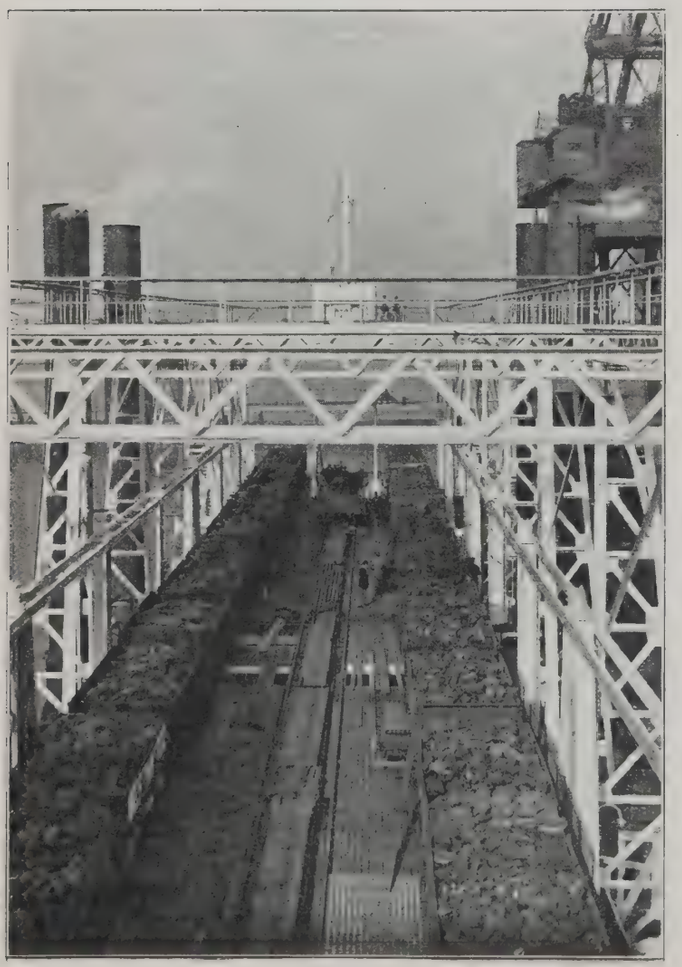


Fig. 11.

Fig. 12.

THE ALEXANDRA DOCK EXTENSION AT NEWPORT.

(*Concluded from page* 180.)

In this the final article of the present series we propose to say something of the new pumping and power-station which has been built in connection with the dock extension. The station is at present equipped with pumping machinery for maintaining the level of water in the dock and also ultimately for pumping out the graving dock which it is intended to construct on the west side of the lock. The station also contains electric generating machinery for supplying light and power for the general purposes of the dock. Ultimately it will probably be extended and will also contain pumping plant for the hydraulic power system. In the first instance we will deal with the dock pumping machinery, which is the most important part of the installation. In the first article of this series we made reference to the fact that the water in the dock system is maintained at a higher level than high-water of ordinary spring tides. The height maintained is 3 ft. above this level. As a result of this arrangement the whole of the wastage of locking has to be made good. The old Alexandra Dock is supplied with make-up water from the Ebbw River by means of a feeder which connects the north end of the dock with the river at Bassaleg, about 2 miles inland. This supply ultimately became insufficient, and was supplemented about nine years ago by an electrically-driven pump on the south jetty of the North Lock. The construction of the dock extension and the new lock has now necessitated a still further increased supply, and the new station has been built to meet the demand. It is situated on the east side of the lock entrance, and is indicated in the plan of the dock given in Fig. 1, on page 33 *ante*.

A plan and cross-section of the station are given in Figs. 146 and 147, on Plate XIX. It is in the main a brick building with slate roof. The foundations are of concrete, and their construction necessitated some very heavy trench work. A general idea of the arrangement will be gathered from Fig. 147. The station is divided into a main engine-house, 170 ft. long by 47 ft. 6 in. wide ; a boiler-house, 108 ft. long by 53 ft. wide ; economiser, water-softening and feed-pump houses. The northern end of the engine-house is devoted to the electrical plant, which consists of two 500-kw. generating sets, space being provided for a third. The floor of this part of the engine-house is at quay level, but there is a basement below at about 13 ft. below quay level, which contains the condensing plant. The southern portion of the engine-house, in which the pumping plant is installed, has its floor level at about 25 ft. below quay level, and an asphalt course has been run through the whole structure in order to ensure dryness in this sunk part of the building. The pumping-plant consists of two steam-driven centrifugal pumps, and space is reserved for a third.

Below the floor of the lower part of the engine-house there is a suction-chamber from which the pumps draw their supply. It consists of a brick-lined chamber 78 ft. long by 25 ft. wide by 17 ft. deep, and is shown in section at the right-hand side of Fig. 147. The southern end of this suction-chamber is connected to the River Usk by a brick culvert, the entrance to which is in the east wall of the lock outside the outer gates. A similar culvert connects the northern end of the chamber with the outer compartment of the lock, the intake being in the east wall of the lock opposite the northern end of the power-station. These culverts can be seen in Fig. 146. Each of them is provided with hydraulic and hand sluices similar to those used on the lock levelling culverts, and already described and illustrated in the second article of this series. The outer end of each culvert is fitted with wrought-iron grids to prevent foreign bodies from being carried into the pumps. In order to deal with the water from the graving dock which it is proposed to build on the west side of the lock, two culverts, each 7 ft. in diameter, have been constructed across the lock, connecting with a well in the suction-chamber near its southern end. These culverts are of cast iron, embedded in the concrete of the lock walls and invert. The western ends of the culverts have been temporarily closed with brick head-walls, which will be removed when the graving dock is built. Sluice-pits have been provided on these culverts between the power-station and the lock, in which hydraulic sluices will be installed when required. The paddles for these sluices are already in place. Immediately to the south of these sluice-pits a drainage-shaft has been formed in the concrete of the lock-wall. Pipes connect the bottom of this shaft with the culverts under the lock, and suction-pipes have been put in connecting the drainage-shaft with the south-west corner of the engine-room, so that drainage-pumps can be installed when required to deal with the leakage into the graving dock when it is empty. The graving-dock culverts, sluice-pits, and drainage-pit are shown in Fig. 146.

At the south-east corner of the engine-room a two-storied store has been built, with a line of rails at quay-level on top of it. This line of rails is connected with the company's railway system, so that a truck containing heavy parts of machinery can be brought into the station and unloaded by the travelling crane which spans the engine-house. This store can be seen in Fig. 147. Below its bottom floor a drainage sump has been formed, in which is fitted an electrically-driven centrifugal pump, controlled by a float. The internal drains of the engine-house, and steam-pipe and other drains, are led to this sump, and the water collecting is discharged to the river by means of the pump. Access to the foundations of the main pumping-engines, and to their lubricating-pumps and oil-tanks, is provided by means of a tunnel under the east side of the engine-room floor. This tunnel is shown in both Figs. 146 and 147. The foundations of the main engine-house under the suction-chamber are carried down to the marl, while the remainder of the engine-house is founded upon the gravel which overlies the marl.

The boiler-house, which is situated to the east of the main engine-house, contains four Lancashire boilers, while space is available for five more. As shown in Fig. 146, the economiser, feed-pump, and water-softening houses are situated immediately to the south of the boiler-house. The foundations of the boiler-house, water-softening, and feed-pump houses, and part of the economiser house, are supported on concrete piers carried down to the gravel, the intermediate spaces being spanned by brick arches. The remainder of the economiser-house, and the low-level coal-bunker to the east of the boiler-house, are carried on timber piles. Part of these arrangements can be seen in Fig. 147. Arched voids are formed in the heavier foundations at various points, and immediately below the feed-pump house a concrete storage-tank has been formed in the foundations, in which a supply of water can be stored in case of failure of the ordinary supply. The chimney, which is situated to the south of the economiser-house, as shown in Fig. 146, is of brick, 187 ft. high from the bottom of the main flue, and is 7 ft. 9 in. in diameter at the top. The foundation consists of a block of concrete 35 ft. square carried down to the marl. The buildings, as we have already said, are mainly of brick throughout with boarded and slated roofs. The economiser-house is an exception, however, as it is constructed of steel framing covered with galvanised iron. Upon the roof of the feed-pump house is a cast-iron water-storage tank, part of which forms a reservoir for the fresh water supply of the station, and the remainder a tank into which the air-pump discharge from the engines can be pumped while the de-greasing plant is being overhauled. The contractors for the power-station foundations and buildings were Messrs. Thomas Docwra and Son, London.

With this general description of the station and its contents we may now proceed to a more detailed consideration of some of the plant, and in doing this should say that the contractors for the whole of the machinery, boilers, economiser, steam-pipes, &c., were Messrs. Cole, Marchent and Morley, Limited, of Prospect Foundry, Bradford. Much of the apparatus was supplied by other firms as sub-contractors to Messrs. Cole, Marchent and Morley, and we will give their names in connection with the various parts of the plant for which they were responsible. We may begin our more detailed description with the boiler-house. This contains four dish-ended Lancashire boilers, 30 ft. long by 8 ft. 6 in. internal diameter, and with "Unit" superheaters fitted in the downtakes. The working steam pressure is 185 lb. per sq. in., and the blow-off pressure 200 lb. per sq. in. The boilers were supplied by Messrs. Edward Danks and Co., Limited, of Oldbury, and the superheaters by the Superheater Units Company, of Swansea. The stokers are of the sprinkler type, and are fed from overhead bunkers.

The coal-handling arrangements are as follow :— Outside the south-east corner of the boiler-house there is a low-level hopper-shaped coal-bunker. The bunker is formed of concrete lined with brick-work, and has a line of rails carried on joists across the top of it. Below the rails there is a horizontal screen to prevent large lumps of coal getting into the bunker. Two hydraulic wagon-tippers are fitted, one at each end of the bunker, by means of which the end-tip wagons in which the coal is received can be discharged through the screen into the bunker. The arrangement is shown in plan in Fig. 146. Sidings for full and empty wagons are provided to the north of the bunker, and an hydraulic capstan is used to manœuvre the wagons. The bottom of the low-level bunker connects with a bucket-elevator fixed inside the boiler-house at its south-east corner. This elevator raises the coal, and discharges it on a U-link conveyor, which distributes it to the bunkers over the boilers. The elevator and conveyor, which are electrically driven, were, together with the sprinkler stokers, supplied by Messrs. Ed. Bennis and Co., Limited, of Little Hulton, Bolton. The coal-tipplers were built by the Leeds Engineering and Hydraulic Company, Limited.

In the feed-pump house are fitted two direct-acting Thwaites feed-pumps and a single-cylinder horizontal engine, which drives the mechanical stokers and the scrapers of the economiser. In the upper part of this house there is a feed-water heater, which receives the exhaust steam from the feed-pumps and economiser-engine, and through which the feed-pumps deliver the feed to the economiser. On this floor is also fixed the motor driving the coal-elevator. The motor is arranged so that it can drive the stokers in case of breakdown of the horizontal steam-engine. The water-softening and de-greasing plant, which is situated in the water-softening house, is a Boby installation, in which the air-pump discharge passes through a measuring tippler, by means of which dry reagents are added to coagulate the oil. The effluent is then filtered by upward filtration through two wood-wool filters, from the second of which it flows into a storage-tank, from which the boiler feed-pumps take their supply. The make-up feed-water, the amount of which is controlled by a ball-valve in the storage-tank, is passed through a separate measuring tippler, which adds the necessary dry reagents for precipitating the salts. The effluent passes through the wood-wool filters above referred to. The economiser is by Messrs. E. Green and Son, Limited, of Wakefield. It consists of 440 tubes, with the usual scraping gear. Space has been reserved for the installation of a second economiser of the same size when additional boilers are put in.

The main pumping plant consists of two centrifugal pumps with twin-impellers direct coupled to triple-expansion vertical steam-engines. Each set has a capacity of 5,000,000 gallons per hour. The engines were built by Messrs. Cole, Marchent and Morley, while the pumps were designed and supplied by Messrs. Boving and Co., Limited, of Union-court, Old Broad-street, London, E.C. They were manufactured by the Lilleshall Company, Limited, of Oakengates, Shropshire. Some of the castings were made by Messrs. Cole, Marchent and Morley. The engines have cylinders 19 in., 29 in., and 44 in. in diameter by 36-in. stroke. One of them is illustrated in Figs. 148 to 151, on Plate XIX. As will be seen, it is of the open marine type, with cylinders carried on steel columns on the front side, and cast-iron columns at the back. The surface condensers and air-pumps are fitted behind the engine. The air-pump, which is of the Edwards type, is driven by rocking-levers from the main engines, as shown in Fig. 150. The valve-gear is of the piston drop-valve type worked by eccentrics on a lay-shaft lying alongside the cylinders and parallel with the crank-shaft. The lay-shaft is driven from the crank-shaft by means of an inclined shaft with worm-gears at each end. The arrangement of the two shafts can be seen in all the figures. The connecting arrangements between the eccentrics on the lay-shaft and the valves can be seen in Figs. 150 and 151, which are side views of the high and intermediate-pressure engines. The inlet valves at top and bottom of each cylinder are operated by independent eccentrics, while the exhaust-valves are worked from a common eccentric which actuates a rocking-

THE ALEXANDRA DOCK EXTENSION AT NEWPORT; CENTRIFUGAL PUMP.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C. E., WESTMINSTER, ENGINEERS; MESSRS. BOVING AND CO., LIMITED, LONDON, CONTRACTORS.

Fig. 152.

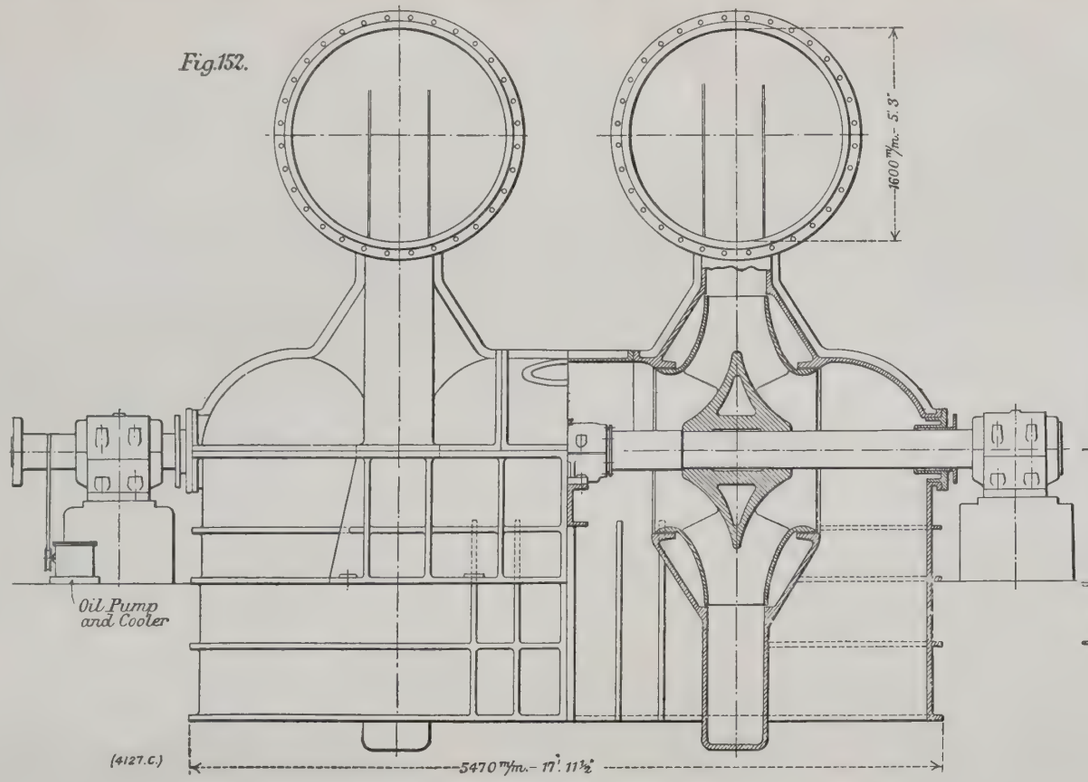


Fig. 153.

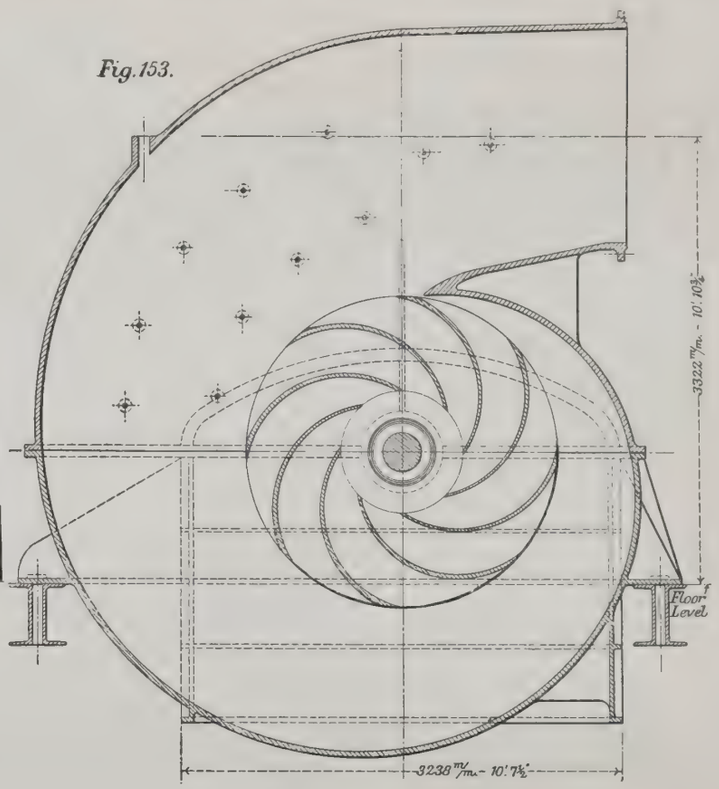


Fig. 154.

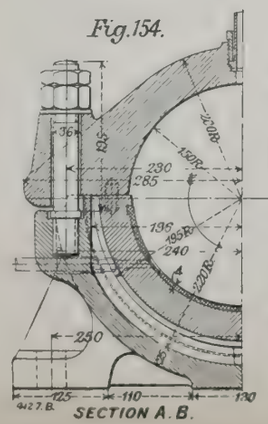


Fig. 155.

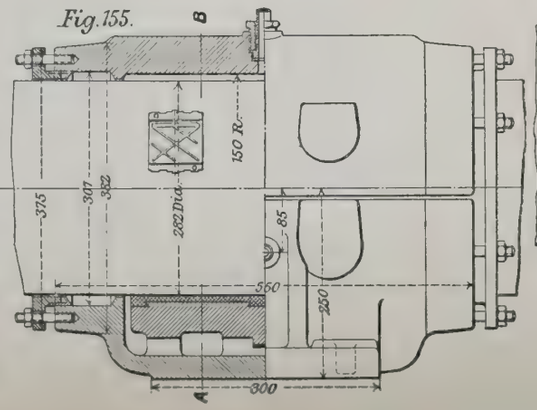


Fig. 156.

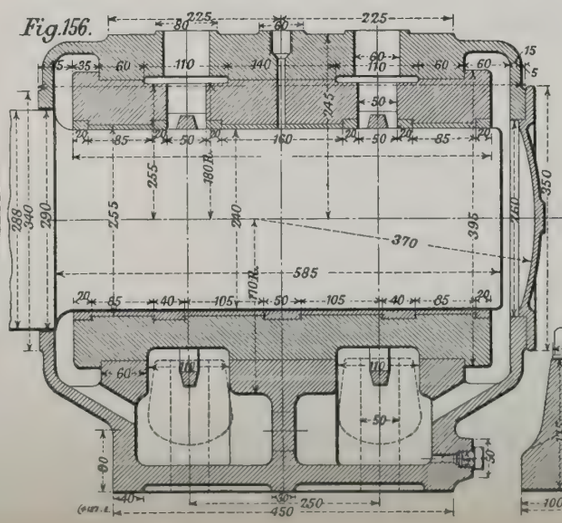
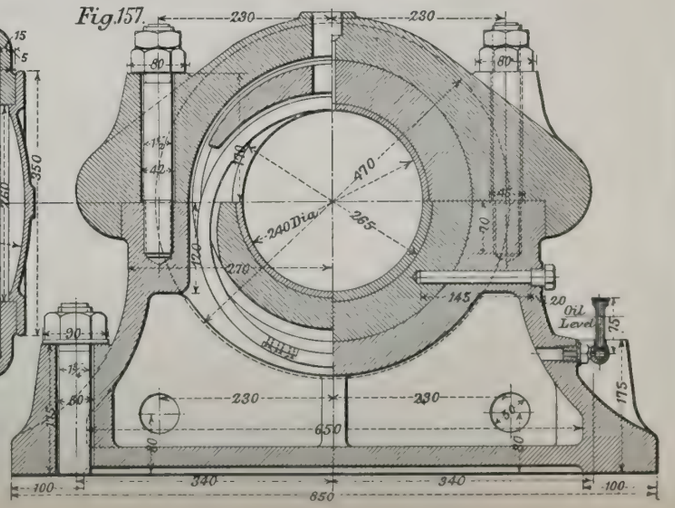


Fig. 157.



THE ALEXANDRA DOCK EXTENSION AT NEWPORT; CENTRIFUGAL PUMPS.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C. E., WESTMINSTER, ENGINEERS.

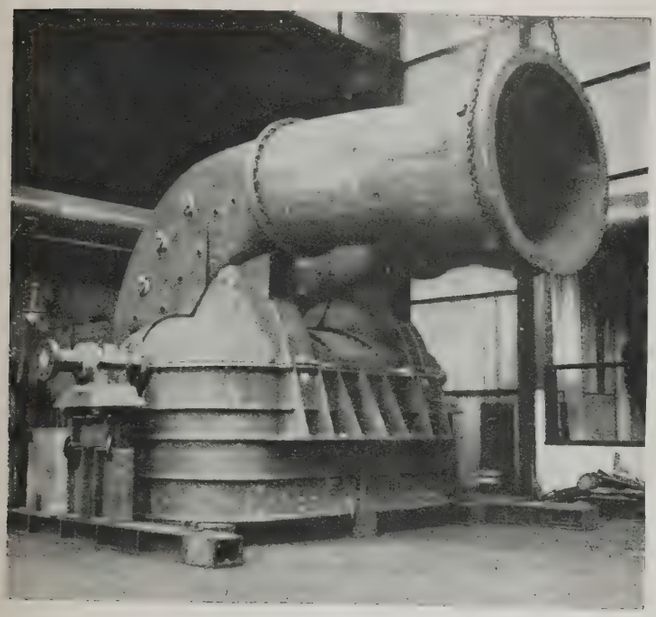


Fig. 158. Front View of Pump.

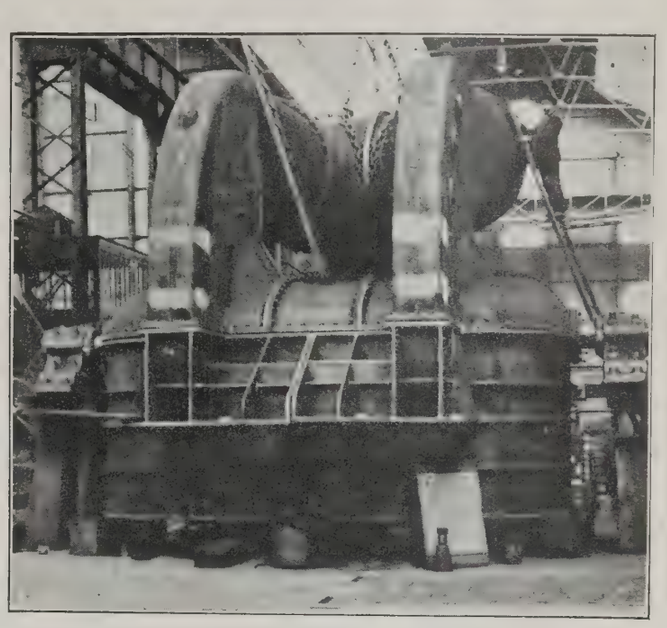


Fig. 159. Back View of Pump.

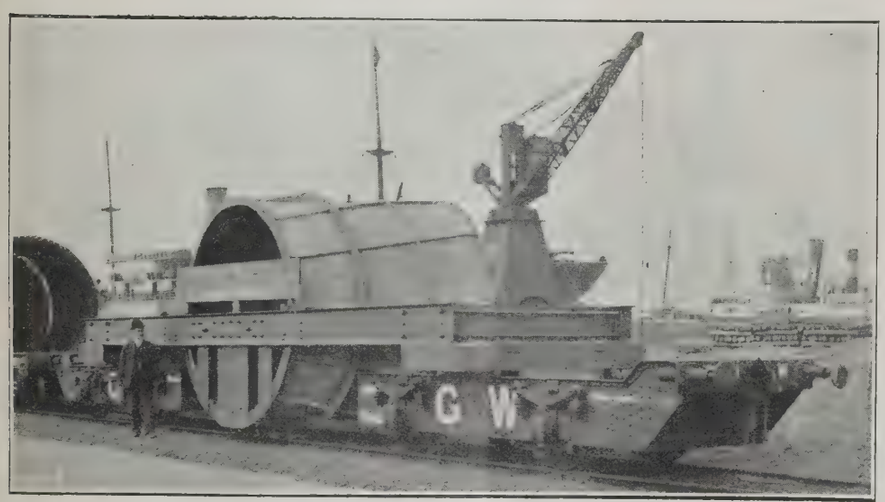
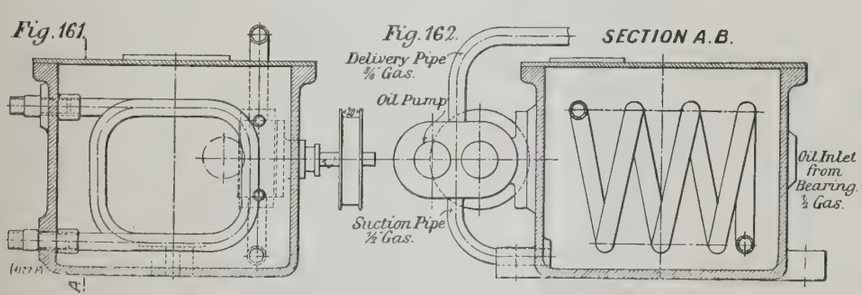


Fig. 160. Pump Loaded for Transport.



Figs. 161 and 162. Details of Oil-Cooler.

plate. The cut-off of the high-pressure cylinder is controlled by the governor, while that of the intermediate and low-pressure cylinders is controlled by hand. Provision is, however, made for controlling the cut-off in all three cylinders from the governor if required.

The engines have to work economically over a considerable range of speed owing to the great variation in static head which may occur on the pumps. At high water of a spring tide the static head may be only 3 ft. or 4 ft., whilst when pumping out the graving dock it may rise to a maximum of 37 ft. The governor-gear of the engines is accordingly designed to vary the speed from 75 to 130 revolutions per minute. Each engine is fitted with a governor of the Hartnell type, running on a vertical shaft driven by bevel-gear from the lay-shaft which works the valve-gear. The governor is controlled partly by a vertical helical spring fitted on the governor itself and partly by a weight on a horizontal lever connected by link-work to the governor. The governor-casing and this weight and lever arrangement can be seen in Figs. 148 and 150. The weight can be moved along the horizontal lever by a hand-operated screw-gear. The effective load on the governor can therefore be increased or reduced by altering the leverage of this weight, and the speed at which the engine is governed is thus varied.

Owing to the great variation in the head against which the pumps work, it is obvious that when starting up against a low head—*i.e.*, when pumping from the river during high tide—the pressure in the pump-casing might become excessive if the engine speed became too high before the delivery-valve was opened. To meet this risk a special safety device has been fitted. It consists of a small vertical cylinder fitted on the delivery-pipe of the pump between the pump and delivery-valve. The interior of the cylinder is connected to the delivery-pipe, and its piston is loaded so that it will rise when the water-pressure in the delivery-pipe reaches a maximum which is considered safe. The piston in rising operates an electrical relay which releases a detent spring. This spring disconnects one of the links between the governor and the adjustable weight described above, with the result that the engine speed is at once reduced to its minimum.

The circulating water for the condensers is obtained without the use of circulating pumps by by-passing a small quantity of water from the delivery side of the pumps back through the condensers into the suction-chamber. A single-acting lift-pump is fitted alongside the air-pump, by means of which the air-pump discharge is pumped into a rising main to the de-greasing plant previously described. In the event of the de-greasing plant being out of use for cleaning or repairs, the air-pump discharge is diverted up to the cast-iron tank on the roof of the feed-pump house, where it accumulates until the de-greasing plant is again available. Meanwhile feed-water can be obtained either direct from the town main or from the tank in the foundations of the feed-pump house, which can be used for storing a supply of softened water.

The main pumps, which are direct coupled to the engines, are of the twin type, each housing two 8 ft. diameter impellers discharging in two separate delivery-chambers of spiral shape, which are connected to the 94-in. sockets of the riveted steel collector-pipe by means of cast-iron Y pieces. Delivery-valves, 94 in. in diameter, are fixed between the pumps and the collector pipe-sockets. The collector-pipe connects to the common steel delivery-culvert, which is embedded in the concrete between the engine-house and the lock-wall. The collector-pipe and sockets are well shown in Fig. 170, on page 224, although this view scarcely conveys a fair idea of the large diameter of the

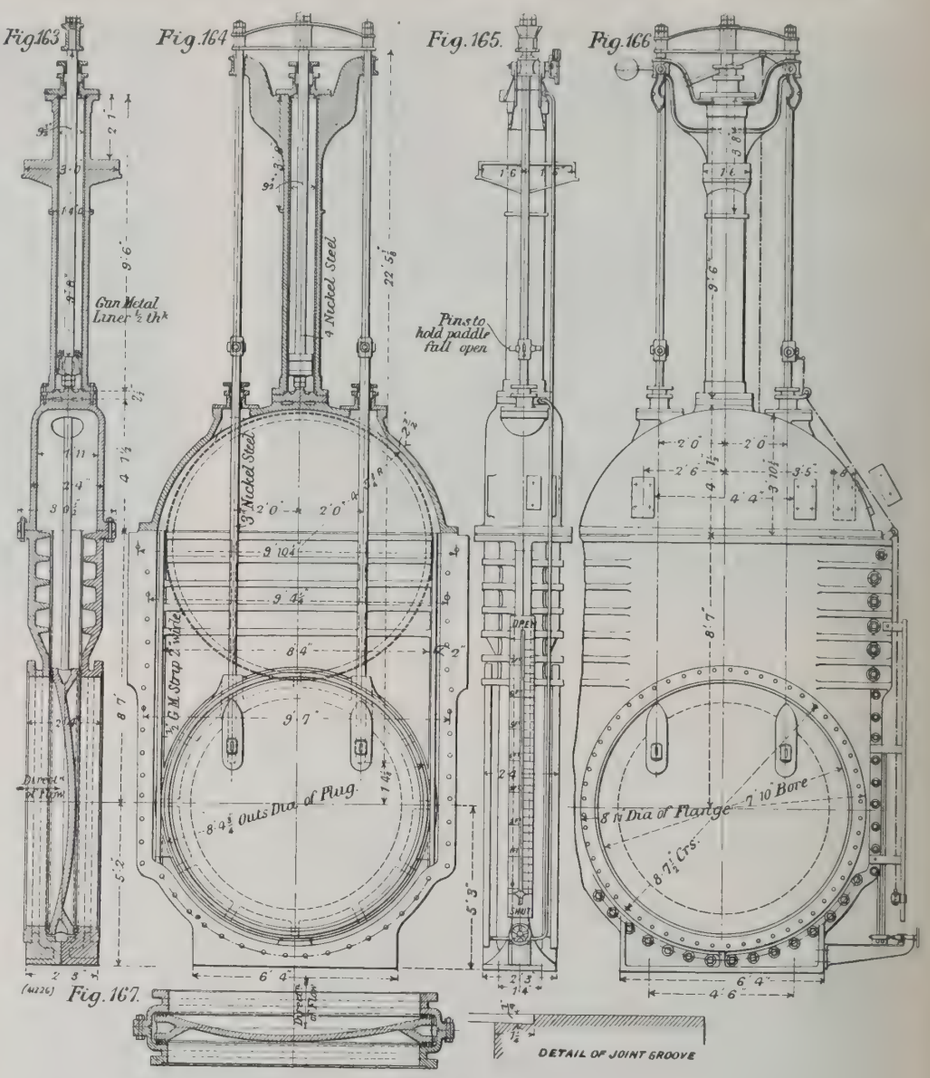
pipes. The northern end of the pipe is connected to the 144-in. diameter cast-iron culvert running along the back of the east wall of the lock, and delivering into the lock, as described in the first article of this series. These arrangements are shown in the plan of the station given in Fig. 146, on Plate XIX. An interesting feature of the discharge-culvert is the 8-ft. diameter vent-shaft, placed near the junction of the collector and cast-iron culvert, as shown in Fig. 146. The calculation in connection with this vent-shaft formed a complicated problem, involving as it did the simultaneous consideration of pressure variation in the pump and in the long culvert. The latter may contain 400 tons of water moving at a velocity up to 9 ft. per minute. If no vent-shaft were provided, and the delivery valve were closed, the pumps being stopped simultaneously, the water-hammer resulting would be detrimental to the pipe-line. With the vent provided the pressure rise when closing the discharge-valve does not reach 1 lb. per sq. in. Owing to the kinetic energy of this water column, governing difficulties were inherent to the scheme, which had to be met by providing heavy fly-wheels on the engines, ensuring the necessary speed and load changes being effected without hunting. The vent-shaft is covered with a grid at the top.

The pumps draw from the suction-chamber, before described, through 120-in. suction-pipes, of which one is illustrated in Fig. 173, on page 224. The pump-casings are split in horizontal and vertical planes to facilitate manufacture and access to the internal working parts. The bottom casing, which is illustrated in Fig. 172, on page 224, is embedded in the concrete roof of the suction-chamber, and rests with its large ribbed foot-plates on heavy steel girders anchored in the concrete. One of these girders can be seen in Fig. 147. The casing is oval in shape, and is connected to the circular wrought-iron suction-pipe by a separate casting, which is solidly anchored to the roof of the suction-chamber. This casting, erected in position on the suction-pipe, is shown in Fig. 173, on page 224, while it is shown mounted on a specially-built railway truck for transport from the builders' works in Fig. 160, on page 219. The top casing of the pump is bolted on to the lower one, as shown in the general views of one of the pumps, given in Figs. 158 and 159, on page 219. These views also show the foot-plates by which the lower casing is carried, and the oval lower flange to which the suction-pipe casting is bolted. The upper casing has three manholes, for the inspection of the interior, while stay-bolts are fitted to strengthen the spiral-shaped portions. These bolts are pitched so as to secure even distribution of stresses over the large areas of the delivery-chambers. General drawings of one of the pumps are given in Figs. 152 and 153, on page 218.

The main shaft of each pump is carried on external bearings entirely independent from the pump casing. This is shown in the various figures. Hemp-packed stuffing-boxes with gun-metal glands, necks, and water-seal rings are fitted to the casing where the shaft passes through. These stuffing-boxes are arranged to keep the shaft tight against either vacuum or pressure, either of which may exist inside the pump-casing according to the tidal conditions prevailing. The main shaft carrying the two impellers is of nickel steel, furnished with gun-metal sleeves where it passes through the stuffing-boxes. It is 25 ft. long. It is shown with the impellers in place in Fig. 171, on page 224. The main bearings are white-metal bushed. That next the engine is provided with thrust-rings and forced-oil lubrication, as indicated in Fig. 152, which shows the oil-pump drive from the main shaft. Some details of the oil-cooler are given in Figs. 161 and 162, on page 219. The other bearing is ring lubricated, and is detailed in Figs. 156 and 157, on page 218. The bearings are split on a horizontal plane. Between the impellers the pump-casing is fitted with an internal white-metal bearing, supporting the centre of the shaft. This bearing, which is illustrated in Figs. 154 and 155, on page 218, is provided with hemp-packed glands at each end to prevent water getting access to the bearing, and is lubricated by a dead-weight grease-forcer outside the pump-casing. The half-coupling by which the pump is connected to the engine is forged in one piece with the pump shaft, and is bolted to the corresponding half-coupling on the engine shaft. The pumps are fitted with the usual appliances, such as ejectors and gauges. The latter

ALEXANDRA DOCK, NEWPORT; THE SLUICES.

CONSTRUCTED BY MESSRS. J. BLAKEBOROUGH AND SONS, BRIGHOUSE.



are assembled together with the engine gauges on the common instrument-board close to the engine stop-valve, enabling the driver to follow the working of the combined sets while controlling the stop-valve.

The delivery-valves which are fixed between the pumps and the sockets of the collector-pipe were supplied by Messrs. J. Blakeborough and Sons, of Woodhouse Works, Brighouse, Yorkshire. One of them is illustrated in Figs. 163 to 167, above. They are 94 in. bore in the waterway. The width over all from face to face of the flanges is 28 in., and the diameter of the flanges is 107 in. The valves are operated by hydraulic cylinders fixed above them, and operating crossheads which connect up to the plugs by vertical rods. The arrangement is clearly shown in the figures. The cylinders have an internal diameter of 9½ in., and are lined with gun-metal. The connecting-rods are of nickel steel. The valves work under an hydraulic pressure of 700 lb. per sq. in., and the bodies were tested to a head of 43 ft. The complete valves in their closed position have a height of 30 ft. 2⅛ in., and when open of 38 ft. 4⅛ in. The total weight of each valve is somewhat over 25 tons 16 cwt.

As the pumping-plant has to work every day, a high degree of economy has been aimed at and secured. It was specified that 25,000,000 gallons should be pumped by each set, on each tide, during five hours, from the River Usk into the dock extension, against a head varying with the tide from 13.7 ft. to 19.7 ft. In actual practice much wider ranges of head occur, which are, however, economically dealt with by adapting suitably the speed of the sets as well as the time of pumping. In addition to this main duty the pumps were specified to empty the proposed dry dock within 110 minutes. During the tests to ascertain the capability of the pumps to carry out this duty, a total head of 39 ft., including 20 ft. suction lift, was dealt with. We give below some results of tests on pumping set No. 1, which have been furnished to us by Messrs. Boving and Co. :—

Total head specified	min., 13.7 ft. ; mean, 15.7 ft.; max., 19.7 ft.
,, ,, obtained	min., 13.7 ft.; mean, 16.7 ft.; max., 19.7 ft.
Duty of pump specified	25 million gallons per 5 hours.
,, ,, obtained	28.35 million gallons per 5 hours.
Steam consumption for pumping 25,000,000 gallons in 5 hours, guaranteed	34,000 lb.
Steam consumption, &c., required	27,100 ,,

While the engines were indicated, readings were taken simultaneously at the lock in order to ascertain levels and volumes pumped, and the following results were obtained :—

Time of Pumping.	Quantity Pumped in Gallons.	Total Head in Feet. Min.	Mean	Max.	Average Steam Consumption per W.H.P.H.	Mean Efficiency of Pump during Period.
						per cent.
12.24—12.32	675,000	—	15.35	—	14.4	86.0
12.16— 1.28	6,450,000	11.6	23.8	36	14.2	80.2

In working out the above efficiencies the brake horse-power was computed from the indicated horse-power by deducting 2.4 lb. per sq. in. from the actual indicated referred pressures. The best steam consumption per W.H.P.H. was obtained when working against a mean head of 22.7 ft. The steam required per W.H.P.H. amounted to 12.5 lb., including all losses in the condensing plant and drains. The pump efficiency at this duty was

THE ALEXANDRA DOCK EXTENSION AT NEWPORT; PERFORMANCE DIAGRAMS.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C. E., WESTMINSTER, ENGINEERS.

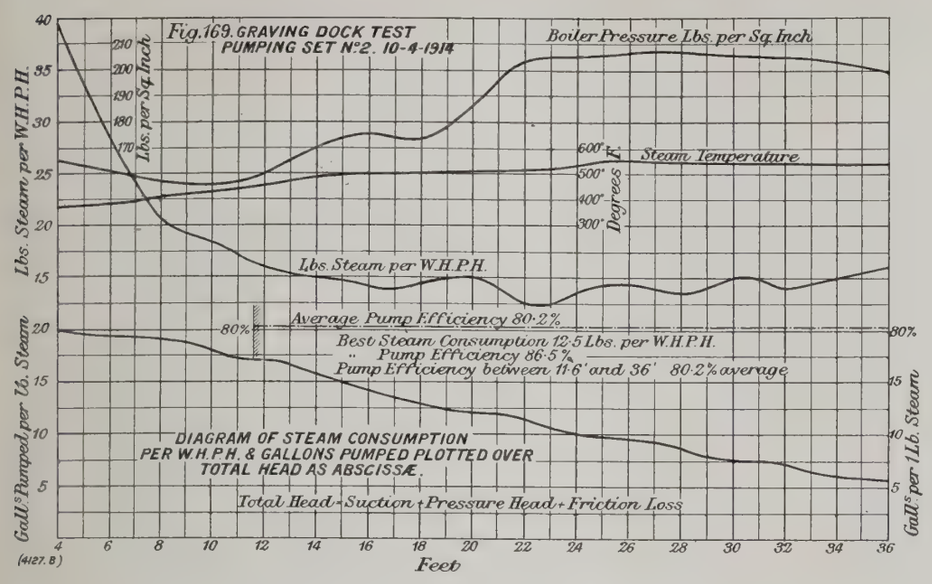
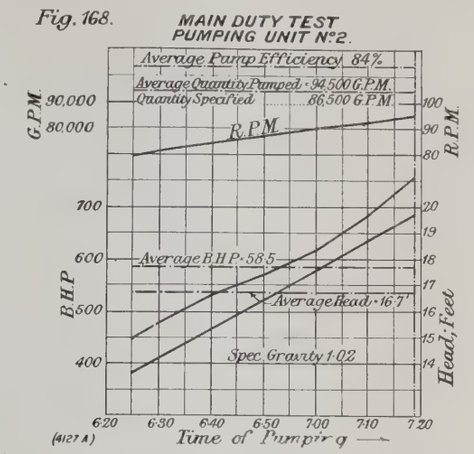


Fig. 169. GRAVING DOCK TEST
PUMPING SET N°2. 10-4-1914
Boiler Pressure Lbs. per Sq. Inch
Steam Temperature
Degrees F.
Lbs. Steam per W.H.P.H.
Average Pump Efficiency 80·2%
Best Steam Consumption 12·5 Lbs. per W.H.P.H.
Pump Efficiency 86·5%
Pump Efficiency between 11·6' and 36' 80·2% average
DIAGRAM OF STEAM CONSUMPTION
PER W.H.P.H. & GALLONS PUMPED PLOTTED OVER
TOTAL HEAD AS ABSCISSÆ.
Total Head = Suction + Pressure Head + Friction Loss
Lbs. Steam per W.H.P.H.
Gall's Pumped per Lb. Steam
Gall's per 1 Lb. Steam
Feet
(4127. B)



86.5 per cent. Figs. 168 and 169, above, show the results of a similar test to the above on pumping set No. 2, and the variations of steam consumption per W.H.P.H. during the whole period of graving dock pumping. The steam consumptions include that used in connection with the condensing plant, and the results are remarkably good considering the very difficult problem of dealing with varying pumping head and long-delivery culvert.

The only part of the station equipment with which we have yet to deal is the electric plant. The generating units consist of two direct-coupled, three-crank, triple-expansion, vertical enclosed, high-speed engines, coupled to three-phase, star-wound 3633-volt 50-period generators of 500 kw. capacity. The engines were built by Messrs. James Howden and Co., Limited, of Glasgow, and the alternators by the British Thomson-Houston Company, Limited, of Rugby. This latter firm also supplied the switch-gear, motors, and other electrical machinery. The engines have cylinders 15½ in., 22½ in., and 35 in. in diameter, by 15½ in. stroke. Their normal speed is 300 revolutions per minute, and they are controlled by horizontal shaft-governors actuating both the throttle-valves and the cut-off of the high-pressure cylinders. The control of the cut-off gear is by means of an oil-pressure relay, which rotates the high-pressure piston-valve, the oil supply being maintained by the oil-pump, which lubricates the crank-shaft and connecting-rods. The engines have forced lubrication throughout, with mechanically-operated sight-feed lubricators for the cylinders. The alternators have direct-coupled exciters, which are arranged so that either can be used to excite both generators. The surface-condensing plant for these sets is installed in the basement, and is driven by three-phase semi-enclosed motors direct-coupled to centrifugal circulating-pumps, and driving Edwards' three-throw air-pumps through spur-gearing. Single-acting lift pumps are attached for pumping the air-pump discharge into the rising main to the de-greasing plant. The circulating-water supply is taken from the main delivery culvert of the centrifugal pumping plant, and is delivered through the condensers into a drain outside the station, through which it flows to the dock.

The switchboard is of the British Thomson-Houston Company's standard pattern, and consists of eight panels—namely, two generator-panels, one station transformer-panel, which supplies three single-phase transformers from which the various auxiliary motors of the station are supplied at a pressure of 440 volts, and five feeder-panels, two of 150 kw. capacity and three of 100 kw. Space is provided for a third generator-panel and additional feeder-panels. All the high-tension gear is enclosed in stone cells behind the switchboard, and isolating switches are provided mechanically interlocked with the doors of the cells, so that access to a cell is prevented until the isolating switch is opened.

In concluding our description of the Alexandra Dock extension we should, perhaps, point out that, although we have dealt with much hydraulic machinery, no reference has been made to the hydraulic power station. This omission is explained by the fact that for the present the whole of the hydraulic supply for the new works is being taken from the old station, which is situated at the north end of the Alexandra North Dock, and which replaced four earlier small stations in 1904. This station, as will be seen from the plan of the dock system given in Fig. 1, on page 33 *ante*, is at some distance from the new lock, and, as we stated at the beginning of this article, it is probable that an hydraulic pumping installation will be put down in the near future at the new station with which we have been dealing.

INDUSTRIAL NOTES.

THE way in which all classes of the nation are answering the call to duty in the present crisis, so suddenly sprung upon us—a crisis which our Government made almost superhuman efforts to avert—forms a most pleasing feature in an otherwise very gloomy state of matters. It is not in our province to record the patriotism evinced by the *personnel* of our fighting forces and by the new recruits to these forces. But a word of commendation for the great industrial army is being well merited by all workers. The non-fighting element of our population has commenced well, and every man is carrying out steadfastly the work entrusted to his care. All workers' differences have been set aside for the present, in view of the dangers which lie ahead. If proof of the patriotism which at the present juncture animates all classes of the British community were needed it would be afforded by the eagerness with which men of all crafts are trooping from smaller yards to our naval shipbuilding yards for completing in the shortest time possible all units for our fleet now in hand in the latter yards. Employers and the leaders of the shipyard trade unions, we are informed from another quarter, are in constant communication with the object of expediting all important work. The men agree to work overtime where required, and to do all in their power for rapidly completing Government orders. No disputes are to interfere with work. This proves a splendid spirit of national patriotism.

Thus, as an illustration of the situation which now obtains, we may state that a joint meeting of representatives of the Tyne shipbuilding, North-East Coast engineering, and North-East Coast ship-repairing employers, and representatives of twenty-two trade unions affiliated with the industries named, was held a few days ago at Newcastle.

The unions represented were : — Amalgamated Society of Engineers, Steam-Engine Makers' Society, United Machine Workers' Association, Boilermakers' Society, Joiners' Society, Shipwrights' Society, Blacksmiths' Society, North of England Brass Turners' Society, Patternmakers' Association, Braziers and Sheet-Metal Workers' Society, Northern United Enginemen's Association, Brass Moulders' Society, Furnishing Trades' Association, Plumbers' Association, Sheet-Iron Workers' Society, United Kingdom Society of Amalgamated Smiths and Strikers, Wood-cutting Machinists' Society, National Amalgamated Union of Labour, National Union of Gas and General Workers, Painters' Society, Friendly Society of Iron Founders, and the British Steel-Smelters' Association.

The following resolution was unanimously passed :—

"That this joint meeting of representatives of Tyne shipbuilding, North-East Coast engineering and North-East Coast ship-repairing employers and employees unanimously agree to recommend their respective constituents that all working restrictions be removed and all necessary facilities granted in order to accelerate the completion of Admiralty and War Office work—as specially asked by the Admiralty and War Office—during the present national crisis.

"It is understood that the employers will endeavour to employ all men available and arrange for night shifts where practicable in preference to excessive overtime.

"All existing machinery between employers and trade unions will continue and be requisitioned where necessary."

Similar meetings, at which corresponding resolutions were passed unanimously, have been held on the Clyde and at other naval shipbuilding centres.

Another illustration of patriotism is afforded by the fact that the dispute in the London building trades has been settled at a conference of employers and trade unionists; the threatened lock-out throughout the country need not now be feared; there will be no lock-out. The Mersey Dock Board strike is also settled; a discussion took place between representatives of labour and of the Board, and an amicable agreement was reached early on Friday morning last, the 7th inst. The strikers returned to work on the same day, and all the questions which led to the strike are to remain pending until January 1, or until the conclusion of the war. It has been agreed that all points at issue between the men and the Board will be discussed as follows :—The Board, or other principal officers as the Board may elect, will receive a delegate of any particular union, but will not receive delegates from any federation of unions. The delegates must be accompanied by some of the Board's men, who need not necessarily be members of the particular union, as an earnest that the matter they may come about is one that affects the men. The Board are to be satisfied that a *bonâ fide* majority of the workers employed by them desire their representatives to be accompanied by a delegate. In the meantime the present rates of pay and hours of labour obtain. The Board's men who have been out on strike are to be reinstated as and when their services are required.

To the two above instances we may add the following :—The marine engineers who had been on strike for several weeks have been given permission by their union to resume work; the Shipping Federation state that the men are offering themselves freely at all the ports and at the old wages. The Manchester Road Vehicle Builders' Association, in "view of the disturbing outlook," decided, at a meeting held on the 5th inst., to call an immediate settlement of the strike which had been in progress in their trades for the last eight weeks. On the same day representatives of the ship-repairing industry wrote to the Secretary of the Admiralty stating that ship repairers subordinate all interests to the needs of the

nation, and place their docks and premises to the fullest extent at the Admiralty's disposal. "Employers and employees everywhere," they affirm, "can be relied upon to lay aside all labour differences for the present, and enable the industry to present a united front and place its whole resources at the service of the country."

On Saturday last, the 8th inst., representatives of the Deputies', Enginemen's, and Mechanics' Associations in the Northumberland coal trade waited upon the owners at the Coal Trade Offices, Newcastle, with a view to the adjustment of wages for the next three months. Mr. Thomas Taylor presided.

Mr. Taylor intimated that in consequence of the reduced price shown by the ascertainment for the past three months, the miners' wages were liable to a reduction of 2½ per cent. In the ordinary course a reduction of 1½d. per day would have been claimed from the respective associations. Owing to the crisis that had arisen in the country, and the consequent suffering entailed upon all classes, the owners had decided to forego their claim for three months, and wages would remain as they were for that period. At the different collieries in the country the pits would be worked as often as possible, in order to mitigate the hardship inflicted.

Mr. J. M. Gillians replied on behalf of the joint bodies, and Messrs. Coulthard, Weighall, and Batey thanked the owners for their decision and reciprocated the sentiment expressed.

The First Commissioner of Works has issued the following note with reference to the Government's building programme :—

"It appears from various inquiries addressed to the Commissioners of Works that there exists some apprehension lest unemployment should be increased in the building and other trades by suspension during the present crisis of building and engineering operations provided for in the estimates of the Office of Works recently approved by Parliament. It is, therefore, desirable to state publicly at once that it is the intention of the Commissioners of Works to proceed with all services in their charge, to employ as many men as possible to carry out such services, and to develop and expedite their building programme in any way practicable.

"As the Minister mainly responsible for Government building, the First Commissioner of Works would wish to take this opportunity of expressing his sincere hope that private individuals, companies, firms, and contractors will spare no effort to follow the policy of the Government in this matter, so far as circumstances admit."

According to the *Iron Age*, representative men in blast-furnace, steel works, and rolling-mill operations will be named to co-operate with safety experts of the Pennsylvania State Department of Labour in the framing of uniform regulations for the safety of such plants. About twenty committees, representing various lines of industry, have been named by the department, and their draft of regulations will be submitted in the latter part of the year.

Textile machinists in this country are certain to be extremely harassed should the war continue for even a few weeks, and some definite policy as regards working may be arranged by the firms concerned. In fact, such a step has already been unofficially proposed. Many textile machinists have orders in hand for Russia and other countries on the Continent, which they may be unable to deliver, although ready for despatch. The importance of the European trade to this industry may be estimated from the figures of exports of textile machinery to the countries concerned, as given in the Board of Trade Returns for 1913. The values of the exports of textile machinery during 1913 were :—Russia, 995,306*l.*; Germany, 783,945*l.*; France, 735,926*l.*; other countries in Europe, 1,161,948*l.*

We are informed that instructions have been issued to the Labour Exchange managers to register applications from volunteers for harvest work. Any person wishing to offer his services should therefore communicate with the nearest Labour Exchange.

The Holderness (East Yorkshire) farmers who attended the corn market at Hull on Tuesday last, the 11th inst., stated that they were greatly handicapped in harvesting operations owing to the impressment of horses by the military authorities and the loss of farm hands called up. Employment in the farms has been offered to townsmen.

Arrangements have also been made at Birmingham to ensure a full supply of labour to farmers; the latter will soon have to gather in their crops, but so far they have not applied for hands to the Birmingham Labour Exchange.

On Tuesday last, the 11th inst., a meeting was held of the India Section of the Manchester Chamber of Commerce, when it was decided that a deputation should wait upon the India Office to urge the advisability of issuing an Imperial proclamation authorising delay in the completion of time contracts as between English suppliers and Indian consumers, and also as between parties in India. The reason for the representation is the impossibility of securing sailings. The India Office declared its willingness to receive a deputation, which has since called upon the India Office authorities.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, July 29.

THE peculiar spectacle is presented in this midsummer of ordinary quietness of unusual activity in steel. The advance of 1 dol. a ton a few days ago on bars, plates, and shapes came as a surprise, especially as the mills have so much idle capacity. It is a bold move, and was intended to let buyers understand that makers were determined to convince them that the end of low prices had come. Cheaper pig-tin led to a shading in tin-plate. Canning requirements are so heavy that even with American tin-plate mills running at maximum capacity, importations are increasing. The buying of material for railroads is better. Negotiations for cars are pending; one order in sight is for 10,000 for the Harriman lines in Pacific territory, 4600 for the Southern Pacific, 4000 for the Union Pacific, with other inquiries aggregating 15,000 cars. Some two weeks ago inquiries for structural material totalled about 100,000 tons. Within a week orders for one third of this quantity have been fixed; the balance will soon be placed. It has been a busy week for the implement makers. A goodly number have placed orders for enough steel to see them through to the end of the year. The steel-makers will not do business on next year's account except at an advance. Buffalo pig-iron makers booked orders for 45,000 tons for tunnel-plate segments, which increases pig-iron orders in that centre to 150,000 tons within three weeks. Every succeeding crop report shows still more favourable conditions. The larger builders of machinery, engines, and of electrical equipment report some improvement. The bituminous coal production for 1913 shows an increase over the previous year. Total output of all mines, 570,048,125 short tons; men employed, 747,644; average bituminous output per man, 833 tons—an increase of 18 tons over 1912—and in anthracite 532 tons per man—an increase of 47 tons per man.

August 5.

The war disturbances have as yet had no perceptible influence on the American steel industry. Prices are firmer than a week ago, a little more business has been done, and in some localities production has been increased. The price advance noted a week or two ago has stimulated buying in small lots for early construction purposes. A local electrical company has ordered 5000 tons for building construction. Next Monday the Government will open bids on material for three battleships. The dock near New York to handle the Chilian ores for the Bethlehem Steel Company takes 2000 tons of steel piling and bars. The Cincinnati Court House order for 7000 tons will be placed in two or three weeks' time. Measures greatly to increase the supply of vessels for Atlantic transportation purposes are being taken. The prospective absence of European competition in steel products in South American countries, it is believed, will impose some additional responsibilities on the mills of this country. The prospective early departure of a vast number of miners from the Pennsylvania coalfields may disarrange the present facilities for supplying both domestic and trans-ocean demand. An inquiry for 16,000 tons of rails for export is now pending. Railroads are placing liberal orders for track supplies. Car orders for the past week aggregate over 3500. A number of new orders are in sight. The tone of the market must improve. There has been a freer movement in all lines of pig-iron, especially in low-grade for cast-pipe purposes. New business at the plate-mills is moderate. The outcome of the European upheaval is watched with deepest concern for its reflex influences on American trade conditions, which in turn will affect demand.

OUR RAILS ABROAD.—There was a good demand for British rails in July upon Indian and Australian account, but less business was done with other countries, and especially with Argentina, so that, upon the whole, the exports for the month showed some falling-off, declining to 43,133 tons, as compared with 53,570 tons in July, 1913, and 39,718 tons in July, 1912.

CONTRACTS.—The "Apexior" boiler compound of Messrs. J. Dampney and Co., Limited, of 85, Bishopsgate-street, E.C., has been adopted by the Victoria Falls and Transvaal Power Company, Limited, for all their water-tube boiler plants at their stations at Rosherville, Simmerpan, Brakepan, and Vereeniging. A supply has also been obtained for the boilers of twenty locomotives built for the Assam Bengal Railway Company.

ENGINEERS AND THE WAR.

TO THE EDITOR OF ENGINEERING.

SIR,—There must be a considerable number of engineers, men like myself, who are in the late forties and early fifties, and consequently considered rather old for active service in the field, but who are in their prime for administrative and organising work.

Such engineers can take responsibility, can manage men, and know how to get things done. They have carried out work of every description and in all parts of the world, and possess wide experience of men and things. They could execute works of construction and destruction for the defence of our coasts and ports when their general design had been indicated by the military branch of the profession; and they could deal with such matters as mechanical transport and the organisation of supply services.

I therefore suggest that engineers over the age of forty-five, who possess suitable qualifications, professional and physical, should forward their names to the Institution of Civil Engineers, with a request to the Council to notify the Government that they are available.

The younger men will, of course, join Territorial units.

Yours very truly,

August 7, 1914. J. G. CAREW-GIBSON.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—How the steam-coal trade regained its lost activity, up to the point of the paralysis of Continental shipping, is shown in the official returns relating to the traffic at Hull for the past month. The total imports were 762,013 tons, a decrease of only about 4000 tons, but the total for the year—3,885,596 tons—was about one million tons less than for the same period a year ago. The exports for the month increased by 37,000 to 454,736 tons, as compared with last year, but on the seven months business decreased by about half-a-million tons, the aggregate being two million tons. The Denaby and Cadeby Collieries sent nearly 100,000 tons; Grimethorpe and Frickley, 54,000 tons; and Brodsworth, Bentley, Manvers Main, and Bullcroft, about 30,000 tons each.

South Yorkshire Coal Trade.—The steam-coal position has undergone little, if any, improvement since last week. Many of the South Yorkshire pits are having the greatest difficulty to maintain work even in its present irregular form. Not only has the export trade withered, but a fresh and very serious difficulty has arisen in the shortage of pit props, for which producers have hitherto relied entirely on Norway and Russia. With a view to surmounting the difficulty experiments are being made in cement props reinforced with strips of steel. On local industrial account there is a slightly better inquiry. Those firms engaged on urgent orders for the British Government are big consumers. Apart from this branch of buying very little is going into many of the staple trades, but owing to the depletion in the ranks of pit-workers, as a result of mobilisation, holiday feasts, and other causes, the output is not greatly in excess of the demand, and values are firmly held. The improvement in house coal is fully maintained. Stocks at pits and dépôts are greatly reduced. Prices are not quotably different. Slacks are a neglected market. Gas fuels move freely for contract delivery. Coke is dull and unsteady. Quotations: — Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. to 13s.; Derbyshire best brights, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 10s. 3d. to 11s. 3d.; small nuts, 9s. to 10s.; Yorkshire hards, 11s. to 12s.; Derbyshire hards, 10s. to 11s.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.; smalls, 2s. to 3s.

Iron and Steel.—Though faced with a crisis of unparalleled seriousness, the South Yorkshire iron and steel manufacturers are cool and collected, and are handling the position in a way that reflects credit upon their business "nerves." It was fully expected that most of them would follow the example of leading silver-plate manufacturers, and would close down for an indefinite period after exhausting the arrears of orders on their books. Instead, they have decided by mutual co-operation to do everything in their power to keep the works running for the greatest possible length of time. With this end in view they are distributing orders over as lengthy a period as is consistent with reasonably delayed delivery, and have reduced the number of working hours to what will provide a minimum living wage. In the raw material market the outlook is not so disturbing. Now that all outside supplies of cheap material have been stopped, consumers have been obliged to fall back upon the higher-priced locally-produced material, with the result that makers are able to secure slightly improved rates upon the low figures that obtained for so long a time. This does not necessarily mean increased profits, however, as hematite makers are incurring additional costs in surmounting the difficulty of securing adequate supplies of ores. Special arrangements are being made regarding the working of overtime in the armament factories, but the other branches of the engineering trade are very slack. There are a few orders on hand from the more wealthy of big companies and big bodies; but there is very little movement in tool-steel or railway and tramway materials, a slump in Continental business having been followed by a reduction of orders on home account. The special and high-speed steel industry is also affected, for even where there is a demand for supplies, the lack of certain alloys which cannot be supplied without shipping, seriously interfered with the output. Steel-tool makers are busily engaged providing for the needs of the armament works. Billets are dull.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday the pig-iron market was still closed, but with the reopening of the banks on Friday morning business was resumed. In the forenoon there were no dealings, but Cleveland warrants were strong, and sellers named 51s. 6d. cash, 51s. 9d. one month, and 52s. three months, with buyers at 3d., 4d., and 6d. less respectively. The afternoon session was quiet, but prices were further advanced. The turnover was limited to one lot of Cleveland warrants at 51s. 8½d. cash, with buyers over at that figure, and sellers at 51s. 10½d. For the other positions sellers named 52s. 1d. one month, and 52s. 6d. three months, with buyers at 51s. 10d. one month, and 52s. three months. On Monday morning the prices for Cleveland warrants made an upward bound, and 4000 tons were done at 52s. 6d. cash, and from 53s. 6d. to 53s. 7½d. one month, with sellers over at the latter figure, and at 53s. 4½d. cash. Closing buyers named 53s. 1½d. cash, and 53s. 6d. one month, and three months iron was not quoted. The advance was 1s. 6d. over Friday's close. In the afternoon buyers were again desirous of covering, and prices were advanced further. The business amounted to 3000 tons of Cleveland warrants at 53s. 10½d. and 54s. one month, and 54s. 3d. October 14, and closing quotations were called 53s. 6d. cash and 53s. 10½d. one month sellers, but the three months position was again neglected. On Tuesday morning an easier tone prevailed, and 1000 tons of Cleveland warrants were put through at 53s. 1½d. cash, and 53s. 3d. one month, and at the close sellers quoted 53s. 3d. cash and 53s. 6d. one month. There were no quotations for three months. In the afternoon the market was again the turn easier, and 1500 tons of Cleveland warrants changed hands at 53s. ten days, and 53s. 4d. one month. The closing quotations were called 53s. 2d. cash, 53s. 5d. one month, and 53s. 10½d. three months sellers. When the market opened to-day (Wednesday) the tone was quietly steady, and only one lot of Cleveland warrants was done at 53s. 1½d. cash, and closing sellers quoted 53s. 3d. cash and 53s. 6d. one month. In the afternoon there was a little more doing, and Cleveland warrants amounting to 2000 tons changed hands at 53s. 0½d. nine and thirteen days, and at 53s. 4d. one month, with sellers over at the latter figure, and at 53s. 1d. cash.

Sulphate of Ammonia.—Practically no change has taken place in the sulphate of ammonia market, and the demand is of the most meagre description. The output has been greatly curtailed, owing to so many of the blast-furnaces being out at present.

Scotch Steel Trade.—The past week has been rather a difficult one in the Scotch steel trade, but the position is certainly a little better. The large withdrawal of shipping facilities upset things a bit, but as soon as there is a reasonable chance of vessels getting a safe journey export business will be resumed, provided the insurance rates ease off and the advance in freights does likewise. The only business doing at present is for the home market, and with Germany and Belgium out of count the local makers are once again having a run. Of course, there is really not a very heavy tonnage going through, and few of the works are running full, but better prices are being secured. The latter are necessary owing to the scarcity and high cost of raw material, but producers can be depended on not to overstep the margin, knowing that America can offer fairly good competition.

Malleable-Iron Trade.—The West of Scotland malleable-iron makers report business as being slow but hopeful. Nothing very much in the way of improvement is anticipated until prevailing conditions settle down a little. At a meeting of the associated makers it was decided to advance local prices by 10s. per ton, making the quotation for "crown" bars 7*l.* 2s. 6d. per ton, less 5 per cent. for Glasgow delivery. The export price is now up to 6*l.* 12s. 6d. or 6*l.* 15s. per ton net, f.o.b. Glasgow.

Scotch Pig-Iron Trade.—The Scotch pig-iron makers are moving along slowly, and there is not a very heavy demand for material. In the meantime the shipping trade is nil, and the home demand for the ordinary qualities, although improving, is not of any great significance. Prices are firm.

WIRELESS-TELEGRAPH OPERATORS FOR THE NAVY.—The Secretary of the Admiralty desires it to be known that candidates qualified as wireless-telegraph operators who may wish to enrol in that capacity in the Royal Naval Reserve for service in the Fleet should apply immediately direct to the Commodores at the Royal Naval Barracks at Chatham, Portsmouth, or Devonport, who will furnish particulars of the conditions of service.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—The council of the Institution beg to suggest that there are two important directions in which the members may be of great service to the nation at the present time:—First, to place their services as electrical engineers at the disposal of the War Office and of the Admiralty; secondly, to be in readiness to fill vacancies in public services, electric power-stations, tramways, railways, &c., caused by the calling up of the Reserves and Territorial forces. The council desire not only to receive offers of services from members of the Institution, but also that all members should assist them to obtain the names of as many qualified men as possible (whether or not members of the Institution) willing to offer their services in the directions indicated. The council add that they have offered to place at the disposal of the War Office, for immediate occupation and free of charge, the available portions of the Institution building, of a total area of 10,000 sq. ft.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is quite a brisk business doing in pig-iron. Sales, however, are entirely confined to home business, any attempt at over-sea transactions having been abandoned for the time being. The most marked internal demand is for hematite, production of which threatens to be considerably curtailed by difficulty in obtaining adequate supplies of foreign ore. Three hematite furnaces have already been damped down, and three running on Cleveland iron are being put out of operation. The total number of furnaces now blowing on the North-East coast is only sixty-seven. No. 3 g.m.b. Cleveland pig-iron is rather readily realising 53s., at which figure quite a number of sales have occurred, whilst No. 1 is 55s. 6d., and No. 4 foundry 52s. 9d. No. 4 forge is very scarce, and is fully 52s. 6d. Mottled iron is 52s., and white 51s. 9d. East Coast hematite quotations vary somewhat. They have risen rather rapidly, and a general impression prevails that they are likely to advance still further. Up to 66s. has been paid for mixed numbers, but the conditions were exceptional, and the general market rate may be given at 65s. All the foregoing quotations are for early delivery. There is practically nothing passing in foreign ore. Sellers intimate that they could do business if they could guarantee delivery, and they quote on the basis of 21s. ex-ship Tees for Rubio of 50 per cent. quality, with the proviso, however, that freights can be fixed. Coke is by no means plentiful, owing to the closing of several collieries; but with foreign demand cut off, the shortage should not be of long duration. Durham blast-furnace coke of average quality is at present realising up to 17s. 6d., delivered at Tees-side works. Buyers hesitate to purchase at such a figure, and sellers intimate that they are not prepared to make forward contracts to any extent.

Shipments and Stocks of Pig Iron.—For the time being shipments are practically suspended, only a few small cargoes to coastwise customers having been cleared during the past few days. With exports stopped, stocks are steadily accumulating, though not to the extent that might have been expected. Makers' stores are probably increasing, but to what extent is not ascertainable. The stock of Cleveland pig-iron in the public warrant stores here now stands at 86,826 tons, 4797 tons having been added since the beginning of the month.

Manufactured Iron and Steel.—Producers of manufactured iron and steel take a very firm stand, and hint at still further advances in quotations in the near future, as raw material is rising. There is now considerable pressure to buy joists, and there is a renewed demand for shipbuilding material. Rails are in only moderate request, and this is the quietest branch of the industries. Messrs. Head, Wrightson and Co. are understood to have booked a substantial order for bridge-work in connection with Indian railway extensions. The following are the principal market quotations:—Common iron bars, 7*l.* 10s.; best bars, 7*l.* 17s. 6d.; best best bars, 8*l.* 5s.; packing iron, 5*l.* 15s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 7*l.* 10s.; iron ship-rivets, 8*l.* 10s.; iron girder-plates, 7*l.* 15s.; steel bars (basic), 6*l.* 15s.; steel bars (Siemens), 6*l.* 15s.; steel ship-plates, 7*l.*; steel ship-angles, 6*l.* 15s.; steel boiler-plates, 8*l.*; steel joists, 6*l.* 12s. 6d.; steel strip, 6*l.* 5s.; steel hoops, 6*l.* 10s.—all less the customary 2½ per cent. discount; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.*; heavy steel rails, 6*l.*; and steel railway sleepers, 7*l.*—all net at works; galvanised corrugated sheets, 24 gauge, in bundles, 11*l.* 10s. f.o.b.—less 4 per cent.

THE INSTITUTION OF MECHANICAL ENGINEERS AND THE WAR.—The Institution of Mechanical Engineers, by its President, Sir H. Frederick Donaldson, K.C.B., has offered to the Prince of Wales the use of the vacant top floor of the extension building, free of charge, during the continuance of the war, for the administrative purposes of the Prince's Fund. The offer has been warmly accepted, but the Institution has been asked to allow the rooms to be used by the Office of Works for the purpose of accelerating the designs and specifications for many public works which it is intended to put in hand as quickly as possible, in order to afford employment. As this is work quite in character with the objects of the Prince's Fund, the Institution has gladly fallen in with His Royal Highness's views.

THE CARR BRIDGE ACCIDENT ON THE HIGHLAND RAILWAY.—The accident which occurred on the Highland Railway on June 19, when a bridge over a stream gave way near Carr Bridge, has been reported on by Lieut.-Colonel E. Druitt. The cause of the accident was the destruction of the bridge by a storm of phenomenal character and of a severity quite unforeseen. The bridge as originally built of stone and brickwork was a sound job to all appearances, making adequate provision for the stream it crossed. The exceptional rainfall and consequently high-water level, together with the rapid fall of the bed, resulted in erosion which the structure could not withstand. As a consequence it failed when a passenger train to Inverness was passing over it. Five passengers were drowned and ten injured. The report lays no blame on the railway for the occurrence. The bridge is to be rebuilt of wider span, with increased protection in heavier abutments and wing walls, solid concrete invert extending to the end of the wing walls, and a curtain at each end of the invert sunk to a depth of 10 ft. The new foundations will be carried much lower than the old ones.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has been greatly affected by the sudden war conditions which have arisen. Fresh business is practically suspended, and has also been interfered with by a Royal Proclamation relating to exports. Some cargoes have been despatched for the French Government and also to Egypt. Chartering has been restricted to Admiralty business.

Housing at Newport.—The Planning Committee of the Newport Town Council recommends that in the East Usk district, where the Local Government Board has authorised a housing scheme, the number of dwelling-houses should not exceed twenty to an acre, that the houses should be built singly or in blocks not exceeding eight in a block, that main streets should be 40 ft. to 50 ft. wide, and side streets 30 ft. wide, and that a betterment clause should be inserted in the scheme when circumstances justify it.

The Continental Situation.—Sir Alfred Mond, M.P. for Swansea, called a meeting of business men at that town on Saturday evening to discuss the present international situation. In the course of his address, Sir Alfred said he knew of one engineering firm which had already had three inquiries due to the cancelling of contracts placed in Germany. Mr. Henry Bond (of Messrs. Richard Thomas and Co.) had written to him, giving a hopeful prospect for the tin-plate trade, pointing out, for instance, how business with the Continent was after all only two-sevenths of a total manufacture of 500,000 tons per annum; and that the home trade amounted to 203,000 tons. We might expect a reasonable demand to continue from such countries as Roumania, Italy, Portugal and the Netherlands; and he believed France would in a short time resume her orders. There was reason to suppose, too, that there would be a great demand for tin-plates for packing. The impossibility of obtaining petrol to-day in London was because there were no tins to put it in, the Government having commandeered all the tins for their own purposes. There should be a brisk demand in the near future from petrol consumers in Canada and the United States.

Messrs. Guest, Keen and Nettlefolds.—The directors of Messrs. Guest, Keen and Nettlefolds, Limited, recommend a dividend upon the ordinary shares at the rate of 10 per cent. per annum for the half-year ending June 30, together with a bonus of 1s. per share. For the last eight years the company has made regular distributions upon its ordinary shares at the rate of 15 per cent. per annum.

UNIVERSITY COLLEGE.—The hand-book of the Faculty of Engineering at the University College of the University of London has recently been issued for the forthcoming session. Its contents include lists of officers and staff of the college, particulars of college societies, and information relating to scholarships and exhibitions. It also gives particulars of entrance requirements and curricula in engineering, mentioning the fees for all the different subjects and courses, and details of the laboratory and workshop equipment of the college. Copies of the hand-book can be obtained from the Provost of the College, the address of which is Gower-street, London, W.C.

THE SHIPPING, ENGINEERING AND MACHINERY EXHIBITION.—It appears fairly certain that owing to the disturbed conditions arising from the European war, this important Exhibition, which was to have been held at Olympia between September 25 and October 17 next, will have to be postponed. We understand that the circumstances of the case have been put before exhibitors who had engaged space, with the result that about 95 per cent. of them have already voted for the postponement. Quite apart from this, however, it seems, in view of the Government requirements, very doubtful if Olympia would be available for the purposes of the Exhibition at the proposed dates. Of course, the postponement of such an Exhibition involves not only great inconvenience, but also probably a considerable monetary loss to those engaged in its organisation, and this being so, the promoters trust that they will receive such support as will enable them to arrange for the holding of a very successful Exhibition next year under more favourable auspices.

THE READING RAILWAY ACCIDENT.—The cause of the accident which occurred on the Great Western Railway at Reading seems to have been a combination of a mistake and lapse of duty. In this accident, which happened on June 17, it will be remembered, an excursion train drew out of Reading in the up direction and fouled the main up line on which an up express was approaching. The two locomotives came in contact, with the result that the express and excursion train locomotives were thrown over on their sides and the vehicles of the express train damaged. The report of Lieut.-Colonel P. G. von Donop to the Board of Trade states that the small amount of damage sustained is testimony to the substantial construction of the coaches. It appears that the fireman of the excursion train mistook some action of the guard, standing on the platform with his flag, for a "right away" signal, which he passed on to his driver without assuring himself that the starting signal was "off." The driver, accepting the intimation, started his train with the signal against him. When the mistake was found out, it was impossible to pull up before the main up had been fouled. The fault is found to lie with the driver for not satisfying himself that the signal was "off" for him, and in a less degree with the fireman for a like reason.

THE ALEXANDRA DOCK EXTENSION AT NEWPORT; PUMPING PLANT.

SIR JOHN WOLFE BARRY, LYSTER AND PARTNERS, MM. INST. C. E., WESTMINSTER, ENGINEERS; MESSRS. BOVING AND CO., LIMITED, LONDON, CONTRACTORS.

(*For Description, see Page 217.*)

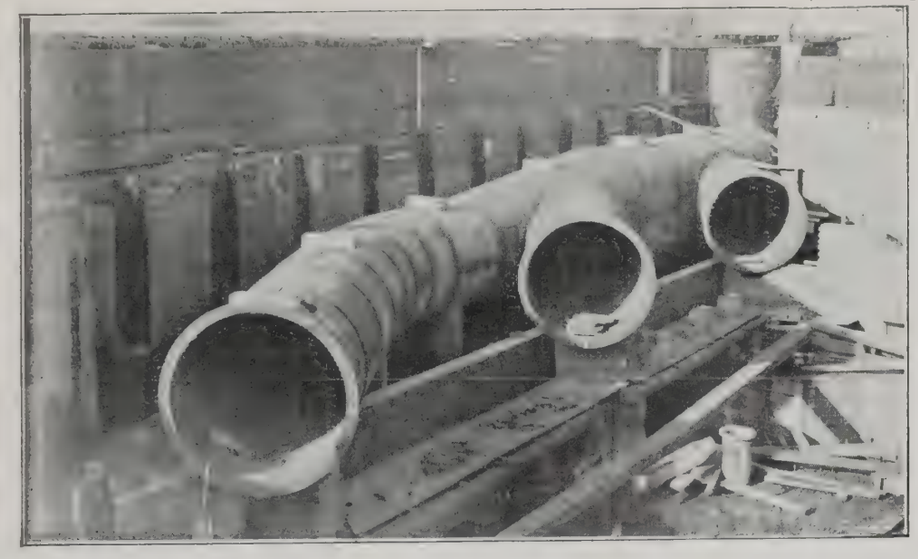


Fig. 170. 12-Ft. Branched Discharge Main from Pumps.

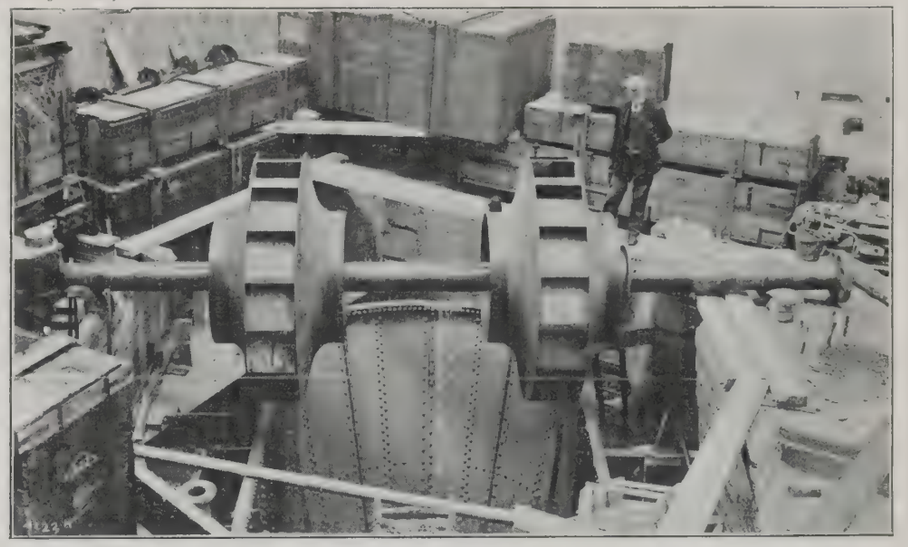


Fig. 171. Main Shaft and Twin Impellers of Pump.

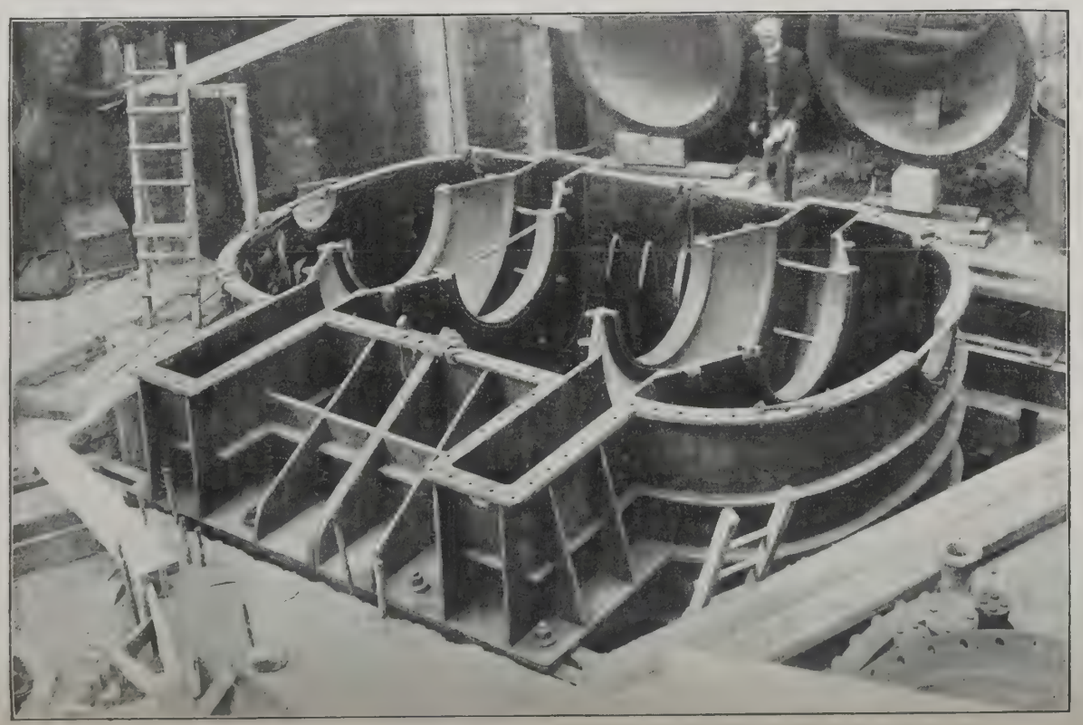


Fig. 172. Lower Part of Casing for Pump.

Fig. 173. Suction-Pipe for Pump.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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Thick ,,	£1	16	0 ($8.75)
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Thin paper copies	£1	16	0
Thick ,,	£2	0	6

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Telephone Numbers—3663 and 8598 GERRARD.

Reading-Cases.—Reading-cases which will hold twenty-six numbers of "Engineering" may be had of the Publisher or of any newsagent. Price 6s. each.

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With a Two-Page Plate of the ALEXANDRA DOCK EXTENSION AT NEWPORT; PUMPING AND ELECTRIC POWER-STATION.

NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, AUGUST 14, 1914.

THE AUSTRALIAN MEETING OF THE BRITISH ASSOCIATION.

On Friday, July 3, the last contingent of the British Association overseas party sailed by the Orient liner Orvieto for Fremantle and Adelaide. Many members had left before by different routes, some *via* the Cape, some *via* America. Geologists, miners and farmers in particular, anxious to study Western Australia, went out by the Ascanius, of the Blue Funnel Line, to form an advance party, which was to join the main body at Fremantle by August 4. They were then to proceed together to Adelaide, where the Aberdeen liner Euripides, which left two days before the Orvieto, and was also due on August 8, was to end her maiden trip round the Cape, and to bring up another contingent. From Adelaide the united party is to travel by train to Melbourne, Sydney and Brisbane. Inasmuch as the sectional meetings will commence at Melbourne and will be continued at Sydney, the official meeting may be said to begin at Melbourne to-day. But the members attend by invitation of the Commonwealth of Australia; receptions and discourses have already been given in Western Australia, and though the sections will not meet at Adelaide and Brisbane, these two capitals will also be centres of the meeting. The official programme will end at Brisbane on September 1, and members will be able to hurry back by train to Adelaide, there to embark on the Orvieto again, which is due in London by October 10—unless they prefer other routes *via* the East Indies, *via* the Sandwich Islands and Canada or the United States, &c. On June 9 the overseas party counted 313 members; this number comprises the invited distinguished foreign scientists.

This is the fifth time that the British Association has left the United Kingdom. When the first visit abroad to Montreal in 1884 was suggested, the question arose whether the Articles of the Association entitled the Council to make arrangements for meetings beyond the United Kingdom. But the meeting proved a success, and their Canadian hosts again invited the British Association to come to Canada—to Toronto this time—in 1897. The next visit abroad was a still more serious matter. In 1905 the Association went out to South Africa; that meant more than a fortnight's sea journey to Cape Town, or further on to Durban, followed by thousands of miles by train to Bloemfontein, Johannesburg, Pretoria, Kimberley, Buluwayo, Salisbury and the Victoria Falls, and back to Beira or to Cape Town. After that the feeling was for a time decidedly in favour of meetings only within the United Kingdom. But when Winnipeg sent invitations for 1909 there was a hearty response, though more than half the Canadian continent had to be crossed by rail to get to Winnipeg, and a journey across the other half was gladly added after the meeting, for studying the development of Western Canada.

When, in 1910, Sir George Reid presented a formal invitation from the Commonwealth of Australia, members were pleased, but also disconcerted. The meeting involved a kind of repetition of the South African meeting, including a long sea journey and days and nights spent in trains, to arrive at the various centres. The length of the actual sojourn in the country was to be about a month, as it had been in South Africa. But there was a month of sea voyage out and the same back again, instead of a little more than a fortnight, and that made a serious difference in the time required. The professorial element hesitated, and teachers of various descriptions, of course, form the nucleus of the British Association for the Advancement of Science. Yet the Commonwealth evidently intended to do everything to enable members to make the best of their short stay, and to relieve them so far as possible of the heavy travelling expenses. Thus the opposition of those who regretted their inability to participate, and the grumbles of those who sneered at picnicking in the Colonies, died down. College authorities were found ready to extend the vacations of intending visitors to Australia a little, and when inquiries were sent out by the Council to old members a year ago, more favourable replies were received than had been counted upon. The result was that a restriction had to be placed on the special facilities provisionally offered. Yet the official list of the overseas party counted more than 300 names, as we have stated already, and members left looking forward to a thoroughly instructive and enjoyable meeting, after a July passage through the sultry Red Sea and the monsoons of the Indian Ocean.

It has been our custom to outline the provisional programme of the British Association, and the present time appears suitable to offer some introductory remarks. Excellent arrangements have been made both here and on the Australian side. The *Federal Hand-Book for Australia*, compiled under the authority of the Federal Council of the Association, for the eighty-fourth meeting of the British Association, and edited by Mr. G. H. Knibbs, of Melbourne, is a volume of 600 pages, full of valuable information on the history of the country, its natives, topographical, meteorological, and geological features, railways, trade, exports, imports, education, &c. This book was presented also to members of the General Committee unable to go to Australia. Every intending visitor was further presented with guide-books to all the States of the Commonwealth. Information as to travelling by a great many routes, mostly at reduced fares, was sent to all members intending to participate. All the members, it is understood, will travel free on the railways; there will be no official party as distinct from other members. Private hospitality has been very liberally extended to a large number of members. To ensure a smooth working of the big scheme, Dr. A. C. D. Rivett, of the University of Melbourne, came over here last autumn, and remained here till recently, as general organising secretary for the Australian meeting.

Professor William Bateson, M.A., F.R.S., will be the President of the British Association, and be introduced as such by his immediate predecessor in the chair, Sir Oliver Lodge. Professor Bateson will deliver the first part of his address at Melbourne and the second part at Sydney. In this he will follow the precedent of the late Sir George Darwin, who presided over the South African meeting of 1905. The subject of his address is not known yet, of course; but it is not improbable that the African precedent will also be observed in another respect. George Darwin carried evolution into the physical world and into the universe, into the microcosm of the atom, and into the macrocosm of planetary systems and stars. Professor Bateson has made evolution in plants and animals his life study; and lecturing upon cross-breeding, hereditary characteristics, and Mendelism at the Royal Institution this spring, he stated that evolution did not to-day stand where it stood ten years ago, and that natural selection had to be abandoned; we may, perhaps, hope that his address will deal with his own sphere of work and a revision of these theories.

The President-elect of Section A (Mathematics and Physics), Professor Trouton, F.R.S., is unfortunately too ill to proceed to Australia, and his address on Adsorption and Absorption of Solutions will be read by Professor A. W. Porter, F.R.S. Discussions will be held in the Section on the Structure of Atoms and Molecules, to be opened by Sir E. Rutherford, in conjunction with Section B, Chemistry; on Wireless Telegraphy (Sir O. Lodge), in conjunction with Section G, Engineering; and on the Present State of the Problems of Australian Longitude (by P. Baracchi, Government Astronomer of Victoria). Astronomical lectures and papers will be presented by the above-mentioned, and by Professor G. G. Abbot, Dr. F. W. Dyson (the Astronomer Royal), Professor A. S. Eddington (Recorder of the Section) and Professor E. W. Brown, while reports on astronomical and meteorological subjects will be presented by Professor H. H. Turner, General Secretary of the Association, and others. Professor W. M. Hicks will bring up the question of the Magneton. Professor E. Goldstein, of Berlin, will lecture on Salts Coloured by Cathode Rays; Professor T. R. Lyle and J. A. Pollock will read

papers on Radiotelegraphy; and Professor W. G. Duffield will refer to the Pressure upon the Poles of a Carbon Arc.

Professor W. J. Pope, of Cambridge, will preside in Section B, Chemistry, and his address as well as his contribution to the joint discussion with Section A may have some bearing on his eminent researches concerning the structure of crystals, elements and compounds. The classification of the elements will also be discussed by Professor Orme Masson, of Melbourne, Chairman of the Federal Council for the meeting. Determinations of Pressures and of Specific Heats will be explained by Messrs. F. H. Campbell and E. J. Hartung, and Mr. V. G. Anderson will direct attention to the Influences of Weather Conditions upon the Amounts of Nitrogen Acids in the Rainfall near Melbourne. The section will discuss Metabolism, together with Section M, Agriculture, which will certainly be very busy under the presidency of Mr. A. D. Hall, F.R.S., of Rothamsted.

Professor E. G. Coker will make Stress Distribution in Materials the subject of his presidential address to Section G, Engineering, and will also contribute papers on Stress Distribution in Short Compression Members and on Temperature Cycles, together with Messrs L. N. G. Filon and W. A. Scoble. Mr. W. E. Adams will speak on Australian Ports in relation to Modern Ships and Shipping; Professor Hudson Beare will give notes on Tests of Petrol-Motor Fire-Engines, and the Resistance to the Flow of Water through Canvas Fire Hose; Mr. J. J. C. Bradfield will speak on Proposed Metropolitan Electric Railways; Professor H. Chatley on the Dynamic Increment of a Single Rolling Load on a Supported Beam; Professor W. E. Dalby will describe the New Engineering Laboratories of the City and Guilds Engineering College, London; and will present papers on Railways and Motive Power and on the Testing of Materials. Professor G. W. O. Howe (the Recorder of the Section) will speak on the Capacity of Radiotelegraphic Aerials; Mr. T. W. Keele on Investigation of Nile River Flood Records from A.D. 641 to 1451 for Traces of Periodicity; Professor L. Luiggi on Irrigation in Italy; Dr. W. Rosenhain on the Behaviour of Metals under Strain and on the Distribution of Phosphorus in Steel; Professor W. M. Thornton on the Limiting Conditions for the Safe Use of Electricity in Coal-Mining and on the Lost Pressure in Gaseous Explosions; Mr. L. A. B. Wade on Irrigation in South Wales; Mr. H. D. Walsh on Applications of Reinforced Concrete to Harbour Work; and Professor W. H. Warren on Australian Timbers. Reports are to be presented on Gaseous Explosions and on Stress Distribution in Engineering Materials. The joint discussion with Section A on Radiotelegraphy has already been mentioned.

We cannot enter into full particulars of the provisional programmes of the other sections, although they will often tempt the engineer to forsake his own section. The Geologists (President, Sir T. H. Holland) will discuss the Physiography of Arid Lands in conjunction with Section E, Geography, and Past and Present Relations of Antarctica, with Sections E, D, Zoology, and Section K, Botany. Evolution and the Origin of Species will be the subject of the presidential address of Professor A. Denaby in Section D, and will further be discussed together with Section K. A discussion on Mimicry with Section K will be opened by Professor E. B. Poulton. The most interesting discussion of the whole proceedings will probably be that to be opened by Sir Douglas Mawson, on Past and Present Relations of Antarctica in their Biological, Geographical, and Geological Aspects, in a joint meeting of Sections D, E, K. Dr. Mawson has postponed the account of his unfortunately terrible experiences in the Antarctic until the meeting—a generous act, considering how he was pressed to lecture when over here recently. In Section E, where Sir C. P. Lucas will preside, Australian geography will rightly predominate. Town-Planning and Colonisation problems will form important subjects in Section F, Economic Science and Statistics, where Professor E. C. K. Gonner will take the chair. Section H, Anthropology (Mr. Everard im Thurn, President), will no doubt attract crowds to hear Dr. A. C. Haddon (Cambridge), Professor von Luschan (Berlin), Mr. Etheridge, Professor Elliot Smith, and other authorities on folk-lore. The subject which the President of Section I, Physiology, Professor B. Moore, has selected for his address is the Value of Research in the Development of National Health. Professor F. O. Bower will preside in Section K, Botany, and Professor John Perry, Treasurer of the British Association, in Section L, Educational Science, sections to which, as well as to Section M, Agriculture, Australians may attach very particular importance.

Our brief epitome will suffice to indicate the important character of the proceedings, to which Australian members will largely contribute. The number of evening discourses and lectures to be delivered is unusually large, in view of the circumstance that so many towns are to be visited. Professor Herdman, the senior General Secretary of the British Association, opened the cycle at Perth on July 28 with "Why We Investigate the Ocean;" Professor Eddington followed there with "Stars and their Movements," Mr. H. Balfour with "Primitive Methods of Making Fire," and Dr. A. D. Waller with "The Electrical Action of the Human Heart." Kalgoorlie was to have a lecture by Mr. C. A. Buckmaster on "School Inspection: a Review and a Retrospect; or Mining Education in England." Adelaide and Brisbane were also to be favoured with many lectures as a compensation for the want of sectional proceedings. Sir O. Lodge ("The Aether of Space"), Professor Sollas ("Ancient Hunters"), Dr. Dyson ("Greenwich Observatory"), Professor H. E. Armstrong ("The Materials of Life"), Professor G. W. O. Howe ("Wireless Telegraphy"), and Sir E. Rutherford ("Atoms and Electrons") are amongst the lecturers there and at Melbourne and Sydney. There are also to be public lectures (not intended for British Association members), including those by Professor H. H. Turner on Comets, by Dr. Rosenhain on the Making of a Big Gun, by Sir H. H. Cunynghame on Clocks, and by Dr. A. C. Haddon, on the Decorative Art of Papua.

Excursions, it need not be emphasised, figure very prominently in the programme, and members were left to make their choice when arriving at the respective centres, though numbers will be limited. Only in the case of the great excursions in Western Australia, Queensland, Tasmania, to Broken Hill, and to New Zealand members were advised to make early applications, or to make their own arrangements.

Australia is young, whatever geologists may teach, among the great divisions of the earth. Its history hardly goes back to 1600, and though it is a country very nearly as big as Europe, its population does not come up to that of Greater London. Canada, the great dominion, which the Association visited in 1909, also differs very little from Europe in size, and just surpasses London in population. Australia had been rediscovered several times before it was understood that the various coasts seen by navigators all belonged to a common continent. The first clear mention of a great Terra Australis—a land separated from the big island of New Guinea by a narrow strait (named Torres Straits later) occurs in the writings of Cornelius Wytfliet in 1598, and Dutch sailors on the way to the East Indies found out that they could catch a favourable wind northward if they sailed some 3000 miles east after rounding the Cape (round which Vasco da Gama had reached Calicut, in India, in 1497-98). On that route they often saw the west coast of Australia, and mapped it all out from Cape Leeuwin (south-west) to the Gulf of Carpentaria. In 1642 the Governor of Java, Antony Van Diemen, sent an exploring party out south-east, under Abel Tasman, who discovered the island now bearing his name, but which he himself called Van Diemen's Land. The continent was mostly designated "New Holland," and was called so by the first Englishman, William Dampier, who went out there on a buccaneering trip to the western shores of Australia.

James Cook, in his exploring cruises of 1768-70, circumnavigated New Zealand, which had been thought to be part of New Holland, and explored the east coast; Cook was sent out by the Royal Society to study the transit of Venus in 1769, it will be remembered. Cook took possession of all the new land under the name of New South Wales. The name Australia was strongly advocated by the navigator Matthew Flinders in 1814, and slowly came into use; but the name Van Diemen's land was sometimes used for the Continent, as well as for the Island of Tasmania. Convicts were sent to the new colonies, to Botany Bay first in 1788, until the settlers resented the inhumane convict system. In New South Wales it was forbidden in 1840, when some 120,000 convicts had been landed there. But Van Diemen's land maintained the system until 1856, when the island changed its name into Tasmania; Western Australia had received convicts since 1843, and only abolished the system in 1868. As regards treatment of the natives, Australia certainly has not a cleaner record than most other colonies. The gold boom in Victoria dates from 1851; the gold-fields in Western Australia were discovered in 1887; the gold-mining industry has, as often occurs, been more indirectly than directly profitable to the land on the whole.

Scientific exploration of the continent began early. Gradually the belief in an absolutely barren desert interior vanished, mines and sheep-farms prospered, towns rose, railways were built, the six different colonies consolidated, after much quarrelling, to a Federation in 1900, and the present King—then the Duke of York—opened the first Parliament of the Commonwealth in 1901. The Commonwealth is anxious to advance. The colleges of the old cities have shown what they can do. New colleges are rising in newer towns, and it is in their interest particularly that the invitation to the British Association was tendered.

THE COLLAPSE OF SHORT TUBES.

In spite of the fact that boiler-flues are used in very large numbers, it cannot be held that the theory of the resistance of tubes to collapse is in a wholly satisfactory condition. No doubt for the immediate ends of the boilermaker and user the empirical formulæ of the Board of Trade or Lloyd's and the like are entirely adequate, being quite reliable within the limits covered in ordinary boiler practice, and very simple in form. This latter consideration is by no means the least important, as complicated formulæ waste time and increase the risk of arithmetical errors. When, however, empirical rules are applied to unusual conditions, disaster is imminent. For example, a bad collapse occurred some little time ago on the Continent in a case in which it was necessary to construct a cylinder $4\frac{1}{2}$ metres in diameter to withstand the external pressure due to a head of 6.1 metres of water. Relying upon one of the old empirical formulæ deduced from experiments on boiler-flues, the draughtsman made the plating only 6 mm. thick, and there were no stiffening-rings. The liability to collapse was aggravated by the fact that the joints were lap-riveted, and the structure was accordingly not truly cylindrical in form. As might have been anticipated, the cylinder collapsed under its normal load, with re-entrant bulges at three places, which were not symmetrically distributed.

No doubt an engineer with a more adequate knowledge of theory and practice would have detected the danger from a mere inspection of the drawings; but at the same time it must be admitted that existing theories as to the strength of short and thin cylinders leave much to be desired. Indeed, experiment itself often yields discordant results. Probably this is inherent in the very character of the failure. As is well known, whilst bars tested in tension give closely concordant results, this is by no means uniformly the case in compression tests. In fact, since failure ultimately originates in some local defect of elasticity or the like, a very close accord between experiment and theory is hardly to be anticipated, the figures recorded tending to lie at varying distances to one side of a theoretical limit-curve.

The collapse of a short, thin tube is a still more complicated phenomena. Indeed, as Professor Unwin pointed out years ago, there is a somewhat close analogy between the failure of a tube by collapse and the failure of a strut by crippling. The number of virtual struts into which the tube divides is, however, a function of the length of the tube, and so far, no very definite law connecting the two has been discovered. As the result of an extensive series of experiments, Professor Carman concluded that a tube 6 diameters long would collapse in the same way as one of infinite length, for which he found the collapsing pressure to be given by the relation:—

$$p = 50{,}200{,}000\left(\frac{t}{d}\right)^3,$$

where the ratio of $\frac{t}{d}$ must not exceed $\frac{1}{40}$. From theoretical considerations, Mr. R. E. Southwell concluded that the length of tube which collapses

in the same way as one of infinite length is equal to :—

$$L = k\sqrt{\frac{d^3}{t}},$$

leaving the constant k undetermined. Professor Carman proposed that, making his assumption, the pressure of collapse of a short tube of length l could be taken as given by

$$p = \frac{6\,d}{l}\,\bar{p}$$

where $\bar{p}$ denoted the collapsing pressure for a tube of infinite length.

In a paper recently published in the *Philosophical Magazine*, Mr. G. Cook, M.Sc., compares the foregoing with the results of experiments he has conducted at Manchester with short steel tubes 3 in. in diameter, of varying lengths, with a thickness varying from $\frac{1}{100}$ in. up to $\frac{1}{5}$ in. The experimental curve he has obtained does not appear to agree well either with Carman's view or with that of Southwell, and apparently the differences are systematic. Mr. Cook does not, however, consider that his experiments are sufficiently numerous to establish the true law, although they were remarkably consistent *inter se*. This, no doubt, is to be attributed mainly to the great care taken in preparing the specimens, which were carefully machined to a uniform thickness. The cost of this preparation was defrayed by the Vulcan Boiler and General Insurance Company.

THE CONDUCT OF BOILER AND STEAM-ENGINE TRIALS

It is a well-recognised truism that the extraordinarily rapid development of the heavy electrical industries is in no small degree attributable to the ease and accuracy with which electrical measurements can be made. Indeed, although this department of engineering enterprise was inaugurated more than a generation ago, the principles on which electrical measurements are based had been pretty thoroughly worked out by the telegraphist, who had, in fact, gone further and perfected many of the most important of the apparatus and appliances still in use.

The steam engineer was less fortunate. Indeed, for a long time the indicator, even in its early imperfect form, was one of the trade secrets of Boulton and Watt, the first public knowledge of it coming, if our memory serves, from so distant a locality as St. Petersburg, where it was used by some engineers from the famous Soho works. Useful tool as the indicator is, it provides neither as convenient nor as accurate a method of measuring power as a good wattmeter. It is not surprising, therefore, that accurate engine-testing was of slow development, and for long remained a scientific or technical curiosity, rather than an effective aid to steam-engine improvement; the more especially as the practical side of theoretical thermodynamics was badly understood, and test results were expressed in a fashion which was perhaps somewhat discouraging to the progressive engineer. For example, some thirty to thirty-five years ago, a very interesting method of engine-testing was developed, in which the heat carried away from the engine by the condensate was compared with the heat supplied. What was most evident in this method of presenting the facts was the smallness of the useful work done in comparison with the total energy supplied. An engine which wasted 85 per cent. of the total heat supply hardly appeared to the casual observer as markedly better than one in which the losses were 1 per cent. greater, whilst it generally cost very considerably more.

It was therefore quite intelligible that most practical engineers preferred to guarantee fuel consumption, lumping together accordingly boiler-room and engine-room losses. So long as the same firm supplied both the steam-generators and the power-generators, the disadvantages of this unscientific procedure were, perhaps, not particularly evident, and the plan had the great advantage of making its appeal to the purchaser in terms readily comprehended, even by those with but rudimentary ideas on thermodynamics.

With the advent of the electric-light station matters, however, changed. The low load factor of some 7 to 10 per cent., at which these stations were worked, made it very difficult to give any satisfactory guarantee of fuel consumption, particularly in the case of the earlier systems, in which a number of small generators were belted up to a (for those days) large engine. This engine had to run the whole twenty-four hours, most of its time under little or no load. The disabilities attaching thereto were sufficiently serious even with direct-current generators, and were woefully augmented when the current was alternating, since some of the earlier alternators are said to have absorbed as much power at no load as at full output. The obvious way out was the introduction of the direct-coupled high-speed steam-engine, in spite of the fact that the earlier forms acquired a reputation succinctly expressed in the opprobrious epithet of "steam-eater," a term specifically invented on their behoof. In spite, however, of the fact that at full load these engines could not compete in efficiency with the large, slow-moving Corliss engines, the full-load efficiencies of the latter were by no means in harmony with the fuel expenditure at the station, since whilst, as the load fell off, the smaller direct-driven units could be cut out one by one, it was necessary to keep the large unit still turning round at but a small fraction of its designed output.

By degrees the economy of the high-speed type improved, and the leaders in this movement found it advisable to establish definitely the high degree of efficiency realised. Fuel guarantees were useless to this end, owing to the peculiarities of station practice already adverted to, and the era of accurate commercial engine-testing commenced. In this work a very important and prominent part was taken by the late Peter Willans, to whom we are indebted for two very important advances. Of these, one is embodied in the now well-known Willans law, the utility of which is on a par with its simplicity. No earlier investigator seems to have observed that the total consumption of a steam-engine, when plotted against its load, gives a curve which never differs very much from a straight line. The second great service of Mr. Willans was the popularising of the method of rating the efficiency of the engine by comparing it with one operating on the ideal Rankine cycle. One drawback has attached to this innovation—viz., that it endowed us with two thermodynamic efficiencies. There is still apparently no definite distinction made between these by Continental writers; but, on the advice of a committee appointed by the Institution of Civil Engineers, the Willans efficiency has been named the efficiency ratio, whilst the thermodynamic efficiency is the ratio of the work done to the total energy supplied. Willans's innovation gave us efficiency numbers of the order of 60 to 80 per cent. in place of, say, 12 to 18 per cent., and the moral effect of the higher figures has probably not been wholly illusory. It is surely more encouraging to realise that some 70 per cent. odd of the theoretical perfection is attained rather than some 18 per cent. at most.

Highly convenient and accurate methods of engine-testing have been worked out on the testing-beds of our high-speed-engine builders, but it would still seem that many engineers are far from being well versed in the precautions necessary for the attainment of reasonable precision. It is improbable that such a trick would be attempted nowadays as that tried some years ago, in which a dynamometer brake was fitted with a stop in the wheel-pit to relieve the engine of most of its load, whilst the presence of this stop was concealed by flooding the pit with water, ostensibly for cooling purposes. Nevertheless, certain engineers, quite capable in their own lines, still do not hesitate to append their signatures to reports of boiler and engine trials made under the crudest conditions, and support claims for economies which are wholly inadmissible.

The Institution of Civil Engineers has accordingly established a further claim on the gratitude of the profession by the timely and authoritative report of an exceptionally competent committee on the best methods of tabulating the results of steam-engine and boiler trials. For this committee the Institution were fortunate in obtaining the services of Captain H. Riall Sankey as chairman, and of Mr. C. H. Wingfield as secretary. A better selection could not possibly have been made. In this report just issued the committee have interpreted the terms of their reference very widely. They have, it is true, prepared most convenient and complete forms* for the recording of results, but they have also compiled what is in fact a most valuable "practical guide to boiler-testing," in which the various sources of error are fully discussed, and the precautions necessary to reduce these errors to a minimum are clearly and exhaustively stated. In their report they distinguish between scientific and commercial trials, it being unnecessary in trials of this second type to record certain data, although these are highly valuable from the view-point of technology, and hence a special set of commercial forms has been prepared, in addition to the more complete set adopted for more exhaustive series of tests.

The greater bulk of the report has relation to boiler-testing, and the very elaborate and complete notes on the instruments required are supplemented by carefully-considered detailed instructions for the conduct of the test. The committee note in the first place that the duration of a test should bear some relation to the weight of fuel consumed. The principal source of error in this lies in the difficulty of securing that the same amount of coal shall be on the grates at the beginning and at the end of a test, and in the same condition. It is, of course, impossible to ensure this equality of conditions with absolute accuracy, and some method of measuring the thickness of the fuel-bed is necessary. The committee recommend for this purpose the use of the tool illustrated in Fig. 1, and with

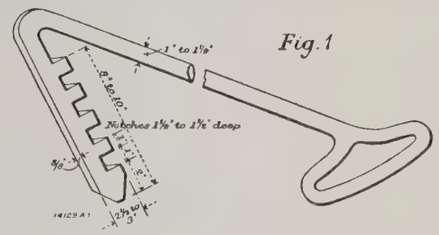


Fig. 1

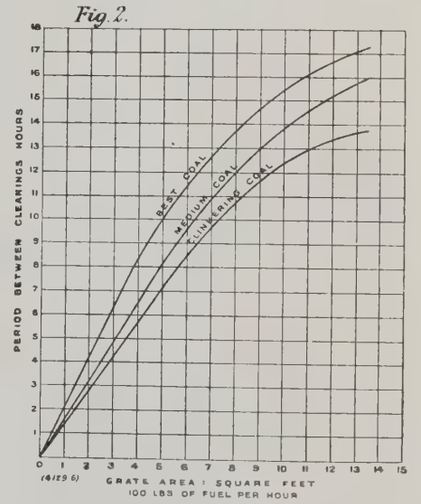
this they say the thickness can be measured within 1 in. In making corrections for differences in the thickness of the fuel, they give the following formulæ :—

Weight of fuel on grate in pounds ... ... = 2.5 A.T. for slack, = 1.7 A.T. for large coal,

where A = grate area in square feet, and T thickness of fuel in inches. They draw attention to the importance of ensuring that the fire is in about the same condition at the end as at the beginning of the trial. An obvious error, to the advantage of the evaporative efficiency, would arise were the fuel-bed burnt down thin, and then made up with green coal just before the conclusion of the run.

As to the length of the trial it is pointed out that this should depend on the rate of combustion. The unavoidable error in the fuel estimation may be as small in a 3-hour forced-draught trial as in a low-power trial of three times the duration. The duration of the trial should, moreover, be a function of the time between cleaning fires, of which the total trial time should be a multiple. If fires

Fig. 2.



are cleaned every four hours, then the test should not be five hours long, but eight hours. The frequency with which the grates are cleaned depends, of course, on the quality of the fuel. Admiralty practice, the committee state, is well represented by the curve reproduced in Fig. 2.

Attention is also drawn to the extreme importance

* Obtainable in foolscap size from the Institution printers, Messrs. Wm. Clowes and Sons, Limited, 31, Haymarket, S.W.

of establishing a uniform *régime* before the test is commenced. The time required for this varies very much with the type of boiler. In the case of a Lancashire boiler there are large masses of brickwork in the flues, capable of absorbing heat at the rate of 30 B.Th.U. per cub. ft. for every 1 deg. Fahr. rise in temperature. Hence, if a test of a Lancashire boiler is started from the cold, much of the heat which is debited to the steam has really gone into the brickwork. Conversely, if such a boiler is forced for some time before a low-power trial, the brickwork acts as a regenerator storing up heat during the preliminary period of rapid firing, to the benefit of the apparent evaporative efficiency recorded during the actual test. The following table gives, the report states, the minimum time at which boilers of different types should be run under approximately the trial conditions before the test is actually started :—

Type of Boiler.	Period of Steaming Prior to Test. At Ordinary Rate.	Under Test Conditions.
Water-tube ...	—	3 to 5 hours
Lancashire ...	2 days	1 hour
Marine... ...	—	½ to 1 hour
Locomotive ...	—	½ to 1 hour

Of nearly equal importance is the maintenance of steady conditions during the trial. If a boiler be rapidly steamed, lowering the water level, which is then made up to the standard level just before the termination of the trial, there may be a disproportionate amount of relatively cold water at the bottom of the boiler. The gauge-glass level, again, is affected by the rate of steaming, being about 1 in. higher under full steam than when the stop-valve is closed.

In sampling fuel for determining its calorific value by analysis, the report says that errors of 4 to 3 per cent. are easily possible, unless very special care be taken. On the other hand, with a skilled and careful observer they may be reduced to as little as 0 5 per cent. A common source of error is the assumption that fuel is of uniform quality if from the same batch. This, the report states, is generally without justification, and "coal must be treated as an essentially non-uniform substance."

In the case of large Welsh or other high-quality coal the sampling should, it is stated, be made by taking half a shovelful from each lot as it is weighed out, before firing. All these samples should be stored in a covered box placed where it is not exposed to heat. The total amount thus collected should not be less than 2 per cent. of the total burnt. In the case of washed coal a difficulty arises owing to the variations in the moisture present. Hence the samples collected should be in a *tared* metal receptacle, and at the end of the trial spread on a shallow metal tray, of which the weight is known. The total weight of coal taken is determined, and the tray is then left for forty-eight hours exposed to a temperature of not more than 120 deg. Fahr., at the end of which period it may generally be taken as fully air-dried, a condition which can be tested by finding if further exposure occasions further loss of weight. After this air-dried state is reached the batch is ready for the securing of a sample by quartering. To this end the Committee recommend that the batch be broken so that no piece is larger than a 2-in. cube. The batch is then thoroughly mixed and piled in a conical heap, which is quartered by flattening it a little and dividing the cone into four right-angle sectors. Two opposite sectors are then rejected, and a fresh cone built up out of the remainder, after further reduction in the size of the lumps. This cone is treated in the same way, the operation being repeated till the final sample amounts to about 3 per cent. of the original batch. The calorific value of a sample thus obtained will, it is said, be a fair average of that of the bulk of the fuel.

Some useful hints are given on the measurement of the feed. In the case of small outputs this may be weighed, but where large amounts of water are evaporated, calibrated tanks must be used. One plan recommended requires two cylindrical vessels, having conical ends, and mounted side by side under a three-way cock, from which each is filled to overflowing alternately. A pipe fitted with another three-way cock connects the two to the feed-tank. Each vessel is filled to overflowing and emptied alternately into the feed-tank. The use of cocks, rather than of valves, is recommended owing to the possibility of the latter leaking by the jamming of, say, a stray fragment of wood between the valve and its seat.

A single calibrated tank may be used where the greater cost of two tanks is a consideration, provided that the feed-tank has enough space above datum level to accommodate half a charge. The measuring-tanks, the report states, should be cylindrical in form, so as not to be subject to the deformations to which flat-sided tanks are liable. The feed-tank, on the other hand, may be of any shape. The conical bottom recommended for the calibrated tanks is particularly necessary at sea, as it is difficult to ensure that a flat-bottomed tank is each time equally emptied.

The Committee remark that leakage may be an important source of error in boiler experiments, since under 150 lb. pressure as much as 1500 lb. of water will pass through an opening of $\frac{1}{100}$ sq. in. per hour. Hence in a boiler trial all connecting pipes are best blanked off. Even so, there is the risk of a certain amount of leakage from the boiler in places where it cannot be seen, the best safeguard against which is a careful flue inspection both before and after the trial. A fair measure of its amount can be effected by blanking off all openings after the trial, maintaining the steam pressure by light firing as required, and noting the gauge-glass drop at the end of four hours.

The radiation loss, the report states, is important but unavoidable. In this connection it may be noted that the use of the term "radiation loss" is unfortunate; but it is probably too late in the day to alter a practice so long established. As is now well known, the radiation losses proper of either boiler or a steam-pipe are remarkably small, the relatively large losses found being really due to convection. To estimate these losses, the taking of a cooling-curve is recommended. This is done by closing (and luting, if necessary) fire-doors, flues, and dampers, and noting the fall of pressure at intervals for a period of six hours. On plotting these results on a curve, the "radiation" loss in the trial conditions is obtained by measuring the slope of this curve at its origin. With a well-set Lancashire boiler the drop in pressure will not exceed some 15 per cent. in the six hours. The steam-pipe loss is reckoned at 4 to 5 B.Th.U. per degree per hour per square foot of surface of bare cast-iron pipe, a figure which is raised to 6 or 7 B.Th.U. if the pipe is exposed to wind. A non-conducting covering 1 in. thick will reduce the loss to two-thirds of a heat unit, or even to half a B.Th.U. per square foot per hour and per degree, if the covering be of specially good quality.

For collecting samples of the flue-gas for analysis, it is recommended that a steel tube, perforated with small holes for the whole of its length, be placed athwart the flue. To obtain reliable results, very much more gas must be sucked out than is retained for the actual analysis.

As already noted, less space in the report is devoted to engine trials than to boiler trials. Where the engine is fitted with a surface condenser, the most accurate results are obtained by weighing the condensate, which is very readily done by turning it into a tank mounted on a weigh-bridge, and noting the time required for a given weight to collect. In this way great accuracy can be obtained even in a comparatively short run. As, however, owing to gland and other leakage, the condensate is always less than the feed, this factor should be borne in mind in demanding guarantees. With large plants there is a difficulty in measuring the power developed. In the case of steam-turbines, this is commonly accomplished by taking the electrical horse-power developed at the terminals of the generator, but the calibration of the latter is difficult and troublesome.

"SUCTION" BETWEEN PASSING SHIPS.

By Sidney A. Reeve, M.E., New York.

(*Continued from page* 198.)

II. Ship-Waves and Sea-Contours.—(*continued*).

The form in which the stream-line ship, derived mathematically from sources and sinks, was left by Mr. Taylor's last addition to its theory, was still unsatisfactory for the analysis of suction between actual ships. Its outline was everywhere convex. Stem and stern were both rounded, there was no hollow entrance or run, and the middle body was not parallel. While such a ship-form might do for the study of the general principles (which, indeed, could be well understood without any stream-line analysis), yet for any estimate of *quantitative* aspects of the problem a better ship-form must be had. The magnitude and exact form of the constrained wave accompanying a typical steamship could be had only by mathematical deductions which were based upon a typical ship-model, having a long parallel middle body, hollow entrance and run, and sharp prow and stern.

To the writer it appeared likely that Taylor's method might be made to yield these results, provided a suitable function of sources and sinks could be found to form the premises. This could be determined only by the cut-and-try method, which, as each try involves tedious repetition of simple computations, proved to be laborious. However, the nineteenth function tried gave a fairly satisfactory model, as may be seen from Fig. 7, the ship-form in which is a mathematical stream-line and not an assumed form, and upon that model all the curves and contours presented here are based.*

Taylor's method was modified slightly in order to facilitate the work of investigating many different premises, by taking a larger number of points and relying upon averages, rather than integrating a separate curve for each one of the thousands of points investigated; yet even with this the method is laborious. The ship's length was divided into twenty parts, and in terms of these longitudinal units, and for each one-fifth the beam extending laterally, the stream-lines were computed over a sea-surface extending nearly a ship's length forward of the stem, and nearly two ship's lengths abeam. In this work only one quadrant, from the course ahead to either beam, need be computed, because the mathematical treatment makes the four quadrants symmetrical. But in actuality the viscosity of the water and the energy lost in wave-making make the constrained wave astern smaller than that ahead.

This plan would apparently give over two thousand observations in each quadrant, but in the regions furthest from the ship many points were omitted, the contours there being of less curvature. Taylor's intermediate curve was plotted on a sheet 4 ft. square, the largest practicable in this case, and final values of stream line widths were computed to four decimal places (preceded by a characteristic), with intermediate computations carried to five or six places. Students repeating this work will do well to plan for greater accuracy than this, for whatever scale is adopted at the start must be adhered to throughout the work. The stream-lines were all drawn as accurately as possible, but the computed values were charted thereon and formed the sole basis for deduction, no values being taken off graphically, except in the use of the "intermediate" curve, where precautions were taken to have the graphical work sufficiently accurate.

Fig. 7 gives the results for a single ship. The model has a beam one-eighth its length, with a parallel middle-body of half its length, sharp stem and stern, and slightly hollowed entrance and run. The draught was taken as four-tenths the beam. The curves are true for a relation of speed to length indicated by any of the following proportions, from which other lengths or speeds can be interpolated; but the numerical scale of elevations will vary with the square of the speed, that noted in Fig. 7 being true only for an 800-ft. ship going at 20 knots.

Length	ft.	200	300	400	500	650	800	1000
Speed	knots	10	12.35	14.14	15.82	18.03	20	22.37

The curves of Fig. 7 are level contour lines. For readers not familiar with the preceding article, it may be repeated that these contours show not actual elevations or depressions of the sea, but surpluses and deficits of sea-pressure in an imaginary sea having just the depth of the ship, and confined by a thin sheet of rigid ice on its surface. These are assumptions necessary for practicable mathematical treatment, but it is obvious that, while the vertical release of the water under actual conditions would vary these curves somewhat, yet that their relative disposition cannot be far from those shown.

* Students should be cautioned that all writers on this stream-line topic complain of the labour and tedium of computation. The writer appreciated this only after he had become involved. The processes are simple, and anyone in command of a corps of clerks could easily carry the Taylor method to further and better results than are here presented. But anyone attempting to investigate alone, as a spare-time occupation, must be prepared for very slow and tedious progress.

Through the centre of the ship's displacement are drawn the 45 deg. lines which would be its mean sea-level contours if its displacement were reduced to a single point. Asymptotic to these lines are the approximately hyperbolic mean sea-level contours due to the elongated form of the ship. These hyperbolas extend indefinitely away from the ship, but all the other contour-lines are closed curves, or would be if the diagram were sufficiently extended.

Between the limbs of each hyperbola, ahead and astern of the ship, rises an oblique cone of water at stem and stern, reaching an altitude of 8 ft. above mean sea-level. This altitude, it is to be remembered, is *exclusive* of the bow waves or stern waves. It is relatively to this conical surface that these waves raise their crests and depress their troughs. While the peak of this constrained wave is sharp, its base is very broad. At a distance of half a length ahead of the stem the sea is elevated 3 in. over an area extending more than a length athwart the course. But on either beam the depression of the sea is still more marked in extent. For five-eighths of a length out away from either rail the sea is a foot or more below normal level, while the 3-in. depression extends out to a distance probably of several lengths, not measurable on the diagram. It is this wider area of depression than of elevation which probably has given the name "suction," rather than "repulsion," to the phenomenon. It is noticeable that the deepest depression does not occur directly abeam, but on either bow or quarter, where occurs a pocket reaching a depth of 9 ft. From this point the water-line rises to less than 5 ft. below normal, sinks again to more than 5 ft., where the curvature of the bow alters to the straight lines of the middle body, finally rising to less than 4 ft. at mid-length. The peculiar form of the 4-ft. curve led to its being checked by a fresh computation for that district upon a larger scale; but the result only confirmed the earlier curve, strengthening the writer's confidence in the virtual accuracy of the entire diagram.

The symmetry of these constrained waves as between bow and stern depends not merely upon the assumption of perfect fluidity in the sea-water, but upon levelness of sea-bottom. Should the ground beneath the ship be rising, this constrained wave will be in process of formation, to the magnitude shown, from the smaller constrained wave of deep water; and this formation must take place first at the bow. This explains how it is that a high-speed boat, such as a destroyer, will feel a bank many feet beneath its bottom, so forcibly as to fetch the crew up against rails or bulkheads. As the bow passes over the bank this cone of water must form ahead, while the stern has yet no corresponding cone pushing it ahead.

These contours also explain how it is that a ship's resistance is so markedly increased in shoal water. It also explains how a high-speed boat seems to settle in the water. One case is reported where a paddle-steamer failed to come to speed on her trial trip, it being found finally that her paddles had not been located with a view to this depression of the water on either beam, so that before she attained full speed the floats lost their full contact with the water. In all ships of appreciable speed having a painted water-line the uncovering of the underbody throughout the greater portion of her length by the trough of the constrained wave is plainly visible. The heaping of the water about her stem is more or less obscured by the bow-waves; but at the stern, although the stern-crest is smaller than the bow-crest, the regathering of the water under the counter is usually plainly to be seen. The importance of a fine run for taking advantage of this phenomenon is apparent when it is noted that in the model of Fig. 7 the amount of energy constantly being stored in the constrained wave is some 40,000 horse-power. The bulk of this power is being as constantly regained at the stern, but because of the viscosity of the water, not all of this enormous supply comes back. It is the office of the ship's run to regain as much of it as possible.

III. Interaction between Two or More Ships.

The problem of determining the distortion of the sea-surface in the neighbourhood of two ships moving on parallel courses, and overlapping, which is the standard position for the development of suction forces, is impossible of exact mathematical solution, so far as the writer is aware, even with the aid of the imaginary sheet of ice and the restriction of the water to motion in horizontal directions. But the stream-line method offers at least two ways of securing approximations to the truth which are near enough to shed very much more light upon the situation than is available in our present state of knowledge.

The first method consists in taking two sets of stream-lines identical with Fig. 7, overlapping them in the relationship between the two vessels which is to be investigated, and then adding them.

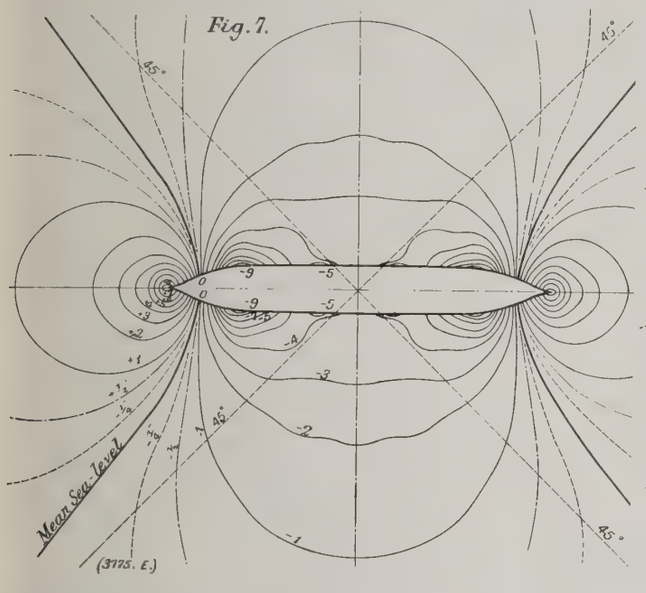
The result of such a procedure is shown in Fig. 8, which is derived from two ships like Fig. 7, placed on parallel courses a half-length apart, with one ship lapping a quarter-length over the other. The resultant stream-lines and sea-contours are quite accurate, but they have now lost their practical value as being founded upon ship-models fairly typical of actual ships. For the models secured by this mathematical method are themselves fluid (until we imagine them momentarily solidified), and therefore each ship-model has now become warped, narrowed, and distorted by the influence of the sources and sinks forming its neighbour. The beam has been reduced about one-half, the axis of the model is no longer straight nor coincident with the intended course, while the general heading of each model has been sheered away from its neighbour.

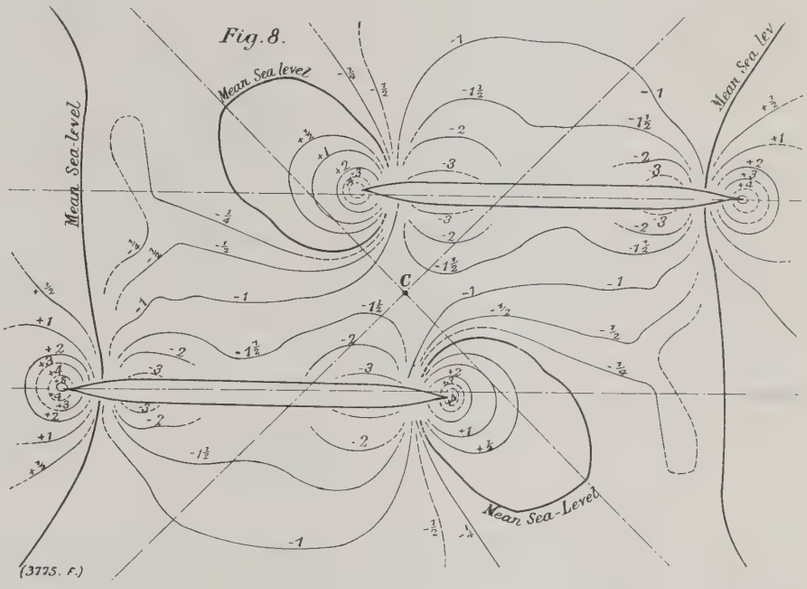
All of these features tend to minimise the mutual hydraulic reaction due to the solidity, in actual practice, of the neighbouring hulls which is called "suction." Nevertheless, Fig. 8 shows plainly, in comparison with Fig. 7, the general directions in which the sea-contours about each ship are modified by the presence of the other. First, following out the 45-deg. lines from the centre of displacement C common to the two ships, it is evident that the area of superpressure included in the "hyperbola" ahead of the leading ship must be unsymmetrically placed. All the curves depicting the cone of superpressure ahead of the leading ship corroborate this view. Her head is being steadily pushed to port more than is visible in the small scale reproduction of the curves.

But it is also true, as could not be predicted from the general disposition of the 45-deg. lines, that the head of the following ship is also being pushed to port by a cone of superpressure ahead, which bears much more obliquely than in the case of the leading ship. It is the pressure of this cone of water, into one side of which the following ship is always heading, which crowds her over towards the other's quarter. It is the rapid exaggeration of this cone, both in altitude and obliquity, by the piling up of all the water displaced by the leading ship, as soon as the following ship yields at all to its insistent pressure, which explains the suddenness with which suction collisions occur, and the complete unmanageability of the following vessel as soon as she is permitted to head in the slightest degree towards the other.

It is also to be noted that in Fig. 8 the altitude of all four cones of water has been exaggerated, both in comparison with Fig. 7 and with each other; for, since the beam of the vessels has been halved, the cones of Fig. 8 should naturally be only 4 ft. high, and the same at each end of the ship. But in Fig. 8 the cones at the overlapping ends are nearly 5 ft, and at the distant ends well over 5 ft., in height, or nearly a quarter larger than proportionate to Fig. 7. At the same time the larger cone constantly retards the progress of the leading ship, while accelerating that of the following vessel.

One of the earliest instances of hydraulic interaction between following ships (Narragansett-Providence, in 1869) witnessed how this last-mentioned feature may lead to the actual towing of a slower consort for considerable distances by the leading and slightly faster of two vessels upon parallel courses in restricted waters, purely by "suction." This is what is called in America a "wireless tow." The phenomenon may not result in collision. In the case cited the "towing" continued for several miles. The final collision, occurring in Hell Gate, may, or may not have been materially aided by suction forces. The action is common in suction collisions, and one of the best, although late, warnings which the pilot of a following vessel may have is the sense that his ship is being "picked up" or accelerated by the faster ship which has almost passed. When this occurs, although collision may not be inevitable, it is a sign that his ship is in unstable steerage, and that the first irregularity of sea-bottom, or projecting pier, or even the approach of some otherwise harmless third vessel, may precipitate a disaster against which all his skill and engine power will be unavailing. But even a slight sheer away from the other ship, taken in time, will suffice to avert it.





One method by which Fig. 8 might be developed into a set of contours for typical ship-models would consist in starting all over again, from initial functions of sources and sinks which would be arbitrarily selected upon curvilinear axes (convex towards each other), and of double strength, so judged that when the two sets of stream-lines were added the effect would be to straighten out the hulls into normal shape, on straight parallel axes. But this method promises an exaggeration of even the laboriousness inherent in the work reviewed thus far. While its fruits would be mathematically exact, and therefore worthy of full confidence, its penalty in the form of labour was too forbidding for the writer's command of leisure, and an easier "side step" was taken around the difficulty.

This consisted in going back to the original set of stream-lines from which Fig. 7 was developed, and superposing them as for the preparation of Fig. 8, but then regarding the two hulls as remaining solid. This method gives very closely the volume of water entrapped by each stem as it cleaves its course, which volume must find its way aft as best it may, constrained by solid hull and sea-bottom and superficial ice. The question then remaining is: Along what stream-lines does this water distribute itself?

This question cannot be answered mathematically, but the guidance provided by the composition of Fig. 8 permits a fair estimate to be made as to how the exact stream-lines would be influenced by the additional water entrapped on each side of each hull by the solidity thereof. The estimate thus applies merely to a minor correction of values already obtained with mathematical accuracy, and, although the form of the contours is influenced considerably by the method of correction adopted, it is thought that the result is fairly accurate. It at least shows accurately the direction in which Fig. 8 would be modified if the hulls were solid; and the amount of correction in this direction might easily be more than that shown in Fig. 9. This diagram I would therefore style a "mathematical conjecture."

The mathematical form of correction must be one easily applied to thousands of points in repetition. The one most readily suggesting itself, in view of this requisite and of the facts become familiar during the preceding work, was to assume that the surplus or deficit of water entrapped by the stem is distributed over the sea-surface away from the ship's side in what amounts to a logarithmic curve, approaching zero as the distance increases indefinitely. That is to say, it was assumed that $1/n$th of the surplus or deficit was retained between the first two stream-lines, $1/n$th of the remainder between the next two, and so on. The factor n was given a different value arbitrarily, in the light of the preceding work, for each different point of the ship's length.

Whatever criticism may be directed at the choice of this particular method of distribution, it is beyond question that the true stream-lines for two solid hulls like Fig. 7 must consist of a distortion or correction of the stream-lines on which Fig. 7 was built, by some factor which has its greatest effect at the ship's side, with a gradual dissipation of that effect with lateral distance which can never become complete. Considering that the uncertainty applies to a minor fraction of a minor correction—the form of the resultant contours depending chiefly upon the particular localities in which a positive or negative correction is appended to a previous positive or negative departure of stream-line from parallelism, rather than upon the magnitude of the correction itself—it is believed that Fig. 9 is worthy of credence, as offering the only approximation to the truth regarding following ships which has yet been offered from even a semblance of a mathematical basis.

The contrasts between Fig. 9 and Figs. 7 and 8 are numerous and interesting. In the first place, whereas Fig. 8 is inevitably symmetrical, from its mathematical origin, in the sense that it makes no difference in which direction the two ships are moving, in Fig. 9 this is no longer true. Owing to the different surplusage of water entrapped by the two stems, which surplus must then travel throughout the length of the solid hull before again exerting its influence upon the water on the other side of that hull, the contours about one hull are appreciably different from those about the other. The oblique cone of water ahead of the following ship is quite different, both in magnitude and angle, from that following the leading ship. The excess of pressure from one quarter over the other, which is the principal force acting to sheer the ship off her course, is much greater in the following than in the leading ship—which explains again how it is that it is usually the following ship which is deflected.

In general, however, Fig. 9, which is really derived by a quite different and independent line of reasoning from Fig. 8, corroborates that diagram. The leading ship is seen to be sailing continuously up-hill, against a cone of water at its stem which is 3 ft. higher than that at its stern, while the following ship is likewise sailing down-hill all the time into a relative hollow of equal depth. This is caused by the leading ship's shouldering the burden of displacing the water for both of them, the reaction from which displacement rises under the stern of the following ship, and aids her progress.

In Fig. 9 the pairs of cones of water ahead and astern of the ships respectively are each merged into a single "hyperbolic" cone asymptotic to the 45-deg. lines, whereas in Fig. 8 they were separate; but this is because in Fig. 9 the ships lap by four-tenths of a length, whereas in Fig. 8 they lapped by only a quarter length. It is probable that a slightly greater lap than four-tenths would exaggerate the mutual distortion of contours and the development of suction forces, but the labour of computing even a single relative position was so great as to be prohibitive of any comparative investigation of different ones. In Fig. 9, as in Fig. 8, the lateral distance between the two courses is a half-length, but in Fig. 9 the beam of the ships reduces the minimum distance between hulls to about 0.385 of a length. In both diagrams the full-line contours are those drawn through computed points, while the broken lines indicate where the contour was interpolated by estimate.

While Fig. 9 gives the best foundation from which to estimate the effect of variations from its particular arrangement of dimension of hulls, the results of this particular arrangement can best be seen in the form of profiles of the water-lines of the two ships—assuming again that the computed pressures of Fig. 9 might be translated into actual elevations of water by the removal of the imaginary superficial sheet of ice, without altering the values. Such profiles are given in Fig. 10, in which the vertical scale is exaggerated five-fold for better visibility. They are plotted directly from Fig. 9.

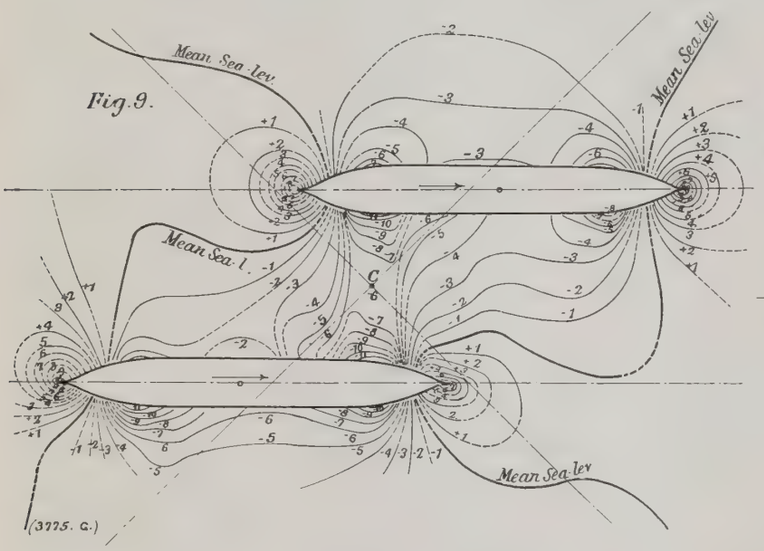
On each profile is shown a conventional centre of lateral pressure C, taken at one-fifth the ship's length from the stem. Comparing the two profiles, and remembering that the steering of any ship depends upon the horizontal moment developed between the rudder forces at the stern and this centre of lateral resistance C (which is always well forward in the direction of the ship's motion), it again becomes obvious why it is that it is usually the following vessel which is diverted from its course. Until Fig. 9 was developed, this explanation had to depend upon the fact that the following vessel was usually the smaller and weaker. Now, however, it appears that the forces at work upon the after vessel are so much larger than upon the leading ship, even when the ships are of equal size and speed, that the following vessel must still be the one more liable to diversion from her course, even when somewhat larger.

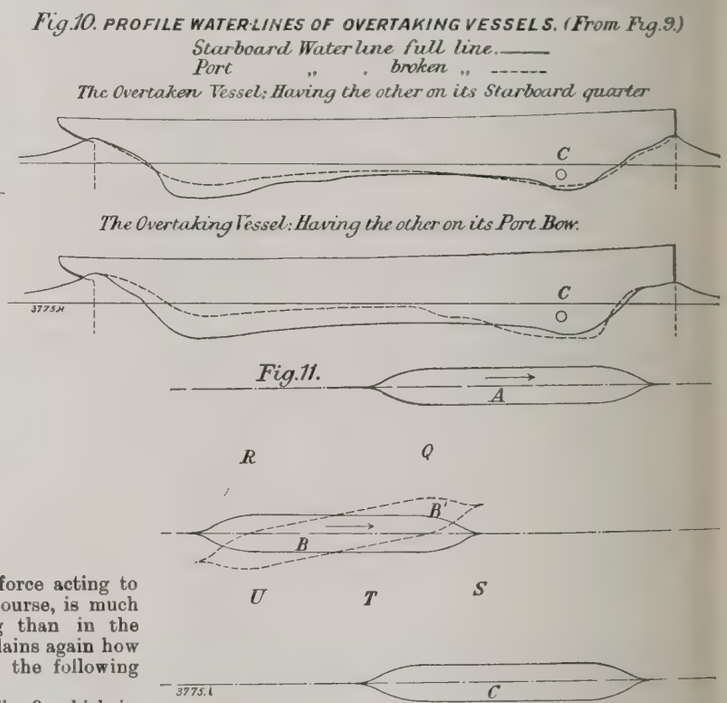
As to speed, it is not evident just what difference it would make as to relative forces. The suction forces are the mutual product of the two ships, acting co-operatively. They are the result of the aggregate rate of displacement by the two vessels, so that any increase on the part of either ship must result in the exertion of increased divertive forces upon both.

Fig. 10 should make it plain why it is that a vessel in the grip of suction forces pays no attention to a hard-over helm. Making every allowance for the exaggerated vertical scale, the length of after-body, far from the centre of lateral resistance, which is exposed to a head of several feet of water-pressure acting laterally, is overwhelmingly larger than any lateral force imaginably to be developed by or on a rudder. It is utterly impracticable to build or navigate ships so as to defy suction-forces. These forces can only be avoided, and that only by foresight.

But the most important question of all: Why do not suction collisions happen more frequently, and why do they happen unexpectedly in situations apparently encountered frequently before in safety? remains to be answered. The answer involves the third wall of the "Venturi" passage-way between the two ships—namely, the sea-bottom, or else some equivalent outlying factor not yet brought into the discussion.

Figs. 9 and 10 are based upon a degree of





propinquity which is seldom reproduced in actual navigation, even disregarding our mathematical assumptions of imaginary ice, &c. That is to say, ships seldom move at full speed on parallel courses within half or third a length of each other, in water barely sufficient to float them. The explanation of why suction-collisions do not occur is that even a moderate deepening of the water below their draught rapidly moderates the forces at work, so that by the time the water is deep enough to permit full speed, it is deep enough to make fairly close overlapping courses safe. The explanation why suction-collisions do occur when they do is usually the fact that a moderate contribution of solidity to the ship's environment, by sea-bottom or by a third vessel, or an accentuation by even a slight convergence of courses, is competent to exaggerate back into control these forces which the previous depth of water had rendered innocuous.

For deep water, while reducing the intensity of the constrained wave, correspondingly increases its volume or extent; and it also permits increased speed on the part of the ship. It is when the ship passes suddenly from deep to shallow (or otherwise limited) water that trouble arises. This great volume of constrained wave, moving at a speed above that attainable by the ship in uniformly shallow water, piles up into a degree of intensity which it could never assume in uniformly shallow water. If it begets disaster, it does so by suddenly releasing an enormous accumulation of energy which the ship has been carrying with her, in addition to that currently at work.

A glance at Fig. 9 will show how rapidly all the conditions creating suction will be exaggerated by any angular swing of the following ship toward the leading one. The two pockets, 11 ft. deep, on her port bow and starboard quarter are there because a surplus of water is trying to get to its ultimate destination, which is off her port quarter, as rapidly as possible. To give it the necessary horizontal acceleration a drop in head must occur. But how much more will this region off her port quarter lack its supply of water if the bow swings toward the leading ship, cutting off the channel between them, while the stern swings out, lengthening that route for the water?

But what most commonly happens is that while the courses remain parallel the ships run over a hump in the sea bottom, or they pass a pier-head or bank, which, when opposite the trailing ship's starboard quarter, reduces the pathway for water, and therefore deepens the pocket on that portion of the hull—the former being the more common cause of disaster. Such a combination of circumstances will instantly exaggerate into uncontrollability suction forces which previously—perhaps during a considerable period of overlapping—had proven harmless. It may be that the vague fear of suction, so often mentioned by pilots as felt when steering such following courses, had been stilled by such preceding period of security, only for the relaxation of alertness just at the time when the alteration in the depth of water created the real danger. Too many suction collisions occur just where the water shoals slightly to permit disregard of this factor, although it is impossible to bring it into any mathematical discussion. Nor are the data of actual disasters sufficiently accurate so that the shoal can often be located exactly, in relation to the ships, when action occurred. But it is seldom that unquestionable suction occurs when only the two ships are present, surrounded by open water.

A similar contributing factor in many of the minor cases occurring in American inland waters is a third vessel. Fig. 11 shows how such a combination may produce disaster. A and B are ships moving in the same direction on parallel courses and overlapping. C is a third ship upon another parallel course. If C be moving in the same direction as A and B, B is plainly (from Fig. 9) steering in very unstable equilibrium, sailing steadily downhill into the pocket created by the displacement of A and C. The slightest swerve of B's head towards A, as at B^1, will not only starve the Q-region of water needed at R, as would be true if C were not present, but will trap an over-supply of water between B^1 and C, exaggerating the pocket at U and creating an additional one at T. B's head will be crowded towards A and her stern and middle body drawn towards C with irresistible forces, which grow stronger with every additional degree of swing.

Not only are there several instances where this situation has led to disaster after two of the three ships (say A and B) had sailed closely but safely for some time, but there are a few cases where the only plausible explanation of an otherwise inexplicable sheer of B into A was that C had exerted this same effect, even although passing in the opposite direction. These are all in the restricted channels connecting the Great Lakes, used by boats of heavy tonnage; but the speed was correspondingly low, a circumstance minimising the danger of suction.

Only two attempts have been made, to the writer's knowledge, at the experimental determination of suction forces. One was the Taylor experiments with models in the Washington towing-tank already mentioned. These observations confirmed in every way the hydraulic theory already presented. They were limited in their educational value, however, by the fact that the models were fixed relatively to each other, thus preventing any knowledge as to how rapidly these forces are enhanced by the natural swing of the vessels towards each other. Any determination of this acceleration will, of course, be very difficult; but since it is quite impossible by mathematical analysis, and is virtually impracticable even with models (because the prime question is whether such action occurs more or less rapidly, in full-size ships, than the human organism can act), it is unfortunate that the idle ships of the British or United States navies cannot be utilised for this purpose. When suction was the thing anticipated and under measurement, it would be easy to make the experiment safe.

The other known set of experiments was made with actual vessels, if small ones, by Professor A. H. Gibson and Mr. J. H. Thompson (reported in ENGINEERING, September 27, 1912). These experiments also corroborated hydraulic theory in every respect. Their chief drawback was the inequality in length between the two boats, as well as their small size. One, a steam-yacht, used as the leading vessel, was virtually three times the length of the other, a motor-boat. From Fig. 9 it will be obvious that it is important that the two ships be at least similar in length. In one prominent suction collision, however—the Brockton-Hartt—the leading boat was much larger than the attracted boat; and in this instance, too, arose a beautiful example of interaction between the constrained wave of the smaller boat and the échelon wave of the larger (the two waves being of similar length) as the contributing cause which converted an otherwise safe situation into a disastrous one.* This collision is further the more remarkable in that it occurred in comparatively deep water, outside Sandy Hook, between vessels of comparatively light draught.

In the next issue there will be given a brief description of a few of the more prominent or illustrative suction collisions. Anyone who has studied the entire list of such recorded disasters will be impressed with the clear way in which all but a very few are explicable as natural, if not inevitable, phenomena, so soon as the foregoing hydraulic theory is applied. But he will also be impressed with the variety of combinations of circumstances which may arise to create suction forces powerful enough to produce disaster, and thus to record themselves in civil suits at law. These combinations are too many to be always remembered, nor can the list of possible ones be already exhausted. We have not yet finished with suction disasters. While channels are continually being deepened, longer, deeper, and more powerful hulls are appearing at an even higher rate of progress.

For these reasons the subject cannot be dismissed without at least a word as to the possibility of preventing future suction collisions. The general education of pilots is one obvious measure of relief, and it is to that end that the present article is primarily aimed. But another more formal and reliable preventive is feasible, in the writer's belief, and this is an amendment to our international navigation laws covering the case of overtaking vessels. The suggested amendment (which is offered tentatively, by one who is not a certificated navigator) should read to this effect:—

That when an overtaking vessel asks for and receives from the leading vessel permission to pass, by the exchange of the usual signals, the acquiescence of the leading vessel shall enforce upon both vessels the slowing of their engines, those of the following vessel being reduced to "half speed," and those of the leading vessel to "slow," which condition is to be maintained until the overtaking vessel's stern has passed clear of the overtaken vessel's bow. In restricted waters such a procedure is the only safe alternative to the overtaking vessel remaining astern until wider sea-room has been reached.

(To be continued.)

* See next issue for description of this accident.

STRESSES IN A PLATE NEAR A PLUGGED HOLE.

*The Distribution of Stress in a Tension Strap having a Circular Hole Filled with a Plug.**

By Dr. K. SUYEHIRO, Member.

THE present paper is an extension of a paper entitled "The Distribution of Stress in Plates having Discontinuities, and some Problems Connected with It," published in ENGINEERING in 1911 (vol. xcii., pages 280, 291). Though such a purely scientific paper as this bears little on matters of practical importance, the experimental researches upon the same subject made by Professor Coker have encouraged the author to publish it.† In this paper the notation is kept, as far as possible, the same as in the previous one. But in order to avoid the trouble of referring to the previous paper, some parts of it are recapitulated here:—

Two-dimensional polar co-ordinates.

P = Radial normal stress—*i.e.*, stress component, in the direction of radius, across circumferential area.

Q = Transversal normal stress—*i.e.*, stress component across radial area in the direction of tangent to a circle.

R = Shearing stress along radial or transversal plane.

u and v = Radial and transversal displacements of a point respectively.

E = Young's modulus.

σ = Poisson's ratio.

μ = Modulus of rigidity.

$\lambda = \dfrac{E\sigma}{1-\sigma-2\sigma^2}$.

The present problem is one of plane stress, and not of plane strain, so that the plate will not only be strained in its plane, but also in the direction of the normal to the plane.

By applying the method of "generalised plane stress,"‡ such a problem can be solved as if it were one of plane strain, provided that the elastic constant λ is replaced by a new constant λ', and ordinary stress and strain are replaced by mean "stress and strain." Thus the stress-strain equations in this case are:—

$$\left.\begin{aligned} P &= \lambda'\Delta + 2\mu\frac{\partial u}{\partial r} \\ Q &= (\lambda' + 2\mu)\Delta - 2\mu\frac{\partial u}{\partial r} \\ R &= -2\mu\omega + 2\mu\frac{\partial v}{\partial r} \end{aligned}\right\} \text{Stress-strain equations,}$$

in which

$$\lambda' = \frac{2\lambda\mu}{\lambda+2\mu},\quad \overline{P} = \frac{1}{2t}\int_{-t}^{t} P\,dz, \text{ \&c.},$$

$$\frac{\partial \overline{u}}{\partial r} = \frac{1}{2t}\int_{-t}^{t}\frac{\partial u}{\partial r}\,dz, \text{ \&c.},$$

t being the half thickness of the plate, and ω and Δ the rotation and dilatation respectively.

It can be shown that the general solution satisfying the displacement equation of equilibrium is:—§

$$\begin{aligned} u = {} & Mr + Nr^{-1} + \left(\frac{1}{2}\frac{1+\log r}{\lambda'+2\mu} + \frac{\log r}{2\mu}\right)(A'_1\cos\theta + B'_1\sin\theta) \\ & + \sum_1^{\infty}\left(\frac{n+2}{\lambda'+2\mu} - \frac{n}{\mu}\right)\frac{r^{n+1}}{4(n+1)}(A_n\cos n\theta + B_n\sin n\theta) \\ & + \sum_2^{\infty}\left(\frac{n-2}{\lambda'+2\mu} - \frac{n}{\mu}\right)\frac{r^{-n+1}}{4(n-1)}(A'_n\cos n\theta + B'_n\sin n\theta) \\ & + \sum_1^{\infty}\Big[r^{n-1}(-D_n\cos n\theta + C_n\sin n\theta) + r^{-(n+1)} \\ & \qquad (D'_n\cos n\theta - C'_n\sin n\theta)\Big] \quad . \quad . \quad (1) \end{aligned}$$

$$\begin{aligned} v = {} & M'r + N'r^{-1} + \left(\frac{1}{2}\frac{\log r}{\lambda'+2\mu} + \frac{1+\log r}{2\mu}\right) \\ & (B'_1\cos\theta - A'_1\sin n\theta) \\ & + \sum_1^{\infty}\left(\frac{n+2}{\mu} - \frac{n}{\lambda'+2\mu}\right)\frac{r^{n+1}}{4(n+1)} \\ & (-B_n\cos n\theta + A_n\sin n\theta) \\ & + \sum_2^{\infty}\left(\frac{n-2}{\mu} - \frac{n}{\lambda'+2\mu}\right)\frac{r^{-n+1}}{4(n-1)}(B'_n\cos n\theta - A'_n\sin n\theta) \\ & + \sum_1^{\infty}\Big[r^{n-1}(C_n\cos n\theta + D_n\sin n\theta) + r^{-(n+1)} \\ & \qquad (C'_n\cos n\theta + D'_n\sin n\theta)\Big] \quad . \quad . \quad (2) \end{aligned}$$

* Paper read at the spring meeting of the Society of Mechanical Engineers, Japan, April 2.

† "The Distribution of Stress Due to a Rivet in a Plate," by Professor E. G. Coker, ENGINEERING, March 28, 1913.

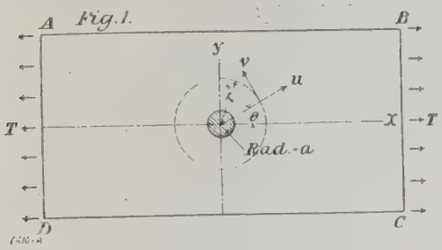
‡ Love's "Mathematical Theory of Elasticity" (Second Edition), pages 135 and 205.

§ Love's "Mathematical Theory of Elasticity" (First Edition), vol. i., page 336.

We have to determine the constants in these equations in such a manner that the displacement components u and v satisfy various boundary conditions peculiar to the present problem.

Now let a rectangular thin elastic plate $2t$ thick, pierced with a circular hole (radius a) in its centre and filled with a plug, be subjected to edge traction (T per unit area) in its plane, normal to the sides A D and B C (Fig. 1). If the breadth of the plate is supposed to be sufficiently large compared with the size of the hole, the

Fig. 1.



displacement of a distant point will not be influenced by the presence of the hole; so that the displacement of such a point is given by:—

$$u_{r=r'} = \frac{1}{2}\frac{T}{E}(1+\sigma)\,r'\cos 2\theta + \frac{1}{2}\frac{T}{E}(1-\sigma)\,r' = \frac{T}{4\mu}r'\cos 2\theta + \frac{T}{4}\frac{\lambda+2\mu}{\mu(3\lambda+2\mu)}r'$$

$$v_{r=r'} = -\frac{1}{2}\frac{T}{E}(1+\sigma)\,r'\sin 2\theta \quad = -\frac{T}{4\mu}r'\sin 2\theta$$

in which r' is the distance of the point from the centre, which is large compared with a. Comparing these equations with (1) and (2), we may assume that the equation giving the displacement components u, v of a point in the plate to be as follows:—

$$u = \left(-D_2 r - \frac{1}{2\mu}A'_2\frac{1}{r} + D'_2\frac{1}{r^3}\right)\cos 2\theta + Mr + N\frac{1}{r}$$

$$v = \left(D_2 r + \frac{1}{2(\lambda'+2\mu)}A'_2\frac{1}{r} + D'_2\frac{1}{r^3}\right)\sin 2\theta,$$

in which

$$D_2 = \frac{T}{4\mu}$$

and

$$M = \frac{T}{4}\frac{\lambda+2\mu}{\mu(3\lambda+2\mu)}.$$

Remembering that

$$\lambda' = \frac{2\lambda\mu}{\lambda+2\mu},$$

we have

$$\left.\begin{aligned} u &= \left(\frac{T}{4\mu}r - \frac{1}{2\mu}A'_2\frac{1}{r} + D'_2\frac{1}{r^3}\right)\cos 2\theta + \frac{T}{4}\frac{\lambda+2\mu}{\mu(3\lambda+2\mu)}r + N\frac{1}{r} \\ v &= \left(-\frac{T}{4\mu}r + \frac{\lambda+2\mu}{8\mu(\lambda+\mu)}A'_2\frac{1}{r} + D'_2\frac{1}{r^3}\right)\sin 2\theta \end{aligned}\right\} \quad . \quad (3)$$

Substituting these into the stress-strain equations, we have:—

$$\left.\begin{aligned} P &= \left(\frac{T}{2} + \frac{3\lambda+2\mu}{2(\lambda+\mu)}A'_2\frac{1}{r^2} - 6\mu D'_2\frac{1}{r^4}\right)\cos 2\theta + \frac{T}{2} - 2\mu N\frac{1}{r^2} \\ Q &= \left(-\frac{T}{2} + 6\mu D'_2\frac{1}{r^4}\right)\cos 2\theta + \frac{T}{2} + 2\mu N\frac{1}{r^2} \\ R &= \left(-\frac{T}{2} + \frac{3\lambda+2\mu}{4(\lambda+\mu)}A'_2\frac{1}{r^2} - 6\mu D'_2\frac{1}{r^4}\right)\sin 2\theta \end{aligned}\right\} \quad . \quad (4)$$

Next suppose that the plug is of the same material as the plate, and just fills the hole without exerting any initial stress on the plate. Then the following assumptions may not be unreasonable:—

1. The radial displacement, as well as the radial normal stress of the plate and plug, will be equal over the contacting boundary.

2. The shearing stress over the contacting boundary will be nil—*i.e.*, the friction between the plate and plug negligibly small.

Now in virtue of the condition (1), and the equations (3) and (4), and remembering that the displacement of the centre of the plug is zero, we may deduce the value of the component displacement u' v' of the plug from the general equations of displacement (1) and (2) as follows:—

$$u' = \left(-\frac{\lambda'}{6\mu(\lambda'+2\mu)}a_2 r^3 - d_2 r\right)\cos 2\theta + m r$$

$$v' = \left(\frac{2\lambda'+3\mu}{6\mu(\lambda'+2\mu)}a_2 r^3 + d_2 r\right)\sin 2\theta + m' r$$

(For the sake of distinction, the constants are here written in corresponding small letters.) Substituting the value of λ', these are transformed into:—

$$\left.\begin{aligned} u' &= \left(-\frac{1}{12}\frac{\lambda}{\mu(\lambda+\mu)}a_2 r^3 - d_2 r\right)\cos 2\theta + m r \\ v' &= \left(\frac{7\lambda+6\mu}{24\mu(\lambda+\mu)}a_2 r^3 + d_2 r\right)\sin 2\theta + m' r \end{aligned}\right\} \quad (5)$$

from which the stress components P′, Q′, R′ of the plug are found to be as follow:—

$$\left.\begin{aligned} P' &= -2\mu d_2\cos 2\theta + \frac{2\mu(3\lambda+2\mu)}{\lambda+2\mu}m \\ &= \left(\frac{3\lambda+2\mu}{2(\lambda+\mu)}a_2 r^2 + 2\mu d_2\right)\cos 2\theta + 2m\frac{\mu(3\lambda+2\mu)}{\lambda+2\mu} \\ R' &= \left(\frac{3\lambda+2\mu}{4(\lambda+\mu)}a_2 r^2 + 2\mu d_2\right)\sin 2\theta \end{aligned}\right\} \quad (6)$$

All the necessary equations being thus found, we have to determine the constants A'_2, D'_2 and N in the equation (4) in such a manner that the equations for the stress and displacement of the plate and plug satisfy the boundary conditions given above.

Now by the conditions (1) we obtain the following relations:—

$$u_{r=a} = \left(\frac{T}{4\mu}a - \frac{1}{2\mu}A'_2\frac{1}{a} + D'_2\frac{1}{a^3}\right)\cos 2\theta + \frac{T}{4}\frac{\lambda+2\mu}{\mu(3\lambda-2\mu)}a + N\frac{1}{a}$$

$$= u'_{r=a} = \left(-\frac{1}{12}\frac{\lambda}{\mu(\lambda+\mu)}a_2 a^3 - d_2 a\right)\cos 2\theta + m a$$

and

$$P_{r=a} = \left(\frac{T}{2} + \frac{3\lambda+2\mu}{2(\lambda+\mu)}A'_2\frac{1}{a^2} - 6\mu D'_2\frac{1}{a^4}\right)\cos 2\theta + \frac{T}{2} - 2\mu N\frac{1}{a^2} =$$

$$P'_{r=a} = -2\mu d_2\cos 2\theta + \frac{2\mu(3\lambda+2\mu)}{\lambda+2\mu}m.$$

Fig. 2.

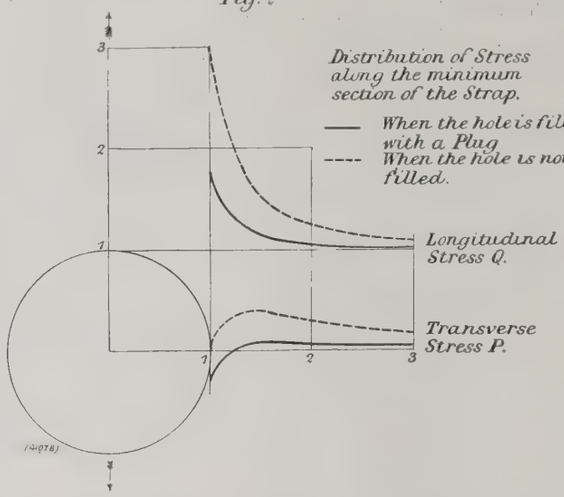


Fig. 3.

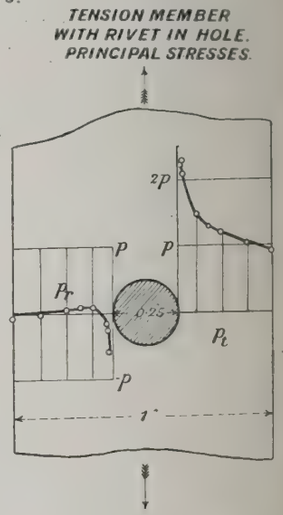


Table I.

	Distance from the centre = r ..	1.00	1.10	1.20	1.30	1.40	1.50	1.75	2.00	2.50	3.00
Filled	Longitudinal stress = Q ..	1.750	1.515	1.363	1.263	1.196	1.149	1.081	1.047	1.019	1.009
	Transverse stress = P	−0.250	−0.102	−0.015	0.034	0.060	0.074	0.083	0.078	0.061	0.047
Not filled	Longitudinal stress = Q ..	3.000	2.444	2.073	1.821	1.648	1.520	1.325	1.219	1.118	1.074
	Transverse stress = P	0.000	0.215	0.318	0.363	0.375	0.371	0.330	0.281	0.201	0.149

Radius of hole $a = 1$. Edge traction $T = 1$.

This set of equations must hold for all values of θ. Therefore:—

$$\frac{T}{4\mu}a - \frac{1}{2\mu}A'_2\frac{1}{a} + D'_2\frac{1}{a^3} = -\frac{1}{12}\frac{\lambda}{\mu(\lambda+\mu)}a_2 a^3 - d_2 a.$$

$$\frac{T}{4}\frac{\lambda+2\mu}{\mu(3\lambda+2\mu)}a + N\frac{1}{a} = m a.$$

$$\frac{T}{2} + \frac{3\lambda+2\mu}{2(\lambda+\mu)}A'_2\frac{1}{a^2} - 6\mu D'_2\frac{1}{a^4} = -2\mu d_2.$$

$$\frac{T}{2} - 2\mu N\frac{1}{a^2} = \frac{2\mu(3\lambda+2\mu)}{\lambda+2\mu}m.$$

Also, by the condition (2),

$$R_{r=a} = \left(-\frac{T}{2} + \frac{3\lambda+2\mu}{4(\lambda+\mu)}A'_2\frac{1}{a^2} - 6\mu D'_2\frac{1}{a^4}\right)\sin 2\theta = 0,$$

and

$$R'_{r=a} = \left(\frac{3\lambda+2\mu}{4(\lambda+\mu)}a_2 a^2 + 2\mu d_2\right)\sin 2\theta = 0.$$

Therefore,

$$-\frac{T}{2} + \frac{3\lambda+2\mu}{4(\lambda+\mu)}A'_2\frac{1}{a^2} - 6\mu D'_2\frac{1}{a^4} = 0.$$

$$\frac{3\lambda+2\mu}{4(\lambda+\mu)}a_2 a^2 + 2\mu d_2 = 0.$$

Rewriting these equations with a slight rearrangement, we arrive at the following simultaneous equations for six unknowns, A'_2, D'_2, N, a_2, d_2, and m:—

$$-\frac{1}{2\mu a}A'_2 + \frac{1}{a^3}D'_2 + \frac{\lambda a^3}{12\mu(\lambda+\mu)}a_2 + a d_2 = -\frac{T}{4\mu}a$$

$$\frac{1}{a}N - a m = -\frac{T}{4}\frac{\lambda+2\mu}{\mu(3\lambda+2\mu)}a$$

$$\frac{3\lambda+2\mu}{2(\lambda+\mu)a^2}A'_2 - \frac{6\mu}{a^4}D'_2 + 2\mu d_2 = -\frac{T}{2}$$

$$\frac{2\mu}{a^2}N + \frac{2\mu(3\lambda+2\mu)}{\lambda+2\mu}m = \frac{T}{2}$$

$$\frac{3\lambda+2\mu}{4(\lambda+\mu)a^2}A'_2 - \frac{6\mu}{a^4}D'_2 = \frac{T}{2}$$

$$\frac{(3\lambda+2\mu)a^2}{4(\lambda+\mu)}a_2 + 2\mu d_2 = 0$$

from which we obtain the values of the constants as follows:—

$$A'_2 = -\frac{T(\lambda+\mu)}{3\lambda+2\mu}a^2$$

$$D'_2 = -\frac{T a^4}{8\mu}$$

$$N = 0$$

Substituting them into (4) we have

$$P = \frac{T}{2} + \frac{T}{2}\left(1 - \frac{a^2}{r^2} + \frac{3}{2}\frac{a^4}{r^4}\right)\cos 2\theta$$

$$Q = \frac{T}{2} - \frac{T}{2}\left(1 + \frac{3}{2}\frac{a^4}{r^4}\right)\cos 2\theta$$

$$R = -\frac{T}{2}\left(1 + \frac{1}{2}\frac{a^2}{r^2} - \frac{3}{2}\frac{a^4}{r^4}\right)\sin 2\theta.$$

These are the required equations for the stress in the plate.

Among these the transversal normal stress is most important; its maximum value is $Q = 1\frac{3}{4}T$ at the points $r = a$, $\theta = \frac{\pi}{2}$ or $\frac{3\pi}{2}$.

Thus on the boundary of the hole in the minimum section of the plate there occurs a tensile stress of intensity of $1\frac{3}{4}$ times the average. Remembering that if the hole is not filled a tensile stress three times as intense as the average is set up at the same points, the stress on the boundary, in this case, is very much reduced by the presence of the plug.

The stress along the minimum section is given by

$$\text{Longitudinal stress } Q = \left(1 + \frac{3}{4}\frac{a^4}{r^4}\right)T.$$

$$\text{Transverse stress } P = \frac{1}{2}\left(\frac{a^2}{r^2} - \frac{3}{2}\frac{a^4}{r^4}\right)T.$$

The distribution of stress worked out from these equations, together with the same when the hole is not filled, is shown in Table I. and Fig. 2, in which both T and a are taken as unity.

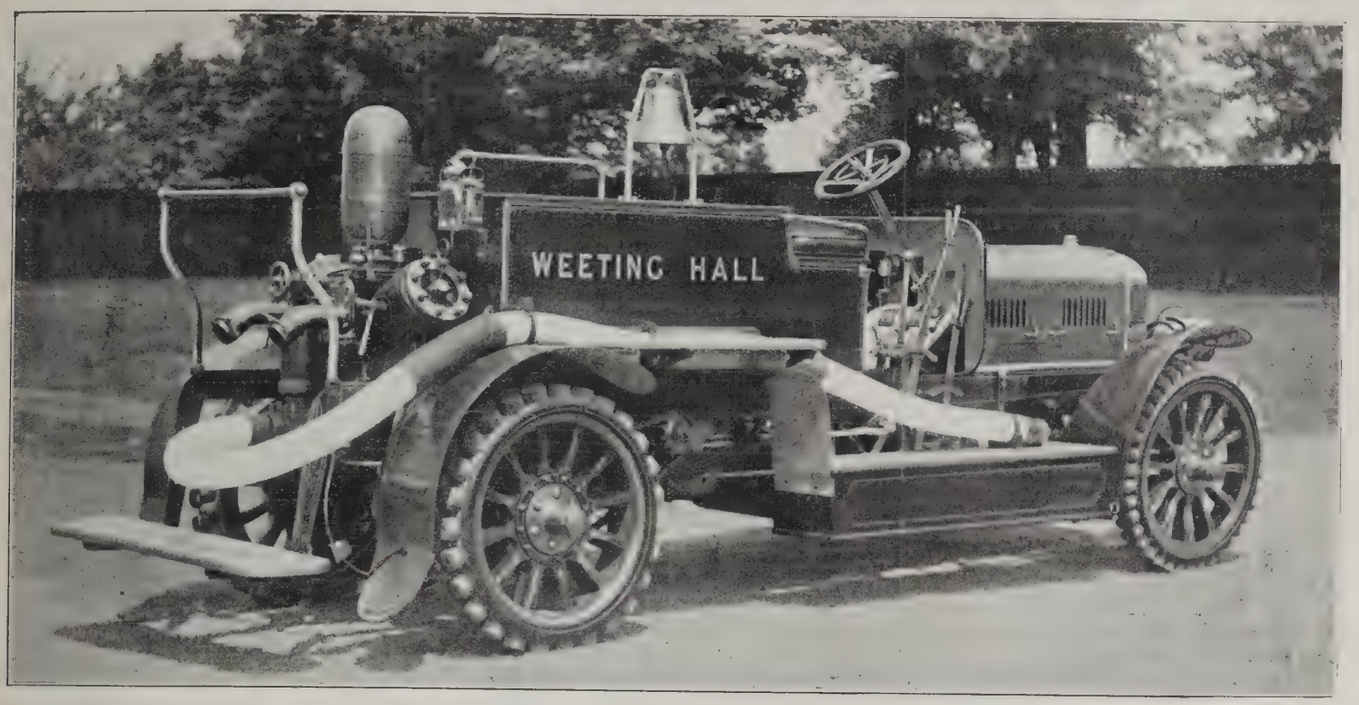
Fig. 3 is the result (for the case of the hole filled by the plug) experimentally determined by Professor Coker, using a photo-elastic method. It will be seen that the general features of the stress distribution well coincide with my theoretical investigation.

To conclude, the present investigation discloses the fact that an engineering structure can be partially relieved from stress concentration due to the presence of a hole by filling the hole with a plug.

Aero Engines.—The Secretary of the War Office announces that the naval and military aeronautical engine competition is now closed, and that the results will be published shortly.

35-HORSE-POWER MOTOR FIRE-ENGINE.

CONSTRUCTED BY MESSRS. MERRYWEATHER AND SONS, LIMITED, ENGINEERS, GREENWICH.



Practice in the design and construction of fire-brigade apparatus changes from time to time, and at present there seems to be a tendency on the part of fire-brigade officials to ask, in order to supplement the larger-sized units, for automobile pumping plant of a similar capacity to the standard size laid down as being most convenient for the use of the London fire establishment by the late Sir Eyre M. Shaw in the early 'eighties, having a pumping capacity of about 200 gallons per minute, a few of which, we believe, are still in commission. Since the advent of the petrol-motor fire appliance, pumps of more than double that capacity have been in vogue, and some of these have been illustrated and described in these pages from time to time. The demand for lighter and smaller motor pumping apparatus, however, exists, and to meet it Messrs. Merryweather and Sons, Limited, of Greenwich, have just put on the market a "Light Brigade" automobile fire-pump, the first of which type we illustrate herewith.

This machine, although constructed on much the same lines as the heavier and more powerful types above referred to, has several important differences in details of design. The petrol-motor has four cylinders, 100 mm. in diameter by 130 mm. stroke, and gives 35 horse-power on the brake. The transmission is by a leather-faced cone-clutch, and a change-speed gear of standard design, with three forward speeds and one reverse, arranged in a single steel casting, which also carries the differential gear and the clutch to the pump-drive pinion. The drive to the rear wheels is by roller-chains, as in all Messrs. Merryweather's motors. The spring-suspension to the rear axle is on the lines of modern car practice, suitably modified to deal with the larger load. The centre of the spring is fixed to a bracket carrying the differential shaft and compression stays, the forward end being carried by swinging shackles, and the after end attached direct to the solid forged flaps on the rear axle. There is ample accommodation for hose and gear and a full crew of firemen.

The most interesting feature of the machine is the pump itself, which is constructed generally on the lines of the firm's well-known "Hatfield" pattern, having three plungers worked from a single crank. In the new pattern the barrels, instead of being fitted with solid single-acting plungers, as hitherto, have double-acting cylinders, giving six delivery impulses for every revolution of the pump crank-shaft. The suction-valves are so arranged that the clearance is very small, and almost the whole of the air in the barrels is displaced at the end of the stroke. A sufficiently high vacuum is obtained to enable the pump to lift water from a depth of 27 ft. without any special priming device. This pump is designed to deliver 220 gallons per minute at a pressure of 130 lb. on the pump, and a pump pressure of 150 lb. per sq. in. can easily be obtained on a slightly reduced quantity. The single working jet is $\frac{1}{16}$ in. in diameter, and reaches a height of 140 ft. when working through a short line of hose, the quality of the jet being compact and steady. A large automatic by-pass valve is arranged between the suction and delivery passages, so that shut-off nozzles can safely be used without undue shock to the hose and fittings.

The machine illustrated has been supplied for the protection of Captain Hall's estate at Weeting, Suffolk, which covers a considerable area and has several large farms on its outskirts. The water supply on the estate is procured from wells in the chalk, the water reaching to within 15 ft. or 20 ft. of the ground level. It will be noticed that wide "K.T." tyres are fitted to enable the machine to travel well on soft grass land.

"Chinese Self-Taught."—This is the title of a book by Mr. J. Darroch, Litt.D., published at the price of 4s. in the "Self-Taught Series," by Messrs. E. Marlborough and Co., 51, Old Bailey, London. The series in question already comprises twenty-four different languages, including Esperanto and Latin; the books appeal to tourists and travellers, since they are got up in the form of guides to conversation. The one for Chinese gives the English words, the Chinese equivalents in Chinese characters, and the pronunciation of the latter.

Iron Minerals in Germany.—The imports of iron minerals into Germany in June were 1,369,409 tons, as compared with 1,249,987 tons in June, 1913; while the exports were 196,667 tons, as compared with 222,117 tons. The principal imports in June were:—From Sweden, 509,486 tons; from France, 320,011 tons; and from Spain, 271,320 tons. The principal exports were:—To Belgium, 114,133 tons; to France, 77,148 tons; and to Austria-Hungary, 3999 tons. The aggregate imports for the first half of this year were 6,748,053 tons, while the aggregate exports were 989,127 tons. The corresponding totals for the first half of 1913 were:—Imports, 6,843,646 tons; exports, 1,374,980 tons.

An Australian Institution of Engineers.—A scheme has been set on foot, and probably by now brought to a successful conclusion, for laying the foundations of an Australian Institution of Engineers. There are no means under Commonwealth law of enabling the various technical bodies of the several States to come together to form one inter-State organisation, and the only way by which such a condition can be brought about is for each body to adopt identical constitutions under their own State laws. The Victorian Institute has taken a definite step in this direction, and, we understand, has adopted an incorporation scheme which has been evolved mainly by the efforts of Mr. J. A. Smith, Past-President, and Colonel J. Monash, President. A wide constitution has been drawn up, and was approved at a meeting held on June 10. There was some hesitancy as to whether it was wise to adopt the title given above, but it was explained that the object of the whole scheme was to bring engineers in Australia together, and that there was no intention of arrogating the suggested title to the Victoria branch alone. It was hoped the other States would follow suit, and the Victorian body would always be known as the Victorian Branch.

Third Sea Lord of the Admiralty.—With the approval of His Majesty the King, Rear-Admiral Archibald G. H. W. Moore, C.V.O., C.B., Third Sea Lord on the Board of Admiralty, will hoist his flag in H.M.S. Invincible, on August 15, and will be succeeded as Third Sea Lord by Rear-Admiral Frederick C. T. Tudor, C.B., at present Director of Naval Ordnance. It is further announced that Rear-Admiral Sir David Beatty, K.C.B., M.V.O., D.S.O., commanding the First Battle-Cruiser Squadron, has received the acting rank of Vice-Admiral.

On Accumulator Electrolytes.—The July issue of the Proceedings of the Société Belge des Electriciens states that most of the patents taken out in those countries where there is no preliminary examination cover re-inventions, not genuine inventions. This is due to the fact that the majority of researchers explore fields which are not familiar to them and neglect to inform themselves thoroughly on all points. According to our contemporary, this state of matters prevails in the construction of electric accumulators more than in any other branch of industry. The immobilisation of the electrolyte, for example, constantly gives rise to a number of patents dealing with processes some of which have been known for the last thirty years or more.

The Productograph.—It is often a difficult matter to determine the reason why differences in the productive capacity of machines, or ranges of machines, arise. Constant supervision is necessary if these differences are to be reduced to a minimum, which often means that the manager himself has to take an active part, and several times a day visit each department. That such work is onerous and often inconvenient must be admitted, and, therefore, the apparatus called the Productograph merits careful consideration. Briefly, the Productograph occupies a comparatively small space, is placed in the manager's office, and indicates clearly the constant operation and output of the machine. It has already been employed in connection with machines of widely varying character, and is shortly to be tried in connection with textile machinery. If successful, there is no doubt that it will prove of immense value to the spinner and manufacturer, because wide variations in production are often met with, especially on the weaving side. Essentially the apparatus—which is of American origin—comprises a lead-paper chart mounted on a revolving cylinder, and spaced to show each hour and minute of the working day, a series of magnets, and a corresponding series of needles. The magnets, on being energised, attract the needles, and cause them to trace a line on the chart, the number of these lines and their length indicating the operation and output of the machine. On the various machines switches are carried, and wires run from them to the magnets. The switch consists of a small cast-iron box, with the switch-arm connected with a rotary or other moving part, from which an accurate record of the machine's operations can be obtained. A reduction gear is located inside the switch-box, and this reducing gear actuates a plunger in an air-chamber, which makes the contact by bringing two springs together. Immediately after making a contact, the plunger returns to its original position, so that, in whatever position the machine is stopped, the switch cannot be short-circuited.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Canada: The Commercial Intelligence Branch of the Board of Trade is notified by the Toronto Commissioner of Works that tenders are invited by the Toronto Department of Works for the construction across the Don Valley (in connection with the Bloor-street viaduct) of a bridge of five steel-arch spans, with piers and approaches. The width is 86 ft., and the approximate length is 1618 ft. At their own cost tenderers may also submit proposals for the construction of a reinforced-concrete bridge.

Spain: The *Gaceta de Madrid* states that a Royal Decree has been passed approving a new project for reconstructing the La Galera mole at the port of Algeciras, the estimated cost of which is 1,409,170 pesetas (about 52,200*l.*). The directing engineer of the works is to proceed, without delay, to study such preliminary works as the repairing of the Verde Island breakwaters, and the dredging of the anchoring ground necessary to ensure a good roadway to the La Galera mole.

Mexico: The *Diario Oficial*, Mexico City, contains the text of a contract entered into between the Secretario de Estado y del Despacho de Comunicaciones y Obras Públicas and Señor Licenciado Enrique Torres Torija for the construction and working of a railway line in the States of Tabasco and Chiapas. The line is to start from Montecristo, pass through Palenque, Tumbalá, Simojovel, and Santa Marta, and terminate at San Cristobal, with a branch line from Montecristo to Tenosique. The concessionaire must complete at least 20 km. (about 12½ miles) the first year, and the same distance during each succeeding year; the whole distance has to be completed within ten years. The concession is for fifty-two years.

SIGNALLING ON RAILWAY TRAINS IN MOTION.*

(Six Brief Descriptive Papers by French Engineers.)

Northern Railway (Chemin de Fer du Nord).

Description of the Fixed Ramp, The Electro-Automatic Whistle on Locomotives, and the Electro-Automatic Indicator for Trains Passing Distant Signals.

By A. Sartiaux, Engineer-in-Chief of the Traffic and Working Department.

The following descriptions and drawings have been put together by the author to explain to the members the system now being used experimentally on the Chemin de Fer du Nord.

The author, at the same time, wrote that Mr. Moutier, the chief engineer of the technical department of the railway, will be glad to put himself at the disposal of the members, to explain the apparatus further, at the meeting.

[*Translated.*]

Fixed Ramp or "Crocodile."—The fixed ramp is an apparatus which is set in the centre of the track, parallel to the rails at a distance from the signal, varying, as the case may be, from the foot of the signal itself to 200 m. (about 218 yards). Fig. 1 is a diagram of the electric circuit. The ramp consists of an oak beam A, Fig. 2, 2 m. long (6 ft. 6¾ in.), resting on two wrought-iron supports B, B'. The oak beam, which, to start with, has been soaked in boiling linseed oil so as to preserve and insulate it, carries a cover-plate of brass resting on small wooden bushes or porcelain washers, and firmly screwed to it. A stout square piece of copper, which is riveted to the plate, is connected to the wire from the battery. This square piece lodges in a hollow carved into the wood, and closed by a small galvanised-iron plate. If the speed of the train exceed 50 km. (31 miles) per hour when going over the fixed ramp, two such ramps are used, placed end to end, in order to increase the duration of contact. The fixed ramp rests on the sleepers, on which it is held by wood screws; but care is taken in the first instance to pack between the supports and the sleepers cushions of tarred felt, so as to reduce the vibrations due to trains passing. Facing the nose of the ramp in the direction of motion of the trains is another wooden beam, also fixed on the sleepers. This is the shield C, the surface of which slopes up. Sometimes a shield is provided facing each end of the fixed ramp. This shield is intended to protect the nose D of the fixed ramp from being caught, torn, or lifted by any piece projecting from the engines or the carriages. The fixed ramps should always be set in the centre of the track. The surface of the brass plate should be 10 cm. (nearly 4 in.) above the level of the rails. To place the fixed ramps in position, a special gauge is used, Fig. 3. The maintenance of the contact surface of the fixed ramp in proper condition is effected by rubbing the brass cover-plate with a cloth, and some very fine sand if it be very dirty; if soiled only, it can be cleaned with a damp cloth and thoroughly dried. Care must be taken that no dirt accumulates round fixed ramps, and in the winter they must be carefully freed of all snow. Again, when sleepers are changed there must be no accumulation of ballast round them.

The Electro-Automatic Whistle.—The whistle is an electro-automatic apparatus intended to warn drivers that they are reaching a distant signal set at "danger." This apparatus, Fig. 4, which is installed on all locomotives, consists of a bronze bell-whistle A, and a lever C (carrying a plunger-valve H), which the tube B puts into communication with the boiler or with a compressed-air cylinder, the whole being bolted on to a cast-iron box fixed to the screen of the engine, in front of the driver. The lever C also carries a rod F, round which is a strong spring continually tending to pull the lever down and let steam or compressed air into the whistle. The rod F joins at its other end the arm G of a Hughes electro-magnet D. If a current be sent through the coils in a certain direction, the magnet immediately ceases to attract its armature, the lever C comes down, and the whistle A keeps going until the driver brings back the lever and the armature by pressing on the hand-lever E.

The Brush.—One of the wires of the electro-magnet working the whistle connects with the body of the engine and goes to earth through the wheels and the rails, the other wire goes under the engine through a cable, perfectly insulated, and connects on to the brush shown in Fig. 5. The brush consists of a series of small brooms of hard but elastic copper wire, soldered on to a metallic plate, which the cable aforementioned connects to the electro-automatic whistle. This apparatus is either adjusted at the loco shed to a maximum of sensitiveness in uncluching, a battery of three cells being used, or the engine is driven over a fixed ramp called a "testing" ramp, set at the exit from the shed, and which is directly fed by a battery of four cells, as shown in Fig. 6.

The Switch and the Electric Circuit.—The signal vane is provided with a switch, which is worked by a finger keyed on the signal-post. This switch serves to control the position of the signal-vane as well as to release the whistle. It is adjusted so as to work the bell registering at the signal-box the position of the signal, and to release the whistle the moment the disc has turned 70 deg. round from its normal position of "line clear." The brass plate having been connected with the positive pole of the battery placed near the disc, the negative pole joins on to the switch, which sends the current to earth when the disc is turned to danger, and disconnects it the whole time the line is clear. Fig. 1 (above) explains the general installation and shows the electric circuit. The battery registering at the station the position of the signal-vane has eight cells, the one connected to the fixed ramp has twelve cells. Both batteries are protected in a little cement shed built at the foot of the signal-post. It is important that earthing be perfect.

Indicator for Trains Passing Distant Signals.—The indicator for trains passing distant signals is intended to give audible and optical warning to the station officials and the pointsman that a train is approaching. It consists of two fixed ramps A A', Fig. 1, the first of which works the electro-automatic whistle as aforesaid, and the second the warning-bell every time a train or an engine goes over it, this irrespective of the position of the signal-vane. The warning apparatus installed in the signal-box consists of a loud warning-bell provided with a little vane, which becomes visible when the Hughes electro-magnet, which is inside the apparatus, has been released by the brush going over the second fixed ramp. The appearing vane closes the circuit of a local battery which includes a loud trembling bell.

Eastern Railway (Chemin de Fer de l'Est).

Description of and Modifications to Electrical Warning and Recording Apparatus.

By F. Lancrenon, Locomotive and Rolling-Stock Superintendent.

The author sent a printed descriptive notice with detailed plans relating to the electrical warning and recording apparatus in use upon a certain number of locomotives on the Chemin de Fer de l'Est. He also sent a statement of several modifications made to the apparatus during the experimental period.

[*Translated.*]

Extracts from the Printed Descriptive Notice.

Ramps.—The fixed contact or ramp is a contrivance placed parallel to the rails in the centre of the track, and at a distance from the signal-post, varying from the foot of the post itself up to 400 metres to suit the requirements. The ramp consists of an oak beam 2 m. (6 ft. 6¾ in.) long, resting on two cast-steel chairs. These chairs are screwed to the sleepers and rest on cushions of tarred felt, so as to decrease vibration. The oak beam is soaked in boiling linseed-oil, so as to preserve and insulate it. It carries a brass plate covering its surface. This plate rests on wood bushes or porcelain washers, and is screwed down firmly. Its surface is kept at 100 mm. (nearly 4 in.) above the level of the rails. F, Fig. 7, is a galvanised-iron cover closing the hollow cut into the beam to take the connection from the battery. The wire joins on

Fig. 1. DIAGRAM OF ELECTRIC CIRCUIT

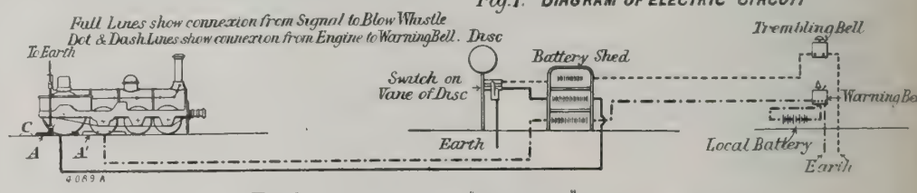
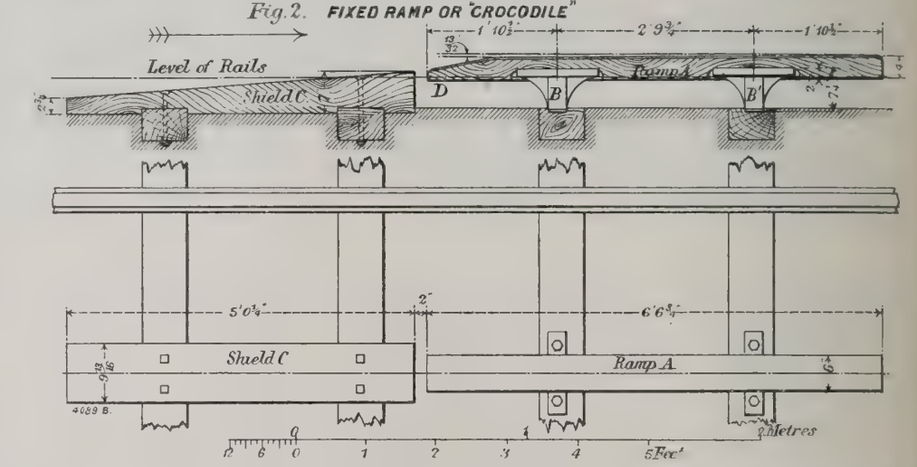


Fig. 2. FIXED RAMP OR "CROCODILE"



plate, which the cable aforementioned connects to the electro-automatic whistle. This apparatus is either adjusted at the loco shed to a maximum of sensitiveness in uncluching, a battery of three cells being used, or the engine is driven over a fixed ramp called a "testing" ramp, set at the exit from the shed, and which is directly fed by a battery of four cells, as shown in Fig. 6.

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Switch.—The switch at the signal-disc, which connects the two sets of batteries with the ramp, is in a cast-iron box, Figs. 9 and 10, page 236. The lever B is keyed on the shaft A, which is connected to the signal-disc. The shaft A carries several cams for different purposes. Two of these, D and E, are used in connection with ramps. Two springs, F and G, face cam D; two others, H and K, face cam E. When the disc is at "danger," Fig. 9, the lever B brings cam D to bear on the end of the spring F. This, in its turn, bearing on G, establishes the connection between the termini L and N, so that the positive pole of one of the batteries is connected with the ramp (L and N joining with the battery and the ramp). When the disc is at "safe," Fig. 10, cam E bears on H, bringing it down to bear on K, thus connecting the termini M and N, so that the negative pole of the other battery connects with the ramp. The profile of the cams is such that contact is established when the disc has still to turn round 20 deg. before it is at "safe" or at "danger."

Warning Apparatus.—This is similar to the apparatus described for the Nord, but a horn is used instead of a bell-whistle, which means that more steam is required. In order to provide for this, an additional device, called a servo-motor, is introduced.

In Fig. 11 the rod of the valve A carries at its other end a piston B, which is acted upon by the steam which the plunger-valve H (Fig. 4, page 238, du Nord), has allowed to escape. As soon as the pressure of the steam on B becomes greater than that of the spring keeping the valve A back, the latter opens and the horn is fed directly

* Paper read before the Institution of Mechanical Engineers at Paris, July 7, 1914.

from the boiler. In plan is shown a pipe C. This in certain cases is added to serve a second servo-motor, which brings the armature of the magnet back into position, so that the driver has nothing to do with the reclutching, and cannot stop the warning too suddenly. Five different devices have been tried for this :—

(*a*) The first is a liquid speed-lag, working cataract way between two cylinders of different sizes, the larger one of which contains a piston, which its rod connects with the lever of the electro.

The escape through the small cylinder can be regulated so as to vary the speed of movement of the piston.

(*b*) The second device disconnects the lever and the armature, so that the driver has no more control of the apparatus until it is set to work once more by the brush going over another ramp.

(*c*) The third is purely automatic, and consists of an auxiliary servo-motor, which brings the armature back.

(*d*) The fourth is a combination of the first and the third.

Fig. 3. GAUGE FOR RAMP.

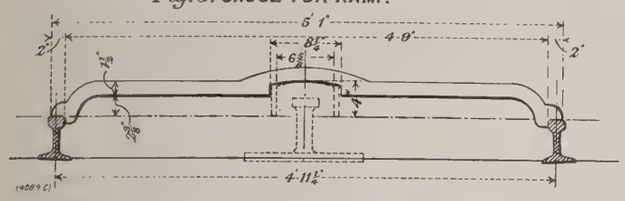


Fig. 4. ELECTRICALLY OPERATED WHISTLE

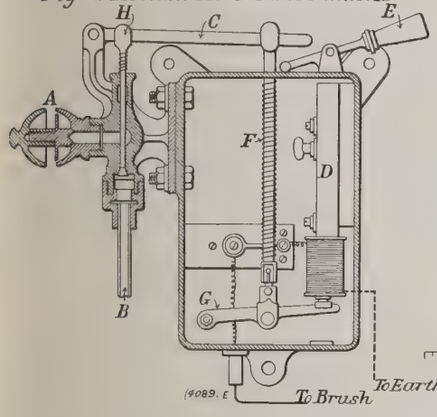
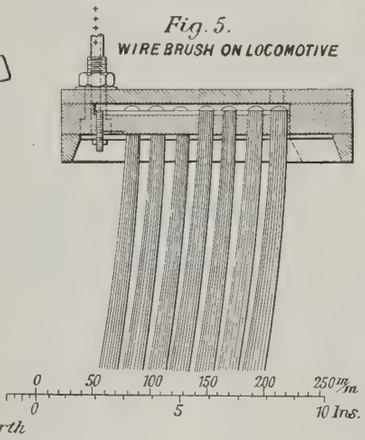


Fig. 5. WIRE BRUSH ON LOCOMOTIVE



(*e*) The fifth is a device which the driver has to set by hand. Once he has set it, the armature goes slowly back into position, and the driver has no more control over it.

Again, the lever D is added so that the driver may work the horn himself, in case he wants to send special signals.

Recording Apparatus.—The record is taken on the tape of the speed-indicator itself (Flamand system). A third stylo-nib is fixed between the two others recording the time and the speed, and dots down the position of the signals passed. The apparatus consists of two Hughes electromagnets with their poles reversed, so that one is demagnetised by a positive current, and the other by a negative current. The two electros are in series, and join on at one end to the wire from the brush. The other end is connected to the engine, and thence goes to earth. Under those conditions, supposing the disc is at "danger," one of the magnets will be demagnetised (the other keeping its armature), and the stylo will make a mark on one side of the normal line. If the disc be at "safe," the other magnet will be demagnetised, and a mark will be recorded on the other side of the normal line. We have thus from the two ramps four combinations, Fig. 12. The leverage of the armature is too weak to work the stylos, so as to ensure a distinct mark. The small leverage they give is used simply to work an auxiliary mechanism, which, in its turn, works the stylo. In Fig. 13 the armatures A, B, the arms of which turn freely round the shaft L, are acted upon by two springs, which tend to pull them away from the magnet, so that immediately one of the armatures is released it is pulled back. On the arms of the armatures are two pins C and D. Either of these pins will, when one of the armatures is released, press against a lever E F, which is pivoted at its centre and tilt it one way or the other until one of its ends bears on one of the toothed plates G or H. These plates, which carry three teeth each, gear with the drum of the speed-indicator through a bracket M keyed on the shaft L, and bearing on the arms of the armatures A and B. When one of the armature arms moves away from the magnet, it presses the bracket back and turns the shaft L. A lever arm O, which is keyed to L and kept in position by a spring, then releases the ratchet P of the tooth-wheel Q and a small lever R, which then presses against an eccentric S keyed on the shaft of the drum of the indicator. The rotation of this eccentric S engages and releases the ratchet P, and Q turns round. As Q is keyed on the same shaft T as the toothed plates G and H, the latter turn round with it, thereby causing the levers E F to tilt up and down. This movement is carried to the stylo-pen through the lever V, which is keyed on the same shaft as E F. At one end this lever V carries a pin which presses against another lever W keyed on the shaft X. The movement is then communicated to the pen through a third lever keyed at the other end of the shaft X.

The machinery stops thus: The arm M carries a catch which bears on another toothed plate U, keyed on the shaft T immediately under M. As soon as this catch engages in the tooth of the plate U, the shaft T ceases to turn. The jerk is immediately taken up by the spring acting on the lever O, the ratchet P of the wheel Q unclutches, and the lever R is brought back away from the eccentric S.

1. *Apparatus Fixed on the Track. Cells.*—The two batteries installed at the disc have been replaced by a single battery, each pole of which is connected alternately to the ramp and the earth.

"*Crocodiles*" *or Ramps.*—The ramps described in the book of instructions have been replaced by a ramp in the shape of a gridiron, and composed of bars or angle-bars parallel to the track. The object of this modification is to eliminate the causes of failure due to hoar-frost. Experiments have been carried out on a ramp, the surface of which was protected against hoar frost by petroleum oil dropping over it continuously.

2. *Apparatus Fixed on the Engine. Brush Collector.*—The modification to the brush follows that of the ramp. Instead of a collector consisting of copper wires, a very rigid brush is used, Fig. 14, made of steel blades with a section 1 mm. by 3 mm. (0.04 in. by 0.12 in.). These blades are made up in bundles of four. Their passage between the bars of the ramp scrapes off the hoar-frost and a good electric contact is ensured under all conditions.

Warning Apparatus.—In future the unclutching of the armature at the registering apparatus (signal being at "danger") will be used to work the warning apparatus. This unclutching force will be increased by means of compressed air, or by gearing with the main shaft of the speed-indicator. In the first place a balanced valve will feed the air-whistle placed in the driver's cab; in the second case the admission of steam will be done mechanically. Thus the servo-motor and corresponding electric circuit will be dispensed with.

Control of the Working of the Apparatus.—For this purpose the unclutching of the armature at the registering apparatus is used (signal being at "safe"). This sets a bell ringing when the engine passes a signal at "safe." The driver thus knows if his apparatus is in working order.

Fig. 6. DIAGRAM OF CONNEXIONS.

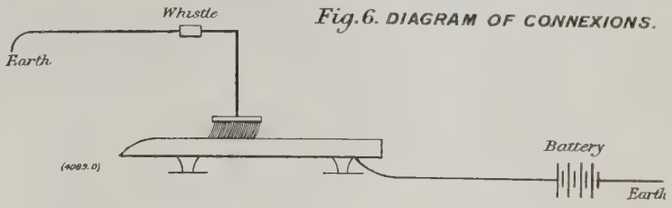


Fig. 7. RAMP SECTIONS

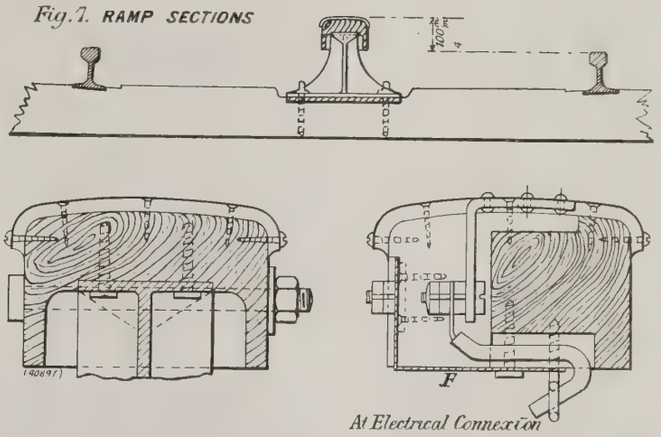
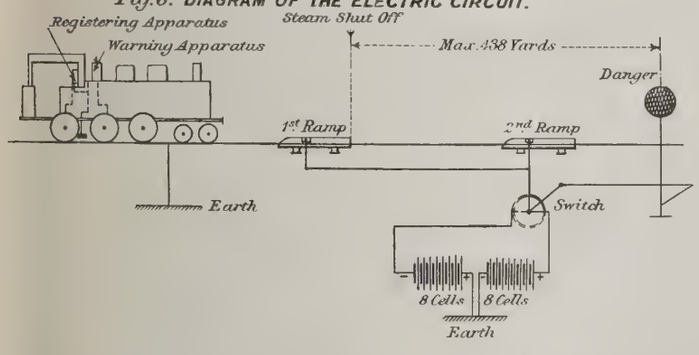
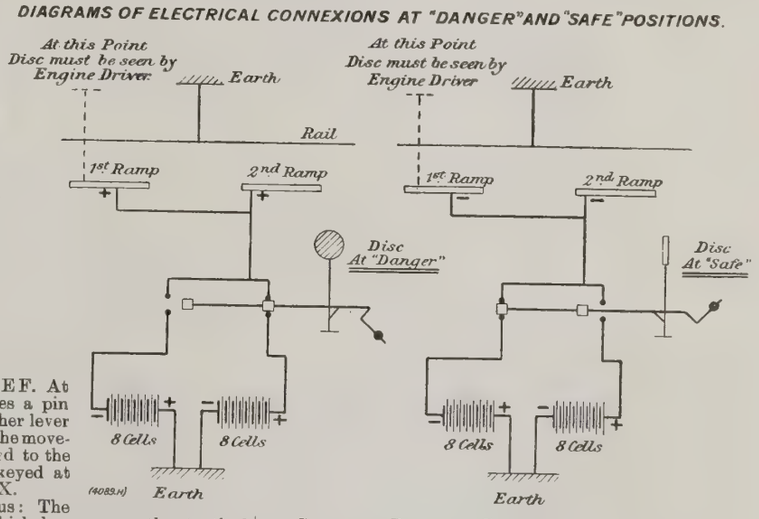


Fig. 8. DIAGRAM OF THE ELECTRIC CIRCUIT.



DIAGRAMS OF ELECTRICAL CONNEXIONS AT "DANGER" AND "SAFE" POSITIONS.



SOUTHERN RAILWAY (CHEMIN DE FER DU MIDI).

Electro-Automatic Warning and Danger Signal Recording Apparatus.

By A. HERDNER, Locomotive and Rolling-Stock Superintendent.

The author has sent a copy of service instructions, describing the warning and registering apparatus for danger signals adopted by the Chemin de fer du Midi, subject to the approval of the head office. He also sent a drawing showing the general installation of the apparatus on one of the express engines, together with a diagram of the installation on the track. The warning and registering apparatus, which is now being experimented upon on twenty engines and thirty automatic signals, differs from the one mentioned above, in that the battery is placed on the engine instead of on the track. Moreover, the original apparatus does not possess an appliance by which the driver's vigilance may be controlled.

[*Translated.*]

DESCRIPTION OF THE INSTALLATION.

Apparatus Mounted on the Engine.—This consists of :—

1. A metallic brush-collector fixed on an insulated support under the rear platform of the engine, Fig. 15.

2. A special steam-whistle controlled by a servo-motor, Fig. 16. The latter receives steam from the boiler through a pipe branching off the pipe through which steam is supplied to the whistle, and is normally closed by a valve controlled by an electro-automatic contrivance to be described hereafter. The steam-pipe of the special whistle is provided with a stop-cock at the boiler end, so that, in case of necessity, the warning apparatus may be cut off.

3. An electro-automatic contrivance, by Lartigue and Forest, fixed on the screen of the cab, and working, on a shaft, two special stylo-pens of the Haussbaelter speed-indicator, as well as the valve admitting steam to the servo-motor of the warning whistle. The shaft of this apparatus carries a hand-lever within reach of the driver.

4. An insulated conductor connecting the brush to the electro-automatic apparatus, which is itself earthed through the body of the engine and the rails.

5 An appliance controlled by a hand-lever within reach of the driver, and working one of the special pens of the speed-indicator.

Appliance Mounted on the Track.—This comprises for each disc:—

1. An electric battery.

2. A fixed ramp, which is installed on the track, parallel to the rails near the disc, in the line of action of the brush, insulated from earth, and connected by an insulated wire to one of the poles of the battery, Fig. 17 (page 237).

3. A switch disposed so as to establish the connection between the second pole of the battery and the rails when the disc is turned to "danger."

The Operation of the Apparatus.—The moment the driver of a train sights a disc turned to "danger," he must immediately work the handle of the control apparatus, which then causes a special pen to trace a particular mark on the paper of the speed-indicator.

When the engine arrives at the stop-signal, the collector rubs on the ramp, and the circuit becomes closed—on one side through the switch of the disc and on the other through the brush in contact with the ramp. The current then passes through the electro-automatic apparatus and releases it, so that its shaft works simultaneously the two special pens of the Haussbaelter indicator, and the steam-valve of the servo-motor. The two pens trace on the same vertical on the paper of the speed-indicator two particular marks, which must follow the single mark made by the controlling device; the valve, admitting steam to the servo-motor, sets the warning whistle going.

The driver stops this by pressing on the lever of the shaft, thereby closing the valve and bringing back the armature of the electromagnets, and thus closes the steam-valve.

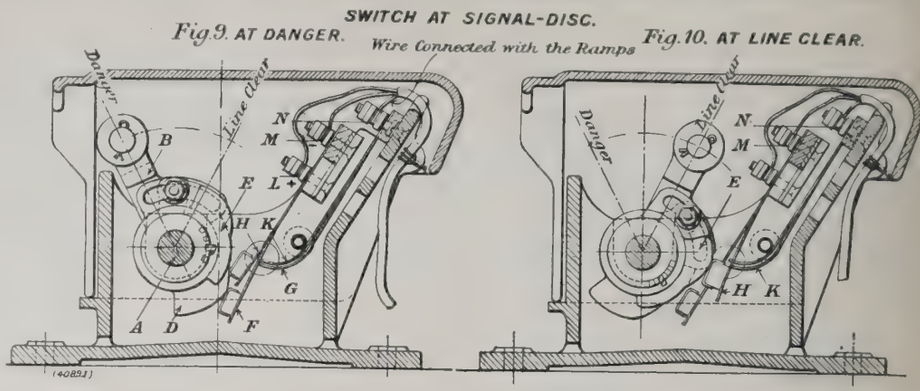
Instructions to be Observed in the Working of the Warning and Recording Apparatus for Stop-Signals.

Article 1.—The use of the warning apparatus for stop-signals in no way modifies the directions which the drivers must follow in the presence of "danger" signals and of extinguished or doubtful signals.

Article 2.—Any automatic home-signal which is set so as to cause the warning-signal apparatus and the recorder to act must be considered as at "danger," whatever may be the position of its flag or of its vane.

Article 3.—Drivers must report in their journal all incidents referring to the working of the warning and recording apparatus (normal working, non-working in the presence of a disc provided with the special appliances, working at the wrong time, &c.).

Article 4.—The officials at the sheds, who couple the



The Engine has gone over the two Ramps, the "Disc" being at "Danger."

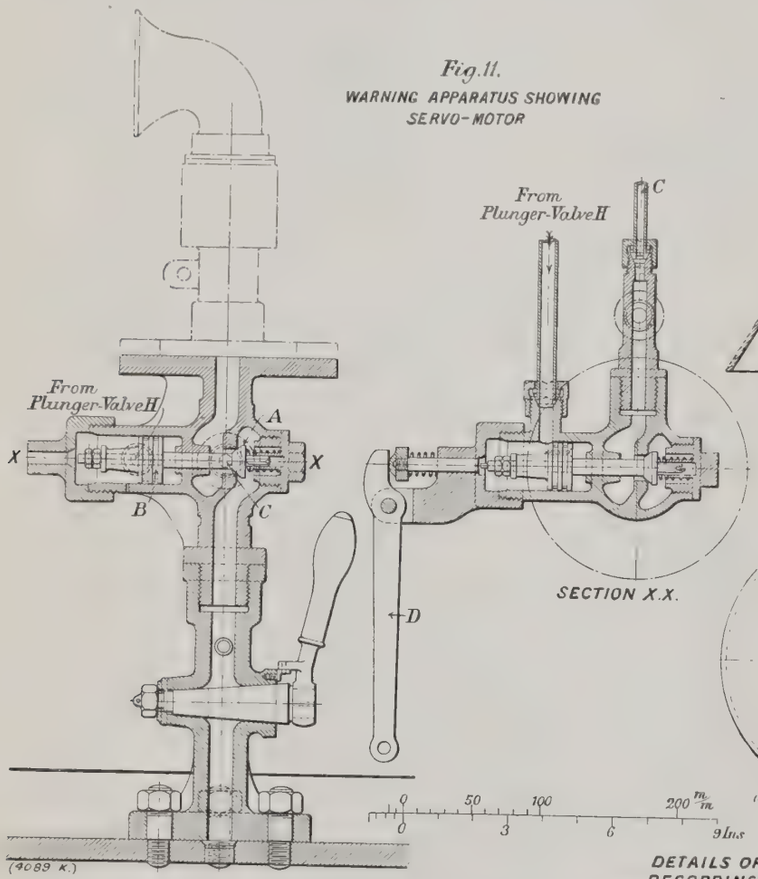
The Engine has gone over the two Ramps, the "Disc" being at "Line Clear."

The Disc was set at "Danger" after the Engine had gone over the 1st Ramp.

The Disc was set at "Line Clear" after the Engine had gone over the 1st Ramp.

(The horizontal line is traced by the stylo-pen when at rest.)

Fig. 12.



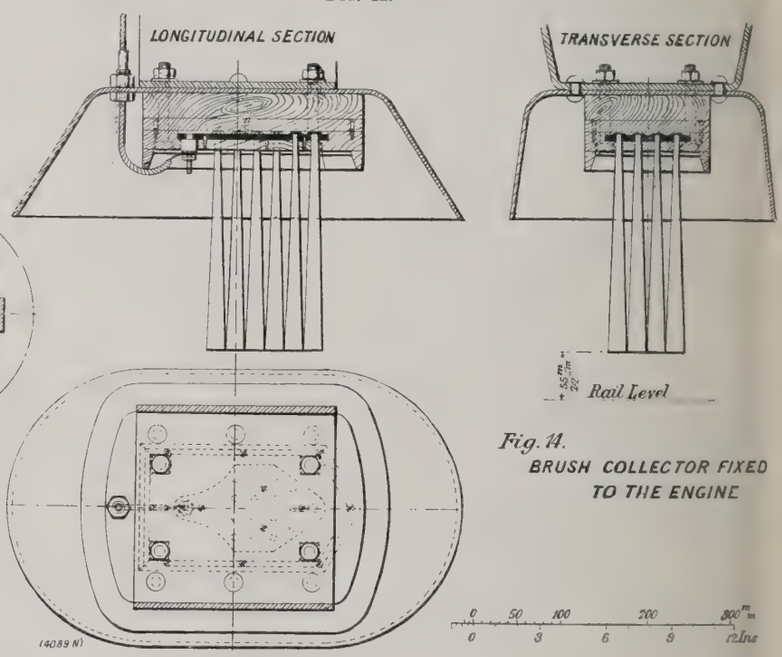
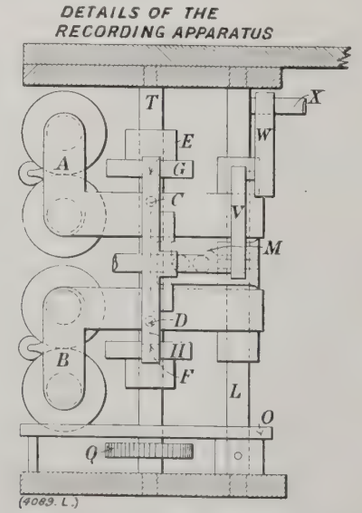
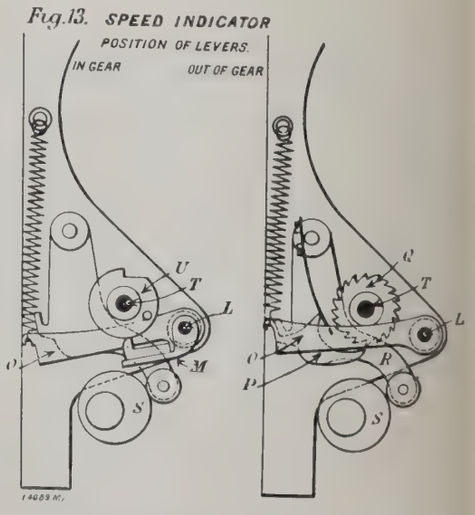


Fig. 14.
BRUSH COLLECTOR FIXED TO THE ENGINE





engines fitted with the warning and recording apparatus, will report in the ordinary way any breach of orders and regulations in force which an examination of the diagrams will disclose. They will ask the drivers who have not operated the apparatus of control in due time to give immediate explanation. They will, besides, prepare at the beginning of each month, for the preceding month, reviews of all the incidents relating to the working of the electro-automatic apparatus mounted on the engines belonging to their sheds. These reviews will be addressed to the district engineer, who will forward them on the 15th of each month to the locomotive superintendent.

STATE RAILWAYS (CHEMIN DE FER DE L'ETAT).

Mr. A. Claveille, general manager of the State Railways, states that four safety devices are being subjected to comparative tests on the Chemin de fer de l'Etat. These are :—

(*a*) The Cousin system, fitted to 55 locomotives.
(*b*) The Van Braan system, fitted to 28 locomotives.
(*c*) The Augereau system,* fitted to two locomotives.

Fig. 15. ELECTRO-AUTOMATIC WARNING AND REGISTERING APPARATUS FIXED TO SIDE OF CAB

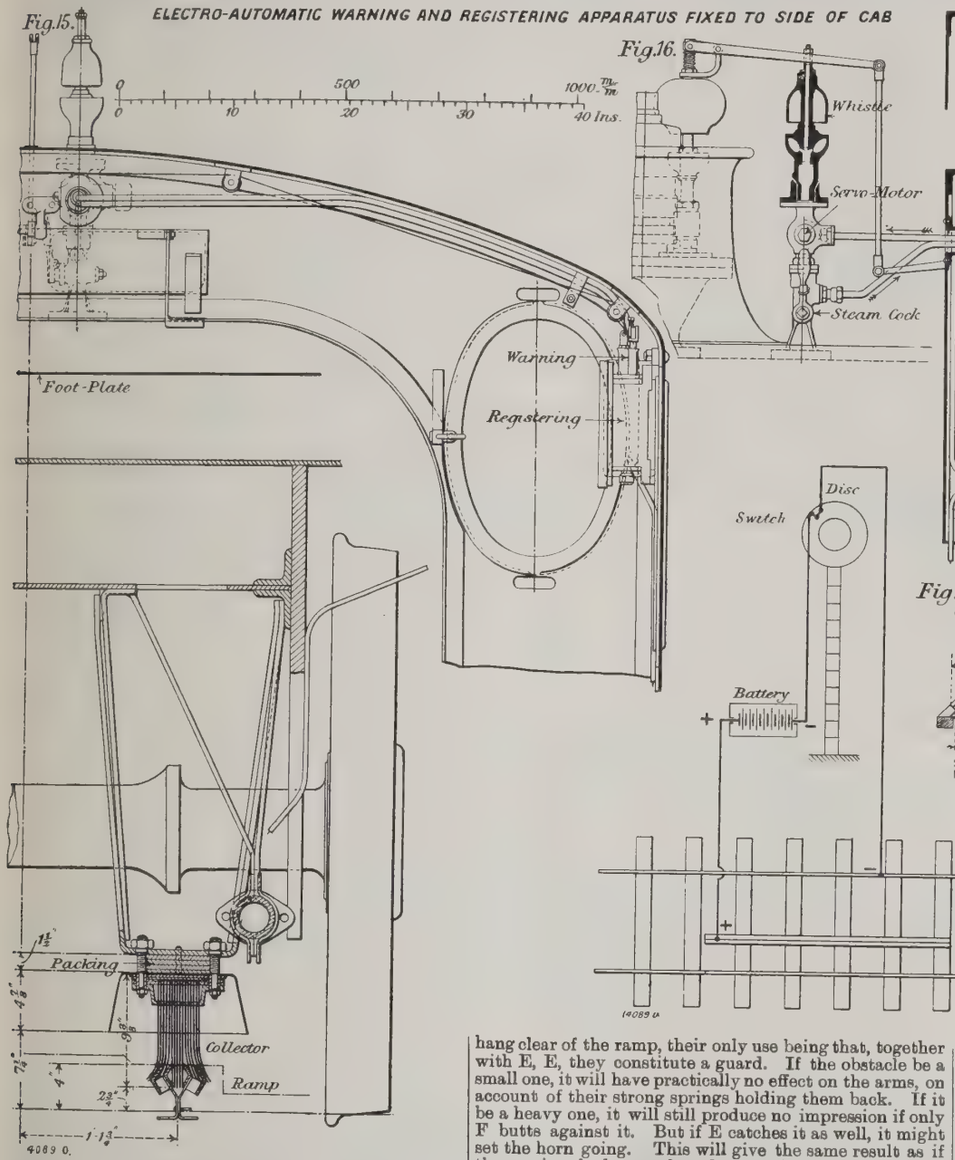


Fig. 16.

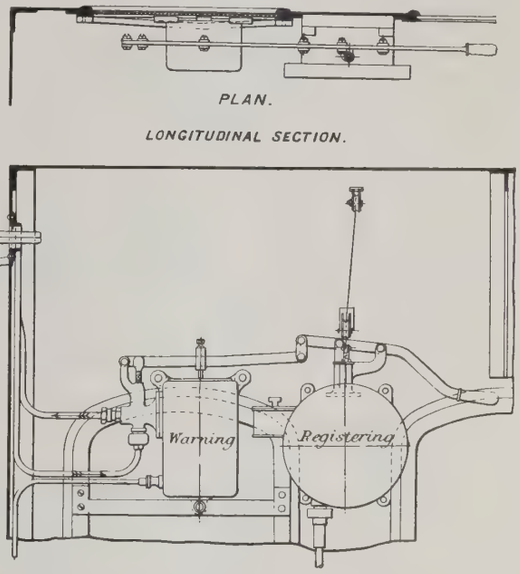
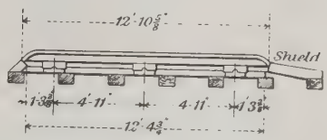


Fig. 17. RAMP, WITH DIAGRAM SHOWING GENERAL INSTALLATION.



(*d*) The "Est" type apparatus, fitted to 27 locomotives. These different systems are still in the experimental period.

The following descriptions are taken from a printed book describing the Cousin system, and from drawings which have been sent to the Institution.

Summarised Translation.

The Warning Apparatus.—A tube A, Fig. 18, page 238, is supported by two brackets bolted on the frame of the engine, and is fixed in them by two pins.

This tube extends right through. A steel rod B moves freely in it longitudinally, in the direction of the arrow, as shown, its total displacement in that direction being $x = 9$ mm. (0.35 in.). Two pins, *a a*, pass through the rod, through the tube A and through two rings *b b*, to the outside of which they are riveted. The longitudinal motion of these pins is provided for by two slots made in the tube A. At its left extremity the rod B screws on to a buffer, which butts against the piece carrying the electrical connection for the recording apparatus. A spring brings B back into position—*i.e.*, from right to left. Passing round the tube A are four sleeves—two sleeves *c* and *d* to the left and two to the right. These sleeves are toothed at one end, so as to unclutch in only one direction of rotation. This is, for the pair of sleeves to the left, the reverse of what it is to the right, as indicated by the arrows, Fig. 18.

Cast on each sleeve are two keys—one on each side. These slide in grooves inside the sockets C and D, and compel the sleeves *c*, *d* to turn with the latter. The sockets carry hanging arms E, F. At the top they are coupled to four strong springs fixed inside the cylinders *e*, *f*, these springs tending to bring them back into position the moment they are displaced. The hanging arms E, E are those which come into contact with the ramp and move to an angle when they pass over it, being immediately brought back into position by their springs when they are clear of the ramp. As will be seen, these arms are the only two which admit a longitudinal displacement of the rod B. They are called the "active" arms. The other two arms F, F, called the "neutralising arms," hang clear of the ramp, their only use being that, together with E, E, they constitute a guard. If the obstacle be a small one, it will have practically no effect on the arms, on account of their strong springs holding them back. If it be a heavy one, it will still produce no impression if only F butts against it. But if E catches it as well, it might set the horn going. This will give the same result as if the engine had passed a danger signal—an accident which will be determined when the record chart is examined. Such an accident is termed in French a *déclenchement intempestif*, which means "unclutching out of season."

The apparatus works in this way :—When the arm E comes into contact with a ramp it is set at an angle and turns the socket C partially round. This twist is taken up by the sleeve *c*, which unclutches away from *d*. As the latter is kept from sliding, *c* has to travel longitudinally. In so doing it carries with it the ring *b*, and thereby the rod B. Again, the buffer screwed to B moves back with the latter. The top edge of this buffer bears in a recess cut in the piston G. As soon as the buffer moves back the piston is brought down sharply by its spring until it bears on the bolt which goes through it. It is this sharp thud of the piston which unclutches the apparatus at the horn, and sets it blowing.

Reclutching takes place thus :—The arm E goes back into position the moment it is clear of the ramp, and the two sleeves *c* and *d* clutch again; but the buffer of the rod B is still bearing against the piston, and the driver has to turn the hand-lever to pull the piston up. The electrical connection is simply used for the recording apparatus, which is the same in the main as described for the Eastern Railway.

The "Crocodile" or Ramp.—A, Fig. 19, is an angle-iron of fixed length and profile, pivoted at B on a bearing C, which is bolted to the channel-iron D. E is a counterweight, regulated so that A balances very sensitively, and just bears on the cam G with its pin F. This cam is keyed on the same shaft as the two sectors H, J, which are weighted, and is regulated so that it sets the "crocodile" in position long before the danger signal is fully on. A chain, the end of which is pinned to H, establishes the connection with the signal. Inside the channel iron is a switch, which works on and off, according to the positions of A, and rings a bell in the signal-box.

PARIS, LYONS, AND MEDITERRANEAN RAILWAY (CHEMIN DE FER DE PARIS À LYON ET À LA MEDITERRANÉE.

By L. MARÉCHAL.

Mr. L. Maréchal, Locomotive and Rolling-Stock Superintendent, wrote that he could not for the present make any definite statement regarding warning and signal-recording apparatus on the line, as these had but recently been fixed on a few engines running on certain sections, and were being experimented upon.

Mr. Maréchal referred besides to the difficulties inherent to the winter season, and suggested that it would be premature at this stage to say how efficient the apparatus was likely to be. This made him desirous not to make any statement before a long trial had taken place. But he would add that experiments were being carried out on 140 express locomotives and on 415 kilometres (258 miles) of double track, with 316 discs fully equipped. Though it was not possible to describe the apparatus, owing to the continual improvements carried out and the constant changes, yet he was willing to give the general principle on which it worked.

[*Translated.*]

The warning and recording apparatus for signals at "danger," which is now being experimented upon on the Paris, Lyons, and Mediterranean Railway, works thus when the engine goes over a ramp :—

1. It actuates a special whistle, which warns the driver and the stoker.

2. It traces on the roll of the speed-indicator a conventional sign, the position of which fixes the signal which was at "danger." Both these results are obtained simultaneously by means of an assemblage of devices placed on the track and on the engine.

The apparatus placed on the track comprises an insulated conductor, called a "crocodile" or ramp, fixed between the rails near the signal corresponding to it, a

* A printed book and drawings of this system were received at the Institution just before going to press.

switch worked by the same signal and connected to the ramp and the rails.

The apparatus on the engine consists of:—A brush which rubs on the ramp when the engine passes over it; a pneumatic horn giving the warning; an automatic device for unclutching and sending compressed air through the horn; an automatic device acting on the registering mechanism of the speed-indicator; an electro-pneumatic relay which provides the unclutching device at the horn and the registering apparatus with the compressed air required; a battery which provides the electro-pneumatic relay with the current required; a compressed-air receiver which feeds the apparatus (on engines already provided with pneumatic brakes no extra receiver is necessary, the one used for the brakes serving both purposes).

This warning and registering system is based on the combined use of electricity and compressed air. It makes it necessary to use switches and ramps similar to those adopted on other railways where the system is entirely electrical. In this latter case, electricity is the medium which brings about the unclutching of the apparatus during the very short time that the engine takes to pass over a ramp. This unclutching means a certain force being exercised, which, however weak, is not a negligible quantity, so that at very high speeds there might easily be failures.

In the Paris, Lyons, and Mediterranean system, electricity comes into play only to release the armature of the electro-magnet of the relay and close a circuit on the engine itself, without doing any mechanical work. Through this local circuit of the electro-pneumatic relay (which is fed electrically from the battery on the engine and pneumatically from the receiver) being closed, the compressed air becomes the agent which definitely provides the mechanical power required for unclutching and reclutching.

Orleans Railway (Chemin de fer de Paris à Orléans).

Audible Signals intended to Repeat Signals Along the Line.

By E. Solacroup, Locomotive and Rolling-Stock Superintendent.

[*Translated.*]

For more than fifty years the Orléans Railway has adopted a signalling system consisting of signals placed at a distance in advance of the danger-point, the unclutching of which, when set at "danger," is revealed by the explosion of two cartridges placed automatically on the track when the signal is at "danger." These signals, which are placed at a great distance from the point they protect, are the order for "stop-dead" when set at "danger." To steam past them brings a heavy punishment on the drivers, who therefore keep a vigilant look-out; and it is very seldom that they pass the posts, at any rate, not for a long distance. If, on account of atmospheric conditions, or a moment's inattention, a driver does not notice the stop-signal, he will be warned of its presence at the moment he passes the post by the explosion of the two cartridges, which the signal has guided on the rails when turned on to "danger."

The distance between the point which is to be protected and the signal-post is such that, even if the driver, due to circumstances as just mentioned, does not take measures to stop his train until after he has heard the explosion of the cartridges, he has still ample time to pull up before he reaches the obstacle.

The report produced by the explosion of the cartridges is so loud that it is impossible for anybody on the engine or in the front carriage not to hear it. This system has therefore the advantage not only of warning the driver himself of the presence of a stop-signal, but also the officials on the train, and the travellers even; and, generally speaking, everyone who happens to be in the neighbourhood when the train passes a stop-signal. Therefore this system constitutes a safety device which is just as efficient, if not better, than a locomotive cab-signal. It has besides proved itself to be so, as there is no accident on record on the Orléans Railway due to a driver having passed a stop-signal in front of him.

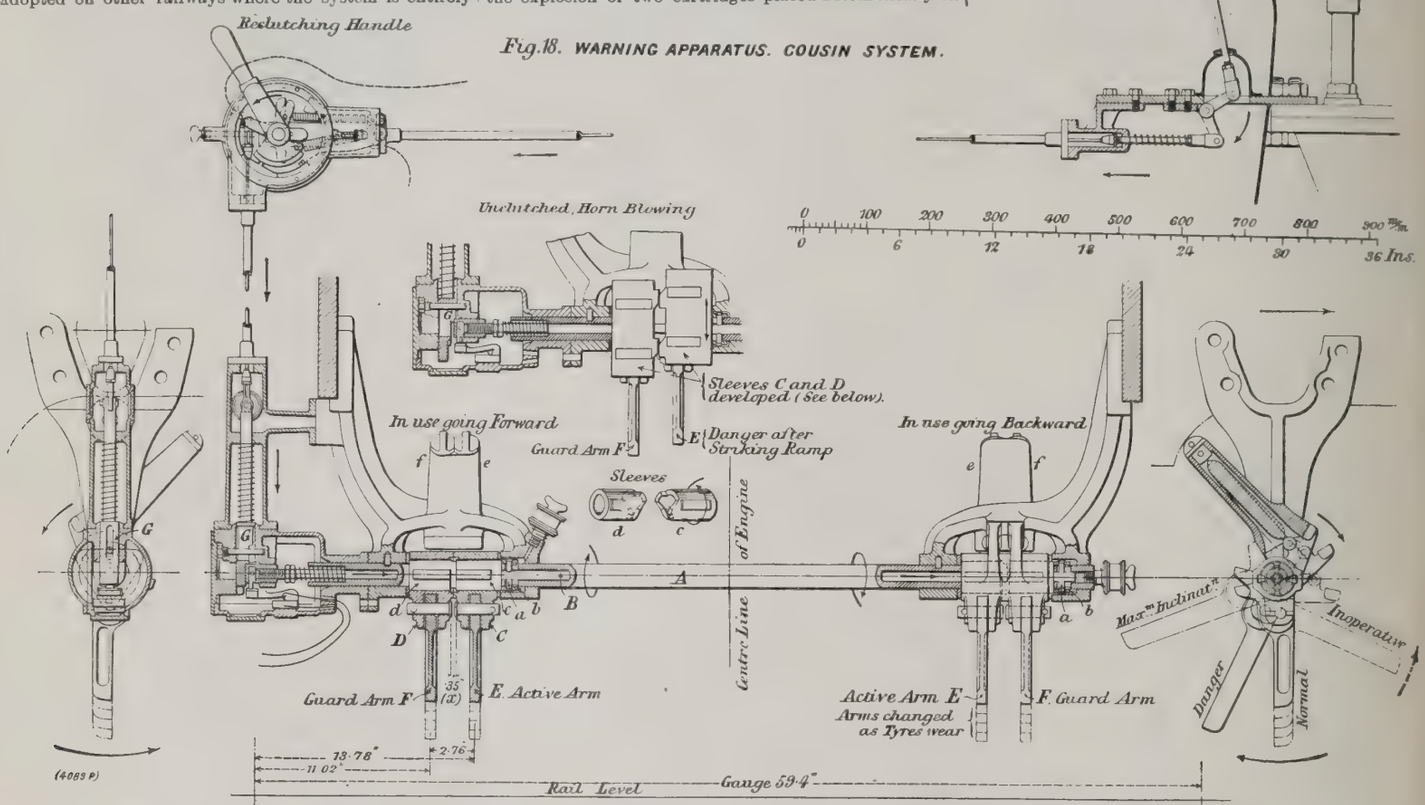
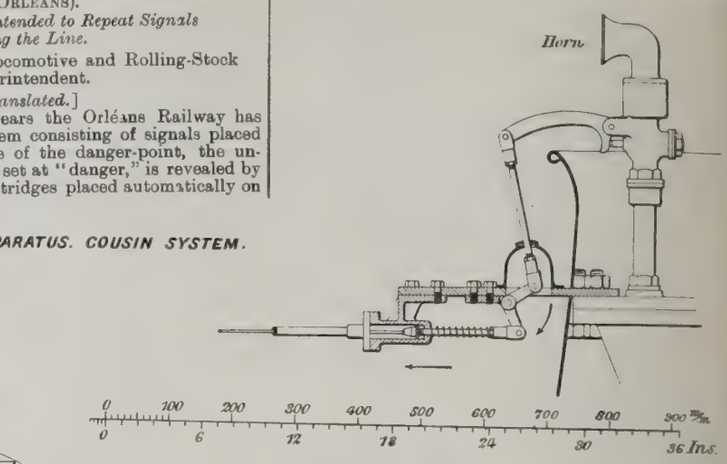


Fig. 18. WARNING APPARATUS. COUSIN SYSTEM.



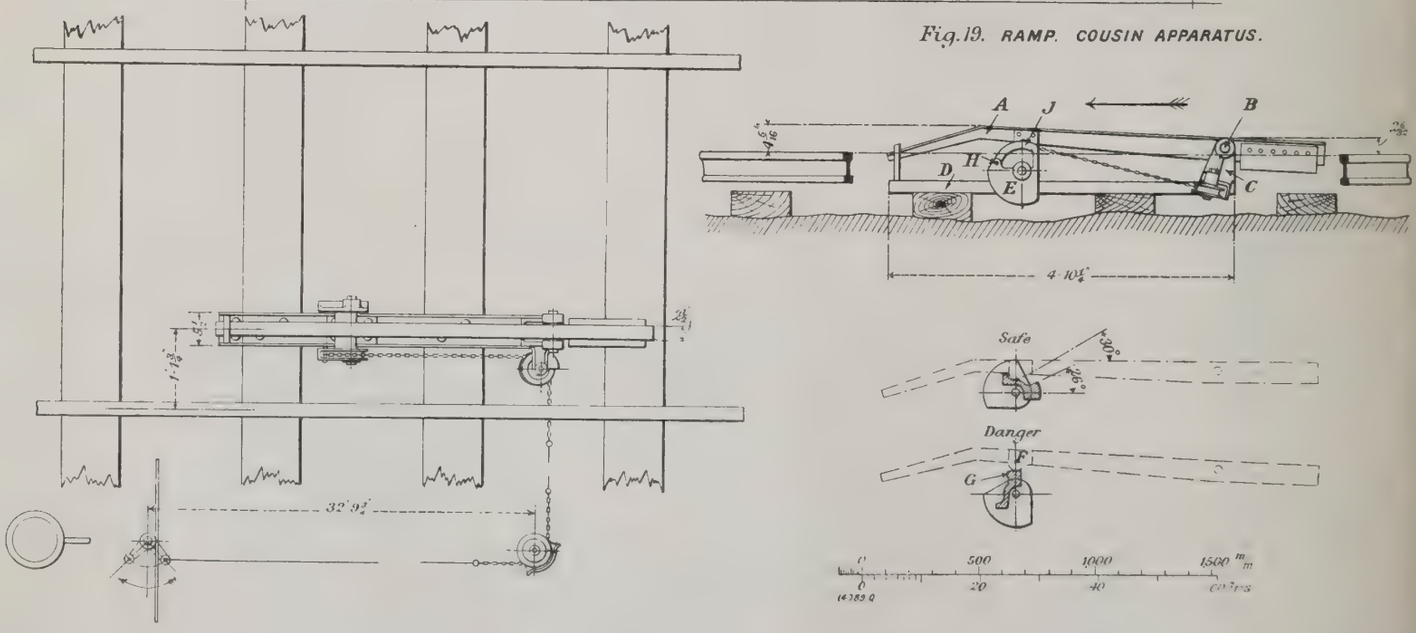


Fig. 19. RAMP. COUSIN APPARATUS.

THE PRODUCTION OF WHITE SALT FROM ROCK-SALT.

IT can scarcely be said that much progress had been made in the mechanical appliances for the production of white salt from rock-salt until the "Tee" process was perfected, and as success has been achieved not only in the methods adopted, but in the product from the furnaces, a description of the works now in operation at Carrickfergus, Ireland, will be of interest. First, as regards the process generally, it may be said that it differs from all existing methods, and consists in reducing the rock-salt to a molten state in a furnace, and separating the impurities from the pure salt by blowing compressed air through the molten mass. Owing to the difference in their specific gravities, the impurities sink to the bottom of the molten mass, and the pure salt remains at the top. In the early experimental stages the rock-salt was first melted in a furnace, and then run out into a converter, into which compressed air was blown, when the impurities settled to the bottom. The entire mass was then allowed to cool, when it was broken up and run through grinding machinery to reduce the crystals to the required sizes. Later on, the pure salt on the top of the mass in the converter was run into moulds, where it was allowed to cool, then broken up and ground as before. The furnaces were originally partly gas and partly oil-fired, and were somewhat after the style of a Siemens steel furnace, having air-regenerators only, the entire contents of the furnace in rock-salt being melted and then run out through launders to the converters at intervals, about four times per 24 hours. This arrangement proved to be somewhat expensive to work, and by a suitable arrangement of launder the furnaces were then made "continuous"—*i.e.*, the rock-salt is continually fed into the melting-chamber, and a continuous flow of molten salt is maintained through the tap-holes into the rotary pans, where the crystallising and delivery of finished salt is also continuous, the entire plant being worked from Sunday night at 8 P.M. to the following Sunday morning at 8 A.M. The next stage in the evolution of the mechanical appliances was to run the purified molten salt out of the furnace into open cast-iron pans, where, by means of hand-rakes, it was kept in an agitated state, during the process of cooling, when it crystallised; this did away with the necessity for grinding machinery. The open cast-iron pans were, however, soon replaced by mechanically-operated rotary pans, which now form the crystallising plant at the Carrickfergus works, owned by the International Salt Company, Limited. These rotary pans are made either single, double, or triple, according to the grade and quantity of crystallisation required, and deliver the finished crystallised salt to the elevators, which convey it through the screening-house to the finished store, the salt being deposited in a finished state ready for the market within half an hour of coming out of the mine. The great saving in time required for manufacture thus effected is one of the features of this process, and this, together with the very high quantity of salt obtained per ton of fuel, and consequent cheapening of production, places this process for salt-refining ahead of any other known method. It is also to be noticed that the salt is absolutely sterilised, and is said to be the only sterilised salt obtainable in the world. The drawings of the works, which are reproduced on the present page and pages 340, 341, and 342, will therefore be studied with interest.

The Carrickfergus works are divided into two portions—the mines and the refining works—these being connected by an electrically-driven aerial ropeway about three-quarters of a mile long. The No. 1 mine is about 480 ft. below the surface level, and is worked by quarrying or blasting, the explosive being placed in holes from 3 ft. to 4 ft. deep by 1¼ in. in diameter, which are drilled by means of compressed-air drills. There are two seams of rock on the company's property, one below the other, but only the bottom seam is being worked at present, as it is more than sufficient for the present output. The No. 1 mine has been worked for about fifty years, about 1 acre (see Fig. 1) being opened up; and as the company possess mining rights under some 17 acres, where there is a known supply of rock-salt, there is an almost illimitable supply. No. 2 mine is not being worked at present. The rock, after blasting, is filled into trucks running on angle-rails, and these are run by hand to the cages, of which there are two, working in a common shaft. The cages are at present operated from the surface by a Robey winding-engine, steam driven, but are shortly to be electrically driven from the power-station at the works. Each cage conveys from 12 cwt. to 15 cwt. per run, and is operated at from 5 ft. to 8 ft. per second.

At the surface the rock is automatically weighed by an Avery weighing-machine, then filled into the aerial ropeway buckets, which convey it to the refining works unloading station. The unloading station, as shown on the general arrangement of works (Fig. 2), extends the entire length of the furnace-house, the rock-salt being deposited in bunkers opposite each furnace as required. The aerial ropeway has a capacity of 25 tons per hour, and is of the travelling-rope type, being electrically driven by a Crompton 20-brake-horse-power motor, through belt and gearing. The average horse-power required is from 10 to 12.

The rock-salt is hand-fired into the three furnaces, where it is melted, and runs by gravity through successive chambers, where it deposits its "slag" or impurities, passing finally through the tap-holes into the patent rotary pans, where it is crystallised. The crystallised salt is continuously discharged into shoots, by a simple arrangement of scoop, which lifts the finished salt out of the rotating-pan. The shoots, as shown in Fig. 3,

Fig. 1

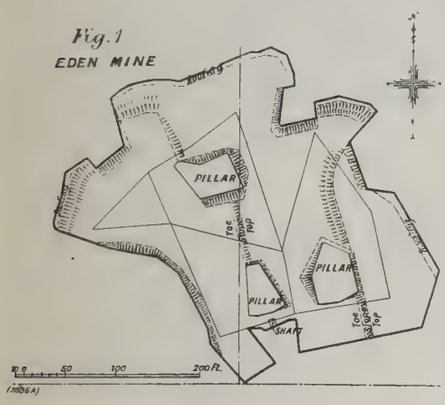
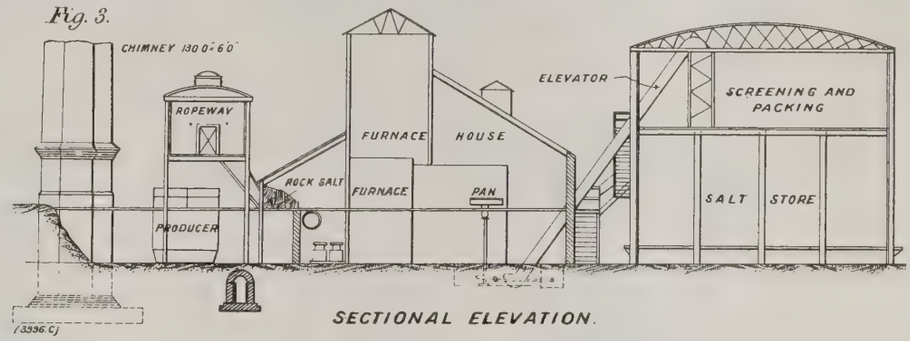
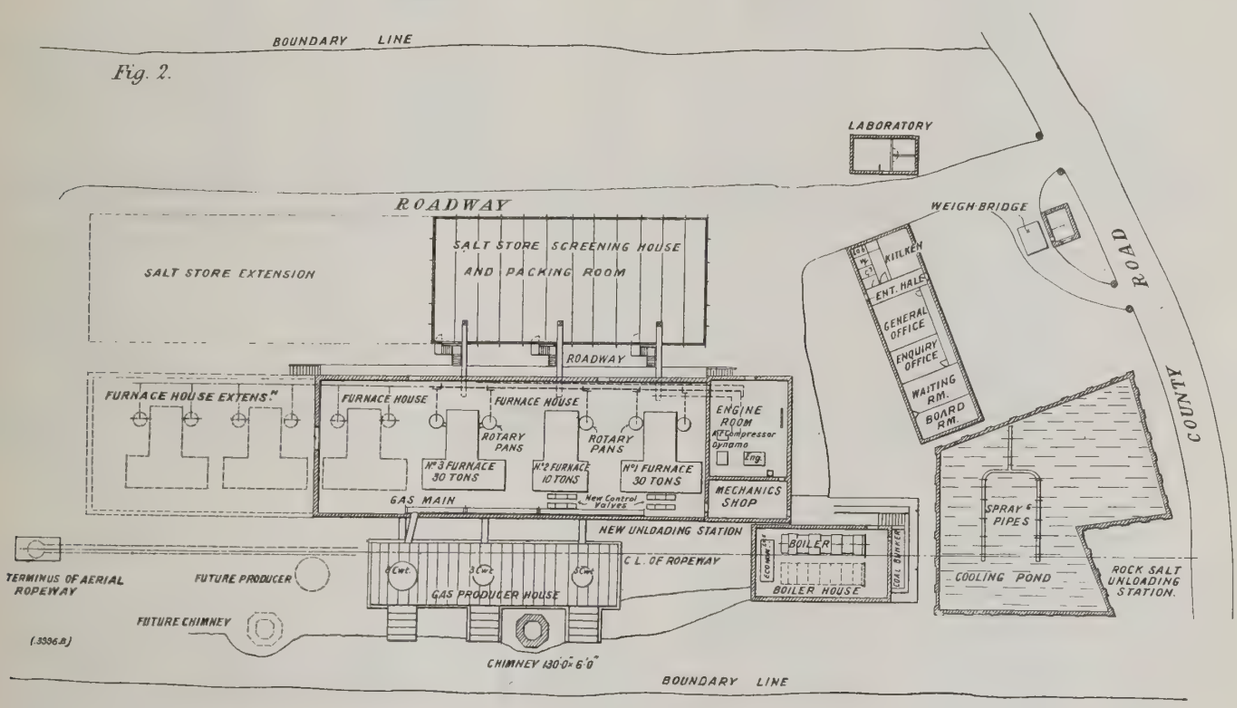


Fig. 3.



SECTIONAL ELEVATION.

Fig. 2.



FURNACES FOR THE PRODUCTION OF WHITE SALT FROM ROCK-SALT.

MR. ALFRED W. BROWN, A.M.I. MECH. E., ENGINEER, BELFAST.

Fig. 4 SECTION THRO' FURNACE CENTRE GAS AND AIR FLUES.

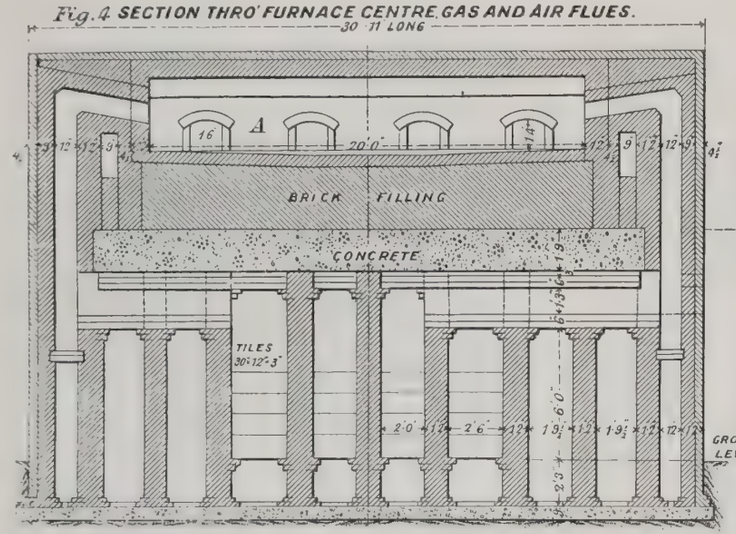


Fig. 6 SECTION THRO' BATH AND GAS REGENERATOR.

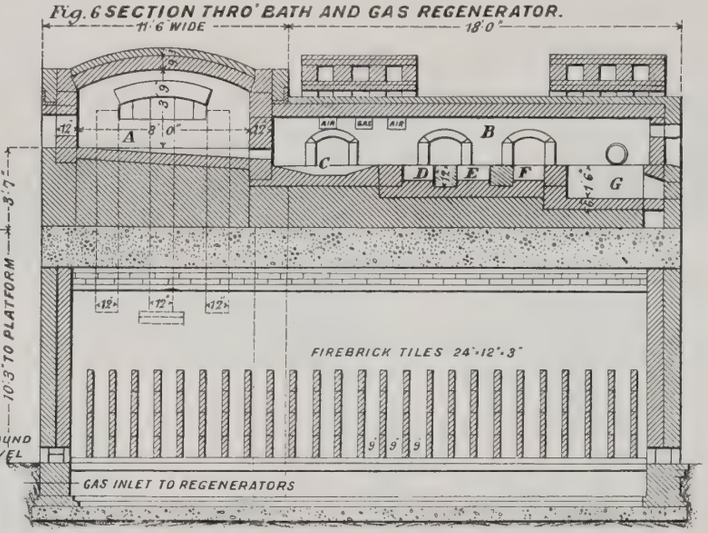


Fig. 8 CROSS SECTION AT BATH.

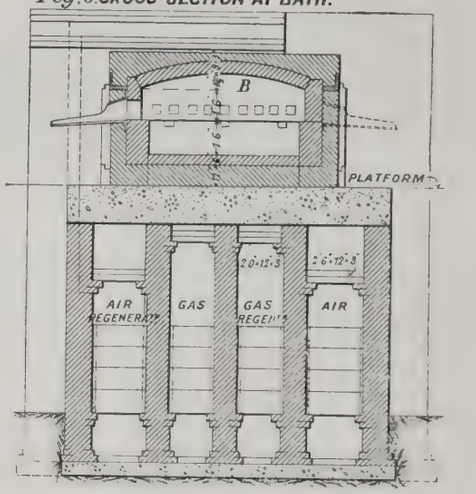


Fig. 5 SECTIONAL PLAN THRO' REGENERATORS.

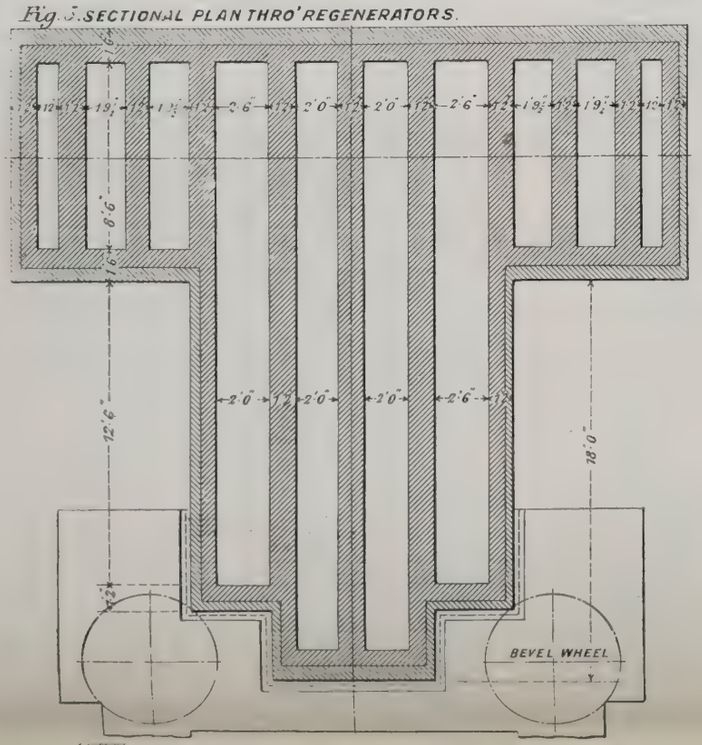


Fig. 7.

SECTIONAL PLAN THRO' FURNACE & BATH.

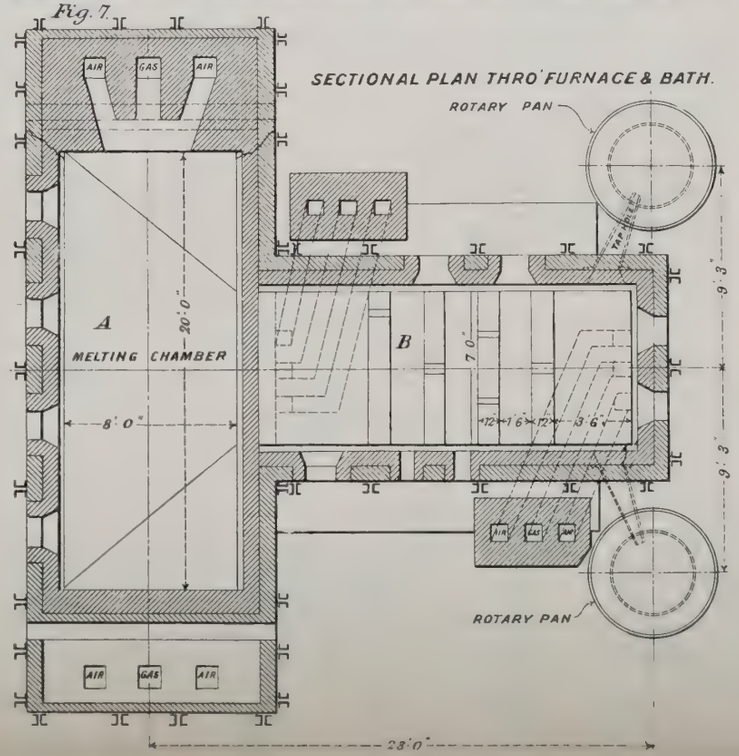
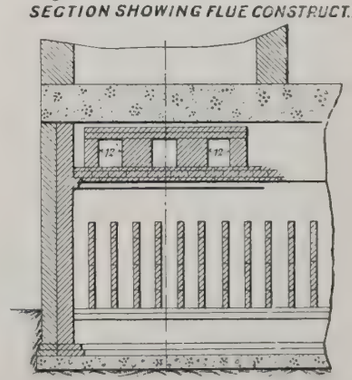
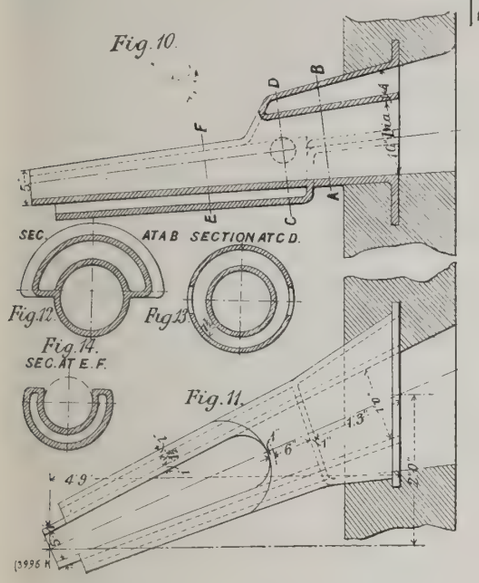
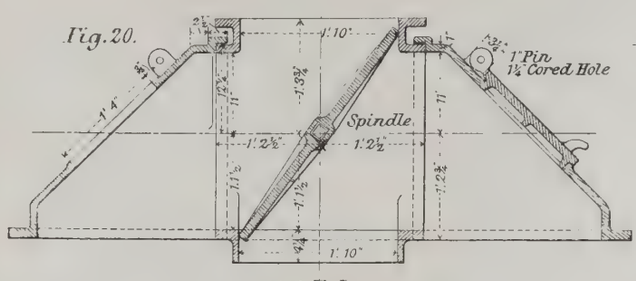


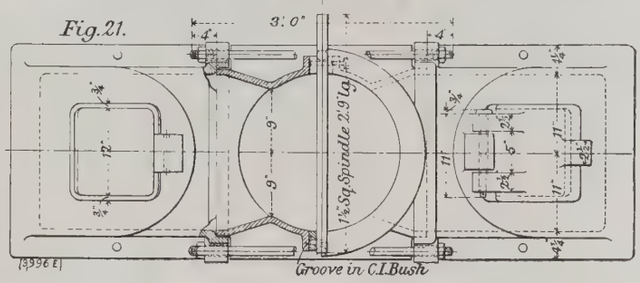
Fig. 9.
SECTION SHOWING FLUE CONSTRUCT.N

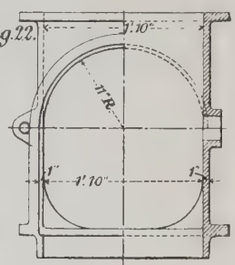


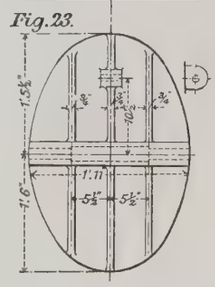
discharge it into the boot of an elevator, which elevates it to the top of the screening-house, where it is screened or separated into the various grades required by the trade, the screens being of a simple stationary type. Underneath the screening-house is the salt store, where the salt is stored in bulk, bags, tins, and packets. The packing-room is situated below the screening-house, so that the salt is mechanically handled from the time it leaves the mine until it is deposited in the finished store, with the exception of the process of hand-firing it into the furnace from the rock-salt bunkers. The works, it will be seen, are designed in the shape of an oblong (Fig. 2), the raw material being delivered all along one of the longer sides, and travelling straight across the works in the course of manufacture, to the finished store on the opposite side. This will greatly facilitate extension, as shown in the dotted lines on the plan (Fig. 2), complete units of furnaces, rotary pans, shoots, and elevators to stores being added as required.

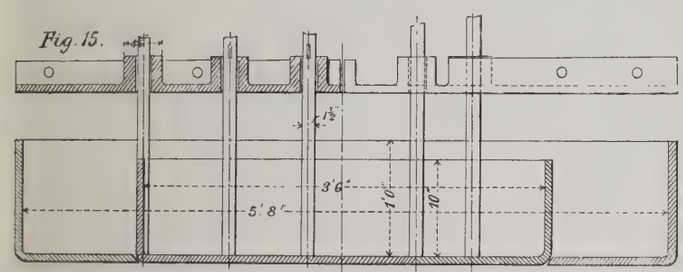


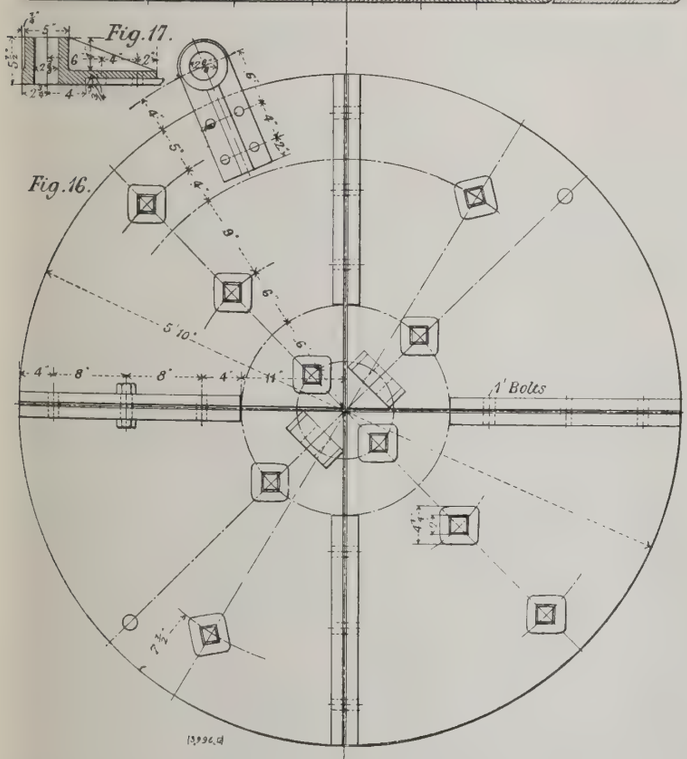


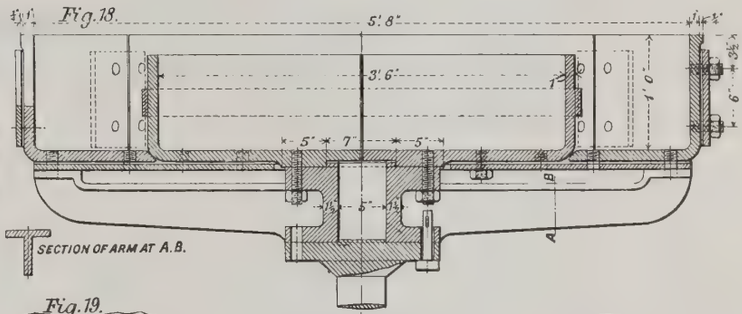


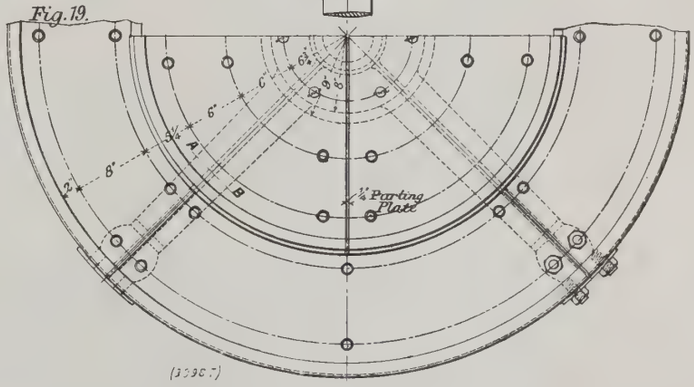












In describing the special features of the refining plant, we take first the furnaces, of which there are three, all of similar design, two being designed for turning out 30 tons of refined salt per 24 hours, and one for 10 tons per 24 hours. All three are, however, capable of melting considerably more than their rated capacity, if required. One of the larger furnaces, that numbered 3 on the plan, Fig. 2, is illustrated by Figs. 4 to 9 on page 240. Like the others, it is built with both gas and air regenerators, and is worked by reversing valves in the usual way. The dimensions of all walls and chambers are given in the sections and plans. The rock-salt is fed or fired on to the "table" of the melting-chamber A, in Figs. 4, 6, and 7, in conical piles, and by gravity runs down the sloping table towards the "bath" B, as it melts, carrying with it (also in a molten state) the "residue" or impurities of the rock-salt. The greater proportion of these impurities is deposited on the floor of the slagging-chamber C, from whence it is removed by a steel ladle, every 15 minutes or so, by the "slagger"—a man whose entire duty is to remove the slag as it accumulates, one slagger being required for each furnace. In each of the chambers D and E there is a horizontal 3-in. wrought-iron pipe, with a number of $\frac{1}{8}$-in. holes in it, through which compressed air at a pressure of from 8 lb. to 10 lb. per sq. in. is blown. The state of agitation into which this throws the molten salt results in a further deposit of slag in both chambers. This is occasionally fished out by the slagger as it accumulates. The last chamber F is the settling-chamber, the purified molten salt passing slowly through it to the reservoir G, from whence it runs through the two tap-holes in the rotary pans.

These tap-holes are of special construction, and sections are given in Figs. 10 to 14 on the present page. They are of cast iron, and are jacketed, so that the gases of the furnace can pass down the jacket, and keep the barrel at a sufficiently high temperature to prevent the stream of the molten salt from cooling or coagulating.

The rotary pans, illustrated in Figs. 18 and 19, crystallise the molten salt in one operation by means

of stationary rakes. (These latter perform the function of agitating the rapidly-cooling molten salt in such a manner as to crystallise it, ready for the market, in various grades and sized according to requirements.) The pans are made of cast iron, in as many as eight sections, and are either single, double, or triple, according to the work for which they are required. They are designed so as to allow for the expansion and contraction due to varying temperature, and some of them have now been running in constant work for over eighteen months without repair of any kind, and in the opinion of the company are still good for many years' service. The pans are all interchangeable, the work of taking off one pan and putting on another occupying about one hour, most of which is taken up in allowing the pan to cool. The aim of the design throughout has been towards simplicity and strength, so as to withstand the varying conditions under which the plant has to work.

The detailed design of a rotary pan is shown in Figs. 18 and 19, the pan itself being built in nine sections—viz., one inner solid plate, 19 in. in diameter; four quarter pieces composing the inner pan, 3 ft. 6 in. in diameter; and four outer pieces composing the outer pan, 5 ft. 8 in. in diameter. The entire pan is held by one solid-steel plate, 5 ft. 8 in. in diameter and $\frac{5}{8}$ in. thick, through

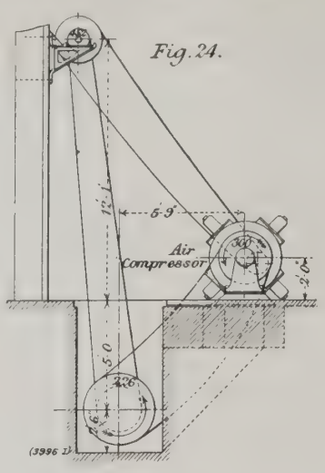


Fig. 24.

which project 1-in. studs, a sheet of asbestos $\frac{1}{4}$ in. thick being placed between the pan bottom and the steel plate to allow of sufficient elasticity and also to help to insulate the pan. The cast-iron spider and distance-piece about 8 in. deep, carried on the top of the upright shaft, forms the connecting link between the pan and the driving mechanism and serves to prevent the upright shaft from becoming too hot. The pan is operated or stopped at will by means of a Hele-Shaw clutch situated in the horizontal cross-shaft.

The stationary rake-plate, which keeps the salt in motion in the revolving pan, is made in four sections, as shown in Figs. 15 and 16, and is supported from the horizontal arm of the operating gear; it is guided by three upright steel columns, which pass through the cast-iron brackets (Fig. 17). The vertical rake-bars of various sizes, shapes and sections, according to their position, pass through the tapered guides, which are cast with the plate, being held therein by steel wedges.

The path of the gases after leaving the gas-producers through the gas-main (which runs along the furnace-house the entire length of the three furnaces), then through the gas-control valves to the reversing-valves, when they pass through the regenerators to both furnace and bath. The air, which is either at natural pressure or forced draught, as required, passes through a reversing-valve to the air regenerators, then to furnace and bath, and meets the gas just as it enters the furnace. The design of this reversing-valve is shown in Figs. 20 to 23, page 241. The exhaust-gases pass away by the regenerators, reversing-valves, and exhaust-flues, which are underground, to the chimney. The heat of the exhaust gases is utilised in various ways for drying and finishing special blocks of salt for agricultural purposes, cattle and horse-licks, &c.

The furnaces are usually maintained at a temperature of from 1800 deg. to 2000 deg. Fahr., and require a partial renewal of the firebrick lining once in two to three years. The exhaust gases enter the chimney at from 450 deg. Fahr. to 550 deg. Fahr. Five men are required in each watch to work a 30-ton per 24-hour furnace, and as much as 12 tons of finished salt to 1 ton of coal has been obtained, the present average being about 10 to 1. At present the slag is not being utilised on a commercial scale, but glass has been made experimentally, and as soon as the quantity of slag is sufficient, the company intend putting down a plant for the manufacture of glass bottles.

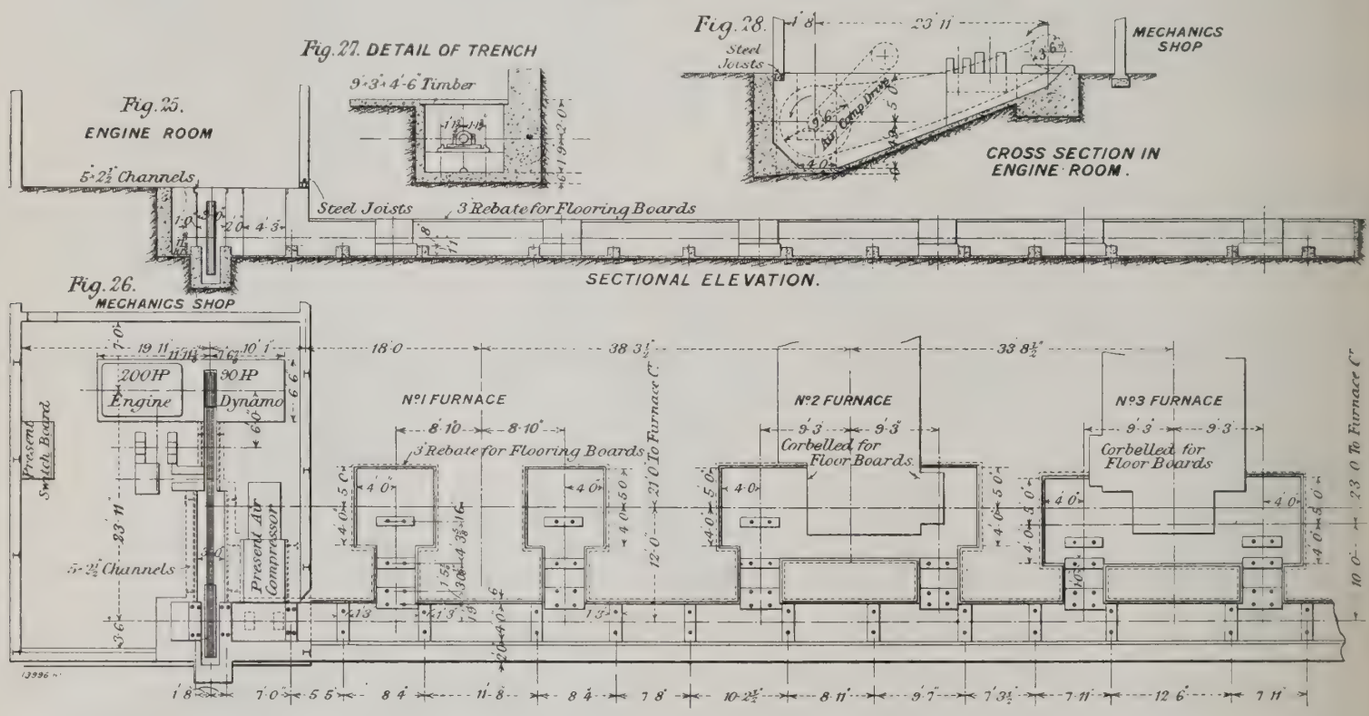
The motive-power plant is designed for driving the mine, ropeway and the necessary transmission for six furnaces (of which three have so far been installed). It consists of a 30-ft. by 8-ft. Galloway Lancashire boiler, evaporating about 8½ lb. of water per pound of coal, and fitted with a Green's economiser of ninety-six tubes, and a downtake superheater by the Superheater Units, Limited, capable of superheating 3500 lb. of steam per hour to 550 deg. Fahr. The boiler works at a steam pressure of 160 lb. per sq. in. The engine, which runs continuously from Sunday to Sunday, is a 200-brake-horse-power triple-expansion high-speed, forced lubrication, surface-condensing engine, by Belliss and Morcom, Limited, using 13 lb. of steam per brake horse-power hour, with direct-coupled 60-kw. Crompton 500-volt dynamo, for transmitting electrical power to the mine. The remaining units consist of a quadruplex air-compressor by Reavell, of Ipswich, for supplying compressed air to the furnaces, two 25-brake-horse-power 220-volt Crompton dynamos for lighting, one being used as a stand-by, an evaporator of 7 tons per 24 hours capacity for the make-up feed-water supply, a Weir boiler feed-pump, and a gravitation feed-water filter by Carruthers, of Glasgow. The entire plant is designed and laid out so that each individual unit can be duplicated for stand-by plant.

The engine drives the first-motion shaft, as shown in Figs. 24 to 27, by means of five 1½-in. ropes running at 5100 ft. per minute, and this shaft drives the rotary fans, elevators, air-compressors, and lighting dynamos. The arrangement of the shafting trenches is interesting, as there is afforded ample room for inspection and overhaul. They are shown in Figs. 25 to 27.

The shafting is designed to be sufficiently strong for working six furnaces. It is carried on self-oiling ring lubricated bearings, the brasses of which are of a special alloy of phosphor-bronze by the Phosphor Bronze Company, Limited. The thrust-bearings are situated at the driving end on each side of the first-motion rope-pulley, and the design allows for the inclusion of two expansion couplings in the shafting required for six furnaces. The drive for the rotary pans is by means of cross-shafts through Hele-Shaw clutches. These cross-shafts are driven by means of machine-moulded bevel-wheels, the entire shafting installation being carried out and erected by Messrs. Ritchie, Hart and Co., Limited, of Belfast. Two very important points in salt-works design were achieved by the arrangement adopted—a clear furnace-house floor over which heavy weights, material, &c., may be carried without interference from shafting, gearing, belts, &c.; and no possibility of salt becoming contaminated by oil dropped from overhead shafting.

The gas-producers are of the pressure type, two being by the Gas-Power Corporation, Limited, and one by the Morgan Company, Limited. The last-named is fitted with a George automatic feeding-gear, and is capable of working three furnaces of a capacity of 30 tons of finished salt per 24 hours. The gas-producers are respectively capable of gasifying 3 cwt., 5 cwt., and 8 cwt. of coal per hour, the Morgan producer being the largest.

The chimney is of brick, and is capable of dealing with the gases from the four furnaces and the boiler; it is 130 ft. high by 6 ft. 6 in. in internal diameter at top. Its stability is calculated to withstand a gale of 100 miles per hour velocity. It may be added that the railway sidings can accommodate some sixty



trucks, so that large quantities of salt in bulk, or of rock-salt, can be quickly despatched for export.

The works have been designed by, and constructed under the supervision of, the company's consulting engineer, Mr. Alfred W. Brown, A.M.I. Mech. E., of Belfast.

"SUCTION" BETWEEN PASSING SHIPS.

By SIDNEY A. REEVE, M.E., New York.

(*Concluded from page* 231.)

IV. ACTUAL INSTANCES OF "SUCTION" COLLISION.

THE following descriptions are condensed from the records of the American Admiralty courts. Usually the quotations are from the decision handed down by the court, summing up and balancing the conflicting testimony. Wherever possible, charts of the date of the collision have been consulted.

Case 6: Andus-Saratoga, September 21, 1877, Hudson River, near Albany (Fig. 12). A south-bound tow, consisting of eleven barges, banked three abreast, was moving parallel with the "dike" (really a wharf, the true dike being on the opposite side of the river). The steamer Saratoga, 300 ft. by 66 ft., also south-bound, undertook to pass between the tow and the wharf. When the bow of the S had overlapped the aftermost barge some

Fig. 12. HUDSON RIVER BELOW ALBANY BRIDGE. Scale, 1 Inch = 1270 Ft. Soundings in Ft.

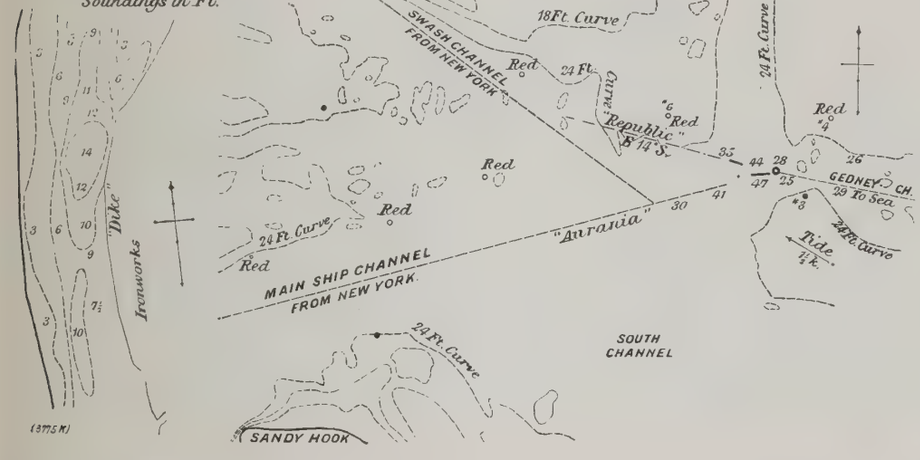


Fig. 13.

40 ft. "the tow sagged down with the wind (which was westerly, but very light) against the S." The Court held that the wind-theory was not upheld by the facts, and hence disbelieved that the "sagging" occurred at all. The term "suction" was not mentioned, but in the light of later knowledge it is a clear case. The courses are such that a shoaling of the water from 14 ft. to 9 ft. occurs just where the wharf also converges on the courses. The vessels probably had a draft of about 6 ft., and their aggregate beam amounted to nearly the width of the channel. Under such conditions suction was inevitable. But its hydraulic theory in this case falls more under that of "canal-waves" than of two-dimension stream-lines, which former the student will find discussed in the references listed in the first article of this series, page 195 *ante*.

Case 14: Aurania-Republic, September 19, 1885, 3.24 P.M., 2 miles north-east by east of Sandy Hook (Fig. 13). This is the first recorded suction collision between first-class liners. In fine weather, with sea smooth, tide flood and wind light, the A (480 ft. by 56 ft. by 26.5 ft. draught, 14.7 knots) and the R (420 ft. by 42 ft. by 25.2 ft. draught, 13.2 to 13.5 knots) collided as they were about to enter Gedney Channel, the stem of the R striking the port quarter of the A when the latter's stem was about 100 ft. west of the buoy (double circle in Fig. 13). The A had come down the (old) Main Ship Channel, and the R down Swash Channel. Each vessel headed for the buoy. There is the usual conflict of testimony as to locations and courses, but the agreement is closer than usual. The Court concluded that the ships were on courses converging by 1½ points, as drawn; but this conclusion disregarded the R's claim as to angles and distances, because at a distance of 500 ft. to 700 ft. apart, one minute before collision, "no possible suction, port helm or other influences from the A, could have had any sensible effect upon the R at that distance, or have sensibly neutralised or delayed the effect of the hard-a-starboard helm, which her officers say the R was then under, and in spite of which, as they say, the vessels came together." But had the Court been equipped with an adequate theory of suction, the decision would probably have been reversed. The Court was misled by the idea that suction is a force drawing the two hulls bodily together, whereas it is almost wholly a sheering or swinging pair of forces, one attracting the bow and the other repelling the stern. It is the forward momentum of the pivoted vessel, and not the attraction of suction, which brings her into the other ship. Thus, in this case, the R was travelling at about 1350 ft. per minute. According to the Court's theory, the point of collision was only some 170 ft. to starboard of the R's course. At her rate the suction-sheer need have been through an angle of only two points, beginning ¼ minute before the impact, to have cleared the space between the two vessels, and at its inception the ships would have been only 400 ft. or 500 ft. apart. "Most of the witnesses on both sides seem to agree that shortly before the collision . . . the stem of the R seemed to be approaching the A's quarter more suddenly and rapidly than their previous angle of convergence would account for. . . . The evidence leaves no doubt that the R's engines were stopped and reversed just prior to the collision." The Court, knowing that the R carried a hard-a-starboard helm, and finding no other explanation, attributes the sheer to the 4-mile breeze! Navigation would be hazardous indeed if a four-mile breeze could entail such a disaster.

Fig. 13 (from a chart of 1884) shows that the water was shoaling rapidly beneath the A, at the rate of 15 ft. in a ship's length, at the time and place of collision. This, coupled with the convergence of courses at an angle variously stated as from 16 deg. to 38 deg., was undoubtedly the cause of the overwhelming suction. Although an unknown depth of tide must be added to the soundings of the diagram, the ships were drawing most of the water to be had beneath the A's stem. Had they met a minute later, over a flat sea-bottom, they would probably have escaped disaster. This same locality became the scene of another suction collision (case 35) between sea-going liners, but at a later date, when dredging had deepened the shoal spots.

Case 17: Hartt-City of Brockton, September 29, 1887, outside Sandy Hook. The B (paddle-steamer 283 ft. long) overtook the tug H (125 ft. long) as both were going to an international yacht race. When Sandy Hook was passed and South Channel reached (see Fig. 13), at about the time when the paddle-box of the B was abreast of the pilot-house of the H, the latter "gave a sudden lurch towards the B, which shortened the distance between the two about one-third. The H then straightened up. Then she lurched again toward the B, and instantly the collision occurred, . . . the bow of the H striking first the port paddle-box of the B and then running under the B's port guard, where . . . . she was near being capsized, most of her passengers being thrown into the sea." The movement of the H is described by "Mr. A." as a "lurch." "It wasn't a case of gradual converging." Another calls it, "a grand swoop right around." Another says, "she made a dive for us." The Court attributed the action to "the powerful action of the B's wheels," but hydraulic theory finds complete explanation in the interaction of the H's constrained wave with the B's echelon waves. The latter are independent of the ship's model, their length depending only upon the speed. The B's speed is stated as "14 to 15 miles." At 14 knots its echelon wave would be 109 ft. from crest to crest, and at 15 knots 125 ft. It is plain that the H's constrained wave must have had a length suitable for interaction with the B's echelon. As one echelon crest came into phase the H took its first lurch. As the next crest came into phase the second lurch occurred. It is not likely that the sea-bottom was a contributing cause, though there are banks about 20 ft. deep in this vicinity, which may have helped.

Case 18: Switzerland-La Gascogne, January 21, 1888, New York Upper Bay; both vessels bound to sea; water 60 ft. to 75 ft. deep. In clear daylight, with no other vessels interfering, the L G (480 ft. by 52.3 ft., 7415 tons gross, 15 to 16 knots), "having come up with the S (329 ft. by 38.8 ft, 2601 tons, 9 to 10 knots), was passing her on the port side at a distance estimated by various witnesses at 150 ft. to 300 ft. The bow of L G had drawn ahead of the bow of the S when the vessels came into collision, the S's bow striking L G on her starboard quarter at an angle of about 30 deg. The Lower Court held the S at fault, but the Upper Court reversed this. Both Courts, in order to develop a consistent explanation in lack of true hydraulic theory, were forced to disregard some well-founded evidence. But with suction properly in mind no violence to the facts is needed. The L G had to port somewhat at this point in the channel, and a very slight convergence of the two courses, if not noticed immediately by the S, would bring the latter into control of suction very quickly. Collision might occur from this cause within 43 seconds from an original distance of 250 ft., or in 26 seconds from 150 ft., if the L G's porting had been only one point.

Case 20: Devereaux-Folsom-Mitchell, August 13, 1890. This was the first case in which the Court considered suction as a cause when the vessels were passing in opposite directions. It occurred in a dredged channel between Lakes Huron and Michigan, about 300 ft. wide by 25 ft. deep. The D (270 ft. by 37 ft.) passed at 4 knots the tug F (185 ft. by 35 ft.), and sheered enough, uncontrollably, as she did so, to collide with the schooner M in tow of the F. The tendency of every ship to "smell" a bank and sheer away from it was mentioned in the decision; and it is certain that this tendency would be exaggerated at the moment the F passed.

Case 21: City of Macon-Nedjed, December, 1890, Savannah River; a variation of the preceding case. When the M (about 300 ft. long) was partly lapping the N (320 ft. by 45 ft. by 19½ ft. draught), about 100 ft. away in a channel 400 ft. to 450 ft. wide by 20½ ft. deep, the N sheered across the M's bows, away from the wharves, and ran on the mud-bank opposite.

Case 24: Mather-Ohio-Siberia, in daylight, date not stated, Mud Lake, St. Mary's River, Great Lakes. Mud Lake is virtually open water, being 3 miles wide by 25 ft. to 30 ft. deep for 100 ft. to 300 ft. on either side of the course. The M (260 ft. by 15 ft. draught) had overtaken the S (274 ft. by 15 ft. draught) about 40 ft. to 75 ft. away on the latter's starboard hand. The O was meeting the S port to port. When the M was about a half-length in advance of the S the latter "sheered suddenly to port, and within less than 60 seconds struck the O," and sank her. "The evidence seems to leave no reasonable doubt that when the effect of suction began to be noticeable these boats were within 40 ft. to 75 ft. of each other, and that the stern of the M was about abreast of the fore-rigging of the S. At this point it is in evidence from both sides that the speed of the S seemed to be increased, and that she ran up on the M some 10 ft. or 15 ft. Yet it is uncontradicted that the steam of the S was not increased. This temporary increase of speed by the slower boat is shown to be one of the effects of suction . . . It has been argued that, if suction had exerted any force upon the navigation of the S, it would have shown its effect by attracting or drawing her closer to the vessel within whose influence she was, and not as a repulsing force throwing her off to port. But evidence of just such an attracting force appears." Evidence is then quoted by the Court tending to

show that the S was first drawn in towards the M, and then, later, whether assisted by a starboard helm or not is not known, sheered off toward the O. The facts emphasise the instability of steerage under such conditions. Perhaps a hard-a-starboard helm was assumed when the first sign of suction appeared, and this, after steadying her against the suction, carried her too far to port for her to recover within the 30 seconds available before she met the O. Or the lack of testimony as to the helm of the S might suggest a jammed helm. In any event suction was plainly the original cause of the disaster.

Case 25: Aureole-Willkommen, January 13, 1898, 2 P.M.; Delaware River, about 1 mile down Deep-Water Point range, with apparently ample room laterally, but very little depth. The bottom is even, but the charted depths are everywhere less than the draught of either ship; tidal depth not known. The A (345 ft. by 46 ft. by 23.5-25 ft. draught) overtook the W (325 ft. by 41 ft. by 22.5-24.5 ft. draught) on the latter's port hand, passing at distances variously stated as from 75 ft. to 300 ft., the Court favouring the smaller distance, as from more reliable witnesses. "Before the A's bow was opposite the W's bridge, the W's pilot ordered the wheelsman to port the helm . . . because he saw the A was coming too close. When the A's bow got abreast of the W's bridge, he says he told the captain to slow the ship to half-speed, and that when her stern got somewhere about half-way between the W's fore-rigging and the bridge he had the engine stopped; that he then asked if the wheel was a-port, and that the chief officer replied that it was hard-a-port; that he then went and looked himself, and found that it was so, and that the A was at that time about 75 ft. to 100 ft. away." When the A's stern came forward of the W's bridge the W took a sheer and struck the A a glancing blow upon the starboard quarter about 35 ft. from the stern. "This sheer of the W the pilot accounts for by what he calls 'suction.'" Both vessels had to return to Philadelphia.

The Court referred to the cases of the Folsom, the Cleveland, the Unit, the Mariel, and the Brockton. "The cases above referred to, judicially recognising the existence of the force called 'suction' and its power, under favouring circumstances, to draw one vessel towards another, cannot be disregarded by this Court."

Case 26: Masaba-Smith-Aurania, "on a bright July day in 1898," in the dredged channel in Lake St. Clair, above Detroit. In 1898 the St. Clair Channel was 350 ft. to 400 ft. wide by 20 ft. deep, the Detroit channel 800 ft. wide, and of equal depth. As it is not stated just where the collision occurred, both widths are given in Fig. 14, which is drawn to scale as to the lengths of the ships and tow-line, but not as to lateral distances, which are unknown. The case is cited as an interesting one of three-ship action, which is plainer from the diagram than from the description. The S was apparently not affected by the M until the Aurora was met, although the first two had been travelling at not widely differing speeds. The S recovered from her first sheer, apparently caused by her bow entering the Aurora's lateral depression, but took a second and uncontrollable sheer just after passing the Aurora. "The Aurania's helm was hard-ported, and the Aurora's engine stopped, and the lever controlling the towing-machine on the Aurora released so that the cable might reel out, there being no time or opportunity to let go the line on either vessel; but so extreme and rapid was the sheer of the S that she struck the tow-line at nearly a right angle, about 100 ft. ahead of the Aurania, parted the wire cable, and then swung around the bow of the Aurania, which struck the S on the starboard quarter. The vessels came together with great force, driving the bow of the A to port and straightening the S up the channel, so damaged that she filled and sank after going a short distance; while the A, with bows badly stoved, forged and drifted diagonally down and across the channel until she brought up on the bottom, aided in this by a stern anchor which she had let go."

Case 35: Martello-Mesaba, September 22, 1900, 10.42 A.M., New York Lower Bay, entrance to Gedney Channel, Fig. 13, but by this date dredging had reduced the slope of the bank to about 10 ft. in a ship's length. Nor is the place of collision so exactly located as in the case of the Aurania-Republic. An ebb-tide of 1 knot was with the ships. Both ships went down the old Main Ship Channel. They passed Sandy Hook with the Martello (370 ft. by 43 ft. by 28 ft. draught, 10 knots) said to be ⅓ mile ahead of the Mesaba (482 ft. by 52 ft. by 29½ ft. draught, 13 knots); but if this gap were closed by the time they reached Gedney, there could have been a difference of only about 2 knots in their speeds. While the Mesaba was passing the Martello on the northern side, "probably from 100 ft. to 150 ft." distant, "when the Martello's stem was about abeam of the Mesaba's amidships, or a little more aft, the Martello's bow was seen to turn to port toward the Mesaba, and it continued to turn more rapidly as the Mesaba advanced, until the bluff of her port bow, about 20 ft. from her stem, struck the starboard quarter of the Mesaba, about 100 ft. forward of her stern, a violent blow. . . . The Martello was obliged to return to New York, while the Mesaba continued her voyage." The Court held that suction was the cause of the collision.

Case 37: North Star-Nourmahal, September 28, 1901, 4 P.M. Swash Channel, New York Lower Bay (Fig. 13, just beyond the northern edge of which, where the eastern bank of Swash Channel is steeper, the collision occurred). The yacht N (247 ft. by 30 ft. by 10 ft. to 16 ft. draught, 15 knots)

Fig. 14. LAKE ST CLAIR

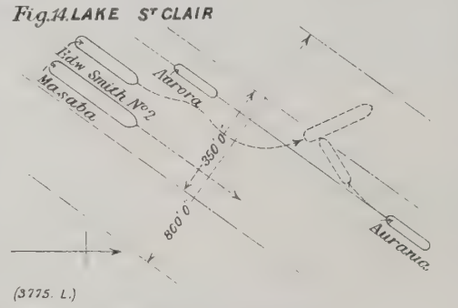
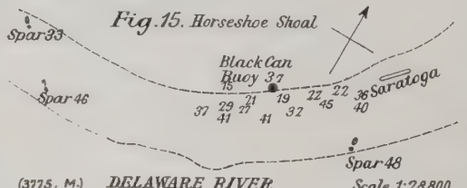
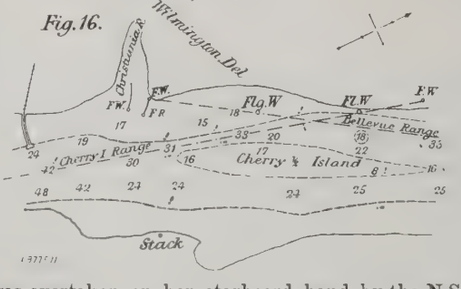


Fig. 15. Horseshoe Shoal



DELAWARE RIVER
Scale 1" = 10,500ft

Fig. 16.



was overtaken on her starboard hand by the N S (320 ft. by 46 ft. by 13 ft. to 15 ft. draught, 17 knots). When the yacht was about 600 ft. ahead of the N S they were "apparently something more than 100 ft. apart, but were drawing slightly nearer, and when the N S's stern reached a point about opposite the bridge of the yacht, the latter, being influenced by the N S's suction, turned towards her, and the vessels came together, notwithstanding a starboard then hard-a-starboard helm on the part of the yacht. . . . There was no change in the course of the N S. . . . The collision can be accounted for in no other way than as a result of suction." The N S was held solely at fault.

Case 39: Denver-Lehigh, March 31, 1906, 5.15 P.M., New York Lower Bay, below West Bank Light.—The steamer D (390 ft. by 17½ ft. to 23 ft. draught, 12 to 12½ knots) overtook and partly passed the sea-going tug L (150 ft. by 15 ft. draught) ("almost as fast"). The L was following a slightly converging course on the D's port hand, about 150 ft. distant. When the stem of the L was abreast, or slightly forward, of the port side of the D's bridge, the L, which was bound up Raritan Bay, to D's starboard, slowed her engines "to let the D get well ahead, and was instantly caught in the suction of that vessel and drawn against her side," contact occurring "with the bow of the L against the D's port quarter, some 40 ft. from the stern, with the tug at right-angles with the steamship." Court held the L at fault for slowing, whereby "she surrendered a certain amount of power" and "became less manageable." Damages were divided. The water was 26 ft. to 31 ft. deep, with no marked lumps in the bottom.

Case 41: Saratoga-Taunton, June 17, 1907, Delaware River, Horseshoe Bend (Fig. 15). This is an interesting case of bank-sheer. The S (430 ft. by 50 ft. by 18 ft. draught), coming down the river at 8 knots with a helping tide of 2 to 2½ knots, struck and slipped off the "seventeen-foot lump" at buoy C 37, sheered suddenly about 4 points across the channel and collided with the T.

Case 43: Parima-Prinzessin Irene, April 4, 1908, New York Lower Bay, 700 ft. to 1000 ft. north of the buoy on point of the shoal between Main Ship and Swash Channels, and 1700 ft. to 1800 ft. west of the red bell-buoy. No Court decision was ever rendered on the facts of this case, the following outline being the result of the author's attendance at the trial. The P (335 ft. by 42 ft. by 21.3 ft. to 23 ft. draught) was going down Main Ship Channel at 10½ knots, when she was overtaken on her starboard hand by the P I (524 ft. by 60 ft. by 22.6 ft. to 24.8 ft. draught) at an estimated speed of 13.8 knots. The ebb tide increased these speeds about one knot, and altered their apparent courses 4 deg. or 5 deg. eastward. When the bow of the P I was abreast of the P's mid-length, and from 150 ft. to 250 ft. distant, the P sheered to port, ran over the perch-and-square buoy, and ran aground. The P libelled the P I as being the overtaking vessel and the cause of her going aground.

The case is, in the writer's belief, a plain case of repulsion of the leading ship during the first phase of passing. The water, which shows a general depth of 31 ft. to 32 ft. (plus 2 ft. of tide), is amply restricted to account for the sheer, which took place against a hard-a-port helm. In addition, the 1:40,000 chart of New York Harbour shows a single sounding of 22 ft. at or just north of the place of sheer; but a chart of 1:5000 which appeared in Court did not fully corroborate this lump. But even without it, a sheer on the part of the smaller ship, passed at such speed and propinquity by a vessel of over three times her tonnage, drawing most of the water in the channel, would be only natural. This case is of further interest in that the officers of the P I were not aware, until they reached Germany, that their ship had been regarded as connected with the accident in any way.

Case 44: Monterey-United States, April 16, 1908, 1.30 P.M., New York Lower Bay, Main Ship Channel, just above the entrance to Swash Channel, in almost the identical spot of Case 43, except further toward the westward side of the channel. Weather clear, wind light, tide last of ebb, netting 0.8 ft. below the mean low water of the chart soundings. The twin-screw steamship M (341 ft. by 47½ ft. by 20 ft. draught, 12 knots) was overtaken, "about abreast of the bell-buoy and well over to the westerly edge of the channel," by the U S (501 ft. by 58 ft. by 27½ ft. draught, 15 knots), which was converging on the M's course by a half-point. The clearance was stated as anything from 75 ft. to 800 ft. (the entire width of the channel being 1100 ft.), the Court favouring 100 ft. "As the U S drew up abreast, the helm of the M was kept 'steady a-port,' a caution to the wheelsman to keep her perfectly straight and counteract any tendency of the vessels to veer together. When the U.S. was from one-third to one-half past and the bow of the M was opposite a point about two points abaft the beam of the U S, the M turned in the direction of the U S, notwithstanding a hard a-port helm and the starboard-engine being put full-steam astern, and the port-engine being kept going ahead to assist the port-helm. Upon its being found that these precautions did not have the desired effect, both engines were reversed at full-speed, but the collision occurred, the bow of the M striking the starboard side of the U S at an angle of about two points. There were two blows, one succeeding the other almost immediately." The U S was damaged to such an extent that it was necessary to beach her. The M was also seriously damaged, but she remained afloat.

The lump in the bottom of this channel, mentioned in connection with Case 43, apparently extends entirely across the channel. The depth at the black spar-buoy opposite the red bell buoy was 26.2 ft. that day. Considering that the M, which must have been close to this bouy, was drawing 20 ft., while the U S drew over 27 ft., the slightest lump in the bottom would suffice, in addition to the

CANADIAN CUSTOMS TWIN-SCREW CRUISER "MARGARET."

CONSTRUCTED BY MESSRS. JOHN I. THORNYCROFT AND CO., LIMITED, SHIPBUILDERS AND ENGINEERS, SOUTHAMPTON.

Fig. 1.

half-point of convergence, to develop a suction sheer. The lateral proximity of the bank on the M's starboard hand would also contribute a strong tendency to sheer to port, towards the U S.

It is also to be noted that, whereas in many cases of suction the sheer occurs in spite of a hard-over helm, in this case it defied the controlling power of twin-screws as well. In the Chicago-Owego case (not reported here) the latter vessel, when she sheered, dragged one tug sideways through the water broadside and overcame the direct engine power of another, working in conjunction with partial power from her own engines. Such facts as these show how uncontrollable is the force of suction when once initiated.

Case 45: Murcia-Sif, November 26, 1908, 2 P.M., Delaware River, Cherry Island "cut," opposite Wilmington, Del. (Fig. 16), weather clear and calm; flood tide. In the "cut," which is about 750 ft. wide by 33 ft. deep by chart, or 29 ft. by testimony, the M (303 ft. by 41.5 ft. by 21 ft. draught) was overtaken on her port side by the S (325 ft. by 47 ft. by 21 ft. draught). Speeds are not stated; clearance stated contradictorily, but, according to the S, 300 ft. to 400 ft. According to testimony on behalf of the initial clearance, when they began to overlap, was 100 ft. to 150 ft., but that "as the S gradually drew ahead of the M the former converged slightly upon the course of the M, so that when the S was about half-way by the M the distance between them had been reduced to from 50 ft. to 100 ft., when the engines were slowed, then stopped, and finally put full speed astern, and the helm a-port. . . . Notwithstanding this manœuvre, the M continued to approach the S more rapidly, and then gave a sudden 'dive' in the direction of the latter, the bluff of the M's port bow striking the S on the starboard side at a point about 100 ft. forward of the latter's stern. . . . Both vessels were injured."

The Court quoted the opinion of Judge Gray in Case 25. In this present case, however, in contrast with Case 39, the pilot of the overtaken vessel was commended for slowing his engines. In this case, too, as in several others, the Court leant toward the smaller of the variously-stated clearances, on the ground that the time available would not permit the sheering vessel to cross a wider intervening space. But as nearly all these decisions have been rendered without any more accurate idea of suction than as a bodily attraction between the two hulls, the rapidity with which a ship in motion can cross lateral space by being rotated rapidly while she moves ahead—which is what suction does, as well as accelerate the forward motion at the same time—has not been appreciated by the Court. This line of reasoning annuls the Court's conclusions as to the probable actual clearance, and makes it probable that many of these suction sheers occurred under initial clearances much greater than those stated in the Court decisions.

Case 47: Kennebec-Strathnairn, January 26, 1910, 8 A.M., Patapsco River, Baltimore Harbour, weather clear; wind light; tide, early ebb. The S (380 ft. by 52 ft. by 24 ft. draught, 2811 tons, 5 or 6 knots) came down the Sparrows Point Channel (100 ft. wide by 25 ft. deep) and made the almost square turn of 70 deg. into the Brewerton Channel (600 ft. wide by 30 ft. deep). There she met on her starboard hand the K (250 ft. long, 1930 tons, 7 to 9 knots), also going down Brewerton Channel. When the ships met, their courses were parallel or slightly converging, the S being from 250 ft. to 300 ft. ahead, so that the K overlapped by 75 ft. to 100 ft.; lateral distance not stated. The vessels came together in the usual suction manner, but without room for as much angular rotation as usual; nor were the speeds high. Consequently the K struck the S with the side of her bow, and while each vessel was damaged, neither was disabled.

CANADIAN CUSTOMS CRUISER.

On the present page, page 246, and on Plate XX., we illustrate the revenue cruiser Margaret, built to the order of the Canadian Customs' Department by Messrs. John I. Thornycroft and Co., Limited, at Southampton. The vessel is designed for custom-patrol service on the Atlantic coast, and was built throughout under the inspection of Mr. Frank L. Warren, M.I.N.A., M.I. Mech. E., of London. The Margaret sailed for Halifax, N.S., on March 25 last. As will be seen from Fig. 1, she has a ram stem and cruiser stern, and presents a very attractive appearance. Her length over all is 200 ft., and between perpendiculars, 185 ft. The moulded breadth is 32 ft., and the depth, 16 ft. The draught is limited to 10 ft. 6 in. when carrying a load of 175 tons. The vessel is largely intended for service in the vicinity of ice, and a double bottom is fitted under the engines and hold forward, the hull is stiffened to resist ice, and the shaft is housed in the hull for the whole of its length. These features can be seen in the longitudinal section, Fig. 3, and in the cross-sections, Figs. 10 to 14.

The boat is very completely fitted up. There is a wireless-telegraphy outfit, and an electric installation, which, in addition to furnishing general lighting and power for the wireless outfit, supplies current for a 24-in.-projection searchlight, fitted in the crow's nest on the fore-mast. The searchlight is of 25,000 candle-power, and is controlled in all its movements by electric power operated from the wheel-house. Alternative hand-control from the crow's nest is arranged for. Refrigerating plant is installed forward in a compartment which can be seen in Figs. 3

and 7. It consists of two CO_2 machines of Messrs. J. and E. Hall and Co.'s make, ice-moulds, cooled drinking-water tanks and store-rooms. The vessel is heated by steam throughout, steam being taken from either of the two boilers, and reduced to 25 lb. per sq. in. by a reducing-valve. In view of the severe climate, a large heating surface—viz., 2½ sq. ft. for 100 cub. ft.—has been allowed for each radiator and coil. Steam coils are fitted to water-tanks where the latter are exposed to the weather. Steam water-heaters are fitted to all baths, pantries, and galley. Those for the baths are of Shanks' pattern, using salt and fresh water; others are of the Watsonia pattern. The radiators in the captain's quarters, state-rooms, saloon, and chief engineer's cabin, consist of copper coils in brass casings. Other radiators are of the Walworth pattern.

On the forecastle-deck there are two 6-pounder quick-firing guns of the Vickers type. They have 22-ft. captain's cutter, and a 16-ft. dinghy. The motor-boat is built on the double-skin system, each thickness being of mahogany, and is fitted with a standard Thornycroft petrol-motor with four cylinders 4½ in. in diameter by 6-in. stroke. The engine is of about 37 brake horse-power, and gives the boat a speed of 10 knots. The remaining boats are carvel built, of selected yellow pine, the lifeboat being fitted to Board of Trade requirements. All boats are fitted with Mill's disengaging gear, and are stowed, under davits, on chocks on the boat-deck. There is a Clarke-Chapman steam boat-hoist on the boat-deck. It is reversible, and has two cylinders 8 in. in diameter by 12-in. stroke. It is capable of lifting 2½ tons at 120 ft. a minute when working with steam at 90 lb. per sq. in. Steering is by means of a balanced rudder, having a cast-steel frame. Screw steering-gear is fitted directly on to the rudder-head in a steering compartment. It is worked on the right and left-hand screw 90 lb. Both these gears were made by Messrs. Harfield and Co.

The arrangement of the accommodation for the officers and crew will be followed from the figures on Plate XX. On the bridge there is a teak house for the wireless' operator's cabin and wireless office, and on the boat-deck a steel house, which contains the wheelhouse and the captain's accommodation. The captain's day cabin is panelled and moulded in polished mahogany, and the sleeping cabin is yellow pine, enamelled white. On the main forecastle deck are arranged lavatories for the officers and crew, lamp-room, carpenters' shop, &c. A hot and cold water system is led to the lavatories. The officers' quarters are in the main deck-house forward. There is a mess-room, panelled in pitch-pine, on the port side, and a pantry and the first and second officers' cabins on the starboard. The main galley is situated at the after end of the boiler casing. It is fitted with a large range, grill hot closet,

Fig. 10. FRAME No 20 LOOKING FOR^D

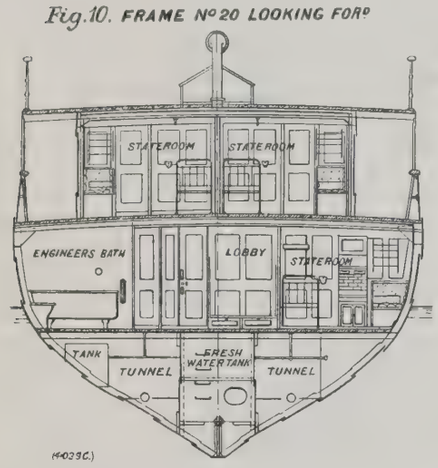


Fig. 11. FRAME No 36 LOOKING FOR^D

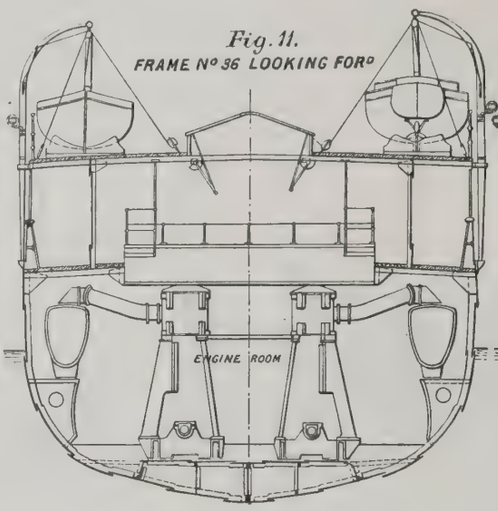
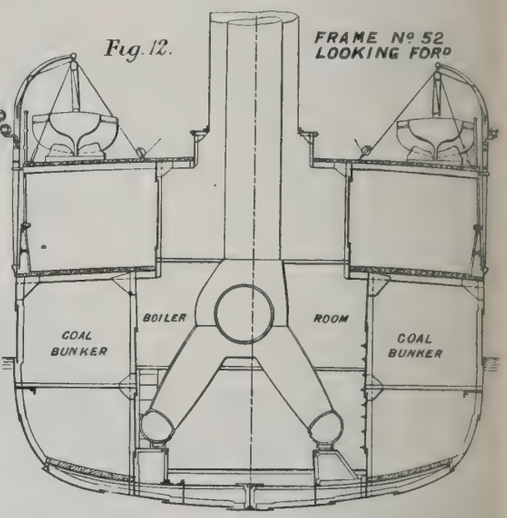


Fig. 12. FRAME No 52 LOOKING FOR^D



telescopic sights, and can be seen in Figs. 1 and 2. The system of pumping has been carefully arranged, steam suctions being led to each water-tight compartment and each bunker and ballast-tank. These places can also be pumped out by means of a 6-in. Admiralty-type Downton pump placed on the upper deck. This latter pump can also be used in connection with the fire, wash-deck, and sanitary services. The sanitary service is normally supplied by a main leading from a steam-pump in the engine-room, which keeps up a constant pressure of 40 lb. per sq. in. on the main. A sanitary tank is fitted on top of the bridge-house for use when the steam pump is not running. This tank is filled off the main or by the Downton pump. A fire-main is run under the upper deck, with rising mains in convenient positions, all fore and aft. These are fitted for 2-in. hose with Nunan and Stove's connections. The main, which is also used for wash-deck service, is supplied from a steam pump in the engine-room at 100 lb. per sq. in. Provision is also made for working this main from the Downton pump. The fresh-water service is carried out in the same manner as the sanitary service, except that the pressure on the main is 30 lb. per sq. in. A service tank is placed close to the sanitary tank for use when steam is not available. These tanks are indicated in Figs. 3 and 5. A 3-in. hand lift and force pump is fitted near the galley for filling the fresh-water tank by hand when necessary. Two large fresh-water tanks, shown in Figs. 3 and 9, are provided below the lower deck. The forward one holds 4000 gallons and that after 6300 gallons. A reserve feed-tank is arranged in the double bottom under the engines. It contains 5000 gallons of fresh water. A sea-valve is fitted for flooding the magazine in case of fire. It is worked from the upper deck.

Fig. 13. FRAME 70 LOOKING AFT

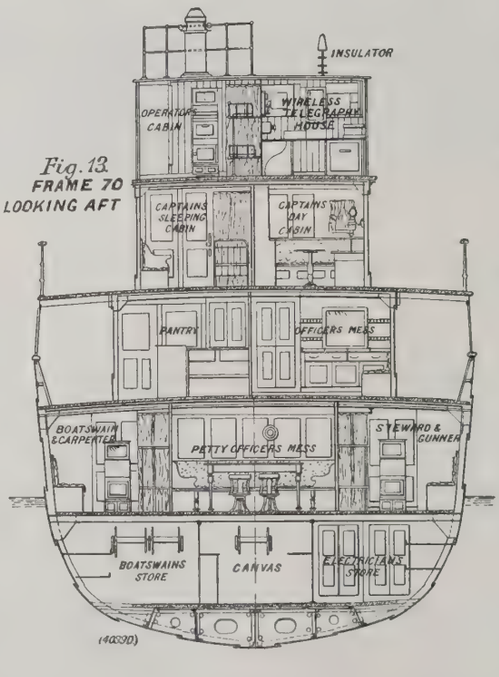
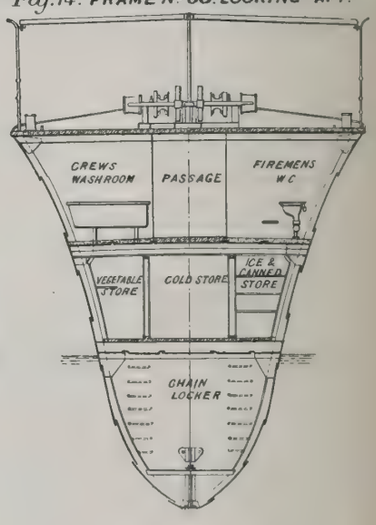


Fig. 14. FRAME No 90. LOOKING AFT.



The vessel is well provided with water-tight bulkheads, the bunkers being made oil-tight also. Sliding water-tight doors of quick-closing type are fitted, all operated from the upper deck. There is one horizontal door to each tunnel in the after engine-room bulkhead, and one vertical door to the passage-way through the cross-bunker fitted in the fore engine-room bulkhead. There is also a vertical bunker door to each side bunker. The boat is rigged as a fore-and-aft schooner, having two pole-masts, the lower part of each mast being of steel and the topmasts of wood. A gaff is fitted on the main mast for signalling and for carrying the main try-sail, and a small signalling-yard to the foremast. The aerials for wireless telegraphy are carried at the top of, and between, the masts, as shown in Figs. 1 and 2. The foremast is fitted with a stay-sail, and the main-mast with a stay-sail and try-sail for use in case of emergency.

The outfit of boats, which can be seen in Fig. 6, consists of a 30-ft. motor-launch, a 26-ft. lifeboat, a

principle. The steam steering-engine is placed just forward of the rudder-head. It has two cylinders 6 in. in diameter by 5-in. stroke. Control gear is led to steering pedestals fitted one in the wheel-house and one on the bridge above. Control shafting is of steel with machine-cut bevel wheels. Stand-by hand-steering gear is fitted on the upper deck above the steering compartment. It is connected to the gear below by bevel-gearing, and a clutch arranged for throwing in or out of connection as may be required. The whole of this gear was supplied by Messrs. J. Hastie and Co. A steam and hand capstan is fitted at the after end of the upper deck for warping purposes. It is capable of giving a dead pull of 6¼ tons at a speed of 80 ft. per minute when supplied with steam at 90 lb. per sq. in. On the forecastle deck forward there is a horizontal steam and hand-windlass capable of working the ship's 1 $\frac{5}{8}$-in. cables, and giving a dead pull of 6¼ tons at a speed of 120 ft. per minute with steam at

bain-maries, &c. The floor is tiled. The aft deck-house forms the main entrance to the engine-room, and at the fore end encloses a gallery around the engine tops. Aft of the engine casing there is a steward's cabin on the port side and a pantry on the starboard side. The main saloon is situated aft of these quarters. It is panelled in polished mahogany, with overheads enamelled white. The furniture is of mahogany, and upholstered in morocco leather. Leading from the saloon there are two main stations panelled in yellow pine and enamelled white. Cabins are fitted with electric bells and fans.

The accommodation on the lower deck aft comprises two state-rooms on the starboard side, fitted similar to those on the upper deck, and bath-rooms, &c., on the port side, fitted with Shanks' appliances. The floors are tiled. Alongside there is similar accommodation for the engineers. The engineers' quarters are at the fore end of the lower deck aft, with entrance from

CANADIAN CUSTOMS TWIN-SCREW CRUISER "MARGARET."

MESSRS. JOHN I. THORNYCROFT AND CO., LIMITED, SHIPBUILDERS AND ENGINEERS, SOUTHAMPTON.

(*For Description, see Page* 245.)

Fig. 2.

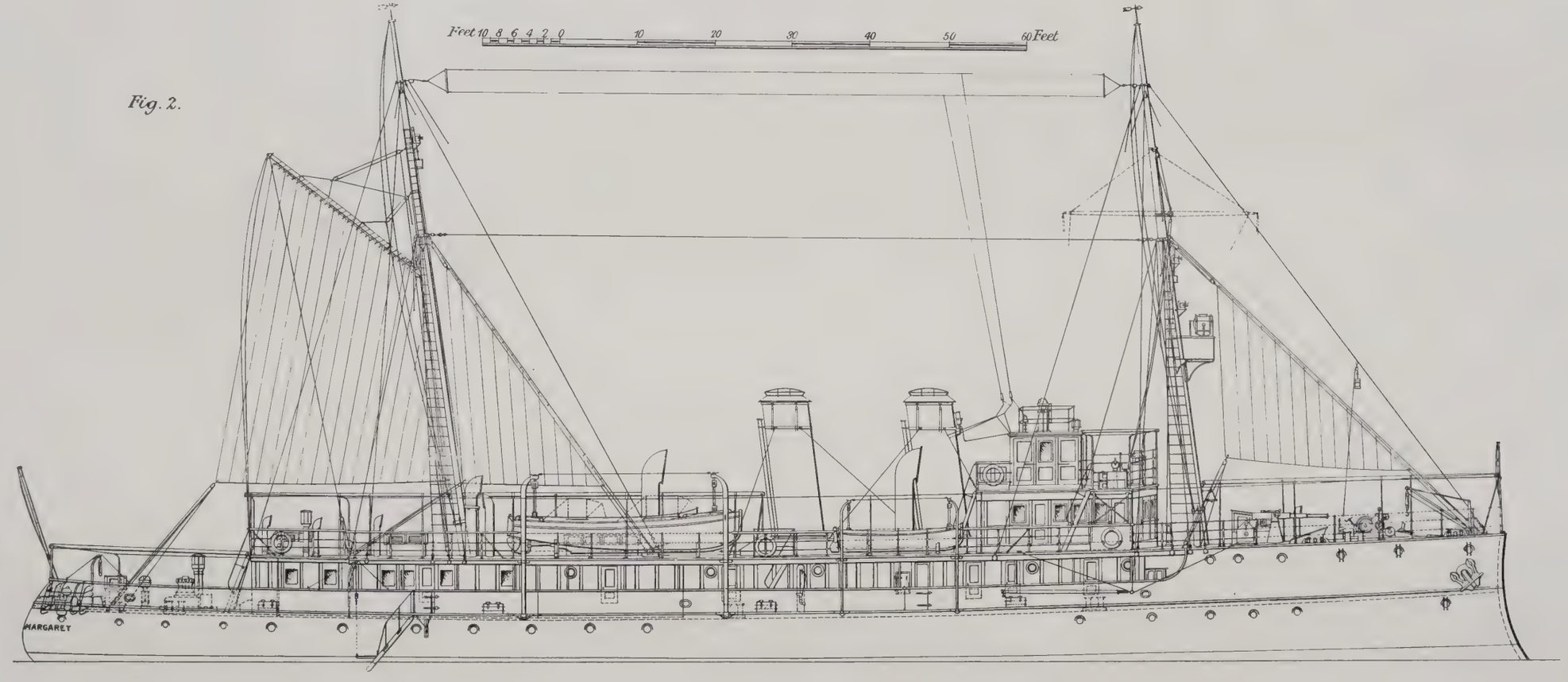
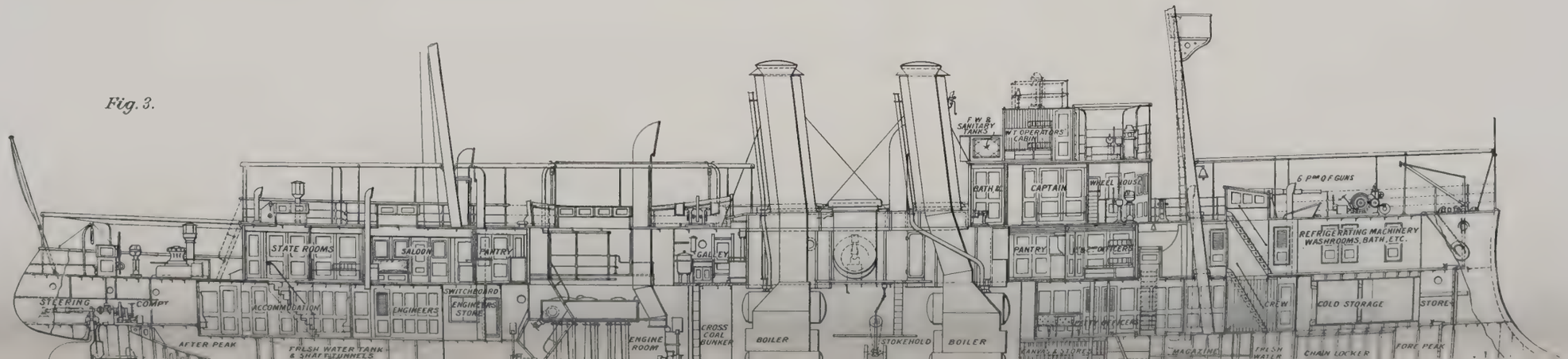


Fig. 3.



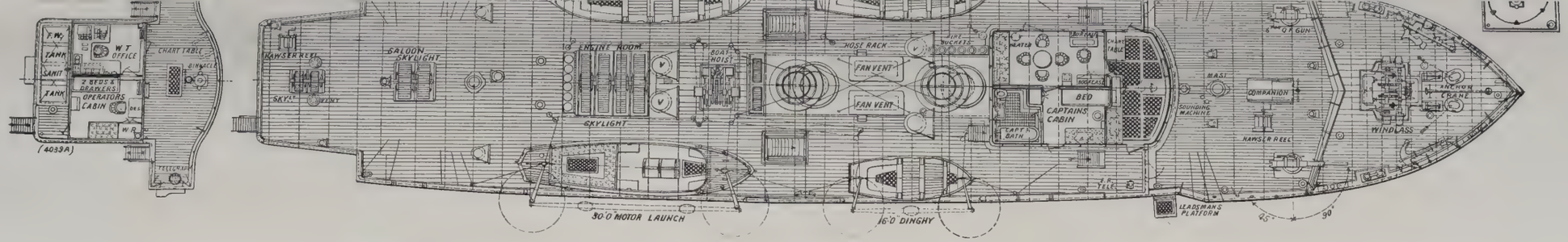


Fig. 7. MAIN DECK

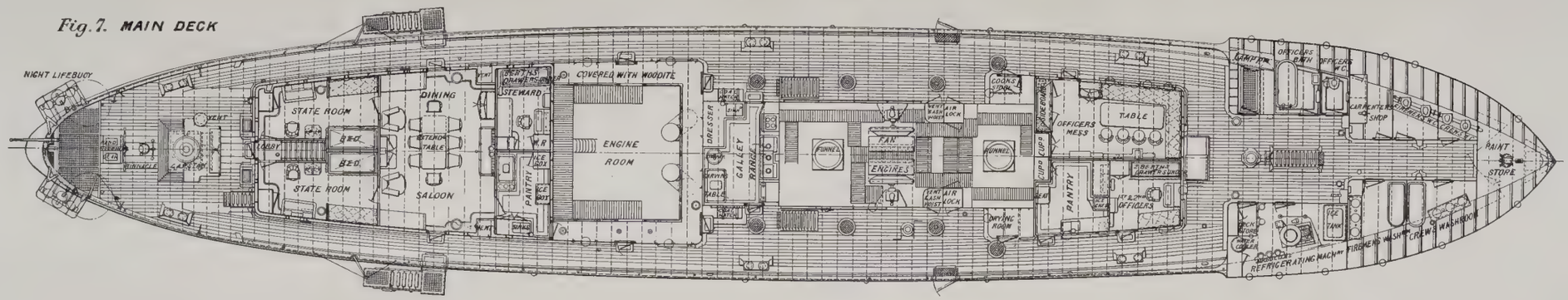


Fig. 8. LOWER DECK

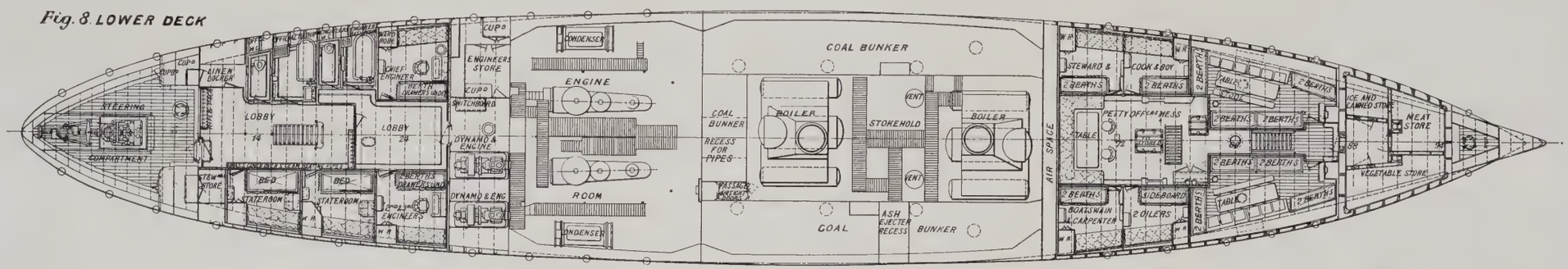
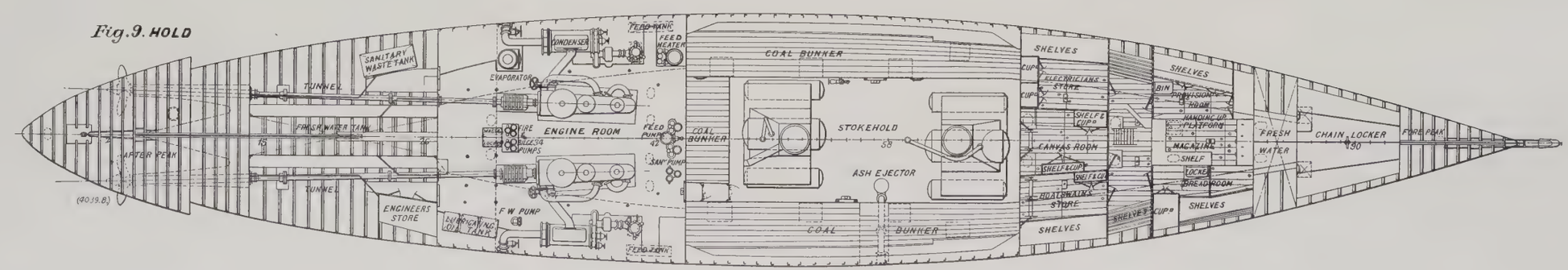


Fig. 9. HOLD



he engine-room. The cabins are in yellow pine, namelled white, with mahogany furniture upholstered n railway cloth. Accommodation for the petty officers nd crew is provided on the lower deck forward. There are four double-berthed cabins, panelled in ellow pine, enamelled white, and a large mess-room n the centre. The seamen's quarters are on the port ide, and the firemen's on the starboard at the forward nd. Hoskins' patent berths and the necessary lockers re fitted in each case. The quarters are lined with ellow pine, painted white.

(*To be continued.*)

INDUSTRIAL NOTES.

The Director of the Department of Labour Statistics tates that employment in July, before the war period, howed a further decline, but still remained good on he whole at the end of the month. There was little hange in the building, iron and steel, tinplate, and ngineering trades, but the shipbuilding trades were ot so fully employed, and there was a decrease in the umber of pig-iron furnaces in blast. There was some ecovery in the lace and hosiery trades, but employ- ment in other branches of the textile industries howed a further contraction, especially in the cotton rade.

Compared with July, 1913, employment showed a alling-off in most of the principal industries. The lecline was most marked in the pig-iron, iron and teel, cotton and woollen trades. In the tinplate rade there was a considerable increase in the number f mills working.

The changes in rates of wages taking effect in July ffected 101,600 workpeople, of whom 28,800 received ncreases and 72,800 sustained reductions, the net esult of all the changes being an increase of 400*l.* per veek. The principal increases affected over 3000 oiners at Glasgow, 8000 surface workers at coal mines n Northumberland, 6100 engineers in Bolton, Bury, nd district, and 3000 timber workers at North and South Shields and Blyth. Among those whose wages vere reduced were 46,000 coal hewers and other under- ground workers in Northumberland, 17,000 ironstone miners, limestone quarrymen, and blastfurnacemen n Cleveland and Durham, and 6250 blastfurnacemen nd iron and steel workers and mechanics in South Wales and Monmouthshire.

The number of new disputes in July was 99, and he total number of workpeople involved in all dis- putes in progress was 98,112, as compared with 82,752 n the previous month, and 126,912 in July, 1913. The estimated total aggregate duration of all disputes during the month was 1,327,800 working days, as ompared with 1,072,900 in June, 1914, and 1,184,500 n July, 1913.

Cases dealt with during the month under the Con- iliation Act include boot and shoe operatives, United Kingdom ; dock, &c., employees, Liverpool ; building rade operatives, at Coventry and at Oxford ; tramway mployees, London County Council ; boot and shoe peratives, Stafford and district ; cotton - spinning peratives, Bolton ; lace-workers, Newmilns ; brick- makers, Bristol ; and tinplate workers, Swansea. Matters have been dealt with by independent chairmen nder the Railway Conciliation Scheme, and an mending award issued by the independent chairman or West Yorkshire, under the Coal Mines (Minimum Wage) Act.

The average weekly number of vacancies notified to ll Labour Exchanges for the five weeks ended July 17, 914, was 26,043, as compared with 25,878 in the revious four weeks, and with 24,608 in the five weeks nded July 18, 1913. The average weekly number of acancies filled for the same periods was 19,488, 19,086, nd 18,562 respectively.

The report for the present month of the United ociety of Boiler-Makers and Iron and Steel Ship- uilders states that the balance in hand was 54,577*l.* n April 11, and 57,584*l.* on July 4. The members igning the book at the end of July numbered 2101 ; he members on home donation numbered 2347 ; hose on superannuation numbered 2468 ; and those n sick fund 2323.

The report of the Associated Blacksmiths' and Iron- orkers' Society for the month ending July 25 gives he statement of accounts for the second quarter ending une 21, which shows a balance in hand of 23,675*l.* he members of the Society number 8393.

The report for July of the United Pattern-Makers' ssociation shows a balance in hand on June 30 of 0,141*l.*, and a membership of 8604.

The *Yorkshire Post* gives the following paragraph :— It will be good news to the many thousands of othing operatives in Leeds, and to citizens generally, hat this district—the most important clothing centre the kingdom—is likely to share in the Government rders for Navy and Army clothing. A local firm of holesale clothiers, accustomed to this particular class work, have been asked to place their factory at the disposal of the Government, which means that other work which they are therefore unable to undertake will get distributed among other houses. A week or two, however, must elapse before activity can become general. The khaki has to be manufactured—largely in the Leeds, Dewsbury, and Batley districts, where some mills are now working full time—and until deliveries of the piece goods are made little can be done at the clothing factories. The Government supply the whole of the materials ; all that the clothing factories have to do is to make them up, and everything has to be carried out strictly according to Government specifications. Only a limited number of firms who make a specialty of the work are on the recognised Government list, and, of course, when they are busily employed thus, the ordinary trade must be done by others."

We are informed that the Swansea coal trade with the French ports has now been resumed. There being now no German competition in the tin-plate industry, a boom is anticipated in that industry, and it is announced that a number of Welsh tin-plate works are going to be started working afresh.

Lecturing on "Arbitration and Conciliation in Trade Disputes" at Cambridge, on Friday last, the 14th inst., Sir George Askwith said that, whatever criticism might be directed against arbitration and conciliation, the advantage of the existence of the principle of conciliation, and in a less degree of arbitration, in trade disputes had been wonderfully vindicated at a time of crisis. Throughout the country, when war became imminent, all the great organisations of employers and workpeople had sunk their domestic troubles and had met together to unite in a concerted effort for the welfare and preservation of the nation. The method of settlement had been by the boards of conciliation that existed in those trades, under their ordinary or independent chairmen, or by means of arbitrators called in under their rules or appointed by the associations' representatives on each side. Great objects could scarcely have been attained without the existence of associations able to control their members, and with their machinery available for the settlement of details which could be applied to the majority of persons engaged in the trade. In fact, the major disputes existing in the country continued in cases where one side or the other was disorganised, or where no association existed suitable for bargaining, carrying authority, and fitted with machinery of conciliation.

But if the machinery had proved, perhaps unexpectedly, to be valuable at a time of national crisis, it could only be so as the result of slow building up and organising in a time of peace. That had, in fact, been the case, not indeed in view of the national crisis, but because, on the whole, both the employers and employed in the great trades had gradually felt that the results of struggle were incommensurate if they could be avoided by discussion, bargaining, and organisation, and because the trades of a country and of the world were so closely interlocked that no fighting could occur without affecting other trades, and also the innocent public. Hence collective action on both sides had been continually growing, and had forced itself to the front, being applied, as it were, at both ends of the scale of labour—by the old trade unions in highly-organised trades, such as cotton, coal, and shipbuilding, and by the State itself in those trades where collective bargaining was impracticable, owing to the position of the people engaged in them, trades commonly known as sweated trades.

Sir George expressed the opinion that the future lay in voluntary action, and not in compulsory arbitration, which he did not think would be suitable in this country, because it could not be enforced. There must be consent to make government or agreement in the long run effective. Organisation was bound to be increased and strengthened in the future, and the only manner in which strong organisations could deal with each other was by having machinery for bringing complaints of each side to the other. Such organisation and such machinery could only be a matter of voluntary agreement, although it might be possible, when the parties desired it, to have in some measure the sanction of the law.

In a letter to the district committees, Mr. J. T. Brownlie, the chairman of the Amalgamated Society of Engineers, and Mr. Robert Young, the general secretary, state the following :—"In view of the fact that the nation is involved in war with European Powers, the executive council have had under consideration a request from the Employers' Federation, due to pressure being brought to bear by the Government, for the completion of vessels required by the Admiralty, and all ordnance work necessary for the nation's requirements. As this undoubtedly has special reference to the working of overtime, the council have given serious consideration to the matter, and to all that is involved therein, and hereby request that district committees shall instruct our members to work the overtime necessary under the circumstances."

The Agricultural Consultative Committee appointed by the President of the Board of Agriculture, issued on Thursday, the 13th inst., a statement in relation to the shortage of harvest labour owing to mobilisation. The Committee announce that active steps are being taken to supply the deficiency, by means of special instructions issued to the Labour Exchanges. The Committee appeal to landowners to facilitate the employment of members of their estate staffs, such as keepers and woodmen, on neighbouring farms. Further, the Committee have accepted a timely offer from the Boy Scouts' Association to use Scouts in the conveyance of messages between farmers and possible sources of labour, and they record the fact that local Scouts are being encouraged to assist farmers in their respective neighbourhoods. Scouts, it is added, are entitled to receive fair remuneration for their work.

The last issue of the *Revue du Travail* which we have received from Belgium is dated July 15, and the information it contains on the state of the Belgian labour market in the month of June last is of retrospective interest only. In June, the number of applications per hundred vacancies was 152, whilst in the preceding month of May the applications numbered 140 per cent., and in June of last year they numbered only 101 per cent. These figures point to a gradual decrease in the trade of the country. Detailed information given in the same pamphlet, and classified according to districts, shows that the iron and steel market was most depressed during the month under review, production being reduced to a minimum. At the present time, all work throughout Belgium is of a necessity, and through no fault of the country, at a complete standstill ; the coal mines have stopped running ; it is probably impossible to work the mine-draining pumps ; the blast-furnaces have had to be neglected and will become useless, even if not destroyed by artillery. . . The damage suffered by Belgium will take years to make good.

The question of holding the Trades Union Congress at Portsmouth next month was discussed last week by the Parliamentary Committee, when it was decided to postpone the Congress for a little time. The Committee will meet again during the first week in September, when the situation will be reviewed, and arrangements made, if circumstances then permit, for the holding of the Congress later in the year.

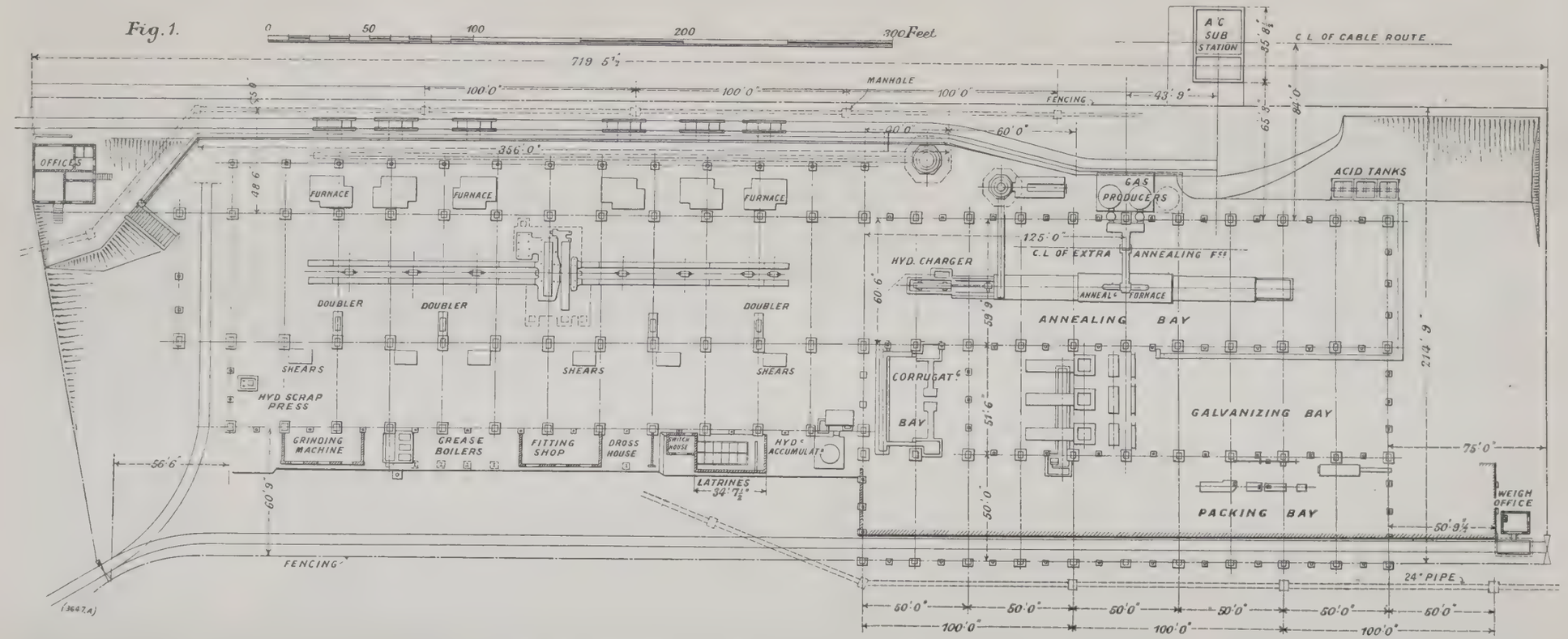
In their fourth annual report, which was issued on Monday last, the 17th inst., the Standing Committee on Boy Labour in the Post Office state that the Post Office have acted on their recommendation to the effect that all discharges of boys of 16 years of age and fit and willing to continue in the service of the Post Office should cease, and, except for 38 cases, which occurred early in the year, no boys at 16 years of age were sent away in 1913 for lack of prospects. In the year before the appointment of the Committee the number who left in these circumstances was 4471. The statistics of absorption are satisfactory, the total number of Post Office places secured by boy messengers (2593) showing an increase of about 900 on that for any previous year. The Committee estimate the total number of permanent situations in the Post Office likely to be taken up annually by boy messengers at close on 2700, against the previous year's estimate of 2275. In 1913, it is stated, only 26 boys entered the Royal Navy as wireless operators, and 10 passed into the Royal Engineers as telegraphists, printers, &c. The War Office have proposed that the scheme for training for the latter corps should be abandoned, but the Committee are averse to this, believing that the scheme will eventually be found advantageous both to the boy messengers and the military service. During 1913 69 boy messengers entered other branches of the Navy or Army. By an arrangement with the Board of Customs and Excise, 22 boy messengers out of 31 with some experience of rowing-boats were successful in a competition for appointments as Customs preventive men, but it seems unlikely that any such number of Customs posts can be relied on as available in normal years.

The future authorised establishment of boy messengers is estimated at 13,000, against 15,788 in 1910.

Personal.—Messrs. Fraser and Chalmers, Limited, Erith, Kent, have appointed Mr. H. A. Sturgess, the Oak, Motherwell, to represent them in Scotland.—The British Electrical Plant Company, Limited, of Alloa, have appointed Mr. Alan Williams, M.I.E.E., of 9, Queen Victoria-street, E.C., as their agent in London and South of England.—The business carried on under the name of Pfeil and Co., at 145 to 157, St. John-street, Clerkenwell, London, E.C., will in future be carried on under the name of Farmer and Co., under which name it was conducted for upwards of 100 years prior to 1874, when it passed to the present proprietorship. Although the name of the firm was German no one of that nationality has ever been connected with it.

ELECTRICALLY-DRIVEN GALVANISED-SHEET MILL AT THE EBBW VALE STEEL WORKS.

Fig. 1.



In the early part of last year a new factory for the manufacture of corrugated galvanised sheets was put into operation by the Ebbw Vale Steel Iron and Coal Company, Limited, of Ebbw Vale, Monmouthshire. The starting of this factory resulted in an addition to the list of manufactures of the company, since, although they had supplied tin-plate and sheet-makers with sheet and tin-plate bars for a number of years, they had not previously rolled sheets themselves. The possession of the new factory puts the Ebbw Vale Company in what is probably a unique position for the supply of galvanised sheets. Such are the resources of the various branches of their works that they are now manufacturing such sheets from the ore, through all the processes of smelting, steel conversion, bar-rolling, sheet-rolling, galvanising, and corrugating; while the fuel required for heating and steam-raising comes from their own pits. The establishment of this branch of manufacture is pleasing evidence of the continuing initiative of a company which can trace its beginnings back to certainly 130 years ago.

In this article we propose to give a description of the works. They were formally opened on March 3 of last year, although they were in operation early in February. The erection and equipment were carried out in twelve months, as the first sod was cut only on February 4, 1912. The works are situated at Victoria, to the south of the Ebbw Vale Steel Works, and adjoining the Great Western Railway Company's Newport and Ebbw Vale line. They have a capacity of 500 tons of finished sheets per week, which will probably be increased in the future, as a large area of ground has been reserved for extensions. The works are conveniently situated for the handling of the raw material and the shipping of the finished product. This may be seen from the plan given in Fig. 1, annexed. The longer dimension of the works, as shown in the figure, lies approximately north and south, with the north to the left-hand side. Accordingly the steel works, from which the steel bars come, would lie to the left if shown in Fig. 1. A line of railway connects the two works, and terminates in two sidings, of which one runs up the north side of the sheet works to such a position that the bars from the steel works can be delivered close to the furnaces. This siding is shown in Fig. 1. The other siding, also shown in the figure, is carried along the west side of the works, and serves the packing bay. These sidings are connected up to the Great Western line, which runs along the west side of the works, as is shown in Fig. 5, on page 252. From Fig. 1 it will be seen that there are also sidings on the east side of the works. These serve for the bringing up of coal for the furnaces and producers, and acid, &c., for the galvanising shop.

The general lay-out of the works will be easily followed from Fig. 1. They may be considered as divided into two parts about midway of their length. The northern half contains the furnaces, rolls, shears, &c., and the southern half the annealing furnace and the galvanising and corrugating machinery. After rolling, the sheets are packed in annealing dishes, which are placed on bogies, and charged into the annealing furnace. From here the material passes in a straight line through the galvanising and corrugating bay, and so on to the packing bay for shipment. The northern half of the works is divided into two bays, with a lean-to roof over the furnaces, while the southern part is divided into three bays, as shown in Fig. 5. The main dimensions of the shops are indicated in Fig. 1, from which it will be seen that the total length of the site, taken over the offices, which are a separate building at the north end, is 719 ft. 5½ in., and the width over boundary fences, 214 ft. 9 in. The buildings are iron-framed structures, with corrugated-iron screens. The floors are covered with iron plates.

The works are situated on a hill-side, as shown in Fig. 5. This fact has allowed a very convenient arrangement for the supply of coal to the furnaces. The furnaces themselves, of which there are six, are situated on the level of the floor of the main rolling-shop. The siding, however, by which the coal is brought up, is situated at a higher level, and on the top of a retaining wall, which is carried for the full length of the works on the east side. Bottom-tipping wagons are used, which deliver to bunkers built in the retaining wall. The coal is accordingly delivered automatically to a convenient position for the furnaces, which are fired from the back. The furnaces themselves are of the combustion type, each consisting of a bar furnace capable of dealing with three heats and a double reheating furnace. They are arranged alternately right and left to facilitate working. They are all connected to a single main flue, which conducts the gases to a brick stack 160 ft. high. The position of the flue is clearly shown in Fig. 1. The ashes are dealt with by an elevator of 4 tons per hour capacity, which delivers them into trucks on the siding. The bars, which, as before explained, are brought by trucks to the siding on the north side of the rolling-shop, are handled from the wagons, or from the stock, by means of a 20-ton overhead electric crane, which transports them to the furnaces. The rails which carry this traveller can be seen in Fig. 4, page 249, which is a general view of the rolling-shop looking north. The furnaces are situated to the right in this view, immediately behind the roof columns. The bars are delivered from the steel works ready cut to length, so that they can be taken direct from the wagons to the furnaces.

The rolls are arranged down the centre of the rolling bay, as is well shown both in Figs. 1 and 4. A centre drive has been adopted, with three mills and one set of cold rolls on each side. The drive is from an electric motor. The mills are of the most modern design, with housings of the American type. The arrangement of the plant, looking from the south end, is well shown in Figs. 4 and 6. The mill foundations are of block concrete, formed with an underground culvert, which gives access to the holding-down bolt hand-holes, and also serves as a drain. All drain-water is passed through settling-chambers before it is passed to the main drain network. The train of mills is driven through single-reduction gearing by a three-phase 50-period 2000-volt induction motor, giving 1000 brake horse-power at 184 revolutions per minute. The motor has a pull-out torque of not less than 2.5 times full-load torque. It drives a pinion of 3 ft. 10 in. diameter through a Reich flexible coupling, and the

ELECTRICALLY-DRIVEN GALVANISED-SHEET MILL AT EBBW VALE WORKS.

Fig. 2.

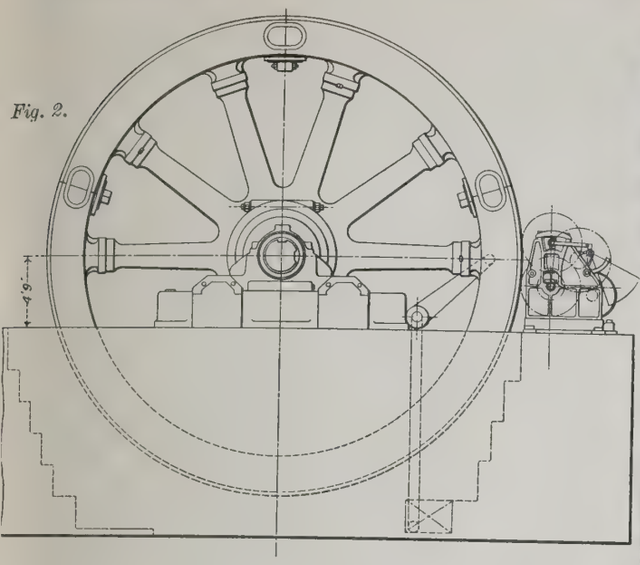
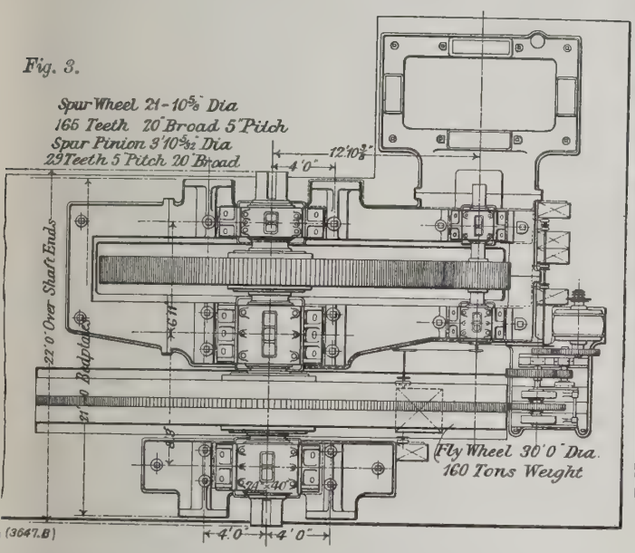


Fig. 3.



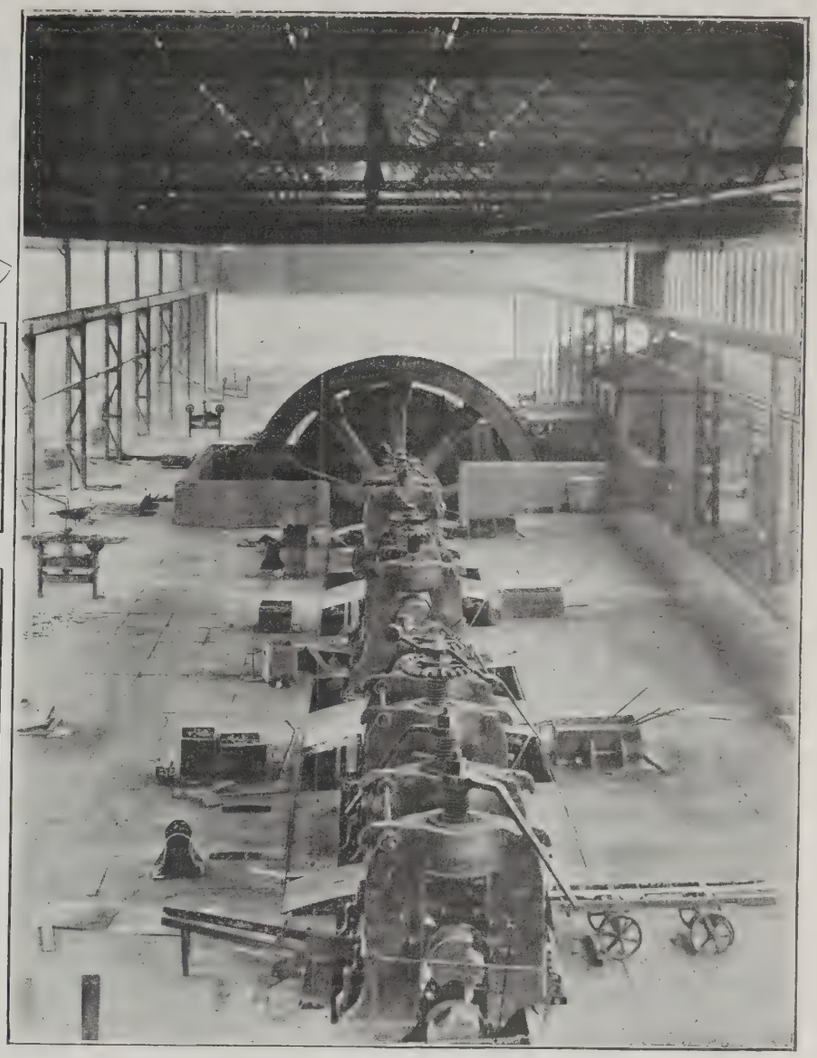


Fig. 4. View of Mill Bay Looking North.

inion gears into a spur-wheel 21 ft. 10⅝ in. in dia-ıeter, which is mounted on the main mill shaft. This ıain shaft also carries a 160-ton fly-wheel, 30 ft. in iameter. The arrangement of the drive is shown in etail in Figs. 2 and 3, above. Fig. 3 gives data ı reference to the gears, which were manufactured y Messrs. Scott and Hodgson, of Guide Bridge Vorks, near Manchester. Other views of the drive re given in Figs. 7 and 8, on page 252.

With the motor running at its normal speed, the ɔeed of the rolls is about 32 revolutions per minute. ı order to give some regulation, however, and to low the rolls to be run more slowly, a liquid slip-gulator and starter is fitted in connection with the otor, which allows it to be run continuously at ; per cent. below synchronous speed. The regulator ıd starter consists of three tanks, connected respec-vely to the three slip-rings and mounted in a cast-on frame. In the tanks are three electrodes, which e raised and lowered by a common hand-wheel, and e so arranged that the rotor circuit is never broken. ıe regulator is provided with straight wrought-iron oling-pipes, and is capable of dissipating 220 horse-ɔwer continuously. A recording and indicating tacho-ɛter is driven from the motor-shaft and records the ıctuations in the speed, while an alarm device is fitted connection with it, which sounds an alarm-bell in case e motor speed drops below a predetermined value. ıe high-tension supply to the motor is controlled by iron-clad pillar containing a three-pole oil-switch ted with a no-volt and overload release, with time-ıit relay. The pillar also carries three isolating ıgs and integrating and indicating watt-hour meters. addition to the main drive the mill is fitted with a rring-gear driven by a 40-brake-horse-power, 360 ɔvolutions per minute, slip-ring motor working from 550-volt three-phase circuit. The barring-gear erates on the fly-wheel, and is arranged so that it tomatically falls out of gear when the mill motor ɛeds up. The gear can be seen in Figs. 2 and 3.

The control-gear is situated in a brick switch-house built at the back of the driving gear. It can be seen in Figs. 4 and 8. The whole of the electrical apparatus in connection with the main and barring drives was supplied by the British Westinghouse Electric and Manufacturing Company, Limited, of Trafford Park, Manchester. The mills are in operation for 24 hours a day, 5½ days a week, the product consisting of sheets up to 40 in. wide by 10 ft. long, and from 10 G. to 31 G. in thickness. The tachograph records show that the motor is always operating close up to its full capacity, and that prolonged periods of overload are not uncommon.

The doublers are shown on the left-hand side in Fig. 4. They consist merely of a fixed cross-arm carrying an hydraulic cylinder, which operates a moving crosshead which comes down and doubles the sheets against a block fixed at floor-level. The moving crosshead is balanced by weights below the floor. Power is supplied to the doublers from an hydraulic accumulator fixed in the south-west corner of the mill-shop. It is shown in Fig. 1. The accumulator, which supplies pressure water at 700 lb. per sq. in., is charged by an electrically-driven three-throw pump. Other tools in the mill-shop are six shears for trimming the sheets to size before they are sent on to the annealing furnace. Five of the shears are of the under-crank type, the other being of the over-crank type. They are all separately driven by electric motors. The sheets, after shearing, are passed through the cold rolls, and are then packed on bogies and taken to the annealing oven. In the rolling-shop there is also an hydraulic press for baling the scrap from the shears. It is placed at the north end of the shop, as shown in Fig. 1, and is driven from the same accumulator as the doublers. Along the west side of the shop there are a series of small outbuildings, containing the fitting-shop and dross-house, &c., and the boilers for the grease.

The annealing bay contains a Dowson-Mason continuous gas-fired annealing furnace and space for a second one of the same size. The furnace can accommodate nine bogies inside and one outside, each bogie taking about thirty-six hours to pass through. The bogies are pushed through the furnace by an hydraulic charger, which is worked from the accumulator in the rolling-shop. The furnace is supplied with gas from two Duff producers, which are fired from the level of the top of the embankment wall already referred to. The furnace-flue is carried to a brick stack, which can be seen in Fig. 5. The larger stack in this view is that for the mill furnaces, and the smaller that for the annealing furnace. After leaving the annealing furnace the loads of sheets are allowed to cool slowly, and are then passed on to the galvanising bay. The lay-out of the annealing bay and the relative positions of the furnace, producers, &c., are shown in Fig. 1.

The galvanising-shop contains a free area at its south end, in which the unloading of the bogies is carried out. At the other end it contains pickling-tanks and three automatic galvanising-machines, which are arranged side by side and in the direction of the length of the shop. In connection with the pickling-tanks, three acid tanks are fixed outside the annealing bay in the south-east corner of the works. These tanks are charged from acid wagons, which come up on the siding alongside, and are connected to the pickling-tanks by ebonite pipes. The position of the tanks and the general lay-out of the galvanising-shop are shown in Fig. 1. The pickling-tanks are of stone, and the sheets are fed into them by hand. They are then passed into wooden washing-tanks and on to the galvanising-machines. These consist of solid-welded galvanising baths, wrought-iron washing-tanks, and brick drying-stoves. The metal baths and drying-stoves are heated by coke furnaces, which are self-contained with the machines. Each machine is fitted with an endless-chain conveyor and a series of rubber rollers, by means of which the sheets are automati-

cally conveyed from the galvanising bath, through the washer and dryer, and out at the far end of the machine. The galvanising plant, which is shown in Fig. 9, on page 252, was supplied by Mr. John Thompson, of Wolverhampton.

After galvanising, the sheets are examined, and passed on to the corrugating-shop. This contains two corrugating-machines, also supplied by Mr. John Thompson. The machines, which are shown in Fig. 10, on page 252, are capable of dealing with sheets up to 12 ft. long, and are fitted with Thompson's patent clamping attachment. The crosshead of each machine has an up-and-down reciprocating motion, the dies continually opening and closing. Continuity and uniformity of pitch, depth and shape in the corrugations, is ensured by the patent clamping attachment. This consists of an auxiliary crosshead, which is connected to the main crosshead through the intermediation of four compressed-air cylinders. The auxiliary crosshead is secured to the piston-rods of the air-cylinders, as can be seen in Fig. 10. When the machine makes its downward stroke, the auxiliary crosshead, which carries an upper registering die, is in advance of the main crosshead, so that it comes down on the part of the sheet already formed, and holds it in position on the lower die. The main crosshead then comes down and forms the next section of the sheet, the auxiliary crosshead being held in position the whole time by the pressure in the air-cylinders, which keep it up to its work, and at the same time allow the necessary relative movement between it and the main crosshead. The air-cylinders are connected up by flexible tubes to an air-compressor. These connections can be seen in Fig. 10.

The packing bay contains certain machines, and among them an hydraulic stretching-machine, also built by Mr. John Thompson. This is capable of dealing with sheets up to 12 ft. long. Other machines in the packing bay consist of machines for curving or flattening the corrugated sheets, in addition to a ridging-machine and slitting-shears. All these machines are electrically driven from a 550-volt three-phase circuit, the motors being supplied by the British Westinghouse Company. The packing bay, as already stated, and as shown in Fig. 1, has a railway siding running down its west side. Owing to the configuration of the site, this siding lies at a considerably lower level than the floor of the bay, so that trucks have to be loaded by lowering the parcels of sheets by a crane. For this purpose a 5-ton overhead electric traveller is provided. It will be seen from Fig. 1 that the siding, although below the level of the floor of the bay, is none the less situated under the roof, so that loading can be carried out free from interference by the weather. The heavy line in Fig. 1 marks the vertical retaining-wall carrying the floor of the shop, and it will be noted that the columns are fixed outside the siding. The entrance to the siding can be seen in Fig. 5, which also shows the weigh-office for dealing with loaded trucks.

The whole of the electric power for operating the works passes through a special sub-station built at the east side, and shown in Fig. 1. This sub-station receives power from the Ebbw Vale Company's Victoria generating-station, which is situated at their steel works. Three-phase power at 2200 volts and 50 periods is conveyed to the sub-station by overhead aluminium transmission lines. The station contains the necessary switch-gear for the control of the overhead lines and of the 2200-volt circuit to the main mill motor. The high-tension gear also controls the high-tension side of two 350-kw. step-down transformers which are housed in the station. These transformers supply the 550-volt circuits for the various smaller motors in the works. The connections between the sub-station and the works are made across a cable-bridge, which is carried well above the intervening railway sidings. The switch-gear and transformers were supplied by the British Westinghouse Company.

In concluding this description we should say that Mr. Walter Dixon, of Glasgow, was the consulting engineer for the electrical part of the equipment, and should express our thanks to Mr. Frederick Mills, M. Inst. C.E., the managing director, and to the other officials of the company for courtesy and assistance extended to us during our visit to the works.

Alloy-Steel Gears in Machine Tools.—The issue of *Machinery*, New York, for the present month, says that alloy steels, such as chrome-vanadium and chrome-nickel, has been used with more or less success for gears in machine-tool construction. One machine-tool builder in the Middle-West has tried both these alloys for gears; very unsatisfactory results were obtained, and he has gone back to ordinary carbon steel, having a carbon content of 0.20 per cent., heat treating the steel in the most scientific manner known. Our contemporary states that with special alloy steels the limits of fluctuation in the heat treatment are much narrower than in ordinary carbon steel, and the material must be handled much more carefully if good results are to be expected. Since using carbon steel the machine-tool builder in question has found that his troubles in the way of breakage and stripping of gear-teeth are practically eliminated.

OXY-ACETYLENE WELDING.

To the Editor of Engineering.

Sir,—In reply to your correspondent, Mr. W. H. Tozer, in your issue of the 7th inst., I can answer his question in the affirmative. Nearly three years ago I welded the crown of a gas-holder of smaller size, the crown consisting of $\frac{3}{32}$-in. sheeting, which is working at the present time and has given satisfaction in every way. On several occasions I have also repaired crowns which have been damaged in transit.

Larger holders with a crown of $\frac{1}{8}$-in. plate would be straightforward work for an expert welder if the following method is carried out:—All seams should be butt-welded. The sections of plate should be shaped and placed in position, taking care to leave a clear space of $\frac{1}{16}$ in. to $\frac{3}{32}$ in. between each section. The operator should then tack the plates together by spotting at every 12 in. or 14 in. until the crown is completed. He should then commence welding the seams, using care to prevent any distortion. When the welding of the crown is completed, it should be placed on the walls of the bell, tacked in a few places before welding, and if extra strength should be required in the seams, the welds should be slightly shouldered.

The oxy-acetylene process is particularly suitable for this class of work, and cannot fail to give satisfaction if performed by an experienced welder.

Yours truly,

Wm. Kempson, Instructor,
August 13, 1914. Oxy-Acetylene Welding.

Yorkshire Colliery Developments.—As regards mining extensions in the Barnsley district, we have to record successful sinking to the Parkgate seam at the new Darton Main Colliery. The pit is near the Darton station of the Lancashire and Yorkshire Railway. The sinking of two shafts commenced in October last year, and has been carried on expeditiously. The seam was reached at a depth of 190 yards. It is fully 4 ft. in thickness, and is of good quality. The second shaft will be carried down to the same seam in a short time, and sinking is to be continued to the Thorncliffe and Silkstone seams, which lie at a further depth of about 70 yards. It is expected that the pit will be opened out rapidly, and that it will eventually find employment for about 1500 men.

War Maps.—We have received from Messrs. Edward Stanford, Limited, 12 to 14, Long Acre, London, W.C., a series of admirable maps of special interest at the present time. One sheet of Central and Eastern Europe includes the part of Europe comprised within the Eastern frontier of France, Tunis, the Island of Crete, the Western Coast of Asia Minor, the Western frontier of Russia and Southern Sweden and Norway. Another sheet is a map of the Netherlands and Belgium, with the Northern frontier of France, Luxemburg and the Western frontier of Germany. A third map is that of France, including Southern England, Northern Spain, the Eastern frontiers of Italy, Switzerland and Germany, and a part of Belgium and of the Netherlands. The three maps, which are most complete, are published, at various prices, according to the manner in which they are mounted. Messrs. Stanford announce that war map No. 4, of the Franco-German frontier, and war map No. 5, of the North Sea, are in preparation.

The City and Guilds of London Institute.—The annual report of the Council of this body, to which the whole manufacturing industries of the country are so deeply indebted for the promotion of technical studies, has just been issued. Amongst the interesting facts brought out is that nearly half the "internal" undergraduates taking engineering in the University of London hail from the colleges of the Institute, mostly from the City and Guilds (Engineering) College, since that at Finsbury has only recently extended its normal course of instruction to three years. At the South Kensington establishment the chemical department has been closed, the work being transferred to the Royal College of Science. Large extensions are, however, being made to the buildings, through the generosity of the Goldsmiths' Company, whose benefactions already amount to 87,000*l*. The equipment of this extension is estimated to cost 24,000*l*. A notable change during the year has been the division of the department of civil and mechanical engineering into two, a separate civil engineering section being formed, with Professor S. M. Dixon as its head, whilst the mechanical section will remain under the direction of Professor W. E. Dalby. The number of candidates taking the entrance examination continues to rise, and numbered 190 last year, the average age being 19.2 years. Of these, 38 had been previously engaged in works, whilst 15 came from other technical colleges and schools. At Finsbury a special third-year course has been added to the curriculum for mechanical engineers, and a similar provision is now proposed for those taking the electrical engineering course. The present two-year courses are, however, to be also maintained, having proved of great value to those apprentices and improvers who are unable to afford the time necessary for the longer training. Valuable as the above institutions are, it may be questioned whether the evening classes organised throughout the Empire by the Department of Technology do not constitute a still higher claim on the gratitude of the public. During the year covered in the report 4859 such classes were organised, and attended by 54,510 students, this being an increase of 511 on the figures of the previous year. Examinations were held in 74 technological subjects, for which 21,878 candidates entered from centres in the United Kingdom alone.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was steady and a fair business of 2000 tons of Cleveland warrants changed hands at 53s. 1d. cash and 53s. 5d. one month. Closing sellers quoted 53s. 1½d. cash and 53s. 4d. one month, but the three months position was not mentioned. There was little change in the afternoon, when 1500 tons of Cleveland warrants were put through at 53s. 0½d. five days and 53s. 3½d. one month, with closing sellers naming 53s. 1d. cash and 53s. 4d. one month. On Friday morning the market was idle, but steady, and Cleveland warrants were quoted at 53s. 1½d. cash, 53s. 4½d. one month, and 53s. 9d. three months sellers. Buyers of hematite were offering 64s. one month, but no dealing took place. In the afternoon Cleveland warrants were firm, and the turnover amounted to 3500 tons at 53s. 1½d. cash, with sellers over at 53s. 2d. cash and 53s. 4½d. one month. On Monday morning the tone was just the turn softer, and 3000 tons of Cleveland warrants were dealt in at 53s. 1d. cash, 53s. 4d. one month and September 22, and at 53s. 9d. three months. At the close sellers named 53s. 1d. cash, 53s. 4d. one month, and 53s. 10d. three months. The afternoon session was dead idle, but sellers of Cleveland warrants made a nominal advance of 2d., quoting 53s. 3d. cash, 53s. 6d. one month, and 54s. three months. Prices were steadier again on Tuesday morning, and the dealings amounted to 2500 tons of Cleveland warrants at 53s. 1d. cash and 53s. 3d. twenty-two days, and closing sellers quoted 53s. 1½d. cash and 53s. 4½d. one month. No transactions of any kind were recorded in the afternoon, when sellers of Cleveland warrants quoted 53s. 1d. cash and 53s. 4½d. one month, with buyers down to 52s. 11d. and 53s. 2½d. respectively. When the market opened to-day (Wednesday) the tone was steady, but no business took place, and sellers of Cleveland warrants named 53s. 1½d. cash, and 53s. 4½d. one month. In the afternoon there was an easier tendency, and Cleveland warrants were done at from 52s. 11d. to 52s. 10½d. cash, and at the close the quotations were 52s. 10½d. cash, 53s. 1½d. one month, and 53s. 7d. three months sellers. The turnover was 1500 tons.

Sulphate of Ammonia.—With an easier demand for sulphate of ammonia the price has got weaker. The shipping trade has gone quite off, and there is little being required for home use at present.

Scotch Steel Trade.—Affairs in the Scotch steel trade are still just a little uncertain, as similar conditions to those prevailing now have no parallel. The majority of the works are quite busy and a lot of business is going through, but raw material and shipping facilities form considerable drawbacks. These, with the absence of foreign competition, have caused fairly heavy advance, in prices, which, it is freely stated, are only the first steps on the upward ladder. Consumers are not coming forward with their orders as one might expect, and dilatoriness in this respect may be a serious matter to them later on, when prices have risen further. The former levels of a month or two back cannot be looked for for a long time to come, and now that Britain and America are left to supply the world's requirements, prices are bound to be on a higher level than formerly. All quotations are without engagement, and for immediate reply. It is difficult to name prices, but for ship-plates the figure is about 7*l*. per ton, less 5 per cent., for local delivery. The export trade is practically at a standstill, although some owners have managed to get their vessels off. The position is daily getting a little easier, and when the outlook becomes clearer, and the war insurance not so heavy, there is every prospect of a considerable revival in the export demand. Meantime, however, inquiries from overseas are not so numerous as makers here would like, but a number of orders formerly given to Continental houses, and now cancelled, have been placed locally.

Scotch Pig-Iron Trade.—There has been a very good demand for the ordinary qualities of Scotch pig-iron during the past week, and sales have been numerous. Prices are considerably up, and are all a matter of arrangement, so no list of current quotations can be given. Contracts for forward supplies are not being entertained, as everything depends on the duration of hostilities.

Scotch Imports of Iron and Steel.—The outbreak of war between Britain and Germany has caused a considerable upset in business circles, and the present month's returns in the matter of imports will show a decided falling-off. During the month of July the registered imports of the undernoted iron and steel manufactures into the ports of Glasgow, Greenock, Grangemouth, Leith, Dundee, and Aberdeen, amounted to 12,667 tons, with a total value of 85,895*l*., and of that lot no less than 10,960 tons, valued at 71,655*l*., came from the Continent. These imports have been growingly steadily, and now that they are cut off, the home makers will become much busier. The details are:—

	Ex-Continent. Tons.	Value. £	Ex U.S.A. Tons.	Value. £
Iron bars, angles, &c.	3,123	20,809	—	—
Steel bars, angles, &c.	2,507	16,302	221	2,331
Iron and steel hoops and strips ..	1,273	8,638	1,486	11,909
Iron and steel plates, not under ⅛ in.	3,975	25,243	—	—
Iron and steel plates, under ⅛ in. ..	82	663	—	—
Total	10,960	71,655	1,707	14,240

Malleable-Iron Trade.—The improvement which has taken place in the malleable-iron trade of the West of Scotland is indeed most welcome, but the scarcity of raw material is a serious matter. The current price for

"crown" bars is now 7*l.* 12s. 6d. per ton, less 5 per cent., delivered locally, and the shipping quotation is also correspondingly higher at 6*l.* 15s. to 7*l.* per ton net, f.o.b. Glasgow. These advances were arranged at a meeting of the local Bar-Iron Makers' Association, held in Glasgow last Friday.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The steam-coal market has undergone very little change during the last week. Though inducements have been held out for shipment to neutral countries, few people are willing to undertake the risk attaching to cargoes. A heavy tonnage is ready for despatch at the ports should those risks be minimised, or more favourable covering terms be offered. The difficulty arising from the shortage of pit props has not been lessened, and the price of the small supplies available has risen 30 per cent. in the last fortnight. On local industrial account there is a brisk inquiry, principally because of the pressure at works employed on British Army and Navy orders. The position at the pits is less satisfactory. Despite compulsory reductions in output, stocks are rising, and owing to congestion at the ports, owners are experiencing a shortage of wagons. Prices are easier. House coal is in steady demand, though the recent panicky rush has ceased. Both at pits and dépôts normal activity prevails. Few stocks are left. Prices are steady at last week's rates. Slacks are stronger, chiefly owing to the fact that many of the hard steam pits are idle. Coke is firmer. Quotations:—Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. to 13s.; Derbyshire best brights, 11s. 6d. to 12s. 6d.; best large nuts, 10s. 3d. to 11s. 3d.; small nuts, 9s. to 10s.; Yorkshire hards, 10s. to 11s.; Derbyshire hards, 10s. to 11s.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.; smalls, 2s. to 3s.

Iron and Steel.—The situation in the South Yorkshire iron and steel trades has not deteriorated to any marked extent during the past week. Manufacturers are beginning to find that, whatever the ultimate effects, the present decline in activity is not nearly so sharp as they were led to expect. The wisdom of local raw-material producers in refusing, prior to the outbreak of war, to enter into long-dated contracts, is more apparent. With the cutting off of Continental supplies common pig and hematites have risen from 5s. to 10s. per ton, and there is prospect of further advances. East Coast hematite has advanced from 68s. 3d. to 77s., and West Coast from 73s. 6d. to 80s. 6d. Owing to the shortage of ore, a number of furnaces have been damped down, and production is now very little in excess of the demand, but smelters are hoping that shipping with neutral countries will shortly be restored, and that the bulk of the blown-out furnaces will be put into blast again. Common pig-irons have appreciated considerably, if to a lesser extent. Transactions in Lincolnshire foundry sorts are reported at 59s., Derbyshire foundry at 60s., Lincolnshire forge at 58s. 8d., and Derbyshire forge at 56s. This represents all round advances of from 5s. to 6s. on the prices nominally quoted a fortnight ago. The most marked advance has been in the case of bars and billets. In accordance with the decision of the South Yorkshire Bar Iron Association, bar iron has advanced from 7*l.* 5s. in the case of crown bars to 8*l.* per ton, delivered less 2½ per cent. With the cessation of Continental dumping of cheap products an equally large advance has been made in the price of basic billets. Soft billets have moved from 4*l.* 15s. to 6*l.*, and hard billets from 5*l.* 10s. to 6*l.* 10s. Everything required for war purposes has, in fact, risen, there having been a phenomenal demand for horse-shoes, hoop-iron, and transport wagon parts. Plates and sheets have advanced by 15s. to 20s. per ton, and hoop iron by 30s. The armament works are engaged at record pressure on orders for guns, shells, and plates for the British War Office, and incidentally are keeping other small departments busily engaged. Nor is there any likelihood of any break in the present activity. Most of the steel works have been occupied for the greater part of the week. Manufacturers anticipate to benefit considerably from the diversion of Continental trade. Already a number of orders have been placed in Sheffield which hitherto were executed in Germany, and there seems every probability of a further improvement on similar lines if the difficulties of obtaining necessary material can be overcome. One of the most serious causes of obstruction is the shortage of tungsten, which, in common with other valuable alloys of foreign production, is advancing in price. Special works will probably be established to overcome the difficulty, American alloys being too dear for local use.

THE INSTITUTION OF MINING ENGINEERS.—The twenty-fifth annual meeting will be held on Wednesday, September 9, 1914, at 10.30 a.m., at the Central School of Science and Technology, Stoke-on-Trent. The following papers will be read, or taken as read:—(1) "The Absorption of Oxygen by Coal," Part II., III., IV. and VI., by Mr. T. F. Winmill, B.A.; (2) "The Absorption of Oxygen by Coal," Part V., by Mr. J. Ivon Graham, B.A.; (3) "Self-Contained Rescue Apparatus and Smoke-Helmets for Use in Irrespirable Atmospheres," by Dr. J. S. Haldane, F.R.S.; (4) "The Unknown Clays in Coal Mines," by Mr. J. W. Mellor, B.Sc. The following papers will be open for discussion:—(*a*) "A Method of Measuring Goaf Temperature," by Mr. T. F. Winmill, B.A.; (*b*) "The Absorption of Oxygen by Coal," Part I., by Mr. T. F. Winmill, B.A.; (*c*) "Self-Contained Rescue Apparatus for Use in Irrespirable Atmospheres" (First Report), by Dr. J. S. Haldane, F.R.S.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The local races timed for this week have been abandoned, but the usual annual holidays are being taken, and, with offices open only in the forenoon, business is on a very limited scale. A lot of pig-iron is being taken up for home use. Traders are not disposed to commit themselves ahead to any extent, and the sales recorded are almost entirely confined to transactions for early delivery. No. 3 g.m.b. Cleveland pig is selling at 53s.; No. 1 at 55s. 6d.; and No. 4 foundry at 52s. 6d. No. 4 forge is in exceptionally heavy demand for Scotland, and, as a consequence, is very scarce, with the result that this quality is realising nearly as much as No. 3. Mottled and white iron are each in the neighbourhood of 52s. As is usual after brisk buying there is a lull in the demand for East Coast hematite pig, home consumers having apparently satisfied their needs for the time being. Makers still hold out for 70s. for mixed numbers, and report a little business at that figure, but second hands have sold at 68s. and 68s. 6d. There is not much doing in foreign ore. A few cargoes have been disposed of this week, one sale of best Rubio being at 20s. 6d., and quotations for other foreign ores are on that basis. There is much difficulty in arranging for ore-boats. A fixture, Bilbao-Middlesbrough, has this week been made at 6s. 3d. Coke is still scarce. Up to 18s. 6d. is named for bee-hive Durham blastfurnace coke of average quality, delivered at Tees-side works, but some patent cokes are offered freely at 17s. 3d.

Shipments and Stocks of Pig-Iron.—Shipments to foreign buyers are at a standstill. There are a few clearances to coastwise customers, but altogether this month's despatches of pig-iron by sea threaten to be very small. Stocks are now steadily accumulating. Makers' stores must be increasing considerably, but to what extent is not ascertainable. The quantity of No. 3 Cleveland pig in the public warrant stores here now stands at 89,972 tons, 7720 tons having been added so far this month.

Manufactured Iron and Steel.—Producers of nearly all descriptions of manufactured iron and steel are now very well off for work. Since the outbreak of war substantial contracts have been made with home customers, and orders are still coming in. Values are advancing. The following are the principal market quotations:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 7*l.* 10s.; iron ship-rivets, 9*l.*; steel bars, 6*l.* 15s.; steel ship-plates, 7*l.*; steel ship-angles, 6*l.* 15s.; steel joists, 7*l.* 2s. 6d.; heavy steel rails, 6*l.* 15s.; and galvanised corrugated sheets, 11*l.* 10s.—sheets less 4 per cent., rails net, and all other descriptions less the usual 2½ per cent.

THE UNITED STATES COAL OUTPUT.—We read in the *Iron Age* that the coal output in the United States for the year 1913 has again broken all previous records. The figure given by our contemporary is 570,048,125 net tons, or considerably more than double the output of 1900, and more than eight times that of 1880. The value of the coal mined in 1913 is given as 760,488,785 dols. (158,000,000*l.*). Compared with the year 1912, the output for 1913 shows an increase of 35,581,545 tons, or nearly 7 per cent. Pennsylvania mined more coal in 1913, both anthracite and bituminous, than in any previous year in the record of the industry. The output reached 265,306,139 tons, of which 91,524,927 tons was anthracite and 173,781,212 tons bituminous.

A HEAVY TRAIN.—The large triple articulated locomotive for the Erie Railroad, of which we recently gave a description, was submitted to a capacity test a short time ago, during which it developed a maximum drawbar pull of 130,000 lb. At a speed of 14 miles per hour, on a section in which the worst conditions were a combination of a 0.09 per cent. up-grade and 5 deg. curvature, this locomotive hauled 250 50-ton steel gondola cars, loaded, and a dynamometer car, the train behind the tender weighing 17,912 short tons. Its total length was 8547 ft., or 1.6 miles. The test was made on the Susquehanna division of the Erie Railroad. In starting the engine was assisted by pushers in order to minimise the risk of damage to the draw-gear.

THE CANNON-STREET RAILWAY ACCIDENT.—Major J. W. Pringle's report to the Board of Trade on the accident which occurred at Cannon-street, on the South-Eastern and Chatham Railway, on June 27, leaves little doubt that this adds yet one more to the list of preventible accidents; in fact, the driver of the train to which the collision was due admits that he was in error owing to an unfortunate assumption on his part. He neglected to look at an indicator placed under his starting signal at Cannon-street Station, and on getting outside accepted an advance signal which, had he attended to the indicator, he would have realised was not intended for him, with the result that his train ran into another coming in the opposite direction. This he might have avoided at the last moment had he noticed that his engine was taking a road he had not anticipated at slip-points; but he seems to have failed to notice this owing to the shouting of men who were endeavouring to attract his attention. The fault lay with the driver for his neglect of the indicator, and his error in connection with the advance signal. The guard also appears to have been attending to parcels, &c., instead of keeping a look-out on this intricate piece of line.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Inquiries have become more numerous, and exporters have shown a greater disposition to overcome any difficulties. Freights have exhibited an easier tendency, while war risks are considerably less serious, the sea being practically clear of the enemy's ships. Notwithstanding, however, the more favourable outlook, it is considered that some time must elapse before normal business can be restored, while there is some apprehension that stoppages of pits among collieries working cheaper coal will continue to be numerous. Supplies of smalls have been in excess of the demand; bunker descriptions have made 7s. to 8s. 3d. per ton, and cargo qualities 4s. 6d. to 6s. 6d. per ton. The best Admiralty steam coal has not shown much change; secondary qualities have ranged from 18s. to 19s.; and ordinary descriptions from 17s. to 18s. per ton.

Providing Employment.—The Carmarthen County Council has decided to proceed at once with the construction of a light railway from Llandilo to Lampeter. The Glamorgan County Council also proposes to proceed with new roads, bridges, and widenings. The object is to find as much employment as possible for the population.

The Tin-Plate Trade.—More tin-plate works are being brought into full operation in the Llanelly district. Messrs. Richard Thomas and Co. have started eight mills at their South Wales works. The Burry Works, owned by the same firm, also started on Friday. At the Old Castle Works fifteen mills have been started out of a total of twenty. The Western Works, the Old Lodge Works, and the Dafen Works have also resumed operations; and six mills of the Duffryn Tin-Plate Works have restarted.

Welsh Steel Rails.—Messrs. Guest, Keen and Nettlefolds have obtained orders for steel rails on Indian account. Prices have shown a sharp advance, and heavy sections now stand at about 6*l.* per ton, free on board.

Labour Disputes Subsiding.—Settlements of three disputes were arrived at by the joint sub-committee of the Welsh Conciliation Board, at an adjourned meeting at Cardiff. These disputes affected over 3500 men, who had been rendered idle. The object in view is to eliminate all labour troubles from the South Wales coal-field during the war. Hopes are entertained that other disputes may be satisfactorily disposed of; the trouble at the Ffaldan colliery was settled on Monday.

The Swansea Valley.—Business in the Swansea Valley has been unsatisfactory in consequence of the war. Collieries have been only working two or three days per week upon local orders, and there has not been anything doing at some pits. The blast-furnaces have been in full operation, and the aggregate production of pig-iron has been heavy. The tinplate trade has shown depression, but it is considered to be reviving.

BOUNTY FOR SHIPBUILDERS.—A telegram from Mr. A. F. Yarrow has been posted in his firm's works at Scotstoun to the effect that if the firm are fully satisfied with the speed of completion, when the last of the three new destroyers, Miranda, Minos, and Manly, on which their men are working night and day and on Sundays, has been handed over, 1000*l.* will be distributed among the leading hands and others.

BRITISH LOCOMOTIVE EXPORTS.—July was another good month in connection with our locomotive exports. The present war in Europe will prove an adverse influence, but account should be taken of the fact that the increased demand which has been noticed of late for our locomotives has set in from other quarters. The main cause, for instance, of the great increase in the July shipments was a much larger demand on Indian account, the engines delivered to British India during the month being valued at 213,479*l.*, as compared with 147,627*l.* in July, 1913, and 23,934*l.* in July, 1912. There was also a very encouraging demand in July for locomotives for Australia, engines to the value of 52,070*l.* being forwarded to that part of the Empire in the course of the month, as compared with 7882*l.* and 8795*l.* The gross value of our locomotive shipments in July was 347,573*l.*, as compared with 234,212*l.* and 164,073*l.*; and for the seven months ended July 31, this year, 2,431,324*l.*, as compared with 1,487,111*l.* and 1,209,934*l.*

BRITISH COAL ABROAD.—The shipments of coal from the United Kingdom in July amounted to 6,599,481 tons, as compared with 6,975,211 tons in July, 1913, and 7,041,866 tons in July, 1912. France headed the list during July of countries importing British coal, with a demand for 1,090,169 tons, as compared with 1,161,473 tons, and 1,047,511 tons; Germany took 922,088 tons, as compared with 867,036 tons and 1,000,068 tons; and Italy, 881,721 tons, as compared with 965,225 tons and 967,491 tons. The war, and regulations arising therefrom, will have a great influence upon the shipments for August. The aggregate exports of coal from the United Kingdom to July 31, this year, were 41,186,419 tons, as compared with 42,501,446 tons in the corresponding period of 1913, and 33,215,189 tons in the corresponding period of 1912. These totals are increased to 43,066,760 tons, 44,323,766 tons, and 34,516,503 tons respectively when account is taken of coke and patent fuel. They were further increased to 55,168,350 tons, 56,294,479 tons, and 44,274,901 tons by the addition of coal shipped for the use of steamers engaged in foreign trade.

GALVANISED CORRUGATED-SHEET WORKS AT EBBW VALE.

(*For Description, see Page* 248.)

Fig. 5. General View of Works looking North-East.

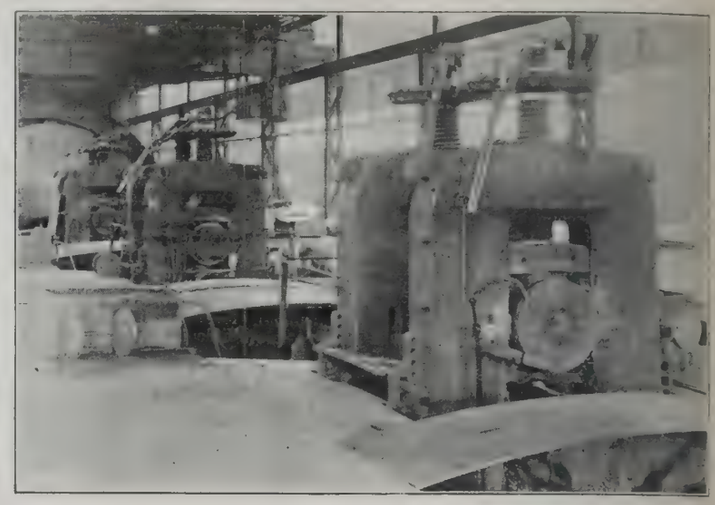


Fig. 6. View of Mills.

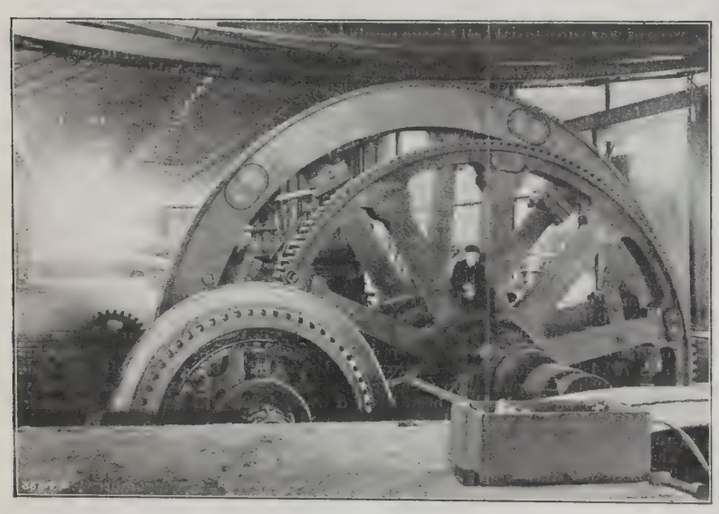


Fig. 7. Driving Gear from Motor Side.

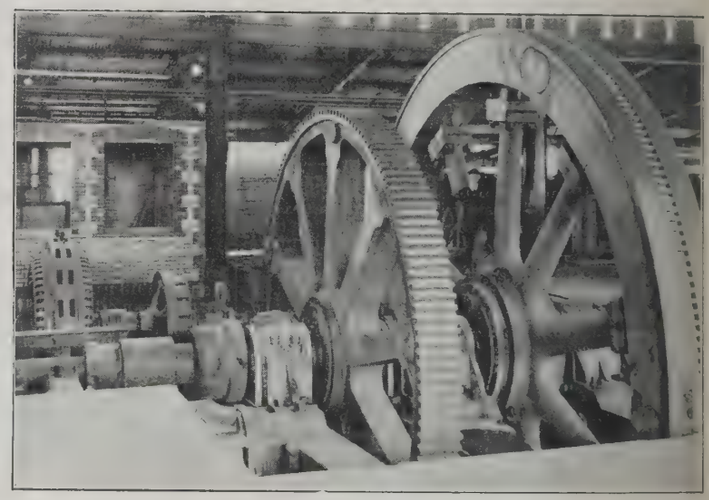


Fig. 8. Driving Gear from Front Side.

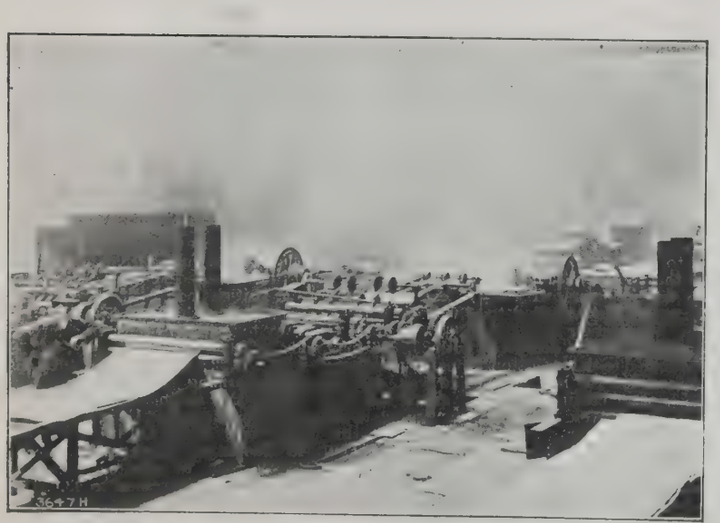


Fig. 9. Galvanising Machines.

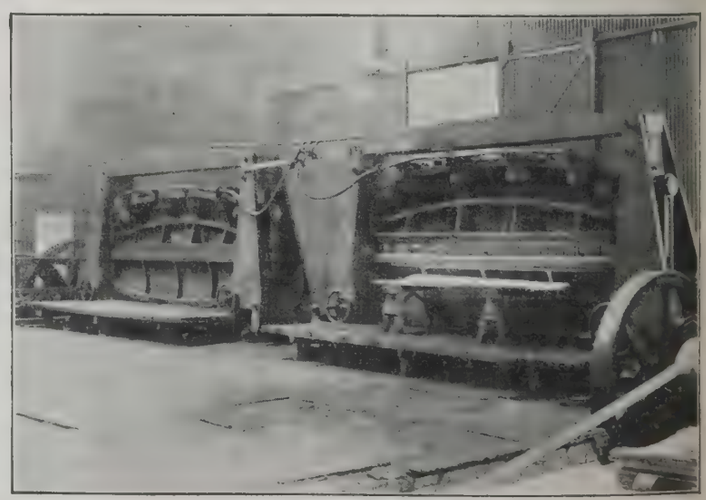


Fig. 10. Corrugating Machines.

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With a Two-Page Plate of the CANADIAN CUSTOMS' TWIN-SCREW CRUISER "MARGARET."

NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to some Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, AUGUST 21, 1914.

THE GOVERNMENT AND TRADE.

IT is only fitting that the Government should utilise as far as is possible that spirit which has so splendidly sustained the best traditions of our race during the most trying fortnight ever experienced by the present generation. With a patriotism and energy, all the greater because so silently exercised, great deeds have been done, and now the most momentous issues can be awaited with calmness, provided the trade of the country can be maintained under normal conditions. The Government has done most efficient service so far as administration is concerned, not only in connection with the defence of the Empire, but in the equally essential function of arranging for financial and commercial equilibrium during the first onslaught of a crisis of extreme gravity. The finance resources of the country have been consolidated and every emergency provided for. The Navy, by its silent yet sure service, has established command of the sea at the most crucial period of our history, and has rendered oversea traffic as safe almost as in times of peace, while the Government, by its State system of war risk insurance, has brought confidence to all shipowners and shippers throughout the world. There should thus be the minimum of interruption to industry and commerce, and the Government has wisely pointed out the advantage which must accrue from all factories being maintained at their normal rate of production. This is essential in order to ease the social condition of the people. The Commercial Intelligence Branch of the Board of Trade have therefore done well to offer guidance and help towards this end by emphasising the importance of prompt and vigorous propagandism, in order to extend our markets by the taking of every legitimate means of utilising the opportunity presented by the cessation of exports from Germany and Austria-Hungary, particularly to our Colonies.

The total exports from Germany during the six years ended 1912 increased from 312¾ to 440½ million sterling. If we take only manufactured articles, we find the increase is from 211 to 284½ million, while in iron and steel and manufactures thereof the advance has been from 35¾ million to 60 million sterling, and of machinery, including locomotives and boilers, from 17.3 to 34.8 million sterling. The Board of Trade have issued a series of memoranda on special groups of trade, in order to awaken our manufacturers to the importance of active effort, with a view of guiding them along the lines on which they could compete in the future more keenly with Germany and Austria-Hungary in neutral markets. One of the industries which has suffered most from German competition is that associated with the manufacture of electrical appliances and apparatus. Owing to the course of legislation in this country, the development of electric traction, and generally the organisation of large power-stations, was delayed and hampered, a point to which there is no need here to refer further. The result was that Continental firms, in the initial stages of the industry, gained valuable impetus before Britain took the work in hand, and we have had great difficulty in overcoming the handicap. In 1912 Germany's exports of electrical appliances and apparatus exceeded 8 million sterling. Of dynamos, our exports in 1913 were 2,269,000*l.*, whereas Germany's total in 1912 was 2,521,000*l.* In the case of electric glow-lamps the disparity is enormous, the exports from Britain being 152,500*l.*, as compared with 2,477,000*l.* from Germany. And so it is throughout practically the whole range of electrical industry. In this respect alone, it will be seen that there is a great field for British endeavour. The textile industry is one of very great consequence, even to engineers by reason of its machinery requirements, and it is found, for instance, that while our exports of cotton stockings and socks in 1913 totalled only 199,000*l.*, those from Germany totalled 3,319,000*l.* in 1912, the last year for which German export statistics are available. The United States, Argentina, France, and almost all countries in the world have been captured by Germany. Of woollen and worsted piece goods Germany's exports totalled 13½ million, and here Canada, Australia, Argentina, Japan, and British India, in the order named, account for a very considerable part of the total. In respect of cutlery our exports were 836,000*l.*, whereas Germany's were 1,747,800*l.*—double our total. In the case of iron and steel wire our exports totalled 1,058,100*l.*, and Germany's 3,176,000*l.*, or three times our total. Of enamelled hollow-ware, &c., our exports were only 531,000*l.*, and those of Germany 1,776,000*l.*—again more than a three-fold total.

The great disparity which is brought out by these Government returns of the British and German exports serves to illustrate clearly the efficiency of Germany from a commercial and industrial point of view. No one can for a single moment have doubted this efficiency, or the keenness with which commerce, particularly overseas commerce, has been pursued by the people of Germany. Time and again we have enforced this, and have sought to point the moral. Consequently there can be no base motive attributable to us in again directing attention to this question. We have contended that if we are to fight Germany in neutral markets we must adopt the German methods so far as these are essential. In the great majority of cases the superiority of our products has been recognised, but less durable and cheaper goods are obtainable from other countries. This is a fault of our qualities. We are an old nation. We seek for that substantiality which is also characteristic of the basis of our national history. We are willing to pay a higher price for a superior article because we recognise its endurance. With new countries it is otherwise; capital is not plentiful, and with a brief past there is not the same recognition of the value of durability. There is therefore, as is pointed out in one of the Board of Trade pamphlets, a tendency to sacrifice quality and durability to the temporary advantage of a saving in price. This seems, for instance, the case in connection with cutlery, and probably accounts for the fact that the German exports in this section are exactly double those of the United Kingdom, notwithstanding the unquestionable universally accepted superiority of Sheffield material. In iron and steel wire, again, where the German exports are treble those of Britain, the same holds good. In the interior of Africa and in the uplands of Australia, the purchasers of fencing-wire, whether plain or barbed, do not think that any advantage is to be gained by the superior and climate-resisting qualities of the British wires, except where they are in use close to the seaboard; so that the black wire is often preferred to galvanised wire. Thus, as our Trade Commissioner in New Zealand points out, practically any wire will last under such conditions, and people want the cheapest. The same applies throughout the whole gamut of manufactures, and the time has probably arrived when in this, as in other matters, the British manufacturer must be prepared to meet the wishes of the client. We would, however, be false to ourselves as a nation if we assumed a superiority throughout the whole field of manufactures. It is right that we should be fair to Germany. The producers of that country who have taken up new industries have profited by a study of our appliances, and, in some cases, have succeeded in achieving greater economy in production with equality in efficiency. They are therefore able to underbid us in some manufactures, assisted as they are also by the procedure of sending to foreign countries, and to Britain even, the surplus productions of their factories, against which there is not debited either establishment charges or profit. Moreover, wages are lower, hours of labour longer, and idle time less, so that, with the same, or as good, plant, the cost of production is lessened.

There are many respects in which our producers do not sufficiently closely study the particular needs of clients. We have persistently advocated that designers in engineering structures ought to utilise as far as possible standard practice, and it must be admitted that there is a sufficient range, for instance, in sections of steel bars and beams to meet all requirements. But in details we show great reluctance in meeting the specified needs of the prospec-

tive purchasers of our manufactures. There is a case, for instance, of tin-plates, where a market was lost because British mills would not roll the particular sizes of plates required for making, without any wastage, the tins needed in a South European country. As the orders were extensive, there was no justification for this refusal to comply with the client's conditions. Again, there is the question of packing goods. We know of a case where a great variety of sizes of barrels—in fact, any odd barrels which could be picked up—were used for a chemical extensively employed for agricultural purposes, and, as a consequence, not only was there immense complication in the charges for transport over-sea and inland, but there was great trouble in the retailing of the casks, because of the variableness of the volume of the contents. The Germans, on the other hand, willingly guaranteed uniformity with 50 kg. casks. The Board of Trade in their circulars make particular reference to this matter of packing the goods for transport, and generally the attractiveness of the goods. It is known, for instance, in the case of Mexico, that the Germans pack the knives, with oil paper around each, in cardboard boxes, and these again are enclosed in zinc-lined wooden cases. In the case of China preference "for German packing and boxing is said to have resulted in cutting out a great deal of British business."

Another important consideration is the representation of British firms in neutral markets; in this respect the Germans have offered an example which ought to be very carefully considered. The agencies for engineering firms ought to be in the hands of trained engineers, so that a maximum of information may be obtainable and the fullest measure of compliance with requirements assured. In other cases it is important that agencies should be placed in the hands of firms with a complete command of a whole country, or a large section of it, so that the field of operations may be very extensively covered. In this way there would be attained a greater selling force, resulting, as is pointed out in one of the Government reports, in greater economy in handling and a more energetic method of marketing. Where repeat articles or small articles are supplied, the agent ought to have some guarantee of continuity or fixity of price, so that the purchaser could indicate his need periodically with some surety that the prices would be constant. In all cases the quotation made should conform with the monetary conditions of the country, and not necessarily be in English notation. This also applies to language in the case of foreign countries. Again, quotations should be made to include all charges. The Germans have made a special feature of quoting "ex-warehouse," which includes all duty and port dues. These efforts towards simplifying purchase operations by clients in colonial and foreign markets are of incalculable advantage, and those who conform to them invariably profit immensely. They involve, we admit, a certain measure of intelligence and care in the commercial departments of our industrial establishments, but we are convinced that with the extension of commercial education, the requisite posts can be filled by capable men, with immense advantage to the export trade of the firm and of the country.

The State has also a duty in this matter of increasing the area of British markets. The Commercial Intelligence Department of the Board of Trade, who are undertaking the new campaign, have done useful service in the recent past, and they will, we doubt not, increase their efforts. But much more can be done, particularly in the ensurance of favourable conditions for transport and for a greater measure of financial assistance in co-operation with the British and Colonial banks. On former occasions (see Engineering, vol. xcii., page 801) we have referred to the assistance rendered by the more liberal banking conditions in Germany, and we see no reason why similar help should not be given by our banking and financial institutions in connection with the foreign and colonial work of our industrial firms. Britain has wakened from a state of complacency in many matters, and we hope that one result will be that the banks will, without in any way jeopardising that safety which is so pronounced a feature of their organisation, see their way to give more liberal consideration to what is, after all, a safe speculative business—the promotion of export business on easy terms. Regarding transport, we regret that some of the shipping companies are dealing very hardly by the shippers, especially at the present juncture. Had the British Navy not maintained the command of the sea, and had the British Government failed to insure war risks by direct financial help, there might have been some reason for heavy freight charges at the present moment; but war risks having been minimised or greatly reduced, the duty of the shipowner to-day is to cast in his lot with all who are doing everything in their power to maintain normal industrial conditions.

THE BALTIC AND BLACK SEA CANAL SCHEME.

The project for joining up the natural waterways between the Baltic and the Black Sea by the construction of artificial connecting channels has recently made an important advance. Although primarily intended for the development of commerce, the strategic value of such a connection between the great seas to the north and south of Russia will not be lost sight of, in view particularly of the demonstration of the value of the Kiel Canal in the German scheme of naval tactics. Thus, an impetus will be given to the Russian project, which cannot be without great influence on the present study of the report of the Government Commission appointed to investigate the whole subject. This Commission, which was appointed by the Duma and Senate four years ago, while intended to make a comprehensive survey of the whole scheme of internal navigation in Russia, was required to give primary consideration to the Baltic and Black Sea Canal scheme, and particularly the proposal to construct locks to circumvent the rapids on the great southern river, the Dnieper, which rapids at present check the complete utilisation of this great natural waterway, piercing northwards from the Black Sea into the very heart of European Russia. With its tributaries it affords navigable channels of nearly 4000 miles, excepting for the obstructing rapids near the mouth. The canalisation, for moderate-sized ships, of a connection between the river north and south of these rapids, now decided upon, must itself have a very important influence on the internal trade of Russia, apart altogether from the advance which would thereby be made towards the realisation of the main project of water communication between the Baltic and the Black Sea.

A study of the map of Russia shows that the rivers of European Russia flow over great, broad plains between the two ranges of the Carpathian Mountains in the west and the Ural Mountains in the east, and that between the Baltic and the Black Sea two of the principal rivers are the Dnieper and the Dwina, the former, as we have said, flowing into the Black Sea at Kherson, and the latter into the Gulf of Livonia at Riga, and thence into the Baltic Sea. These rivers, too, are navigable for small craft for great distances into the interior, although in the case of the Dnieper there are rapids, owing to the great step-like formation, between the towns of Ekaterinoslav and Aleksandrovsk, some 200 miles from the mouth of the river, and in the case of the Dwina in the last 100 miles or so from the mouth to Jacobstad. As will presently be explained, there are projects for instituting electric-power generating-stations at the falls in both instances; but the necessity for navigation will be the primary consideration, the harnessing of waterfalls being subsidiary and contingent upon the requirements of shipping.

The sources of the two rivers at the "divide" are not far apart, and the idea of connecting them by artificial waterways occurred to Peter the Great, who called in a Dutch expert to make a survey of possible routes through which canals could be constructed. Catherine II. supported this work of survey, but it was not until Russia had absorbed the Polish provinces that any material progress was made with the project. The canals then made, early in the last century, were intended for flooding purposes, and not really for shipping. Within the last twenty years, schemes for a deep canal without locks have been worked out, but the authorities considered the scheme impracticable from the financial point of view. Ultimately, as the result of private initiative, a company was formed and laid a scheme before the Government for the construction of a waterway free from locks, and with a depth throughout the navigable channel of 14 ft. The main aim was to develop interior trade, and at the same time to afford a means of transit for merchandise passing through the Suez Canal to the countries on the shores of the Baltic and the Baltic Sea ports. It was proposed in this project to use large boats with motors, which would receive the goods at the terminals of the canal and deliver them either on the waterway or to large ocean-going vessels at the other end. At the same time the strategic value of the canal was recognised, but the scheme did not then meet with sufficient support. Now, however, owing to the more liberal constitution which has been introduced into Russia, and when more attention is being devoted to trade and commerce, there is greater prospect of the Government recognising the value of such an opening up of the natural resources and industrial potentialities of the interior of European Russia. Last year a large number of members of the Duma took the initiative for the actual completion of the Baltic-Black Sea Canal; they urged that exhaustive plans of the entire waterway, at the instance of the Public Works Department, should be ready at the beginning of 1914, and that from next year the Budget of this department should contain annual grants sufficient for the completion of this waterway in the course of five years.

The scheme which commends itself is that to which we have already referred—namely, the joining of the upper waters of the Dnieper and the Dwina, thus connecting Kherson, on the Black Sea, with Riga, on the Baltic. The length of such a waterway would be about 1540 miles. The Dwina extends southward from the Riga port on the Baltic for a distance of 625 miles. Formerly there was a very extensive use of this waterway for barges, of which 21,000 annually traded to Riga with corn and other products from the upper reaches of the river. These barges had a carrying capacity of about 225 tons, and were carried down with the stream when the melting snow created a spate, but they were of little use for carrying supplies up country. Railway competition soon killed this method of transport, and now sailing vessels of from 10 tons to 80 tons or 90 tons capacity are used, and are navigated in both directions. Under these circumstances, the traffic has not increased greatly (except for the floating down of timber, to be made into rafts for shipment at Riga). In the upper reaches, however, for a distance of some 380 miles or so, steamers are in use, while for 940 miles, in tributaries and in navigable channels connected with the River Dwina, small steamers can be navigated. The river, from Vitebsk to Riga, a distance of about 370 miles, has a total fall of 348 ft., but the greater portion of this, as already indicated, is in the lower part of the river. The proposals for three hydro-electric power-stations—one of 4000 horse-power and two of larger power—have been made in association with the canal parallel to the rapids; but, as has already been indicated, these will be subject to the main idea of making a canal through to the Black Sea. It may be said that from the upper Dwina a waterway debouches and communicates with St. Petersburg, but no survey has been made, although it is understood to offer no special difficulty in the way of development for navigation.

It is proposed to make a connection between the upper navigable part of the Dwina and the upper navigable part of the Dnieper, not by using the abandoned canals made 110 years ago, but by following the course of a tributary of the Dwina and one of the Dnieper near the watershed, which is some miles to the west of Smolensk. In the uplands there are two lakes which would be most useful for the feeding of the canals on each side of the water divide. The level of the water of the Dwina at Vitebsk is about 70 ft. lower than that of the Dnieper at the most suitable point of junction. The distance between the rivers to be canalised is under 60 miles, and the proposal under consideration provides for three locks for the Dnieper and eight for the Dwina from the highest point. The cost of this canal, with wooden locks, is estimated at about 19 million roubles, and with stonework locks 6½ million roubles more.

The Dnieper, which is the third largest river in Europe, the Volga and Danube excelling it, has a length of nearly 1350 miles, and in its course there is a population of something like 20,000,000. With the tributaries the total waterway is nearly 8000 miles, of which about one half is navigable for small vessels. The products of the district are corn, timber, ore and coal, and undoubtedly there would be a great development of the natural and mineral wealth were the route to the sea im-

proved. The obstacle, as we have mentioned, is the rapids between Ekaterinoslav and Aleksandrovsk. The largest vessels using the river below the rapids have a capacity of about 1000 tons, and more than 300 steamers and 1200 sailing craft are engaged in the service. Above the rapids the river, so far as it is to be used on the route, from sea to sea, is navigable for a distance of over 800 miles, and beyond this it is proposed to use the Beresina and the new canals already referred to. The Beresina is about 260 miles long and has a fall of about 90 ft., and it is proposed to canalise this portion with fourteen locks. Beyond this, as already indicated, there will be the canals connecting with the Dwina River, flowing into the Baltic. Although in the upper navigable part of the Dnieper there is a fall of 200 ft. in 560 miles, it is thought that it would be practicable to make it navigable for larger vessels without locks, by means of regulation works and dredging. For 160 miles of the distance in the upper navigable region of the Dnieper, sandbanks are experienced, and regularisation and dredging will have to be extensively done; for the next 270 miles the principal work would be the consolidation of the banks, and for the remaining 130 miles or so to the rapids there is granite. Then come the rapids, the river breaking through a granite ridge. The fall in a length of 40 miles is 90 ft. Timber is floated through here, but the river is impossible to navigation, except at spates. Recently projects have been proposed for the harnessing of the water power, and a commission was appointed to investigate the subject. The plan now proposed is to build at the foot of the rapids a dam of granite, with Portland cement mortar. The canal for the passage of ships—parallel to the river, but independent of the flow to the turbines—is to be 90 ft. wide at the bottom, with a minimum radius of 1500 ft.; the depth of water is to be about 7 ft., and the canal is to be constructed of brickwork where it does not pass through the natural rock. The locks are to be made in pairs alongside each other, and to accommodate two vessels of 180 ft. long, with a tugboat of 120 ft. long. The cost of the work in connection with the navigation is calculated to be between 27 and 28 million roubles. The water-power part of the undertaking is designed for three power-stations with vertical reaction turbines; the aggregate capacity throughout the whole year is calculated to be 100,000 horse-power. The current, of 5000 volts, will be transmitted to the distributing stations in the vicinity of Ekaterinoslav and as far as Nishni Novgorod. A French syndicate is understood to have just made an offer to the Russian Government to undertake the construction of the locks and hydro-electric power-stations on the Dnieper.

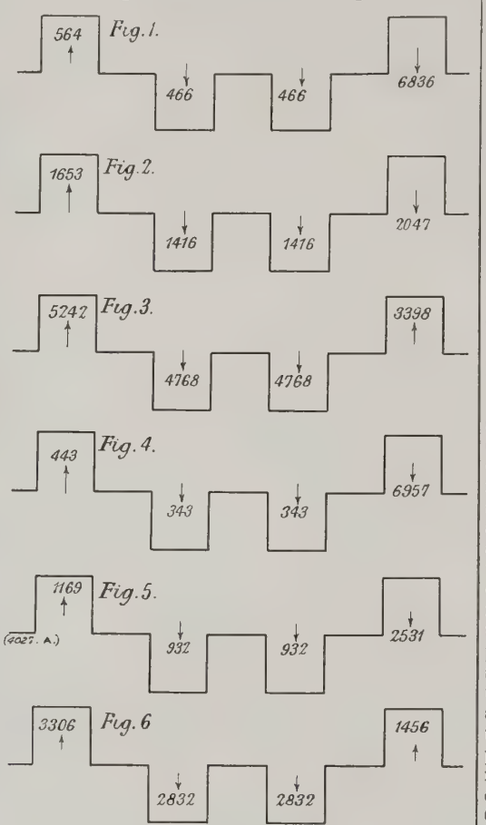
The funds for the improvement of the Dnieper River from the mouth at Kherson to the falls were voted some four years ago, and the work is probably completed by this time. The actual commencement of the work, through the medium of the State, of an undertaking comparable with that of the Siberian railway, will, if decided upon by the Duma, be of great advantage to the commerce and industries of Russia. Mr. A. Pabst, harbour engineer in Riga, who has for years been deeply interested in the movement, and on whose recent lecture on the subject our article is based, is to be congratulated on the progress of the propaganda work.

THE EFFECT OF ENGINE SPEED ON THE WEIGHT OF PETROL-ENGINES.

A question of great interest at the present time is the engine speed which will give the lowest weight per horse-power for the ordinary petrol-engine. In all self-moving machines the weight is a matter of the greatest importance, yet we find that the speed of revolution adopted for different classes of petrol-motors varies a great deal. Thus for motor-cars and motor-cycles in Europe very high speeds are used, while in the United States more moderate ones are adopted, and in aeroplane work, where the weight permissible is smaller than in a car, still lower ones are usual. It is interesting therefore to compare the results obtained by adopting different speeds.

In making any comparison of different methods of construction it is obvious that a given standard of durability must be assumed, as otherwise the comparison is useless. We can always reduce the weight of any machine by cutting down the factor of safety and the margin for wear; hence it is of no use to compare two different constructions unless they have the same margin in these respects.

In considering the effect of the speed on weight, it must be remembered that the cylinder-barrels are usually not by any means the most important part of the engine. Thus even in the actual cylinder casting the valve-seatings and valve-chests, &c., usually weigh more than the actual cylinder-barrels. In the case of the ordinary vertical engine, however, the cylinder casting is by no means the only heavy part, the crank-chamber, crank-shaft, and bearings making up a very large part of the total. The sizes of these depend entirely on the pressures on the bearings, and can therefore be made lightest where the pressures are smallest. The relative importance of the various parts depends on the arrangement of the engine. Thus in the radial type the crank-shaft and case is relatively small compared with the cylinders, and therefore the gain from reducing the latter should be the greatest.



At first sight it would appear that the smaller the cylinders and the higher the speed, the lighter the engine would be per horse-power, and up to a certain speed this is undoubtedly the case. By reducing the size of the cylinders the explosion pressures are reduced, and therefore the various parts can be made lighter. Even if the pressures due to the explosion are the only ones considered, however, the reduction in weight is not in proportion to the increase in revolutions, for two reasons. In the first place, the valves must be the same size for a given power whatever the speed, and therefore there is no saving in weight either in the valves or valve gear. In the second place, the rubbing speed of the journals increases, and therefore their area cannot be reduced in the same proportion as the load. As the size of the crank-case and length over the cylinders is largely determined by the length required for bearings, this means that these parts cannot be reduced in proportion to the reduction in cylinder size.

When really high speeds are used, however, the question is still further affected by the growth of the pressures on the bearings due to the inertia forces of the moving parts. It must be remembered that the petrol-engine is, in this respect, in a very different position from that of the steam-engine. In the latter, every stroke is a working one, and it is possible to arrange that there should be enough cushioning at the end of every stroke to bring the moving parts to rest without this having to be done by pressure on the brasses. The ordinary four-stroke petrol-engine, however, has only one working stroke out of every four. During the other three strokes, therefore, the reversing of the motion of the piston must be effected by the connecting-rod, and this produces heavy pressures on the various bearings. We see the result of this if we consider the case of an engine, with cylinders of given dimensions, run at gradually increasing speeds. Presuming that the valve area is increased in proportion to the speed, the horse-power will go up practically as the speed, and although the valves and valve-gear will have to be made larger, the extra weight of these will not be very great. The weight will thus not go up anything like as much as the horse-power, and the engine will therefore be lighter per horse-power, as long as the inertia forces are ignored. The latter, however, go up as the square of the speed, and at high speeds the pressures due to them greatly exceed those due to the explosion pressures. In this case the strength of the crank-shaft and other parts must be increased to take the stresses, while the bearings must be greatly increased in area to take the pressures. As the rubbing speed is greater, the bearing pressures per square inch must be lower; hence it is evident that the area of the bearings must increase in a ratio above the square of the speed, and there will be a point beyond which the increase in weight will be greater than the increase in horse-power, and therefore the engine will get heavier per horse-power.

Another point which affects the question is the compression pressure used. With a moderate-speed engine a moderate compression can be used, but with very high-speed engines a very high compression must be used in order to get the charge to burn in the available time. The mean pressure during the working stroke is not materially raised by a very high compression, but the maximum explosion pressure is raised considerably, and must be provided for.

We can see the relative effects of the explosion and inertia forces by comparing three engines of the same power, but with different sized cylinders and running at different speeds. Thus, for the sake of example, we may take a moderate-speed engine, with cylinders 4 in. by 5 in., running at 1500 revolutions. Such an engine should develop about 40 brake horse-power. To compare with this we may take an engine running at half the speed and one running at twice the speed—*i.e.*, 750 and 3000 revolutions per minute respectively and all giving the same power. In order to simplify the comparison it is convenient to assume a constant stroke and a varying cylinder diameter, and in this case the cylinder diameters will be 5.66 in. and 2.83 in. for the low and high-speed engine respectively. We may assume that the reciprocating parts of the engines weigh 7 lb., $3\frac{1}{2}$ lb., and $1\frac{3}{4}$ lb. respectively, and that the rotating parts of the crank, lower half of the connecting-rod, &c., weigh 6 lb., of which half is the crank-pin and effective parts of the webs, and half the big-end brasses and lower half of the connecting-rod. Also we may assume an explosion pressure of 300 lb. per sq. in. These are only assumptions, but are sufficiently in accordance with ordinary practice for the purposes of comparison.

Calculating out the explosion and inertia forces, Figs. 1, 2, and 3 show the forces acting on the crank-pin to produce bending stresses on the shaft and pressures on the main bearings. We see that in the extreme low-speed engine the maximum force on the pin is 6836 lb., due to the explosion pressure. In the moderate-speed engine this is reduced to a maximum of 2047 lb., partly owing to the reduction of the cylinder area, and partly to the increased inertia of the parts which acts against the explosion pressure. On the other hand, when we examine the forces on the shaft of the extreme high-speed engine, we see that the maximum force on the shaft is 5242 lb., and is due to the inertia forces at the end of the exhaust stroke.

The size of shaft necessary for strength is determined by the forces acting on the crank-pin and the length between the main bearings. The latter depends very largely on the length of the crank-pin brasses; and this, again, on the pressures acting on them. Accordingly, Figs. 4, 5, and 6 show the pressures acting on the crank-pin brasses of the low, moderate, and high-speed engines respectively. It will be seen from these that the maximum pressure on the brass is 6957 lb. in the case of the low-speed engine, and is due to the explosion pressure. This falls to 2531 lb. in the moderate-speed engine, but rises to 3306 lb. in

the extreme high-speed one, owing to the inertia forces. In considering the effect of the pressures on the size of bearings necessary, it must be remembered that the area depends not only on the maximum pressure, but on the mean. Thus the pressure due to the explosion only occurs for a very short time at the end of each stroke, while the pressure due to the inertia of the reciprocating forces comes at the end of three strokes out of four, and the pressures due to the centrifugal forces act all through the revolution. It must also be remembered that in the low-speed engine, increasing the size of the bearing does not increase the pressure on it to any great extent. In the high-speed engine, on the other hand, the very fact of making the big-end larger increases its weight and therefore the centrifugal force. In addition to this, larger area per unit of load should be allowed for the high-speed engine, on account of the greater rubbing speed.

When these points are considered, it will be seen that the big-end bearings in the extreme high-speed engine will have to be very much longer than in the case of the moderate speed, and probably quite as long as in the extreme low speed. To keep the stresses uniform, the crank-shafts will have to be much in the same proportion. Owing to the extra weight of the crank-pins and big-ends, the actual pressures on the main bearings of the high-speed engine will be greater than shown on the figures, and they will therefore have to be proportionately large. It will be seen that the middle bearing has to carry very heavy pressures indeed at the bottom of the stroke of the two middle cylinders, the two end-bearings having corresponding upward pressures ; these conditions being, of course, reversed each half revolution. This explains why the middle bearing of the ordinary three-bearing engine has to be made of such great length in a high-speed engine.

The above considerations conclusively show that there is a very definite speed which will give the lightest engine, and that if the speed is increased beyond this the weight will increase at a very rapid rate, or the durability will suffer. In order to ascertain the exact speed which will give the best results the conditions should be carefully studied, and the probable weight of the parts determined with fair accuracy. Curves of the pressures and stresses can then be made which will give the desired information. The best speed will depend on the construction of the engine and the standard of durability desired, and, other things being equal, will be lower the greater the standard of durability assumed. It is, however, noticeable that the large majority of successful aeroplane-engine builders keep the revolutions below 1500, although the standard of durability required in an aero-engine is very low.

So far we have ignored the effect of the fly-wheel weight, and have only considered the running at full power. This fairly represents the condition of an aero-engine, but in motor-cars and cycles other points come in. Taking the latter vehicles first, a large proportion of them have single cylinders, and therefore the fly-wheel forms a very considerable part of the total weight. Further, it is often enclosed in the crank-case, whose weight, therefore, depends on the fly-wheel diameter. In this case a high speed is necessary in order to keep down the fly-wheel size. Even here, however, it is probable that the high-speed engine may be overdone, for while the power got out of a given sized cylinder is increasing, the weight of motor-cycles has also increased enormously.

In considering the best speed for a motor-car engine two fresh factors come in. Firstly, the engine must be capable of being run over a considerable range of speed ; secondly, it runs most of its time very much throttled, owing to the fact that it is now desired that a car should be able to climb considerable gradients on its top speed, and therefore a very considerable margin of engine power is provided for this.

The fact that a large range of speed is required favours the high-speed engine, as a large fly-wheel is required to make a very large engine run slowly. This will, however, be less for the six and eight-cylinder engines than for the four. On the other hand, the fact that the engine is largely run throttled favours the low-speed engine, from the fact that the explosion pressures are reduced, while the inertia forces remain the same. This has a very great influence, as will be seen from the fact that in a car with a fair reserve of power, the engine usually works at about a quarter of its possible power. The explosion pressure does not fall quite in proportion to the mean pressure, but it is probable that the greater part of the time, in an engine of the power assumed, it would be below 150 lb. per sq. in. Hence Figs. 7, 8, and 9 show the forces on the crank, and, therefore, on the main bearings at this pressure, the same sized cylinders and revolutions as before being assumed. It will be seen that in this case the maximum is 3136 lb. in the low speed, 1653 lb. in the medium, and 5242 lb. in the high. Further, the mean pressures of the latter are enormous, while in the low-speed engine they are very low. It is therefore probable that the extreme low-speed engine could be built very nearly as light as the moderate speed engine, and a great deal lighter than that with the extreme high speed.

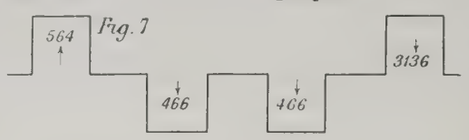


Fig. 7

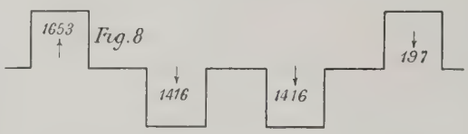


Fig. 8

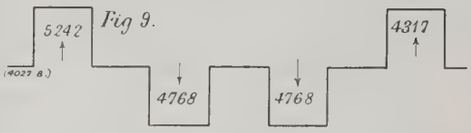


Fig 9.

When we consider the practical advantages of the different types, it will be seen that they all lie with the low-speed engine. Thus the noise of both engine and gear is less, and the difficulties of keeping the engine in tune much less. Hence it is evident that the engine speed should be as low as is consistent with lightness. Taking it all round, therefore, it appears that the motor-car engine should not run at more than about 1500 revolutions per minute when giving its maximum power. As the majority of people desire to drive at a moderate speed, but to have a reserve of power for a spurt, if necessary, this means that in ordinary running it will run at about 1000. This is about the speed used by the majority of American makers of small cars, and although European builders get the same powers out of much smaller cylinders, it is noticeable that for a given actual power and carrying capacity, their cars are considerably heavier as a rule. This matter is of great importance, in view of the very great extension of the American motor trade. Price is only one factor of their sales, the really important point being that their cars are light for their power and quiet ; both these advantages coming largely from the use of the moderate-speed engine.

NOTES.

The Panama Canal.

Steamship service was inaugurated through the Panama Canal on the 15th inst., without, however, any great international ceremony. The first vessel to make the trip was the United States War Department steamer Ancon, on board which were a number of officials and guests, including Colonel Goethals, Governor of the Canal Zone, President Porras, of the Republic of Panama, and others. We regret to note that the closing stages of the work have been marred by one of the worst accidents during the construction of the canal by the United States. The loss of life through accidental explosions has been very small in view of the magnitude of the undertaking. In the Central Division, for instance, though over 23,000,000 lb. of dynamite were used in four years, only eight men lost their lives, and these in the course of handling the material, and not through premature explosions. On July 20, however, a premature explosion occurred at the foot of the Cucaracha, where the drill barge Teredo was at work, resulting in the sinking of this barge in about 30 ft. of water and the loss of three lives, with injury to fourteen men, two others being reported missing. In the eighth article of the series in Engineering, describing the Panama Canal, we gave an illustration and description of this drill barge.* The barge measured 112 ft. by 36 ft. 8 in. and was provided with four timber spuds, and originally had three drill frames, 38 ft. high, on each of which was mounted a 5½-in. rock-drill. Subsequently the barge was equipped with six drills. The casualties were due to the wrecking of the barge subsequent to the actual explosion. A group of eight holes, which had just been drilled in submerged rock, were being charged, when an explosion occurred in the last one to be filled. The whole lot were detonated. The Teredo tilted to one side and sank. The prompt action of two men averted a much worse explosion. On the first signs they cast off and pushed away a barge containing the store of dynamite. This drifted far enough away to get out of the danger zone, and the store was, fortunately, not exploded. It was found impracticable to raise the Teredo, which has, therefore, been cut up and removed in pieces. The barge has been cut by exploding on it lengths of old hose filled with dynamite, fairly clean cuts along the line of the hose being made by this means.

* See Engineering, vol. xcvii., page 40.

Electric Furnaces of Uniform Temperatures.

When the tubular electric furnace was introduced, it was claimed that the difficulty of maintaining a uniform temperature throughout a furnace was easily solved when tubes were wound with wire or ribbon resistance. But it was soon found out that, for accurate scientific research at any rate, the problem was far from being solved. Even when the wire coils were crowded near the tube ends, the temperature at the ends was not the same as in the middle, and in wide open tubes the temperature was by no means constant in a vertical section through a horizontal tube. Probably the best results were obtained by C. W. Waidner and G. K. Burgess at the Bureau of Standards, Washington, by providing a second independent heating coil surrounding the first, and making it project beyond the tube ends. They succeeded by trial only, however, and the uniformity obtained for one temperature—say 1300 deg. Cent.—necessitated a new laborious rearrangement of the coils to secure uniformity again at some other temperature. In Scientific Paper No. 219 of that Bureau, A. W. Gray describes experiments and furnaces in which he realised a most remarkable uniformity of temperature—as perfect almost as the reliability of the thermo-couples permitted of measuring—though only at temperatures up to 700 deg. Cent. so far. In his first experiments he tried the effect of plugging the tube with plugs of considerable length. He took a brass tube, heated it by circulating hot oil on the counter-flow principle through a double jacket, formed by an inner and an outer coil, and plugged the ends with blocks of a heat-conductor, separated by a layer of a poor conductor. The results were very satisfactory. In a furnace specially designed for determining the thermal expansion of metals he then filled the tube practically with a cylindrical block of iron, which was pierced by an upper and a lower square cavity, both horizontal, the one to receive the bar under test, the other to receive a dummy bar ; the tube ends were plugged, and thermo-couples were introduced through the plugs into the two bars. The furnace was heated by a coil wound on its surface. In the second and most recent electric furnace described, which was of similar construction, he surrounded the furnace-tube proper by two concentric tubes, between which the resistance was placed between layers of insulators, and packed the wide outer space between the second tube and the furnace-shell with magnesia and asbestos. The method of winding is novel. The nichrome ribbon is woven into a kind of mat, together with strips of micasbeston (an insulator consisting of mica flakes and a resinous cement pressed into thin flexible sheets) ; the nichrome strip runs longitudinally forward and backward, being folded over at the ends, and the insulator strips run circumferentially. This method of winding is non-inductive and has several advantages. The thermo-couples of platinum and platinum-rhodium are encased in a tube of glazed porcelain, and the wires are kept apart by tubes of unglazed porcelain (within the first tube), and further away by glass tubes which are joined to the porcelain by tees of brass or copper, to impart a certain flexibility to the joints ; the glass tubes are filled with melted paraffin, and spare wires for lengthening or for replacing the connections are coiled around the glass tubes. Thus fitted up, the furnace was fairly satisfactory as regards uniformity of temperature ; but

there was always a drop of temperature within the plugs, which take up a good deal of the tubular space, and beyond them until flat heating coils were placed on the front faces of the plugs (in planes at right angles to the axis of the tube). These flat coils have proved a great improvement. The paper gives full details concerning some points, but not about all. It is mentioned, for instance, that the uniformity of the temperature in the oil-heated furnace was much impaired when the plugs were replaced by plugs of equal lengths of cork or cotton-wool; but the material of the original plugs and of the poor conductor blocks between them is not stated. It is also said that the electric furnace, which has a length of 74 cm., takes a long time to heat up; particulars as to time and current are not given, however.

NOTE ON THE DISTRIBUTION OF PRESSURE AROUND CYLINDRICAL RODS AND BODIES WHEN EXPOSED TO UNIFORM AIR-CURRENTS.

By A. P. Thurston, D.Sc., F.R. Met. Soc., A.F. Aë. S.

During the last few years the author has carried out many experiments on the distribution of pressure around various bodies placed in a current of air. A few of these experiments have already been published in these columns* and elsewhere.†

In response to a special request further particulars are now given of the experiments relating to the distribution of pressure around cylindrical rods and bodies when exposed to uniform air-currents of various velocities.

It is known in a general way that an air-current exerts a pressure on the front of a bar or body placed in it and a suction on the rear portion, and that dead-water regions are formed in the front and rear. Nevertheless, when the pressure at every point on the body is obtained by experiment and plotted, the results are often most unexpected. It is so to some extent with cylindrical bodies.

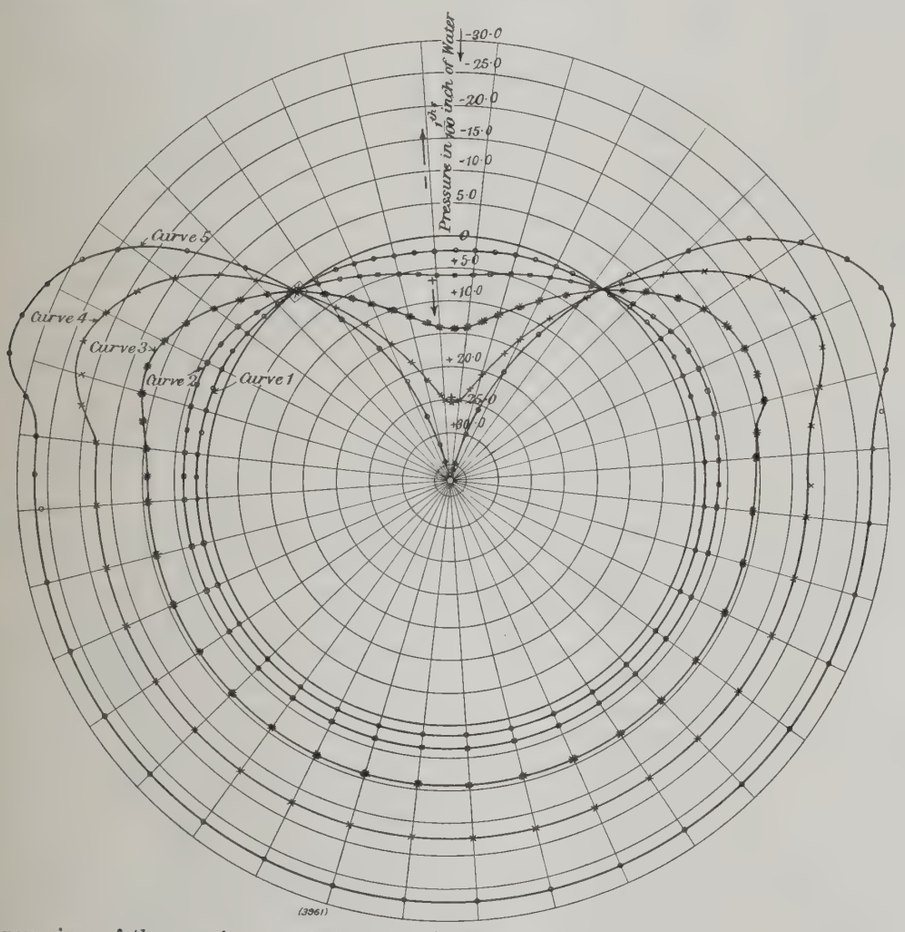
Curves of the pressure distribution around a cylindrical body are shown plotted in the figure above for five different velocities. The periphery of the body is taken as the datum line, and compression is measured radially inwards and suction radially outwards. The readings are in hundredths of an inch of water.

The experiments were made in the following way: A hollow circular rod 0.832 in. in diameter was taken, its ends were sealed and a small hole $\frac{1}{50}$ in. in diameter was drilled in the centre. This tube was placed in a wind tunnel with its axis at right angles to the direction of the air current. One arm of a micromanometer or tilting-water gauge was connected to the interior of the tube and the other arm of the manometer was connected to the static member of a Pitot tube placed in the tunnel. The pressure of the air at the point occupied by the small hole could therefore be determined. Means were provided to allow the rod to be rotated, and a pointer outside the tunnel indicated the number of degrees through which the rod had been rotated. The pressures at the various angles were noted, and are plotted in the radial diagrams in the figure.

If it be assumed that the pressure indicated by the manometer, when the hole in the rod is normal to the air, is the same as that given by the dynamic tube of a Pitot tube, then the velocity of the air is given by the well known equation :—

$$v = \sqrt{2\,g\,h},$$

where v is the velocity in feet per second, h is the pressure in feet of air at the statical temperature and pressure of the air in the tunnel; g is the acceleration due to gravity.



From this equation we find that the velocity of the air for the five curves is as follows :—

Curve.	Velocity in M.P.H.
1	6.2
2	10.8
3	17.0
4	23.0
5	27.4

A butterfly diagram is obtained for every velocity when the pressures are plotted in the manner previously suggested. It will be noticed that in all cases the portion of the rod which is subjected to compression subtends an angle of 78 deg., or 39 deg. on either side of the centre line. Thus a large portion of the bar on the side facing the wind is actually in suction. It will further be noticed that the maximum suction occurs on the side of the bar which faces the wind, and at about 70 deg. on either side of the centre. The curves appear to be of similar shape for every velocity within the range of the experiments. Thus the maximum compression is always in the centre line of the side of the bar facing the wind, the points of zero pressure coincide at 39 deg. on either side of the centre line, and the maximum suction is at 70 deg. to either side.

The author has already pointed out in these columns* that the resistance of a circular bar does not vary strictly as the square of the velocity. M. Eiffel, in a very interesting paper,† has also shown that, at a certain critical velocity, the resistance of a sphere suddenly fails, and that this critical velocity varies with spheres of different diameters, the critical velocity increasing inversely as the diameter of the sphere. Thus the critical velocities were found to be 12, 7, and 4 metres per second for spheres of diameter 16.2, 24.2, and 33 centimetres respectively. In the case of the smallest sphere a critical speed was found at which, as the velocity of the air increased, the resistance diminished. From this he concludes that there are two systems of flow according to the velocity. He also states that the law of the resistance varying as the square of the velocity only applies for velocities higher than the critical velocity.

Professor Morris has shown‡ that the disturbance produced by a rod of 0.825 in. diameter in a current of air covers a much larger area in the case of a small velocity than in that of a high velocity. It would also appear to follow from the author's experiments on the resistance of bars and wires,§ and from the above experiments of Eiffel, that the smaller the wire or rod the greater is the area of disturbance produced since the resistance per unit subtended area increases as the diameter decreases.

Thus it would appear that the form of flow around a circular bar varies both as the diameter and as the velocity. Nevertheless, from the diagrams shown in the figure for velocities ranging from 6 to 27 miles per hour, the general shape of the curves of pressure distribution appear to be substantially similar. It would be interesting to obtain a corresponding series of pressure-curves on spheres and circular bars in the neighbourhood of their critical velocity, and also a series of curves around large circular objects, such as lighthouses, factory chimneys, gasometers, and the funnels of steam-vessels in a high wind, to see if the general shape of the distribution-of-pressure curve changes at the critical velocity or for very large bodies. There is reason to suppose, however, that the shape of the distribution-curve does not vary very greatly as the velocity or the diameter increases.

The Electrical Industries in Japan.—In an article on this subject, the *Scientific American* says that motors, generators, and transformers are built in Japan in large quantities, to meet a very great demand, which increases every year. Carbon-filament lamps are made in the country in a satisfactory way, though some difficulty is experienced in making them for 220 volts, and the filaments of superior qualities are all imported. Porcelain insulators are manufactured in Japan, leaving no room for importation, as suitable raw materials are plentiful; but the making of straight and uniform tubes seems to be limited to the length of about 30 cm. (11.8 in.). Ammeters, volt-meters, and kilowatt-hour meters are largely imported.

The Copper Market.—In their report, dated the 17th inst., Messrs. James Lewis and Son state that the Metal Exchange has been closed during the past fortnight, and no official transactions in standard copper are recorded, though privately 59*l.* to 60*l.* is reported to have been paid for cash, and 61*l.* for three months prompt. Sales of electrolytic at 70*l.* to 72*l.* per ton ex-warehouse are reported, manufacturers of ammunition being in urgent need of it. In New York it is quoted 12⅝ to 12¾ cents per pound. It is stated that in order to maintain prices there will be a considerable reduction in the output of some of the American mines, so as to obviate the accumulation of large stocks by refiners. The shipment of copper to Germany being at present stopped, the average monthly quantity of about 20,000 tons would either have to be retained in the United States or shipped to England and France, increasing the stocks in these countries correspondingly unless production is curtailed. No return of American refiners' statistics for the month of July has been received, and it is said that none will be issued during the war. We are evidently to be kept in ignorance of the position there. No statistics have been received from France or Germany.

* See Engineering, August 8, 1913, Fig. 13, page 181.
† *Aeronautical Journal*, July, 1913.

* See Engineering, January 30, 1914.
† *Comptes Rendus*, No. 27, December 30, 1912.
‡ See Engineering, August 8, 1913.
§ See Engineering, January 30, 1914.

LITERATURE.

Engineers' Costs and Economical Workshop Production. By Dempster Smith, M. Sc. Tech., M. I. Mech. E., and Philip C. N. Pickworth, M. Sc. Tech. Manchester and London: Emmott and Co., Limited. [Price 4s. 6d. net.]

Although one readily agrees with the authors of this excellent treatise that the engineering student has few opportunities of studying this branch of his profession, the book is pre-eminently one for the practitioner, and without the aid of a year, at least, of actual participation in the commercial practice outlined, the student will probably find it a difficult text-book. It is true that a knowledge of the elements of commercial engineering practice should be part of every practising engineer's armoury, however remote his own part in a particular industrial activity may be from the—to a scientific man—unimaginative field of commerce; and the purely technical man will find that the aim of the authors, to treat the subject from the engineers' rather than the accountants' standpoint, has been well achieved.

A study of this work serves to emphasise, more than ever, the need of a practical workshop training as the first essential in the equipment of an engineering cost accountant; and the increasing demand made by manufacturers for reliable and accurate estimates, and clear comparative statements of estimated and actual costs, calls for a practically new class of trained men, trained, at present, where such men are found, solely on their own dynamic initiative, by leaving the beaten paths of technical and commercial sub-division and grappling with the intricacies of the numerous problems of cost-keeping, and the many other questions common to the commercial organisation of the average manufacturing concern. To such men the publication of this book is a noteworthy event.

An outline of the components of the selling-price of a product forms a concise introduction to the volume before us; and it is fair to mention here that this qualification of conciseness is consistently and admirably maintained. Some commendable hints and practical suggestions follow, which will appeal to every executive member of a staff, from the managing director downwards; for example, the note that in the drawing-office should be displayed the capacities of the principal machines of the shop equipment. Many such suggestions might well be adopted by estimating departments, where such exist as established units, as is, perforce, becoming more general.

The consideration devoted to pig-iron, wrought iron and steel, and the non-ferrous alloys, although brief, is valuable, the comparative market prices and tables of casting and forging rates included being particularly useful. Specifications of materials are briefly dismissed, but with sound information as to when and where these are necessary. In the stress of modern competition it is usually found impracticable to include, with every inquiry, an ideal specification, though such would invariably assist, rather than hamper or irritate, the concern tendering. The importance of the provision of complete and definite specifications cannot be exaggerated, but it is found, in practice, that only in large contracts, or for tenders involving a considerable quantity of repetition pieces, as, for example, railway axle-boxes or their bearings, can the work of preparing an accurate specification be incurred. A point of contention may be found in the statement that no patent or proprietary article can be made the subject of a specification. Usually the design may be immune from alteration, but it is often the custom of important companies and corporations, and nearly always of large Government departments, to furnish a detailed specification of the materials of the most proprietary speciality, any addition to the price being of secondary consideration compared with a guarantee of the quality required and specified. Designers will welcome the guidance afforded by the information on the tests prescribed by the British Engineering Standards Committee, which are given in lucid form, covering the usual range of physical tests of the more common materials.

The exhaustive treatment of wage systems is quite beyond the student's requirements, but the general manager will find all the material necessary for the most intensive study of this important part of executive administration. Only those who have actual dealing with the working of piecework and premium systems can appreciate their difficulties, and only with the increasing knowledge of economic principles among the wage-earners can these difficulties be effectively surmounted. Of all the positions in a modern works one of the least enviable is that of the rate-fixer. He is necessarily a man who has extensive practical experience behind him, who is an expert mechanic, and who has an intelligence and clear-wittedness far above those of his fellows. Upon the work of this man (or these men, in the case of a department) depends practically the entire measure of success of the system, upon whichever model it may be formed. The importance of the technical details of the system fades in the light of the importance of the personality of the man responsible for the rate-setting; and in spite of a prevailing opinion among managers to the contrary, the best man to be appointed to the task is not an outsider, but the best mechanic in point of practical knowledge and ability, character and repute among his fellows, provided such a man can be persuaded to undertake the work. Tact and personality play such an important part in the adjustment of wage systems, that the essential qualities of a successful rate-fixer can only be born, not instilled. The authors' treatment of the entire system of the remuneration of labour has an academic excellence, but one looks in vain for the psychological element so keenly observed by the best American exponents of the subject.

Profit-sharing and co-partnership are fairly and sympathetically explained, mainly from the employer's point of view; and, on the whole, no more complete exposition of wage systems can be desired by an employer or manager wishing to formulate his own idea of the best to suit his individual requirements. The following chapter on shop organisation, though brief, introduces a much more practical application of the principles which have proved so successful in America. In fact, the nine pages devoted to this most expansible subject contain material sufficient to frame the fabric of the most complicated system. The planning department advocated is the subject of the most needed reform in the factories, large and small, of to-day, in the engineering field more than in any other; and he is a wise commercial manager who is following the path described so clearly in Chapter VII. of this book. The following chapters investigate in the most praiseworthy detail the differences between theory and actual results in the varied machine-tool operations, and the knowledge compiled by the authors in these succeeding four chapters alone will be deemed invaluable by every practical engineer who applies it. The particulars of the Manchester experiments, the effect of the varying forms of tools, of speeds and feeds, and of lubricants, should be of great assistance to rate-fixing departments everywhere, and, we might very well add, to the machine-tool designer, the relation of the load applied to the machine by the different cuts to the strength and rigidity of the machine having been consistently borne in mind and considered. The case for grinding is briefly but effectively made out, and the whole treatment of machine-tool operations is most comprehensive and convincing, rendering the more critical study of the seasoned practitioner as interesting as the unbiased reading of the student. Even the somewhat risky inclusion of standard times for the more general hand operations is justified, and of all readers of these Chapters, VIII. to XI., the estimator will share with the shop superintendent, or the rate-fixer, his appreciation of the value of the treatise.

The essential corollaries of the modern premium system, and the machining methods which have made the system possible—namely, the strict definition of limits of accuracy and the contingent work of rigid inspection—are well summarised in their natural order in the book, the authors having contented themselves with the enunciation of the practice formulated by the Engineering Standards Committee. The vexed question of establishment charges receives effective and most original treatment, although the system propounded could be adopted only in quite modern concerns where the complete valuation of the plant had been, or could easily be, carried out. It is so easy to theorise upon this topic, and so hard to apply even one's own theory, originated to meet the peculiar needs of one's own concern, that it is more than one can expect to find an absolutely final, standard practice outlined by any one author; however, in one short chapter, one finds here a wealth of suggestion which may inspire much practical application. The whole difficulty as regards the correct allocation of establishment charges lies in the necessity of avoiding as much clerical work as possible, otherwise it would be fairly simple to divide the indirect expenses of an establishment into two or three sections, and to apportion them over the costs of the work by several separate calculations; but the objection at once has to be faced that the extra work laid upon the cost office staff is unwarrantable.

According to this book, the method of Messrs. Wm. Sellers and Co., U.S.A., seems to approximate more closely to strict accuracy than most of the prevalent English systems. The proprietor of an engineering establishment dealing with work of a continually varying or general nature will still find himself loth to employ the method of dividing the total indirect expenses between the individual costs in proportion to the direct labour charges; though here again the difficulties of each case are peculiar, and a study of one's own problem will usually prove to be of more assistance than the blind adoption of any generalised principle. The importance of reserve, maintenance, and depreciation funds occupies the succeeding chapter, the summarised experience of the authors being again usefully employed, and forming an excellent and sound guide on these points.

In these days of rapid and radical changes of machine design the problem of allowing satisfactorily for replacement of prematurely-obsolete plant has become much more difficult than it was fifteen or twenty years ago, before the innumerable innovations had made further inventions possible in almost geometrical progression. In the fierce struggle of modern competition the executive policy which wins is the surprisingly bold and daring one, guided throughout by sovereign prudence and foresight, and in no one line is this more clearly evident than in the repair, maintenance, and replacement of plant. The most successful firms to-day readily provide for the supersession of their high-speed turning, boring, milling, and grinding-tools, about every five years, in some cases more frequently still. The added responsibility of the cost-keeping staff is obvious.

The following chapters of the book on selling expense, railway and shipping rates, are excellent, and quite in order of position; though these take such a regular place in a course of business methods that their inclusion in this volume is justified mainly by the additional convenience for reference thereby obtained. The treatment of cost-keeping could hardly be simplified, and here, and in the final chapter on estimating, will the student really find the subject handled in a manner most applicable to his needs. The broad principles of costing and estimating are not difficult to assimilate, and they have been, therefore, briefly, but effectively, stated in these concluding pages.

The outstanding merit of the book we have been reviewing is the great value of its intensive study of actual practice and experiment in most of the lines of mechanical application, which form the source of productive expenditure, and the value of the information thus collected to the practitioner with little experience of, and less time for, experiments. The demerits are few, and will, of course, vary with the judgment of the readers; but the worst is, perhaps, the brevity of the final chapter on estimating. This, of course, forms another and a difficult subject, and the problems which confront the engineering estimator must, it is true, be left to the powers of solution of his own intelligence and initiative, so that, armed with the knowledge available in the book as a whole, he will feel that its publication has well met a hitherto unsatisfied demand.

Outlines of Mineralogy for Geological Students. By Grenville A. J. Cole, Professor of Geology in the Royal College of Science for Ireland. London: Longmans, Green and Co. [Price 5s. net.]

Considerable experience in the preparation of technical treatises has enabled Professor Cole to compress within a narrow compass a vast amount of information. He covers a large subject whose borders are rapidly extending. It borrows much from the sciences of physics, optics, crystallography, and chemistry, and the author has usefully applied these sciences to illustrate and determine the character of minerals. The application may be extended indefinitely, just as skilful manipulation will devise new methods and artifices to

detect minute variations, but all the generic principles involved in testing and identifying minerals are clearly exhibited and adequately explained.

The book is divided naturally into two sections, the first treating of the character of minerals and the processes of examination, the second giving a description of minerals, or at least those which are more likely to be encountered by geologists. After struggling, not too successfully, with the difficult task of defining a mineral, the author describes the more superficial characteristics—those which do not involve or permit of rigorous measurement. These include colour, hardness, tenacity, lustre, &c., in which the looseness of descriptive terms becomes painfully evident. Where we have not the advantage of a continuous scale and an accurate standard, we suffer from the want of exactness. A rough scale of order can be arranged, of which the oft-quoted "table of hardness" is an example. But colour, in its infinite variety, presents greater difficulties. To give scientific precision to colour terms in everyday use, however desirable, would be to undertake an impossible task, and the author wisely does not attempt it. Scales founded upon the blending of spectrum colours have not proved satisfactory, and since no mention is made of instruments which aim at building up or imitating tints by combination of approximately monochromatic colours in varying amounts, the inference is that the author has little confidence in their convenience or trustworthiness.

The contrast between loose description and accurate measurement is more marked when, in the succeeding chapters, the student is introduced to the rigorous scientific methods employed in crystallography, whether in the geometrical measurement of angles by some form of goniometer, or optically, in determining refractive indices and other characteristics. The attainment of accuracy, the possibility of repeating results, the certainty of deduction, and the rigour of the methods, not only make the study fascinating, but constitute it a vehicle of great educational value. The author writes of the somewhat forbidding subjects of symmetry and crystallographic systems—forbidding only in that they require a particular notation and nomenclature—as one enamoured of a fascinating subject and wishing to make others share his enthusiasm. It must be admitted that the theory is not simple, except approached through a rather severe preliminary course of physics and optics, and practically, difficulties become patent when, in the case of a minute double refractive crystal, it is necessary to determine the amount of double refraction, or the angle between the optic axes in a biaxial substance. Many a clever dodge for making peculiarities more manifest has been worked out by experts, and lies hidden in the transactions of some learned society, but is here placed at the student's disposal, for Professor Cole's acquaintance with the literature of the subject is general and exhaustive. As an example of this clever manipulation, reference may be made to the methods of observing the relation between Refractive Index and Total Reflection, Pleochroism, &c. The care of the conscientious tutor can be recognised in the minute instructions given for the use of the blow-pipe.

In a work intended for students, and to serve as an introduction to more elaborate treatises, it is inevitable that a large section must be devoted to simple description and classification of minerals. The details of special characteristics, whether derived optically or from chemical and blow-pipe tests, are not particularly interesting, though the author often enlivens his text by introducing some note of economic or geologic importance. The method of arrangement, or general order of description, is, however, worthy of notice. The order is decided by the fundamental element present in the mineral, the elements being arranged in the inverse order of Mendeléef's table. The iron group stands first, and the arrangement proceeds through manganese to sulphur, and, finally, to the hydrogen group.

In this arrangement there is apparently no convenient room for the silicates that form so large a part of the rocks that the geologist has to study. Professor Cole prefers to treat them separately in a group by themselves. The reason given for this plan is that the chemist will be most readily attracted to the study of the mineral kingdom if he can apply the processes of chemical reactions and analysis with which he is familiar; while the geologist is not obliged to approach his more difficult work till he has handled and examined a variety of minerals, and become acquainted with specimens where crystalline form is readily apparent. These are matters in which it is safe to trust to the experience of the teacher. In any case, the work is provided with an excellent index to facilitate reference, and this will be found of the greatest service to the chemist, the geologist, or the mining expert and prospector.

BOOKS RECEIVED.

Bericht über die Tätigkeit und Verwaltung der Bremer Feuerwehr und der Sanitätswachen, 1913-14. Bremen: H. M. Hauschild.

Das Verkehrsproblem der Grosstadt mit Berücksichtigung Wiens. Von Privatdocent Dr.-Ing. Fritz Steiner. Wien, VII./1: R. von Waldheim, Jos. Eberle and Co., Andreasgasse 17. [Price 1.50 marks.]

Handbuch der Gastechnik. Band X. *Organisation und Verwaltung von Gaswerken.* Von J. Engländer, Fr. Greineder, E. Kobbert, O. Meyer, and K. Lempelius. Munich and Berlin: R. Oldenbourg. [Price 9 marks, sewn; half-calf, 10 marks.]

Beitrag zur Kritik verschiedener Klappbrückensysteme. Von R. Antze. Berlin-Oldenburg: Gerhard Stalling. [Price 4 marks.]

United States Coast and Geodetic Survey. Special Publications. No. 11. *The Texas-California Arc of Primary Triangulation.* By William Bowie. No. 14. *Determination of Time, Longitude, Latitude, and Azimuth.* Fifth Edition. By William Bowie. No. 18. *Fourth General Adjustment of the Precise Level Net in the United States and the Resulting Standard Elevations.* By William Bowie and H. G. Avers. Washington: Government Printing Office.

United States Department of Commerce. List of Publications Available for Distribution. Tenth Edition—February, 1914. Washington: Government Printing Office.

United States Department of the Interior. Bureau of Mines. Fuel-Briquetting Investigations, 1904-12. By C. L. Wright. Washington: Government Printing Office.

University of Illinois. Bulletins of the Engineering Experiment Station. No. 69. *Coal Washing in Illinois.* By F. C. Lincoln. No. 71. *Tests of Bond between Concrete and Steel.* By Duff A. Abrams. No. 74. *The Tractive Resistance of a 28-Ton Electric Car.* By Harold H. Dunn. Illinois: The University; London: Chapman and Hall, Limited. [Prices: No. 69, 50 cents; No. 71, 1 dol.; No. 74, 25 cents.]

Ontario Department of Agriculture. The Thirty-Ninth Annual Report of the Ontario Agricultural College and Experimental Farm. Toronto: Ontario Department of Agriculture.

Ontario Department of Agriculture. Bulletins. No. 221. *Food Values of Milk and its Products.* By R. Harcourt, B.S.A. No. 223. *Fertilisers in Relation to Soils and Crop Production.* By R. Harcourt and A. L. Gibson. Toronto: Ontario Department of Agriculture.

Transactions of the American Institute of Metals. Vol. VII. Edited by W. M. Corse, Secretary, under the direction of the Committee of Publications. Buffalo, New York: Published by the Institute.

Taschenbuch für den Maschinenbau. Herausgegeben von Ing. H. Dubbel. Berlin: Julius Springer. [Price 16 marks.]

High-Power Gas-Engines. By H. Dubbel. *Translated from the German, and edited and expanded so as to include British Engines and British Practice.* By F. Weinreb. London: Constable and Co., Limited. [Price 18s. net.]

Coal-Mining. By T. C. Cantrill. Cambridge: University Press. [Price 1s. net.]

The Conduct of Boiler and Steam-Engine Trials: Erratum.—We learn that there is an error in connection with the diagram, Fig. 2, which we published on page 227 of our last issue, representing the Admiralty practice in cleaning fires. The legend below the figure should read:—

$$\frac{\text{Grate area (square feet)}}{\text{Pounds of coal per hour}} \times 100.$$

The correction has, we are informed, been made in a later edition of the report from which our figure was copied. In the last sentence in the paragraph immediately below Fig. 1, the word "advantage" was inadvertently written for "disadvantage," since, of course, the green coal will have effected little evaporation though debited to the boiler.

"Fighting Ships, 1914."—At the present time, when practically the whole of Europe is under arms, for reasons which it is needless for us to dwell upon, the book on "Fighting Ships," by Mr. Fred. T. Jane, for the present year, the seventeenth year of issue, is most welcome, as it will prove of great value for reference purposes. It contains illustrations, identification silhouettes, and particulars of the various ships of all the navies in the world. The particulars include the dimensions of the characteristic classes, data on their armament, protection, and machinery, the names of the builders, &c. Among the illustrations are general plans of the naval bases belonging to the larger naval Powers. A special chapter, by Mr. Charles de Grave Sells, M. Inst. C.E., deals with the progress made in naval engineering. The book is published by Messrs. Sampson Low, Marston and Co., Limited, Overy House, 100, Southwark-street, London, S.E., at the price of 21s. net.

THE MUNICH GAS EXHIBITION.

In connection with the fifty-fifth annual meeting of the German Association of Gas and Water Engineers at Munich, a report of which has already appeared in our columns on July 17, page 96, a very comprehensive and well-arranged Gas Exhibition was held, the exhibits filling the Prince Ludwig Halls of the Permanent Exhibition Buildings at Munich, belonging to the Municipality.

The gas production of Germany for the year 1912-13 was graphically represented, showing that, from 1700 works, 2733 million cubic metres were produced. The comparative yearly production was also indicated. There are 1522 million marks of capital invested in the German gas works.

The exhibits illustrating the manufacture of lighting gas were very complete, and embraced methods of conveying the coal from the colliery to the gas-works, the construction of the various kinds of retorts, charging and discharging systems, purification, condensing, coke-quenching, screening, tar and ammonia treatment. In regard to tar it was demonstrated that tar from vertical retorts, being more fluid than the ordinary product, may be used in Diesel engines. The great quantity of water required in gas works was graphically represented, as was also the extent to which electricity is being employed there. Water-gas was represented, and the exhibits generally showed that in the manufacture of gas practically every branch of science is involved.

The fine working model, one-tenth full size, of a works for the production of 100,000 cub. metres of gas per day deserves special mention. Costing about 1000*l.*, it was made from drawings supplied by various gas-plant manufacturers in Germany, and will eventually be placed in the German Museum at Munich. It was made by Friedrich Schroder, of that town.

Mr. Heinrich Koppers showed a sectional model of his horizontal regenerative coke-oven plant, heated by producer-gas, and a model of his complete tar and ammonia plant. An interesting collection of gas mains was shown, from which one drew the conclusion that steel mains are now taking the place of cast iron, but that they require to be carefully coated for protection against oxidation. In the jointing devices which were exhibited, it was seen that resilience is obtained by means of rubber when mains are subject to vibration. High-pressure gas installations occupied an important place, there being some excellent examples shown; compressors, pressure-regulators, and safeguards against stray earth currents from electric tramways were shown in considerable detail.

Gas-meters—wet and dry—penny-in-the-slot, and station-meters were shown. In house-lighting the incandescent system was well illustrated in a series of beautifully furnished and decorated rooms. The usefulness of the inverted mantle was specially exemplified. Distance lighters by means of the by-pass, ferro-cerium, the pill, and by electricity were shown.

In Hall No. 3 was shown a representation of the organisation of the Deutsche Verein von Gas und Wasser-fachwannern; the work carried on in its laboratory at Carlsruhe was excellently demonstrated. Plans and views of old gas-works, &c.; diagrams illustrating the formation of coal; apparatus for guarding against fire-damp; methods of research, and experiments with gas, and various laboratory apparatus were on view, including appliances for light-measuring, analysers, and tar and ammonia testing were exhibited; Bunsen burner tests, and methods of measuring yield in heat and candle-power, were also dealt with.

Some well-prepared diagrams were on view, giving statistics of coal and coke production in Germany; production of gas; number of workmen employed; length of mains and branches; consumption of gas in relation to population; development of the penny-in-the-slot system, and street-lighting in Munich.

Hall No. 3 contained the exhibit of Herr Friedrich Lux, of Ludwigshafen am Rhine, and should be specially referred to, as it included the instruments made by Messrs. Alex. Wright and Co., of Westminster, for whom Herr Lux is the German agent. The exhibit comprised specimens of the well-known Lux purifying material, facetiously called by the German wharfingers "Lux's cocoa," by reason of its appearance, Lux single-pipe suction and pressure-meter, and the two instruments of the English makers—the gravitometer and the caligraph—of which we hope to publish full particulars in an early issue.

Shipping, Engineering, and Machinery Exhibition, Olympia, London, W.—It has been decided to postpone the above Exhibition to a period, between July 13 and September 14, 1915, which will be fixed in consultation with the Hall authorities in the beginning of 1915.

Road Board.—We understand that the Road Board have made some changes in the organisation of their staff, and Mr. H. P. Maybury, who became Chief Engineer to the Board in November last, has been appointed to a new post, with the title of manager and engineer.

FOUR-SPINDLE DRILLING AND TAPPING-MACHINE.

CONSTRUCTED BY THE LANGELIER MANUFACTURING COMPANY, ENGINEERS, PROVIDENCE, R.I., U.S.A.

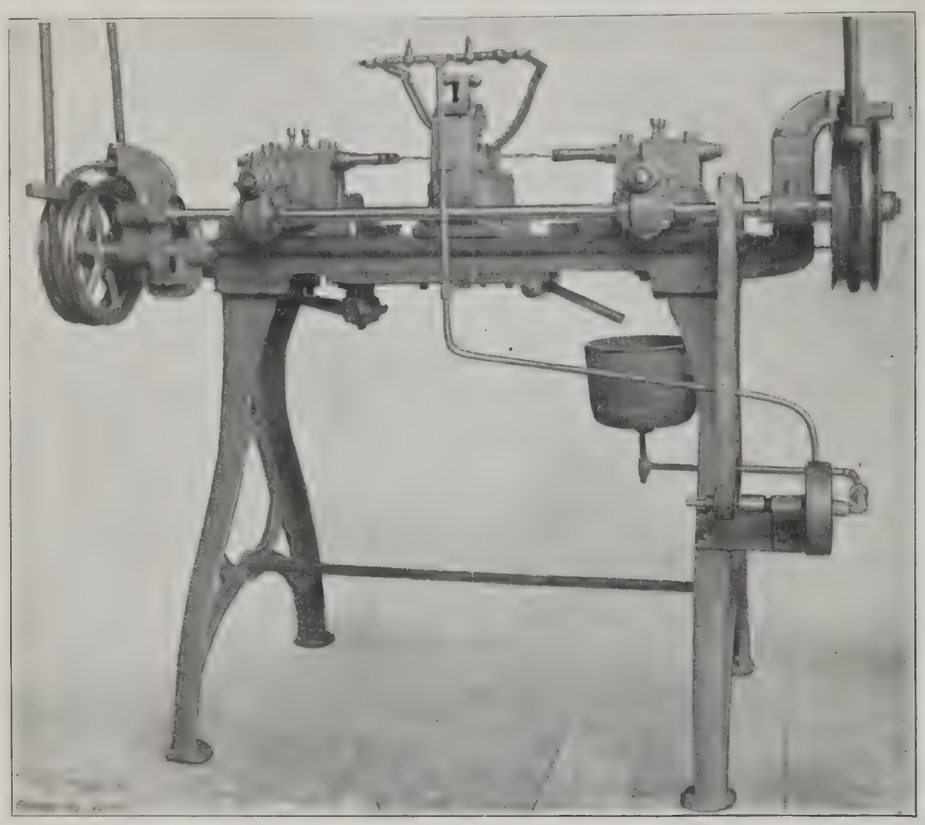


Fig. 1.

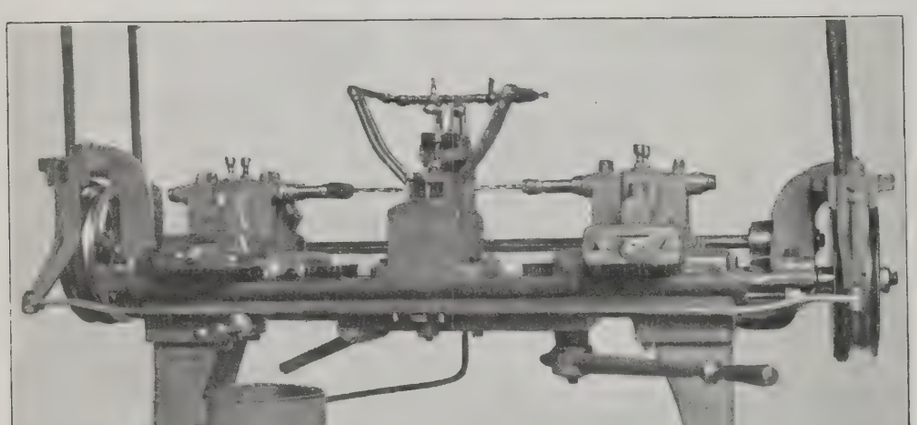


Fig. 2.

The accompanying illustrations show a new type of horizontal multiple-spindle drilling and tapping-machine, designed and constructed by the Langelier Manufacturing Company, of Providence, R.I., U.S.A. The actual machine illustrated, of which Fig. 1 is a back view, and Fig. 2 a front view, has four spindles capable of simultaneously drilling, counterboring, or tapping holes up to $\frac{3}{8}$ in. in diameter in mild steel, cast iron, brass, and other metals, but similar machines are constructed with larger or smaller numbers of spindles, and with different drilling and tapping capacities according to requirements. Figs. 3 to 6 illustrate examples of the class of work for which the machines are intended.

Referring to Figs. 1 and 2, it will be seen that the work is clamped to a stationary table in the centre of the bed of the machine. The vertical distance between the planed surface of the bed at this point and the centre lines of the spindles is $5\frac{3}{4}$ in., so that fairly large work or jigs can be handled on the machine. On each side of the table is a movable head having two spindles; actually only one spindle on each head can be seen in the illustrations, but the other is immediately behind it in the same plane. The two heads are mounted on finished and gibbed saddles, and they may be set so that the distance between the inner ends of the spindles is anything between $8\frac{1}{2}$ in. and $18\frac{1}{2}$ in. The heads are also interconnected, so that the drills or taps are simultaneously fed into or withdrawn from the work by the movement of a single hand-lever, shown on the right-hand side of Fig. 2. Adjustable stops are provided to limit the depth of the holes produced. In order to make the transverse distance between the spindles variable, the front spindle of each head is mounted on a cross-slide, and by turning screws, the ends of which are visible in Fig. 2, the distance between the centre lines of the spindles can be varied from $1\frac{1}{2}$ in. to $3\frac{1}{2}$ in. The spindles are each provided with No. 1 Morse sockets to take drill-chucks or tap-holders with shanks of the corresponding taper; drills or taps of any size up to the standard limit of that taper can thus be used. The thrust on the spindles is taken on thrust-washers of hard phosphor-bronze and hardened steel, and means are provided for taking up any end-play.

Fig. 3 REAMER

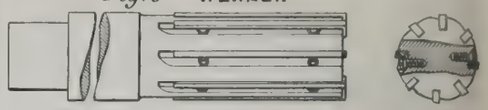


Fig. 4. ADJUSTABLE TAP WRENCH.

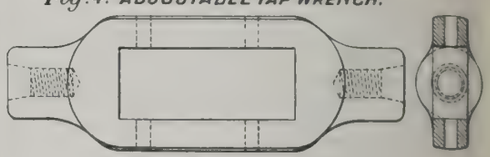


Fig. 5. MOTOR POLE SHOE

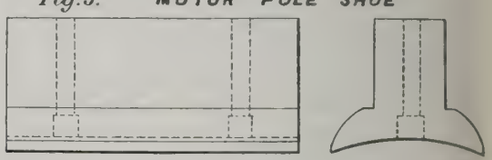
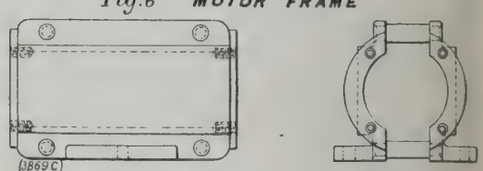


Fig. 6 MOTOR FRAME



It will be seen that the machine is driven by leather belts of circular section, these belts having been chosen because they enable the machine to be reversed more easily and rapidly than would be possible with flat belts, and also because they reduce the floor-space occupied. The belts are $\frac{3}{4}$ in. in diameter, and run on grooved fast and loose pulleys, 10 in. in diameter. The main shaft is situated at the back of the machine, as shown in Fig. 1, and power is transmitted to the spindles by means of spiral gears capable of sliding along the main and transverse shafts; the gears are all completely enclosed to comply with the most stringent safety regulations. When drilling or tapping, the machine is driven by the pulleys shown on the right-hand side of Fig. 1, these pulleys being keyed directly on to the main shaft, but the reverse drive is by means of the pulleys on the left-hand side of this view. These pulleys, it will be noticed, drive the main shaft through spur-gearing, by means of which the speed is increased and the direction of rotation is reversed without using crossed belts. The arrangements are such that when the heads come up against the adjustable depth stops in tapping, the tap-holders automatically unclutch. The operator then shifts the main driving-belt from the fast to the loose pulley by hand, and this movement simultaneously shifts the reverse driving-belt from the loose to the fast pulley, thus reversing the machine and backing the taps out of the holes at a higher speed than that used for tapping. The countershaft, which has been specially designed for this machine, provides two drilling and two tapping speeds which are sufficient for all ordinary requirements.

The machine is provided with a rotary oil-pump, which delivers oil to the drills or taps through flexible-jointed piping fitted with pet-cocks to control the supply. The surplus oil and chips are collected on the bed of the machine, which has a high rim formed round it for this purpose. The oil eventually gravitates into a reservoir fitted with a strainer, from which reservoir the pump draws its supply, so that the oil is continuously circulated. Ample provision is also made for the lubrication of the gearing and all other moving parts.

With these machines it is claimed that large quantities of high-class accurate work can be produced by unskilled operators, and that the ease with which the positions of the spindles can be adjusted adapts them for a very wide range of work. The weight of the machine illustrated is under 16 cwt., and the floor space occupied is about 5 ft. by 2 ft.

STRESS DISTRIBUTION IN MATERIALS.

Engineering Section of the British Association.
*Presidential Address.**

By Professor E. G. Coker, M.A., D.Sc., M. Inst. C.E., President of the Section.

The subject of stress distribution in materials, which I have chosen for this address, is not one which an engineer can claim as his particular province, for it has been, and still is, a fruitful field of investigation for the mathematician, the physicist, and the geologist, and has always been so since the commencement of scientific inquiry; indeed, it must have been the source of speculation and controversy ever since mankind emerged from a primitive state, and began to fashion dwellings, weapons, and tools from the materials at command.

The development of architecture from the earliest dwellings of savage races to the great temples of Egypt and Greece, the bridges and aqueducts of the Romans, and the mediæval buildings of Europe, all bear witness to the accumulation of practical knowledge of the properties of materials and of the stress distribution in structures, which we cannot fail to admire, although we know far too little of the way in which these ancient structures were planned and constructed. The magnificent arched and domed buildings of the Roman period, and the stately cathedrals of later times, with their wealth of architectural form—tower and spire, flying buttress and vaulting—all show how considerable was the practical knowledge of stress distribution possessed by the master builders who planned and carried out these great structures. We, who inherit these buildings as a precious legacy of bygone ages, have at our command far greater resources in the accumulated knowledge of centuries of scientific discovery and invention, and can build more complex structures—great bridges of steel, towering frameworks covered by a thin veneer of masonry, and floating arsenals of the most bewildering intricacy. All these we can show to our credit as the result of the steady increase of scientific knowledge applied to practical ends, but, even now, knowledge of the stresses which come upon these complex structures and machines is relatively small. Scientific investigations of engineering problems of stress still lag behind constructive ability, and defective knowledge is obscured more or less by approximate theories and buttressed by factors of safety, which serve in one instance perhaps, but show in others that they have merely given a sense of fancied security with no real basis, and are more properly factors of ignorance, to be discarded at the earliest moment. Who, for example, can say with certainty what is the stress distribution throughout the compression members of a great bridge, built up of complicated steel shapes and plates, united by stiffening angles, gusset-plates, and innumerable rivets. There is probably good reason for the belief that a great strut is relatively weaker than a small one, when both are designed according to the same approximate formulæ now used in current practice, and engineers are unwilling to take the responsibility for such members in a great structure, without providing a very ample margin of safety to cover the contingencies arising from lack of precise knowledge of the strength of these members. So numerous are the problems which arise in the design and construction of machines and structures that it is, perhaps, not unprofitable to devote a short hour to the consideration of some of the available means which an engineer can use as a guide for his applications of science to construction, since of whatever kind are the professional activities he pursues, his place in the scheme of affairs mainly depends on his ability to make machines and structures for directing and modifying natural sources of power in known ways, or applying them to new purposes as scientific discoveries advance the boundaries of knowledge. The power to do this depends, to no small extent, upon the ability to determine the distribution of stress in a structure, and on the skilful manner in which material can be disposed for the required purpose. It is of some help to our appreciation of the achievements of the great constructors of past ages, if we remember that they probably all held the erroneous view that materials of construction are perfectly rigid bodies; and, indeed, we know that as late as 1638 Galileo Galilei was of that opinion, and that he came to an entirely wrong conclusion as regards the stress distribution in a loaded cantilever. It required the genius and insight of Robert Hooke to make a really great step, with his celebrated theory of the linear relation of stress to strain, and we can appreciate the glow of pride and satisfaction which he must have felt at his great discovery, when he records, in 1675, that "his Majesty was pleased to see the experiments that made out this theory tried at Whitehall, as also my spring watch." Hooke had, in fact, discovered the fundamental principle upon which a theory of the elasticity and strength of materials could be based, and it would be interesting to trace the great advances which were rapidly made from this new vantage ground, whereby the main facts of the distribution of stress in simple members of structures became known, and a foundation laid for the great advances of the mathematical theory. If I am silent upon the enormous developments of the modern theory of the strength of materials it is not from lack of appreciation, but because I do not deem myself adequately fitted to discuss the great work of the elasticians, which all engineers admire, and so few are equipped to follow with the full battery of mathematical tools which have been pressed into service in the pursuit of this great science.

Among the greatest of the services rendered by early pioneers was that of Young, who was the first to notice that the elastic resistance of a body to shear was different from its resistance to extension or contraction, and this led him to define a modulus of elasticity for materials in compression. As Professor Love remarks, "This introduction of a definite physical concept, which descends, as it were, from a clear sky on the readers of mathematical memoirs, marks an epoch in the history of the science." From the standpoint of the engineer, nothing is of more practical importance than the great discoveries of Hooke and Young, that bodies like metal, wood, and stone are "springy" and have a simple linear relation between stress and strain. It is probably within the mark to say that nine-tenths of all the experimental investigations on stress distributions in structures have been entirely based on the fundamental principles which they enunciated, and new uses are continually arising. The recent application of the steam-turbine to the propulsion of ships produced a profound change in marine-engine practice, and incidentally involved an entire reconstruction of methods for obtaining the horse-power developed, which had been gradually perfected from the time of Watt, but were absolutely useless for the new system of propulsion. Hooke's discovery of the essential springiness of metals enabled engineers quickly to devise new instruments capable of accurately measuring the infinitesimal angular distortions of propeller shafts, and from these to determine the horse-power transmitted by the aid of an appropriate modulus.

The construction of tall buildings affords another example where advantage has been taken to determine the loads upon columns by measuring the minute diminutions of length as the structure proceeds, thereby affording a valuable check upon the calculations for these members, and a reliable indication of the pressures supported by the foundations. The distribution of stress in buildings constructed of composite materials, like concrete reinforced with steel, has also been examined by similar methods, and many data for guidance in future constructional work have been obtained, especially in the United States of America. The still more difficult problems involved in the determination of the stresses in joints and fastenings of complicated structures have often been investigated by purely mechanical measurements of strain, and the experimental investigations of Professor Barraclough and Gibson and their pupils, upon the distribution of stress due to riveted joints and curved plates of boiler shells, afford a notable example of the successful application of the measurement of small strains to a stress problem of great complexity.

That "science is measurement" is here sufficiently obvious, and it seems only due to the memory of that great engineer, Sir Joseph Whitworth, to refer to his great mechanical achievements of a true plane and well-nigh perfect screw, which enabled him to measure changes of one millionth of an inch, and thereby gave experimental investigations of strains a new impetus, which is reflected in subsequent work on the subject. Nor must we forget the no less important exposition by Kelvin and Tait, of the scientific principles of instrument construction which have done so much for the design of instruments for the precise measurement of strains. Mechanical measurements cannot, however, completely satisfy all our modern requirements, since they are essentially average values, and fail to accommodate themselves to many of the problems which press for solution. In the quest for exact experimental knowledge, the measurement of stress at a point becomes of paramount importance, and we may therefore inquire what further means the researches of pure science have placed at our disposal for the determination of stress distribution in materials.

It is well known that many materials, when tested to destruction, show a considerable rise of temperature at the place of fracture, especially in very ductile materials; but Weber was the first to discover that a metal wire, when stretched within the elastic limit, is cooled by the action of the load, and this result was deduced later from the laws of thermo-elastic behaviour of materials by Lord Kelvin, who showed that tension and compression loads produce opposite effects, and that materials which have the property of contracting with rise of temperature show thermal effects of the reverse kind. Although the changes of temperature produced by stress are small within the elastic range—less than 1 deg. Cent for most materials—yet their effect upon a thermo-couple is readily measurable if the equilibrating effects of surrounding bodies are neutralised or allowed for, so that stress distribution can be determined by thermal measurements at a point. The correction for such disturbing causes is usually an important factor, and is generally so large that experimental work is more suitable for the laboratory than the workshop; but if all necessary precautions are taken, a linear relation of stress to strain can be shown to hold up to the elastic limit of the material, while above this point the breakdown of the structure causes a rise of temperature of so marked a character that it has been utilised by several investigators as an indication of the yield-point. Experiments upon members subjected to tension, compression, and bending show that thermal phenomena afford trustworthy indications of the stress in materials so diverse as a rolled-steel section, a block of cement, and beams of stone and slate. Although no attempt appears to have been made to investigate stress distributions of any great complexity, it seems not unlikely that thermal methods of investigation will ultimately prove of considerable value.

The transparency of metals to Röntgen rays is another phenomenon which has often been suggested as likely to be of service for work on stress distribution in materials, and Mr. Howgrave Graham and I have examined a number of rolled metals under stress up to the breaking-point, without, however, discovering any change in the appearance of the material as seen on a fluorescent screen. Although our experiments showed no perceptible change, it is, of course, not impossible that an effect may have escaped our notice. Another and still more fascinating field of research on stress distribution is afforded by the doubly refractive properties of transparent bodies under stress, a discovery made by Sir David Brewster almost exactly one hundred years ago, and but rarely made use of since by engineers, although Brewster himself immediately saw its value for experimental purposes, and suggested that models of arches might be made of glass, and the effects of stresses due to loading rendered visible in polarised light. Brewster carries his investigations further, by the invention of a "chromatic teinometer" for investigating the nature of strains, and consisting of plates or bars of glass subjected to flexure in definite ways for comparison with the body under stress. At a much later date (1841) Neumann developed an elaborate theory for the analysis of strain in transparent bodies due to load, unequal temperature, and set, while, still later, the youthful genius of Clerk-Maxwell supplied an algebraic solution for the stress distribution in any plate subjected to stresses in its own plane.

The early history of the development of this branch of science is, in fact, remarkable for notable contributions at long intervals of time, and the almost complete disregard by engineers of its practical importance. The application of optical investigation to the determination of stress distribution in engineering structures and machines has, however, been hindered by causes which, although apparently insignificant, have been very real obstacles, and among these was the absence of a transparent material which could be fashioned into shapes suitable for investigating technical problems. It is not an easy matter, for example, to construct a glass model of a bridge free from internal stress, in the manner suggested by Brewster; and, moreover, glass is extremely fragile under load, especially in cases where the stress distribution in it varies very much, while the cost of construction is very great. Happily there is now no necessity to employ glass for experimental investigation on engineering problems, since modern chemistry has supplied artificial bodies, such as the nitro-cellulose compounds used for many trade purposes, which have optical properties very little inferior to glass, are able to bear great stresses without injury, and also are capable of being fashioned with the ease and certainty of a wooden model. Photographic processes are also able to reproduce the brilliant colour effects caused by stress in transparent materials, so that permanent records can now be made for future reference.

The construction of polariscopes for examining models on a large scale is very essential for technical research, and the great scarcity of Iceland spar of sufficient purity and size for use as Nicol's prisms has caused much attention to be paid to the construction of apparatus for producing plane polarised light by the aid of sheets of glass. Fortunately this presents little difficulty, and although the light is not nearly so well polarised as that obtained from a Nicol's prism, it is sufficiently so for the purpose. Large quarter-wave plates of mica have also been constructed by my colleague, Professor Silvanus Thompson, F.R.S., for obtaining circularly polarised light, and these have proved sufficiently exact and exceedingly useful for large models. It is of importance to show that the stress distribution revealed by a polarised beam of light passing through an elastic transparent material in no way differs from that obtained by other means, and evidence is available in modern researches, especially by Filon, that the experimental results obtained with glass agree with those of the theory of elasticity, while a satisfactory agreement of a similar kind has also been obtained with nitro-cellulose compounds, although not in so complete and direct a manner. Such an agreement may be expected on theoretical grounds, since the values of the elastic constants do not affect the fundamental equations for stresses in a plane; and although for a three-dimensional stress the effect of the stretch-squeeze ratio causes some difference, yet this is usually negligible.

Most of the physical constants of glass have been determined with very considerable accuracy, but other transparent substances have so far received little attention, and their optical constants are not well known. The stress-strain relations of glass and nitro-cellulose have been determined with considerable accuracy, and a useful idea of their relation to metals may be gained from the values of the stretch modulus E and the stretch-squeeze ratio σ.

The accompanying table shows some average values for a few important materials, and it is of interest to note that the stretch-squeeze ratios of cast iron and plate-glass are very similar, while the values of the stretch modulus are nearly as three to two. These two materials also possess other like characteristics: they are both very brittle, and possess well-developed crystalline structure, so that we may expect the properties of cast iron under stress to be very faithfully followed by plate-glass.

Material.	E	σ
Steel	30,000,000	0.25
Wrought iron ...	28,000,000	0 28
Cast iron	15,000,000	0.25
Plate-glass	10,500,000	0.23
Nitro-cellulose ...	260,000 to 300,000	0.40

The high values of the stretch modulus for steel and wrought iron are not, apparently, approached by any transparent material having similar ductile properties, but although nitro-cellulose has a stretch modulus of rather less than one-hundredth that of steel, its stress-strain properties are not unlike. In some recent experiments with a miniature testing-machine, fitted with an arrangement for recording the stress-strain relations of xylonite throughout the whole range of stress up to fracture, the main characteristics of steel appear on a very much reduced scale, and give additional confidence that the results of optical experiments on this material are

* Delivered at Sydney, N.S.W., August 21, 1914.

applicable to metal structures. The complete analysis of stress distribution in a plate is not, however, a simple matter, and the analysis of Clerk-Maxwell is intended to provide a solution based on the properties of the isochromatic and isoclinic lines, coupled with the law that the optical effect is proportional to the difference of the principal stresses at a point, and to the thickness of the plate. A principal stress perpendicular to the bounding planes is assumed to have no optical effect; but since many cases have arisen where there are three principal stress components, it seemed desirable to examine such a case experimentally.

It is a matter of some difficulty to arrange apparatus to stress a specimen in the direction of the incident beam, and, at the same time, observe the optical effect free from disturbing causes, since a transparent medium must be interposed for applying the required load, and this will be subject to stresses which may interfere with the optical effect on the specimen. Some observations on circular plates, clamped at the edges and uniformly loaded over one face, showed that the bending stresses produced in the plate caused very little optical effect, since the tension and compression stresses neutralised one another, while the shear effects also appeared to be practically negligible. The only remaining stresses of importance were those caused by the clamping-plates at the boundary, which produced radial and circumferential stresses having circular symmetry, and as the optical effects of these latter disappeared at a small distance from the edge, a field of view was obtained in which the optical effects of load applied perpendicularly to the plate were quite small, even when the internal stresses were very great.

Two circular plates clamped together to enclose a space between them may therefore be used as windows for observing the effect of a uniform pressure upon a transparent specimen, which latter may be a plate with its faces parallel to the end plates closing the chamber. If cubical compression is applied by a fluid, the principal stresses in the plane of the plate produce opposing optical effects, and any remaining effect is due to perpendicular pressures on the faces. The arrangement of experimental apparatus, therefore, took the form of a pair of transparent windows separated by an annular disc, and firmly clamped together by collars. The central chamber so formed was subjected to pressure of air, or other fluid, up to about 1000 lb. per sq. in., and afterwards the specimen was introduced, and the same pressure applied; but no visible change of effect could be observed. Finally, the specimen was set in the field of view outside the chamber, and pressure again applied by the fluid, but still no change was apparent. In all three cases the optical effects produced were small, and practically alike, so that the experimental evidence appears to warrant the conclusion that a principal stress in the direction of an incident beam of polarised light has no optical effect in a thin plate, or, at any rate, is so small that it may be neglected. That the retardation between the ordinary and extraordinary rays is proportional to the stress difference perpendicular to the incident beam within the elastic limit of the material may, therefore, be taken as reasonably accurate, although future research may show that it is only an approximation, or even that it is more accurate to commence from a fundamental strain equation; but according to present knowledge there appears to be no warrant for such a procedure.

A more pressing difficulty arises with regard to the optical constant connecting the wave-length retardation with the stress difference. The recent researches of Filon on glass show that the value of this constant is curiously dependent on the previous history of the material, especially as regards its heat treatment. Until further knowledge is gained on this matter it appears to be necessary to guard against errors in stress measurement from this cause by a careful selection and treatment of the material used, since for other artificial bodies we may find that the variation in the constant is not less in magnitude, and is at least as complex as in glass. In some instances the stress optical coefficient may be dispensed with, and Filon has shown in cases where a theory of stress distribution has been worked out, and it is desired to compare it with the results of optical measurements, that the isoclinic lines offer many advantages, since they are independent of photo-elastic constants, and the material need only be subjected to small stresses.

The experimental analysis of stress distribution in a body depends on the possibility of finding the magnitudes and directions of the principal stresses at every point, and in practice it is found the simplest plan to determine the directions of stress from the lines of equal inclination obtained in plane polarised light, and to measure the stress difference by a comparison with a wave-length standard, such as a Babinet compensator, or by comparison with a simple tension member set along one of the lines of principal stress, and loaded until the total effect produced is a dark field, denoting a zero value. The difference of the principal stresses is then measured in terms of a simple tension. This alone is insufficient to determine the distribution, unless one of the principal stresses is zero, and, in general, another independent measure must be obtained. This is very conveniently supplied by the change in the lateral dimensions of the plate under stress, since this change may be taken, in the absence of a third principal stress, as proportional to the generalised sum of the principal stresses throughout the thickness.

The determination of the lateral strains in a comparatively thin plate, forming part of a model of a machine or structure, necessitates measurements of extremely minute linear quantities. If, for example, a plate of xylonite is taken, of the maximum thickness obtainable for optical work, a simple calculation shows that these strains must be measured to an accuracy of one or two millionths of an inch. Several instruments have been designed and constructed for this purpose, to fulfil conditions which appear to be essential for successful use. It is necessary to avoid all chance of injury to the surface of a transparent material, so that the measuring points of an instrument can only be pressed lightly against the surfaces, and the weight must, therefore, be supported independently of the model. In instruments so far constructed the measuring mechanism is carried on a U-shaped frame, for convenience of movement from point to point of the specimen. One measuring needle is secured and operated by a calibrating screw, and the other is free to move a multiplying lever system, and thereby tilt a mirror to give an angular deflection, which latter is calibrated by reference to the standard screw when the instrument has been finally secured in place. In recent work the labour of accurately setting the instrument in a number of different positions has proved so great that my assistant, Mr. F. H. Withycombe, has designed a useful adjunct in the form of a mechanical slide-rest, to effect the required changes easily and expeditiously. In one arrangement a bracket carries the measuring instrument on a three-point support, and movement is effected by slides arranged to give displacements along three axes at right angles, and their amounts are measured by micrometer screws to an accuracy of rather less than $\frac{1}{1000}$ in.

These methods of stress determination avoid the difficulties of the Clerk-Maxwell analysis, which necessitates the determination of the equations to both families of isochromatic and isoclinic bands, usually a mathematical problem of considerable complexity. In some simple cases Mr. Scoble and I have verified the accuracy of the method of lateral measurements for determining the sum of the principal stresses by comparing the calculated stresses with the experimental values obtained in a plate of transparent material. We have lately carried these experiments a stage further, and have shown that the measured sums of the principal stresses in steel agree with the calculated values. This experimental solution, in fact, gives the stress at a point in a plate, if the conditions are those assumed by the mathematical case of a plate where generalised equations of stress apply. It is at once obvious, if the utility of experiments on models of this kind is admitted, that experimental evidence is available on a variety of practical engineering problems covering a very wide field of practice, not merely qualitative, but quantitative, and approximating to the needs of the physicist and mathematician, and well within the known variations of the materials with which the engineer has to deal in his daily practice.

During the last few years much attention has been paid to the determination of the stresses in structural elements of primary importance, but only a small number of cases have been examined, since even the simplest problems have proved somewhat difficult, and much time and labour have been spent in perfecting optical and mechanical appliances to suit the special conditions required for investigations on transparent models. A simple example of a case easily examined and of practical importance is that of a tension member subjected to an eccentric load. The optical effects here show a linear distribution of stress due to the combination of direct pull and bending, while the neutral axis moves towards the tension side as the stress increases. Not only can these effects be measured, but if the specimen begins to fail some indication is obtained of the way in which the stress distribution is changed to meet the new conditions, and there is found a tendency to an equalisation of the maximum stress at the boundary, although at present the form of the curve of distribution beyond the elastic limit is largely conjectural.

A case like that of a very short member subjected to direct compression is also not without interest, partly because it reveals unexpected difficulties. In the first place it is not easy to apply a pure compression stress, and if the surfaces in contact are not of the same materials it appears to be practically impossible, since the lateral changes are unlike, and shear stress is therefore produced at the plane of the surfaces in contact. In a short member this shear has a very important influence, and by interposing a thin layer of a material, such as india-rubber, between the pressure plates and the short transparent block, the artificial shear effect produced by the india-rubber is easily shown to influence the distribution throughout, and to increase the stress in a very marked way. Experiments on transparent materials show that the increase of stress may be 20 per cent. or even more. Such an effect is known to take place when cubes of stone are crushed between lead plates, and optical investigations on models have enabled a quantitative measure of the effect to be ascertained in this and other cases, thereby confirming the theoretical investigations of Filon on the distribution of stress in such members under various practical systems of loading.

The local effects produced near the points of application of a load are usually of considerable importance, and their influence on the stress distribution in beams has been examined by Carus Wilson. The stress effects produced by discontinuities in materials are also of considerable interest, and the cases arising from the necessities of construction are infinite in their variety.

The practical importance of an accurate knowledge of the change in stress distribution produced by changes of section in a member is so thoroughly appreciated that it needs no insistence, and it has received much attention from the mathematical point of view. Thus the local effect of a spherical cavity in a member subjected to uniform tension or compression load has been shown by Love to double the intensity very nearly, while Kirsch has shown that a small cylindrical hole in a tension member trebles the stress intensity. If the hole is elliptical the increase of stress may be still greater, and Inglis has shown, among other interesting cases, that if the minor axis of the ellipse is parallel to the direction of the applied load in a tension member, the stress intensity is increased by an amount measured by twice the ratio of the axis of the ellipse. A crack, considered as the limiting case of an elliptical hole, is thus seen to give extremely great stresses at the ends tending towards infinite values for an extremely fine crack. Optical experiments afford an independent means of examining the alterations of stress intensity produced by discontinuities, and the results are found to agree remarkably well with those obtained from the theory of elasticity. The stress at the boundary of a small cylindrical hole in a plate has been found to be almost exactly three times the stress in the full plate, and the effect of holes comparable with the width of the tension member has also been examined in some detail.

In the case of a rivet just filling the hole and exerting no tangential effect at the boundary, there is a lessened tension stress across the minimum section at the boundary hole, accompanied by a marked radial tension. These effects have been recently confirmed in a mathematical discussion by Suyehiro.* Other cases give satisfactory agreement with calculation, and we may feel some confidence that experimental investigation will prove useful in some of the very complicated cases of engineering practice where analysis is difficult, if not impossible.

The effects of overstress in materials may also be examined by optical means, and although the laws relating to stress distribution in overstressed transparent material are not known, the general effects observed in simple cases are fairly evident. If, for example, a tension member of glass is stressed, there is no ductile yielding of the material, and the stress will therefore rise very rapidly at the boundary of a small hole, and fracture will therefore occur with a moderate load. If, however, a ductile transparent material is employed, and the material shows signs of failure at the hole, the breakdown of the structure spreads outwards as the load is increased, until we may have a condition in which within the elastic limit the curve of stress intensity at the minimum section accords with calculation, but at the overstressed part the stress tends to equalise, and the curve of intensity tends to become horizontal near the hole. The mean value of this part of the stress distribution may be inferred from the difference between the total load and the measured values below the region of failure; but the true distribution of the overstress has not been accurately determined, so that the shape of this peak is largely conjectural. The effects of groups of rivets, such as occur in bridges, boilers, and structural members, afford ample scope for further inquiry; but before more exact knowledge can be gained of the condition of stress in a complicated riveted joint it appears necessary to examine thoroughly the very simple cases.

Mr. Scoble and I have examined the case of the load applied by one rivet to a plate with various amounts of overlap, and the stresses around the rivet holes have been measured with fair accuracy.

Other interesting cases of discontinuity in structure are afforded by the engine hatchways, gun-turrets, funnel openings, and the like, in ships' decks, and some progress in this direction has been made by experiments on model decks subjected to loads like those produced when a vessel meets the waves due to a head sea. Even if the utility of transparent models is left out of account, it is generally acknowledged that many engineering problems are often simplified by the use of models of machines and structures on a small scale, where circumstances forbid experimental examination of the actual work. No defence of their use is, I think, necessary, since the employment of models is a characteristic feature of British methods, not limited to engineers. Kelvin did not disdain their use, and his successors, who have done so much to advance knowledge of the ether and the atomic dust, have freely employed their great ingenuity in the construction of mechanical models and diagrams to explain their views, as in the Lodge cog-wheel diagrams of the ether, the planetary systems of atoms of J. J. Thomson and Rutherford, and the grouping of elements by Soddy.

Engineers have not the same great difficulties which confront those who are advancing the boundaries of pure science; their models are very much what they please to make them; but even then problems arise which are sufficiently difficult to tax all the resources of applied science. The behaviour of models considered as similar structures is therefore a subject which engineers are bound to investigate in order to determine the effects of fixed and moving loads, the action of wind, the pressure and frictional effects of steam and other fluids, and many other problems

In the majority of cases the simplest and the most direct method is the experimental study of a model, from which to obtain the data required for calculating effects on a full-sized structure, and hence the laws of similarity have received a very close scrutiny. Although most valuable information can be obtained from models, their usefulness is clearly limited. The effects of the dead-weight of a structure are proportional to the cube of the linear dimensions, and are therefore not usually measurable on a model save in exceptional circumstances, as, for instance, where elastic jellies are employed, as in the well-known investigations of Pearson on the stress distribution in reservoir dams. Nor are questions of stability easy to solve, since the forces producing instability are proportional to the size of the model. On the other hand, stress effects due to applications of load may be measured by the strains produced in a model of the same material, if the loads are proportional to the squares of the linear dimensions. The effects of applied load are studied even better in a model constructed of transparent material, since the variation of stress from

* See page 231 *ante*.

SOME TESTS ON A DIESEL ENGINE.

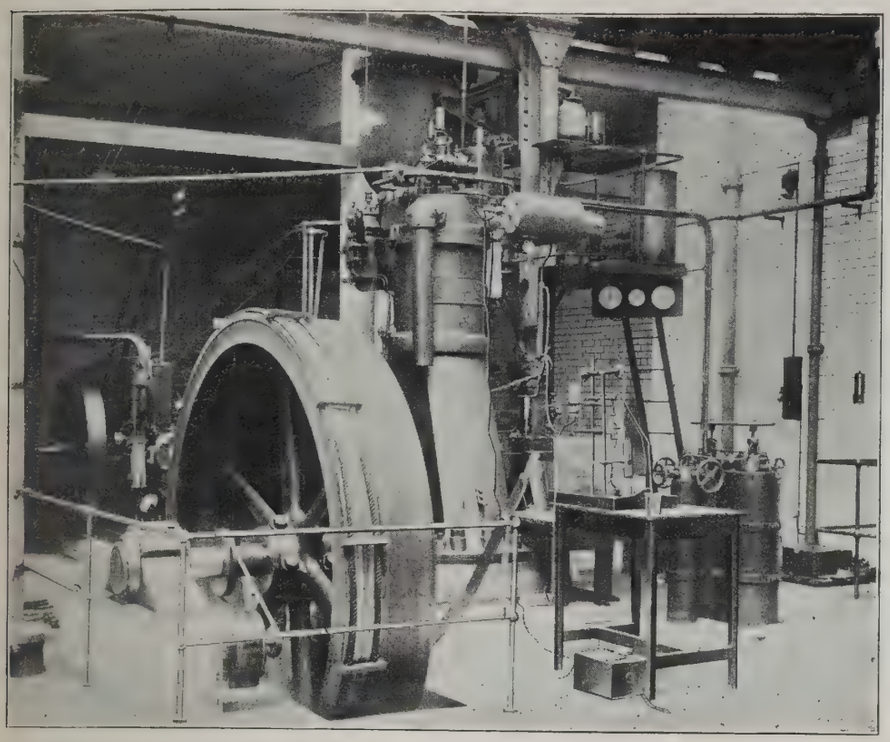


Fig. 1. Experimental Diesel Engine at the Royal Technical College, Glasgow.

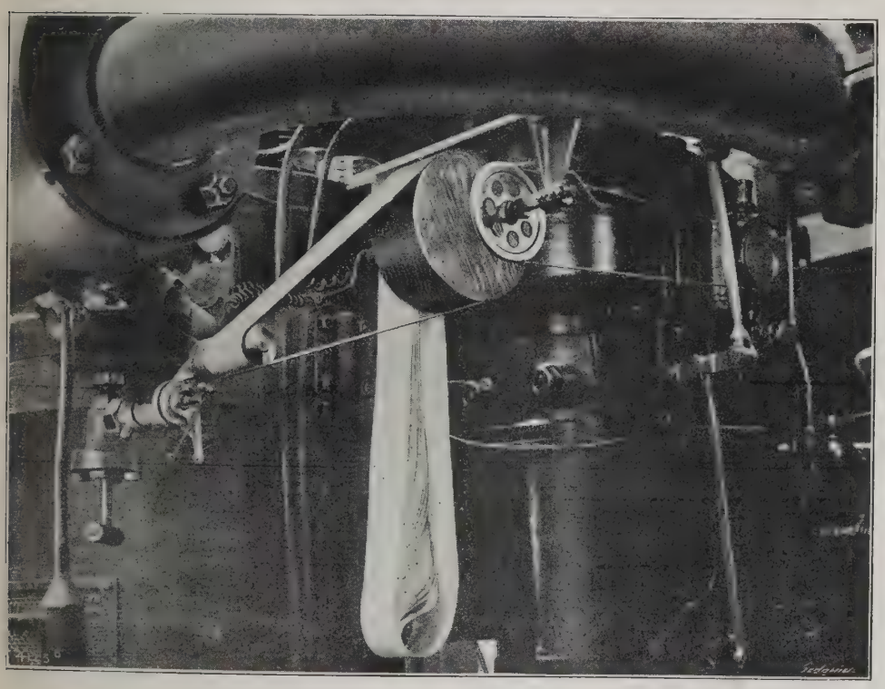


Fig. 2. Method of Taking Rotary Diagram.

point to point can be studied with much greater ease and certainty.

As detailed models of this latter kind present some variations from the usual laws of similarity, it may be of interest to indicate their nature. Questions of deformation clearly involve the elastic constants of the transparent material and their relation to those of the proposed structure, while stress distribution in the solid is influenced by the value of Poisson's ratio. This latter effect is quite small for glass, but may become appreciable with other substance. It is negligible in a model of any material which approximates to a thin plate stressed by forces in its own plane. The optical effects for any given load are, moreover, independent of the thickness of the material, and depend upon the stress difference, so that colour effects are obtained which may be regarded as pictures of shear stress throughout the model. Modern researches on ductile materials like structural steel indicate that such materials fail at some limiting value of shearing stress, and since the places where these limiting values are reached in the model are visible to the eye, the weak places in the design of a structure can be ascertained and a faulty design corrected by purely experimental means. In this connection it is of interest to mention that M. Mesnager, the chief engineer of bridges and roads to the French Government, has recently constructed an elaborate model in glass of a design for an arched bridge of about 310 ft. span. This investigation was considered advisable for a work of this magnitude constructed of reinforced concrete, in order to check the calculations, especially of maximum stresses in the arched ribs, which latter were assumed to be fixed at the ends. The effects of reinforcements were allowed for by determining equivalent sections of glass for the members of the model. Many difficulties had to be overcome in the production of a model free from optical defects, but these were all successfully surmounted. The stresses in the model were determined by the aid of a Babinet compensator, and formed a valuable check upon the calculations for a structure of this great magnitude and somewhat unusual design.

In this brief and incomplete account of a small branch of applied science relating to engineering the fundamental importance of discoveries in pure science is manifest.

The discoveries in pure science and their innumerable applications to practical ends are ever a potent factor working for the common good, and the value which the British Association places upon applied science was most cordially voiced by Professor Bateson in his Portsmouth address, when he said: "To the creation of applicable science the very highest gifts and training are well devoted," and, "The man who devotes his life to applied science should be made to feel that he is in the main stream of scientific progress. If he is not, both his work and science at large will suffer. The opportunities of discovery are so few that we cannot afford to miss any, and it is to the man of trained mind, who is in contact with the phenomenon of a great applied science, that such opportunities are most often given;" and again: "If we are to progress fast, there must be no separation between pure and applied science. The practical man, with his wide knowledge of specific natural facts, and the scientific student, ever seeking to find the hard general truths which the diversity of Nature hides—truths out of which any lasting structure of progress must be built—have everything to gain from free interchange of experience and ideas."

Engineers who are more immediately concerned with the problems of directing the great sources of power in Nature for the use and convenience of man are indeed grateful to our President for these inspiring words, and trust that the ties which unite investigators in pure and applied science will never slacken, but will knit together more closely for a joint advance to a more perfect understanding and utilisation of the laws of Nature.

SOME TESTS ON A DIESEL ENGINE.*

By Walter S. Burns, A.R.T.C.

The object of the following paper is to give an account of some trials made to discover the effect of (1) variation of blast-pressure, and (2) variation of jacket-water temperature, upon the running of a Diesel engine. The work to be described was suggested by Professor Mellanby as a suitable subject for research by the author whilst holding a Beilby scholarship, and was carried out in the laboratory attached to the department of mechanical engineering in the Royal Technical College, Glasgow.

Those familiar with the Diesel engine may know, from their every-day experience, which blast-pressure and which jacket-water temperature give them the best results for different loads, but the information on these points available to the general engineer is very scanty. It seemed desirable that not only should the influence of these factors upon economy be given, but that an attempt should be made to find some explanation for any increase or decrease of efficiency that might be observed from altering either one or the other condition. To obtain this explanation some knowledge of the changes taking place in the cylinder during combustion seemed desirable, and at once the unsuitability of the ordinary indicator diagram for this work became apparent. The combustion part of the cycle takes place when the piston is moving very slowly, so that with the usual reciprocating indicator diagram the record of the pressure changes is crowded into a very small space. The use of rotary indicator-cards was then decided upon, and after many experiments a suitable speed for driving the indicator was selected. A description of the driving-gear will be given later. A large number of the diagrams thus obtained are given in this paper, and it is hoped that they will serve to explain some points that have hitherto not received much attention.

The Diesel engine upon which the experimental work was carried out is shown in Fig. 1. The engine was supplied by the Mirrlees Watson Company, Limited, in 1906, and has since been used for ordinary laboratory purposes. The engine is loaded, as shown, by means of a rope-brake applied to a water-cooled rim, 9 ft. in diameter, bolted to the fly-wheel. A two-stage compressor for supplying the blast and starting air is driven by a crank at the end of the engine-shaft. The engine dimensions are:—Stroke, 18¼ in.; diameter of cylinder, 12 in. Normal revolutions per minute, about 200. The Horn tachograph is driven off a wooden drum on the crank-shaft; the platinum resistance pyrometer for measuring the temperature of the exhaust gases and the gas-sampling apparatus are plainly shown.

The method of taking the rotary diagrams is shown in Fig. 2. The spring and stopper were removed from the indicator-barrel; a card consisting of a circular strip of paper, about 33 in. long by 2½ in. broad, was passed over the indicator-drum and also over a wooden drum fixed to a small spindle parallel to the indicator-drum. The spindle was driven from the cam-shaft, and was fitted with a clutch for starting and stopping the cards. To record the position of the beginning of the stroke on the cards an electrical striker was fitted to the indicator, and was adjusted to make a mark just beneath the indicator-pencil when the piston was at top dead-centre. The striker was adjusted to a known point on the ordinary reciprocating card, the adjustment being made at the electrical contacts at the fly-wheel, as shown in Fig. 3, page 264.

The engine was run throughout the following tests with Pumpherston shale-gas oil of specific gravity 0.864 and net calorific value 18,200 B.Th.U. per lb.

* Paper read before the Institution of Engineers and Shipbuilders in Scotland at Newcastle-on-Tyne.

The oil-measuring apparatus can be seen in Fig. 1.* It consists of two glass vessels connected by a glass tube. When a trial starts the oil is arranged to be at some carefully-noted point in the glass tube, and a measured quantity added. The trial is arranged to finish when the oil-level again reaches the noted point in the glass tube. The analyses of the gas samples were conducted over mercury in a Haldane gas-analysis apparatus. All other necessary observations were taken at five-minute intervals during each test.

The load was kept practically constant throughout each series of tests by adding or taking off small weights, according as the rope friction decreased or increased.

Before starting a series of tests the engine was run from two to three hours at the load required for that series to ensure a steady temperature state being reached throughout.

* For further details of measuring apparatus, see paper on "Oil Fuels" (Transactions of the Institution of Engineers and Shipbuilders in Scotland, vol. lvii., page 195).

Fig. 4 shows a rotary diagram taken immediately after the fuel was shut off, giving the compression and expansion of the air in the cylinder under working conditions. It follows that equal increments of length on the atmospheric line of this diagram represent to scale equal increments of crank angles.

The cards shown travelled about 7.6 in. in one revolution, or about 25.6 in. per second; so that the paper was travelling under the indicator-pencil at high speed, relative to piston displacement, at top and bottom dead-centres; the changes of pressure in the engine cylinder at and around those points can therefore be studied in great detail. In Fig. 4, as in all the other diagrams, the vertical line in the middle of the card is drawn perpendicular to the atmospheric line through the top dead-centre mark as given by the electrical striker. The distances between the short vertical lines near the ends of the atmospheric line show the travel of the card for one revolution of the engine. The atmospheric line in Fig. 4 is subdivided into equal piston displacements, the numbers representing one-tenth of piston displacement on either side of top dead-centre.

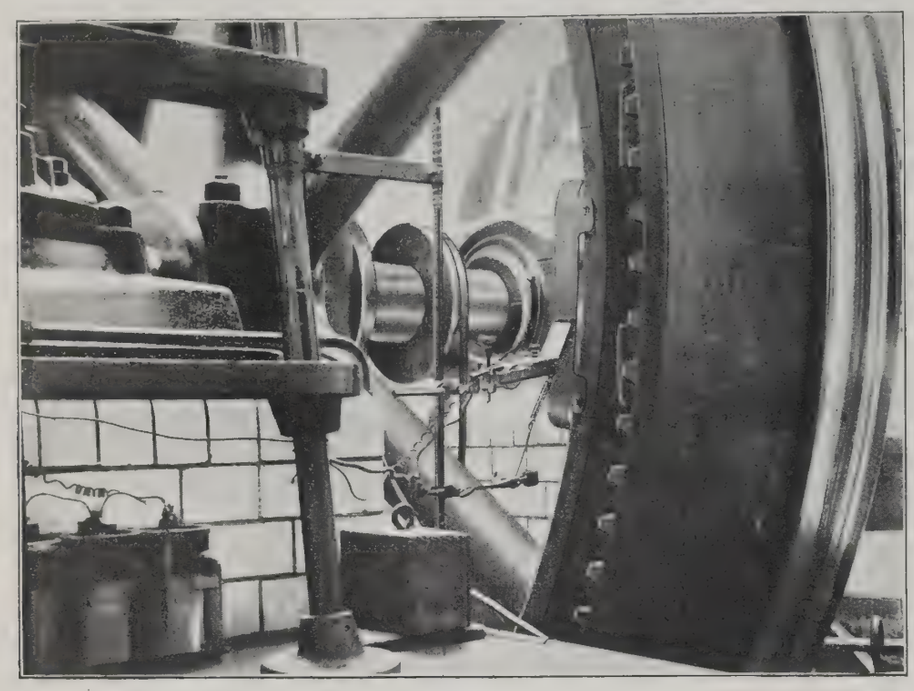
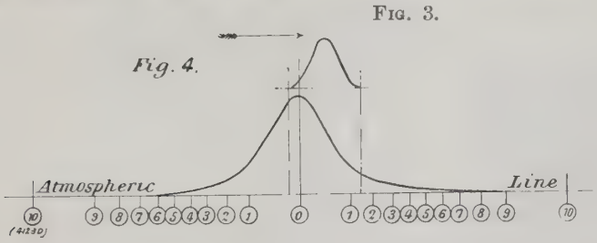


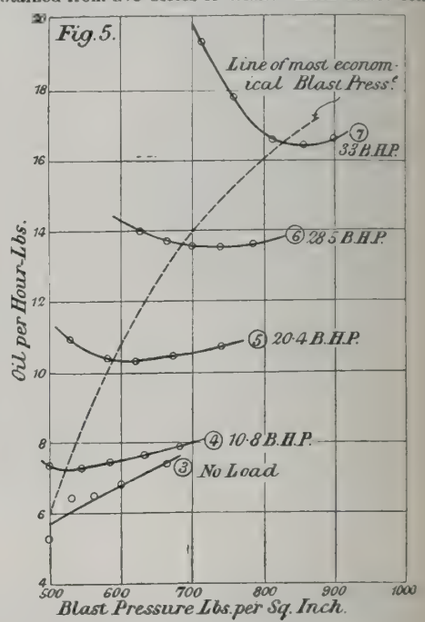
Fig. 3.

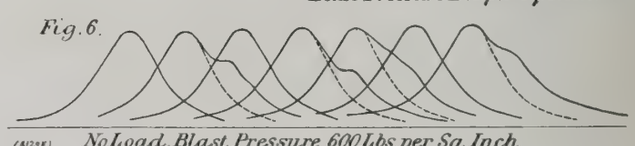


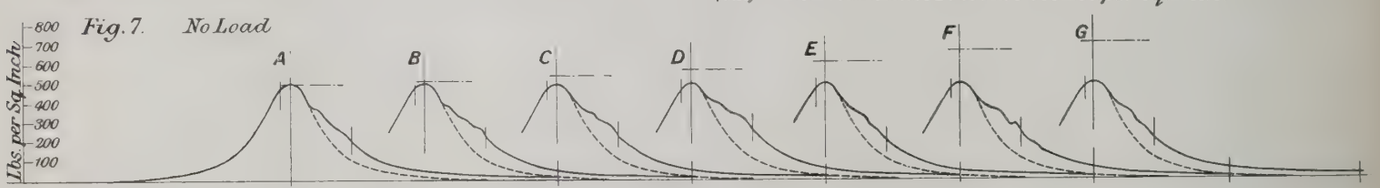
The small diagram in Fig. 4 shows the motion of the fuel-valve, to a magnified scale, relative to the indicator diagram. It was obtained by placing an indicator on the fuel-valve in such a way that vertical displacements of the indicator-pencil were proportional to the movement of the fuel-valve spindle. The indicator-drum was driven at a constant angular velocity by a cord from a wheel on the countershaft spindle already mentioned. On each of the diagrams which follow, the expansion line of the diagram, Fig. 4, is reproduced and shown dotted. The height of the chain-dotted line from the atmospheric line represents, to the scale of the diagram, the blast pressure corresponding with each card. The two short vertical lines, one near the top of the compression curve and the other some distance down the expansion curve, indicate the opening and closing of the fuel-valve on each diagram.

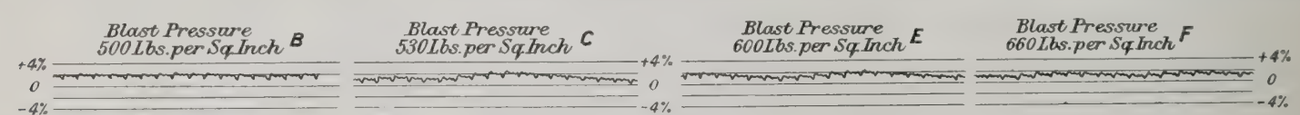
Experiments with Different Blast-Pressures.—The five curves shown in Fig. 5 were obtained by plotting results obtained from five series of trials. Each series consists of five short tests run at different blast-air pressures, the load remaining constant throughout each series. It is evident that unsuitable choice of blast-air pressures causes considerable increase in consumption. For example, by dropping the blast-air pressure from 700 lb. to 600 lb. per sq. in. at normal load (about 30 brake horse-power), the consumption is increased by about 0.37 lb. per hour.

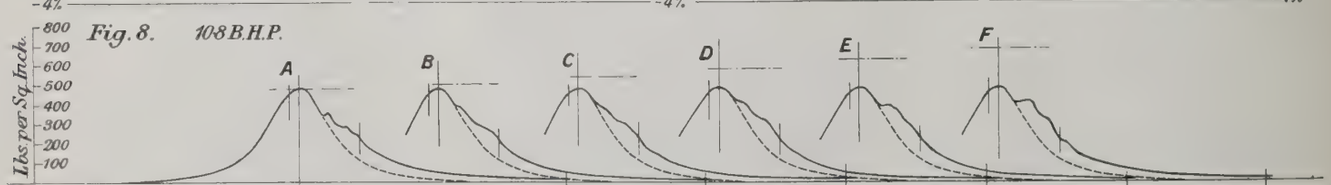
In Table I. are given the results of several of these tests. Only the results for the trial at the most economical blast-pressure in each series are given, except in the case of series No. 10, where the results for all five trials are shown. Figs. 7, 8, 9, 10, and 11 show rotary diagrams taken throughout the whole five series of trials. There is one diagram corresponding to each blast-pres-








Blast Pressure 500 Lbs. per Sq. Inch B
Blast Pressure 530 Lbs. per Sq. Inch C
Blast Pressure 600 Lbs. per Sq. Inch E
Blast Pressure 660 Lbs. per Sq. Inch F
+4%
0
-4%



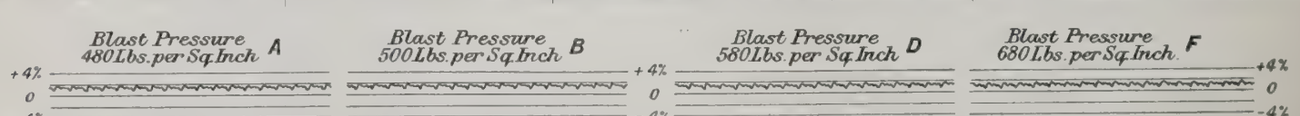
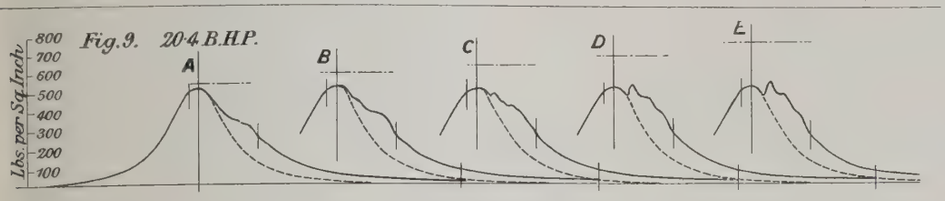
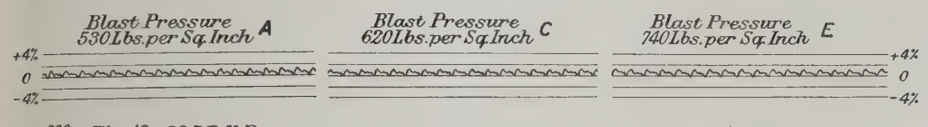
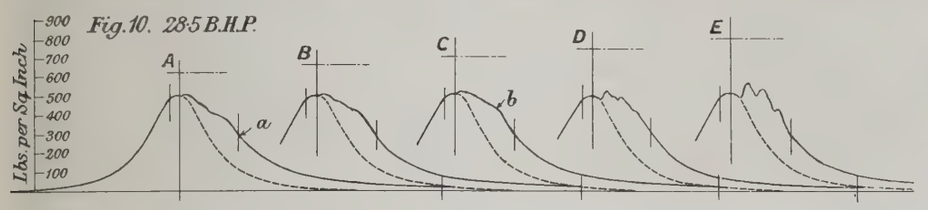

Blast Pressure 480 Lbs. per Sq. Inch A
Blast Pressure 500 Lbs. per Sq. Inch B
Blast Pressure 580 Lbs. per Sq. Inch D
Blast Pressure 680 Lbs. per Sq. Inch F
+4%
0
-4%

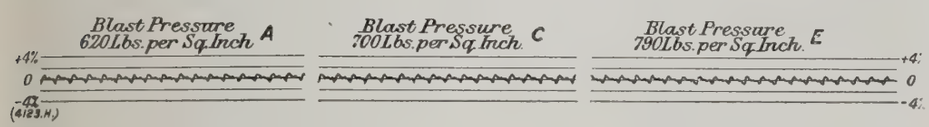
TABLE I.

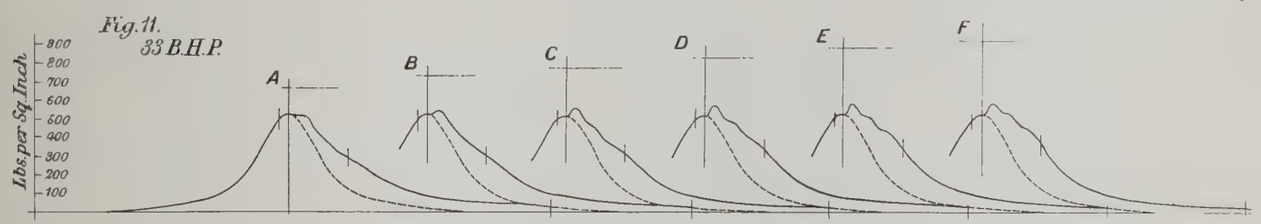
No. of series	7	8	9	10					11
Letter of trial in series	B	C	B	A	B	C	D	E	E
Date of series	17/3/14	24/3/14	31/3/14	10/3/14	10/3/14	10/3/14	10/3/14	10/3/14	23/4/14
Average revolutions per minute	205.8	204.8	203.4	202.4	202.4	202.5	202.2	202.1	201
Brake horse-power	0	10.8	20.4	28.5	28.5	28.5	28.5	28.5	33
Blast-pressure lb. per sq. in.	500	540	580	620	660	700	740	790	860
Exhaust temperature deg. Fahr.	251	381	487	601	584	570	567	566	691
Jacket-water inlet temperature deg. Fahr.	83	74	71	61	61	63	64	66	63
Jacket-water outlet temperature deg. Fahr.	144	156	162	143	141	142	142	143	151
Jacket-water used per hour lb.	249	218	431	754	743	727	729	730	920
Oil used per hour "	5.18	7.23	10.36	13.97	13.62	13.45	13.68	13.87	16.55
Oil used per hour per brake horse-power lb.	—	0.67	0.507	0.489	0.48	0.477	0.478	0.48	0.50

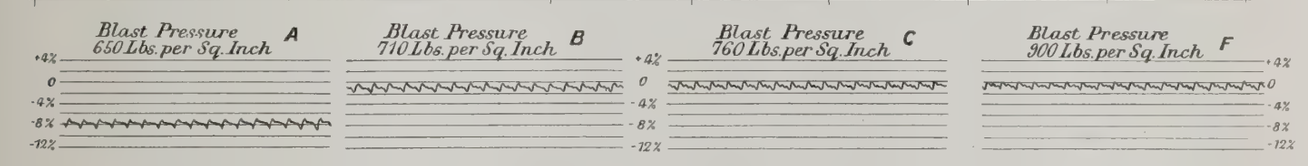


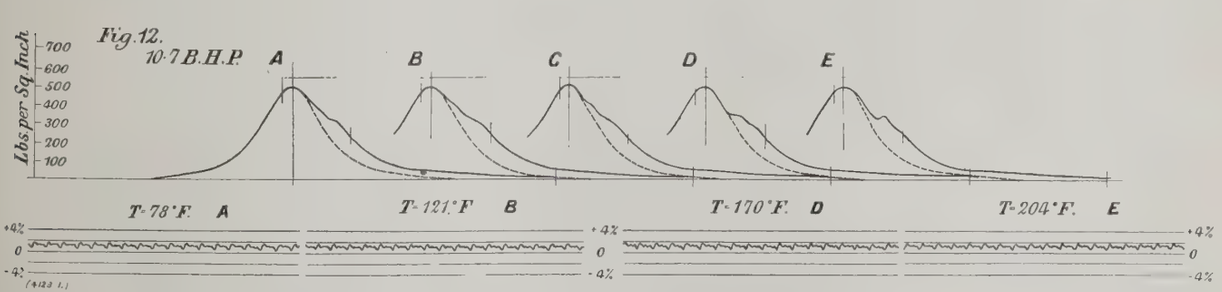









Blast Pressure 650 Lbs. per Sq. Inch A
Blast Pressure 710 Lbs. per Sq. Inch B
Blast Pressure 760 Lbs. per Sq. Inch C
Blast Pressure 900 Lbs. per Sq. Inch F
+4%
0
-4%
-8%
-12%



sure in each series, only that part showing the working stroke being given. Underneath the diagrams are tachograph records, taken at intervals during each series.

An attempt will now be made to draw a few conclusions concerning the behaviour of the fuel from the shape of the diagrams. Consider first the "no load" series, Fig. 7. The tachograph records show that at all blast-pressures there is a considerable amount of hunting. Fig. 6 shows a cluster of cards taken at no load, with a blast-pressure of 600 lb. per sq. in. Corresponding with the hunting shown on the tachograph records, some of the diagrams show a large combustion area, while others show none whatever. Consideration of a large selection of cards show that it is very difficult to choose a set of diagrams illustrating the changes caused by the variation of blast-pressure at no load; because sometimes ignition takes place just after top dead-centre, and at other times ignition takes place when the pressure has dropped to about 300 lb. per sq. in. in the cylinder. From curve 7, in Fig. 5, it is seen that the lower the blast-pressure the more economical is the engine. Diagrams A and B, and also the tachograph records shown in Fig. 7, obtained at blast-pressures of 480 lb. and 500 lb. per sq. in., are comparatively regular. Above blast-pressure of 500 lb. per sq. in. there is great irregularity in the point of ignition of the fuel, until a blast-pressure of about 700 lb. per sq. in. is reached, when the cards again become regular. But in this case the high blast and the excess air already present probably do much to prevent complete combustion.

The tachograph readings, Fig. 8, show that the engine is running steadily, and also that the speed is greatest at the most economical blast-pressure. There is still some difficulty in choosing diagrams typical of those obtained in each test of the series. Here, as in Fig. 7, the large quantity of excess air and the blast air, particularly at high blast-pressures, cause delayed ignition. Of course, in diagram A, at a blast-pressure of 480 lb. per sq. in., the oil is probably not properly pulverised, since the compression pressure of the engine is between 480 lb. and 490 lb. per sq. in., thus causing late ignition of the fuel.

The diagrams shown in Fig. 9 can be relied upon as being typical of the diagrams obtained in each test. The expansion-line on diagram A shows, as at lighter loads, that the oil burns late in the stroke, probably because it is not properly pulverised, causing increase of exhaust pressure and temperature above normal. Diagram B shows that combustion begins almost at the top dead-centre, and the burning is completed considerably earlier in the stroke. In diagrams C and D the blast-pressures cause considerable irregularity about the point of ignition. Sometimes combustion starts at the top dead-centre, giving a smooth expansion curve; at other times the pressure line follows down the dotted expansion line some little distance, then there is a sudden addition of heat, causing a peak in the expansion line. This late ignition is probably due to the cooling action of the blast air. Diagram E shows the ignition later than D, attended by a more rapid explosion of the oil, causing a slight knock in the engine cylinder. The diagrams obtained at this high blast-pressure are all similar to the samples shown.

The diagrams shown in Fig. 10 illustrate changes much the same as those in Fig. 9. As the blast-pressure increases up to the most economical pressure the rate of combustion of the oil increases considerably; for example, in diagram A combustion ceases, and true expansion starts just after the fuel-valve closes (about point "a"), whereas in diagram C combustion is completed, and expansion begun some time before the fuel-valve is closed (about point "b"). At high blast-pressures ignition is retarded, and is attended by a sudden rise in pressure, causing peaks on the diagrams. The ragged nature of the expansion line on diagram C (Fig. 10) is caused by the vibration of the indicator spring and mechanism, due to the sudden increase in pressure.

In Fig. 11, again, increase of blast-pressure, up to the most economical pressure, causes the rate of combustion of the oil to increase considerably. But above the most economical blast-pressure, because of the large quantity of oil injected per stroke at this high load, ignition of the oil seems to take place before the blast air can affect it, even at blast-pressures as high as 900 lb. per sq. in.

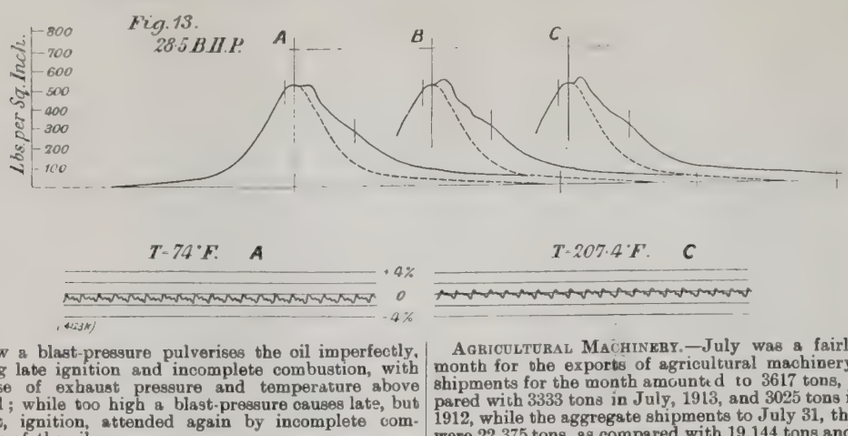
In diagrams A and B combustion is not complete until the piston has moved about one-quarter of the stroke; whereas, in diagrams D and E, true expansion begins when the piston has moved about one-tenth of the stroke. It is of interest here to examine the composition of the exhaust gases.

In test A the large increase in CO_2 and CO above normal in the exhaust gases indicates very bad combustion of the oil, which caused the speed of the engine to drop appreciably, as shown on the tachograph record.

Number of series			7		
Letter of trial in series			A	C	E
Composition of exhaust gases per cent. by volume	Carbon di-oxide		10.29	8.35	7.79
	Carbon mon-oxide		0.85	0.05	0.03
	Oxygen		6.26	9.62	10.35
	Nitrogen		82.33	81.96	81.83

Summing up, at light loads, the excess air already in the cylinder, and the inrush of blast air with the small quantity of oil, cause late ignition and slow combustion of the fuel. Then, as the load increases, and the mixture of pulverised fuel and air becomes richer, there is a correspondingly earlier ignition, and also an increase in the rate of propagation of the explosion. At all loads

SOME TESTS ON A DIESEL ENGINE.



too low a blast-pressure pulverises the oil imperfectly, causing late ignition and incomplete combustion, with increase of exhaust pressure and temperature above normal; while too high a blast-pressure causes late, but violent, ignition, attended again by incomplete combustion of the oil.

Variation of Jacket-Water Temperature. — Diagrams, Figs. 12 and 13, illustrate the effect of variation of cylinder jacket-water temperature at low and high loads. Examination of the trial results in Table II. shows that the higher the temperature of the jacket-water the more economical is the engine. For example, at normal load, raising the jacket-water outlet temperature from 74 deg. Fahr. to 207 deg. Fahr., by cutting down the supply of water, causes a decrease in the oil consumption of fully 4 lb. per hour. There is a marked decrease in the CO_2 and CO present in the exhaust gases at the high temperatures, which also indicates that the oil is being dealt with much more economically. The heat given to the cooling water per unit of time at the low temperature is about five times as great as the heat given at the high temperature. The tacho-

Table II.

No. of series	12		13	
Letter of trial in series	A	E	A	C
Date of series	26/3/14	26/3/14	13/5/14	13/5/14
Average revolutions per minute	204.2	204.8	200.4	202.0
Brake horse-power	10.7	10.7	28.5	28 5
Blast-pressure, lb. per sq. in.	540.0	540 0	710 0	710.0
Exhaust temperature, deg. F.	387.0	391.0	748.0	670 0
Jacket-water inlet temperature, deg. Fahr.	51.5	94.0	53.0	86.0
Jacket-water outlet temperature, deg. Fahr.	78.0	204.0	74.0	207.4
Jacket-water used per hour, lb.	1970	40.8	5380	187
Oil used per hour, lb.	8.10	7.30	18.77	14.43
Oil used per hour per brake horse-power, lb.	0.756	0.682	0.659	0.506
Carbon dioxide*	3.32	2.94	7.96	6.35
Carbon monoxide*	0.46	0.24	0.09	0.05
Oxygen*	19.27	16.99	10.06	12.34
Nitrogen*	78.71	79.83	81.89	81.26

* Composition of exhaust gases per cent. by volume.

graph records in Figs. 12 and 13 show that increase of jacket-water temperature causes a slight increase of speed. This increase of speed is probably due to the cylinder lubricating oil becoming less viscous at the high temperature. Diagrams A and B, Fig. 12, show that at moderate temperatures combustion takes place late in the stroke, and the rate of combustion is slow. Diagrams D and E show that as the temperature of the cylinder walls and piston increases, ignition still occurs late in the stroke, but that combustion takes place much more quickly. As before, selection of typical diagrams is a difficult matter, due to the irregularity in the point of ignition at this low load. Fig. 13 shows that at high loads increase of jacket-water temperature causes more violent combustion of the oil which first enters the cylinder, followed by normal rate of combustion.

As a general conclusion it may be stated that at all loads increase of jacket-water temperature does not seem to affect the point of ignition of the oil appreciably, but causes more rapid and more complete combustion with increased efficiency.

The author desires to express his indebtedness to Mr. R. Royds, M.Sc.; Mr. J. W. Campbell, M.Sc.; Mr. J. H. Sinclair, M.Sc.; Mr. C. Crawford; and Mr. A. Bruce, for assistance during the running of the trials; and to Mr. J. G. King, for the analyses of the exhaust gases.

Canals in Norway.—The old scheme for a waterway between Lake Mjösen, Norway, and the sea is again to the fore, and as a first step the part canalisation of the Glommen is being advocated. The building of several dams on the section Vamma-Mörkfas will facilitate the solution of this important question by the Glommen being made navigable from Oieren to Sarpsborg and on to Frederiksstad. Locks will have to be built by the side of the dams already built, or about to be built, but this is not expected to present any difficulties. The water level above the Sarpsfos Falls will have to be raised to a mean of 23.50 metres above the level of the sea, in order to make the canalisation of Glengshölen efficient. The passage round the Sarpsfos Falls, one of the most difficult features of the plan, will be solved by means of a combination of locks and tunnel, and the whole scheme is looked upon as feasible also from a financial point of view.

Agricultural Machinery.—July was a fairly good month for the exports of agricultural machinery. The shipments for the month amounted to 3617 tons, as compared with 3333 tons in July, 1913, and 3025 tons in July, 1912, while the aggregate shipments to July 31, this year, were 22,375 tons, as compared with 19,144 tons and 20,001 tons. It is to be feared, however, that the progress indicated by these figures will not be maintained, as our shipments of agricultural machinery are made principally to European countries, and the present state of affairs will seriously affect trade in this area.

The Institution of Naval Architects and the War.—Mr. R. W. Dana, the Secretary, has written to the British members of the Institution stating that "the Council have considered whether they could take any useful action for enabling the Institution to render service to the country at the present time. Suggestions have been made for placing members desirous of serving their country in communication with the proper authorities, but the Council are advised by those of their members who are in close touch with the Admiralty that it is preferable for members to make individual application to the proper quarter, stating their qualifications for service; and the Council are of opinion that a similar procedure will be found best in the case of the various organisations now being initiated by the Government and private enterprise for the defence of the country, the distribution of supplies, and the relief of distress. The Council are aware that many members have already taken this course, and that the shipbuilding and marine engineering resources of the country will be materially strengthened by the assistance thus given."

Launch of a Norwegian Battleship.—The Norwegian coast-defence battleship Bjorgvin has just been launched from the Elswick shipyard of Sir W. G. Armstrong, Whitworth and Co., Limited. The Bjorgvin is a sister vessel to the Nidaros, launched from the same yard on June 9. The new vessels have a length of 310 ft. over all, and of 290 ft. between perpendiculars, the breadth, moulded, being 55 ft, and the depth 26 ft.; the draught in service is 16 ft. 6 in. Their principal armament consists of two 9.45-in. guns in armoured gun-houses, and four 6-in. guns. The whole of the armament is being constructed at Elswick, and the whole of the armour is being manufactured at the firm's Openshaw Works at Manchester. The propelling machinery and boilers for both vessels are being constructed by Messrs. Hawthorn, Leslie and Co., Limited, Newcastle-on-Tyne. The designed speed is 15 knots. The new ships are protected by a water-line belt of 7 in. in thickness, tapering to 4 in. at the ends, while the barbettes for the 9.4-in. guns are of 8-in. armour. The upper belt is of 4-in. armour, and extends from the main belt to the upper deck. There is also deck protection of 2 in. thickness. Having regard to the prevailing condition of affairs in the country, the launch was carried out as quietly as possible; only officials of the firm, a few Norwegians, and others directly interested in the vessel, were present.

Reinforced-Concrete Railway Sleepers.—Timber becoming scarce, railway engineers have for some years past been anxious to find other suitable material for the manufacture of railway sleepers. Iron and steel sleepers have not given the results hoped for. The *Moniteur Industriel* records that in 1890 Italian engineers laid at the Ancona stations trial sleepers made of reinforced concrete. Similar trials have been carried out in Switzerland, Germany, and the United States. The results they have given cannot, so far, be considered conclusive. They are generally heavy, and are hence difficult to handle; hitherto they have been made by hand, and their homogeneity depends upon the care with which the man in charge carries out his work. The various systems tried for fixing the rails to the sleepers cannot be considered entirely satisfactory. The cost of these reinforced-concrete sleepers is so high as to be almost prohibitive. A French company—the Compagnie Française du Ferro-Ciment—would seem, according to our contemporary, to have found a means of manufacturing perfectly homogeneous reinforced-concrete sleepers mechanically, by using fine iron turnings, which, mixed with concrete, are pressed together to shape under powerful hydraulic presses. The company is said to have also devised a satisfactory rail-fixing device. Sleepers of this type were laid in December, 1912, at La Charité, in the centre of France, also at other French railway stations, where they are still giving complete satisfaction.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Canada: The Imperial Trade Correspondent at Toronto has forwarded a copy of the report of the Ontario Public Roads and Highways Commission, which was appointed on July 31, 1913. The Commissioners suggest that the province should embark on a fifteen years' policy of road construction, involving a capital expenditure of 30,000,000 dols. (about 6,167,000*l.*). It is recommended that the undertaking should be placed under a Minister of the Crown, assisted by a permanent administrative head and a technical staff. It is estimated that 42,500 miles of township roads will have to be brought up to a reasonably fair standard, and 7500 miles of county roads made able to bear the severe demands made upon them. The Commissioners consider that a successful solution of the problem of good roads depends largely upon a recognition of the fact that self-propelled vehicles have come to stay; indeed, the motor has partly created the problem, for it has proved so destructive to main highways, which resisted the wear and tear of horse-drawn vehicles, that means must be found to guard against a deterioration which now proceeds with a rapidity hitherto unknown. The putting of taxation of motor vehicles on a systematic basis is also recommended.

New Zealand: According to an extract from the local Press, received from the office of H.M. Trade Commissioner for New Zealand, it appears that the borough council of Foxton is making preparations for the extension of the municipal gas works and the erection of pumps and retorts. Tenders are to be called for immediately.

South Africa: H.M. Trade Commissioner for South Africa has forwarded a copy of an explanatory memorandum, prepared by the South African Railways and Harbours Board, relative to harbour improvement works which were provided for in the 1914-15 Estimates. The works are as follows:—Buffalo Harbour, East London: Extension of the eastern breakwater, removal of the east pier, &c., and the extension of the south breakwater by 500 ft., at a total cost of 400,000*l.* It is recommended that this work be carried out without delay, as otherwise East London will be seriously handicapped owing to the larger vessels now trading to South Africa being unable to enter the harbour. Cranes will be required for the work, but no large orders for cement are likely for some time. Port Elizabeth Harbour: An extensive scheme for the increase of accommodation has been prepared, but at present it is only proposed to construct a south breakwater at a cost of 1,500,000*l.* The breakwater will be 8500 ft. long, and built of 50-ton sloping concrete block-work. Two 50 ton cranes, concrete-mixers, and concrete-block yard plant will be required. Durban Harbour: The existing south breakwater is to be strengthened and extended about 125 ft. at a cost of 71,252*l.* A graving-dock is to be constructed at an estimated cost of 780,000*l.* (this is a revised estimate, the original being 500,000*l.*, which is the sum provided for in the Estimates). It will be 1030 ft. long, 110 ft. wide at the entrance, and 41 ft. deep on sill at high-water spring tide, or 35 ft. at low water, and will not be completed before 1920. Cranes, concrete-mixers, light railways, grabs, &c., will be required, and also timber for the cofferdam.

Spain: The *Gaceta de Madrid* contains a Royal Decree, authorising the Dirección General de Obras Públicas to call for tenders for the construction of a wet dock, as an anchorage for small craft, in the port of Cadiz. The upset price is put at 296,742 pesetas (about 11,000*l.*). The *Gaceta* also announces that tenders will be received, up to August 26, at the Dirección General de Correos y Telegrafos, 10, Calle de Carretas, Madrid, for the supply of twenty-five railway coaches, the upset price for which is put at 1,300,000 pesetas (about 48,100*l.*). The notice contains a clause to the effect that the first competition will be confined to railway coaches of Spanish manufacture, but that in the event of no decision being arrived at, a second competition, in which foreign railway coaches may be accepted, will then take place. In the latter event Spanish products will have a preference of 10 per cent. over foreign.

Morocco: With reference to the railway development in Morocco, the *Gaceta de Madrid* contains a law approving the agreement between the Spanish Government and the Compañia General Española de Africa for the concession for the railway from Tangier to Fez.

Slide-Rule for Estimating Power for Steamships.—We have received from Mr. John Rennie, of 1094, Cathcart-road, Glasgow, a sample of a slide-rule he has recently designed for the rapid and accurate estimate of the power required to propel steamships at different speeds. The rule, which is about 2 ft. 8 in. long, is provided with two moving slides and two sets of fixed scales, and by following the instructions given, the complicated calculations involved in estimating the power requirements of a given hull can be effected most easily and most quickly. All the factors involved are provided for by the different scales, including the effect of the beam to draught ratio, to which attention has been drawn by Sir Phillip Watts. By means of the rule, moreover, the economical speed of a ship of given length and stated prismatic coefficient is obtained almost instantly, and the price to be paid for any excess can be ascertained with equal rapidity. The rule, the price of which is fixed at 1*l.* 10s., can be obtained direct from h inventor.

CALCIUM CARBIDE AND NITROGEN PRODUCTS.

In the domain of electro-chemistry the greatest developments recently—at all events, commercially—have been in the utilisation of nitrogen from the atmosphere for the manufacture of nitrogen products. The chemical reactions in the various processes have long been known, but it is only since electrical power has been obtainable in large amount at exceptionally low cost that the operations have been carried out profitably on a commercial basis.

Of the processes so far used commercially for the fixation of atmospheric nitrogen, probably the most interesting is that in which calcium carbide is employed as the medium for the production of calcium cyanamide. The reaction whereby calcium cyanamide is formed was first applied in the laboratory in 1857, but its commercial development is of much later date, and is due to Dr. Adolf Frank and Dr. N. Caro, who, in an endeavour to produce calcium cyanide from calcium carbide, discovered that the reaction did not follow the same course as in the case of barium carbide, but that, instead of calcium cyanide, a substance which was recognised as calcium cyanamide was the result. With the co-operation of Messrs. Siemens and Halske and the Deutsche Bank of Berlin a company was founded, which carried the experiments still further, and demonstrated that with cheap electrical power the process was commercially possible.

Calcium carbide, which first came into prominence as a material for the generation of acetylene in contact with water, is composed of 37.5 per cent. carbon and 62.5 per cent. calcium. It is prepared by subjecting lime (CaO) and carbon (C) in suitable proportions to a high temperature in an electric furnace, when the reaction represented by the following equation takes place :—

Lime.		Carbon.		Calcium Carbide.		Carbon Monoxide.
CaO	+	$3\,C$	=	$Ca\,C_2$	+	$CO.$

When calcium carbide is heated to a temperature of approximately 900 deg. Cent., in an atmosphere of nitrogen it readily combines with the latter, forming calcium cyanamide, known in this country as nitrolim, and at the same time one of the two atoms of carbon of the calcium carbide is separated out. The reaction is as follows :—

Calcium Carbide.		Nitrogen.		Calcium Cyanamide.		Carbon.
$Ca\,C_2$	+	N_2	=	$Ca\,CN_2$	+	C

The reaction is exothermic; that is to say, it produces heat, and this property is utilised in manufacture to promote reaction. To obtain a high efficiency of fixation, it is necessary that the nitrogen shall be pure, and that the conditions as to temperature, &c., be maintained as constant as possible. The finely-powdered carbide used in the manufacture is transformed into a hard stone-like mass of a black-grey colour, the dark colour being due to the carbon separated out from the carbide. When cyanamide is treated with steam, ammonia and calcium carbonate are formed according to the equation :—

Calcium Cyanamide.		Steam.		Ammonia.		Calcium Carbonate.
$Ca\,CN_2$	+	$3\,H_2O$	=	$2\,NH_3$	+	$Ca\,CO_3$

Under ordinary manufacturing conditions an efficiency of extraction closely approaching 100 per cent. is easily obtained. This property of cyanamide renders it extremely valuable, and opens the way to the cheap manufacture of many extremely valuable chemical products. Among others may be mentioned ammonium sulphate—a salt, largely employed for fertilising purposes, which is produced by the fixation of ammonia in sulphuric acid according to the equation :—

Ammonia.		Sulphuric Acid.		Ammonium Sulphate.
$2\,NH_3$	+	H_2SO_4	=	$[N\,H_4]_2\,SO_4$

A further important application is the production of nitric acid, which is effected by means of the Ostwald process of oxidation of ammonia. To this end ammonia is generated from cyanamide and oxidised by air with the aid of platinum catalysers. The reaction, which is a highly efficient one, is represented by fundamental equation as below :—

Ammonia.		Oxygen of Air.		Nitrogen Dioxide.		Water.
$2\,NH_3$	+	$7\,O$	=	$2\,NO_2$	+	$3\,H_2O$

By further oxidation, the NO_2 is converted into nitric acid, HNO_3. By absorbing ammonia in nitric acid, ammonium nitrate is produced according to the equation :—

Ammonia.		Nitric Acid.		Ammonium Nitrate.
NH_3	+	NHO_3	=	$NH_4\,NO_3$

Ammonium nitrate is a powerful fertiliser, but at present is used almost exclusively in the manufacture of safety explosives.

Another important product of cyanamide is dicyandiamide $[CNNH_2]_2$, which in the pure state contains 67 per cent. nitrogen. Urea, one of the most active of nitrogen fertilisers, is also a product of cyanamide, and, according to eminent authorities, the nitrogen in cyanamide passes into this form in its transformation from the amide of cyanamide to the nitrate form in which it is assimilated by the soil bacteria.

The exploitation, commercially on a large scale, of the products resulting from these well-known chemical reactions had its origin in a small company, formed in London some years ago, for the manufacture and sale of a plant for the generation of acetylene-gas from calcium carbide by a dry process. This concern was under the management of Mr. A. E. Barton, and he soon realised that the success of any scheme for extending the use of acetylene-gas was dependent on the adequacy of supply, and therefore the cheapness, of calcium carbide; and he began a most active policy in 1906 with far-reaching effects, as from these small beginnings great things have developed. He first purchased the Alby carbide factory in Sweden as it then existed, with an annual capacity of about 7000 tons of carbide. These works were immediately enlarged, and the output increased to about 14,000 tons of calcium carbide per annum. Two years later there was commenced an entirely new factory at Odda, the most southern point of the Hardanger Fjord, in Norway. This location was determined upon because of the proximity of natural sources of water-power of immense potentiality for the generation of electricity. The new Odda works were constructed to produce 32,000 tons of calcium carbide per annum.

Simultaneous with the building of the carbide works, a factory was installed on an adjacent site by the North-Western Cyanamide Company for an annual production of 12,000 tons of calcium cyanamide, using the Linde system of fractional distillation of liquid air for the separation of the nitrogen required for the manufacture. Two years later a cyanamide plant with a capacity of 16,000 tons per annum was added to the existing carbide works at Alby, Sweden. In these latter works the Claude system of fractional distillation of liquid air is used as a source of nitrogen. The power available at Alby, Sweden, for carbide and cyanamide manufacture gives an average of about 9000 horse-power, and at Odda the combined carbide and cyanamide works utilised a total of about 22,000 horse-power.

In Engineering (vol. lxxxvii.) we described the original installation at Odda. Since then the success of the company's operations and the very satisfactory degree of economy, resulting from the admirable mechanical appliances in use, have encouraged the company to make vast developments at Odda, so that the output of calcium carbide has been increased to 85,000 tons, and of calcium cyanamide to 80,000 tons per annum. The electric power available at Odda will soon be increased to 125,000 horse-power, and the carbide and cyanamide factories will be further enlarged.

The original Alby and Odda works for the production of calcium carbide were owned by the Alby United Carbide Factories, Limited, while the cyanamide works were established by the North-Western Cyanamide Company, Limited. The latter, however, has since been reconstituted, in order to consolidate the various works manufacturing nitrogen products, whether in the form of cyanamide as a fertiliser or as a medium for the production of various nitrates already referred to—ammonium sulphate, nitric acid, &c.—and the new company is known as Nitrogen Products and Carbide Company, Limited. In this company the Alby United Carbide Factories have a large financial interest. In view of the great possibilities of utilising the cyanamide for fertilising and many other purposes, Nitrogen Products and Carbide Company, Limited, have acquired very extensive rights in waterfalls in Norway and in Iceland, in order to generate electric power to increase the manufacture of it. The hydro-electric station near Odda, however, is owned by a separate Norwegian company — the Aktieselskabet Tyssefaldene, of which Mr. Ragnvald Blakstad is the managing director responsible for the works we are about to describe.

The new Nitrogen Products and Carbide Company, however, were successful in obtaining the rights in three waterfalls in Norway—at Aura, Toke, and Blekestad-Bratland. In the case of the first named, the Government concession for utilising the power has been obtained.

The three falls named are collectively capable of producing about 600,000 horse-power, and of this total about 100,000 horse-power is at present being harnessed at Aura for the production annually of 200,000 tons of calcium cyanamide. The company, too, possess water rights in Deti-foss, in Iceland, where at least 410,000 electric horse-power will be available. The rights at present possessed by the company, therefore, will enable a total of about 1 million horse-power to be generated—sufficient for the production of nearly 2,000,000 tons of cyanamide per annum.

They already possess works at Vilvorde, in Belgium, capable of producing 3800 tons of nitrate of ammonia, using the Ostwald process for the production of the nitric acid, the rights of which they possess for all countries in the world, excepting only Rheinland and Westphalia. In order to meet the British demands for nitric acid, the works in Belgium are to be enlarged, and similar works for the production of some 12,000 tons have been projected at Dagenham, on the Thames, and at Trafford Park, Manchester; also establishments of capacities of 9000 tons and 3000 tons respectively in Scotland and Ireland. The aim is to make the British Government independent of outside supplies of nitric acid for the manufacture of explosives, because not only will there be stored at these nitric-acid works a large supply of cyanamide, which will be the raw material for the making of nitric acid, but it will be possible to utilise as a last resort the ammoniacal liquors from coke ovens, blast-furnace residual-recovery plant, and gas works, although these may not give such pure ammonia for the manufacture of nitrates as is that got from cyanamide.

A word may be said regarding the extent of use of nitrates and sulphate of ammonia. Of calcium carbide alone the consumption in this country has reached the remarkable total of 20,000 tons per annum, while cyanamide is being increasingly used as a fertiliser—containing, as it does, 18 to 20 per cent. of nitrogen, as compared with about 15 per cent. in the Chili nitrates. There is no doubt that with an ever-increasing population, and consequently greater demand for food supplies, and with, on the other hand, the steady impoverishment of the soil, such fertilisers will be in greater demand in the future than hitherto. Indeed, Sir William Crookes has made an estimate that in 1935 there will be such a demand for wheat that even if all the available ground were planted with wheat, and the average yield increased from 12.7, as it is to-day, to 20 bushels per acre, there would require to be used 12 million tons of nitrate as fertiliser. Without attempting to estimate the available supplies in Chili, there is the fact, as shown in the appended table, that the exports of Chili nitrate during the past five years have increased 45 per cent., and yet only now total about 2½ million metric tons, while the output of sulphate of ammonia has increased in the same period 53 per cent., but the total is only 1,350,000 metric tons. The latter is a by-product, and is largely dependent on the development in iron manufacture and gas generation, and

Table I.—*Exports of Chili Nitrate and Output in the World of Sulphate of Ammonia.*

	Nitrate. Metric Tons.	Sulphate of Ammonia. Metric Tons.
1908	1,746,000	880,000
1909	1,945,000	970,000
1910	2,274,000	1,100,000
1911	2,400,000	1,130,000
1912	2,542,000	1,350,000

Of the nitrate supply of 1912, 80 per cent. was used in agriculture, and 20 per cent. in manufactures. The approximate consumption in the United Kingdom, 5.60 per cent. of total; in Germany, 33.30 per cent.; France, 14.30 per cent.; Belgium, 12.20 per cent.; Holland, 5.90 per cent.; Italy, 2 per cent.; Austria-Hungary, 0.25 per cent.; Spain and Portugal, 0.50 per cent.; Sweden, 0.15 per cent.; United States of America, 22.20 per cent.; various other countries, including Japan, 3.60 per cent.

Of the sulphate of ammonia output in 1912, 5 per cent. was used in manufactures, and 95 per cent. in agriculture. The approximate consumption in the United Kingdom was 8 per cent. of total; in Germany, 33 per cent.; in France, 7.50 per cent.; in Belgium, 5 per cent.; in Spain and Portugal, 5.50 per cent.; in Italy, 3 per cent.; in United States of America, 16.50 per cent.; in Java, 3 per cent.; in Japan, 6 per cent.; in various other countries, 12.50 per cent.

these sources do not seem to be expanding at all commensurately with the increasing requirements for nitrogenous fertilisers.

Electric Power-Station at Tyssedal.

The electric power for the calcium carbide and cyanamide works at Odda is generated at the power-station at Tyssedal, three miles further down than, or north of, Odda, on the Sörfjord, one of the branches of the Hardanger Fjord. The configuration of the country is particularly suited to the development of electricity from water-power. The mountains rise almost precipitately from the Fjord to a height of about 1000 metres, within a distance of about a mile, and beyond this there is the great plateau separating the western from the eastern parts of Norway. This plateau, although moderately level, has mountains which rise to a height of between 1300 and 1400 metres above the general level, and there are many local depressions, due undoubtedly to glacial action, and some of them of great depth. These depressions form natural regulating reservoirs, now partly used for the storage of water during the spring and autumn floods in order to increase the flow to the power-station during the drier periods when the country is gripped by the frosts of rigorous winter.

Fig. 1 shows the drainage area, which extends to about 380 sq. km. (146 sq. miles). As the annual rainfall since 1896 has averaged 49 in., with a minimum of 36 in (in 1901), there is an abundance of supply. The continuous flow which can be secured economically is 25 cub. m. (883 cub. ft.) per second, and storage can be provided for about 400 million cub. m. (14,126 million cub. ft.). This is obtained by the damming of the Ringedals Vand or Lake, now in process of completion, and the tapping of the Berso Lake, which is also in progress. The Berso range, formed by the Mogeli River coming from the north, is at a much higher elevation than the Ringedals Lake, being 1106 metres above sea-level. The lower Berso Lake, 27 metres below the upper lake, is connected with it by means of a tunnel, which is closed by a segmental gate and a small wooden dam 2 metres high. It is the intention to complete a tunnel and pipe-line from the lower lake to the level of the Ringedals Lake, where an electric power-station will be built later. The exhaust water from this power-station will flow into the Skjæggedals Lake, which is the lowest of the series in the Tysse drainage area. This Skjæggedals Lake was the first to be dammed in connection with Tyssedal power-station on the Sörfjord, the water being conveyed first by tunnel and then by pipe-line to the turbines. It was this installation which was described in a former article in Engineering, vol. lxxxvii. Thus the potential power of the Berso water will be utilised in two steps—first in its fall from the lower lake to Skjæggedals Lake (614 metres), and second in its fall from Skjæggedals Lake to the power system at the Sörfjord (408 metres).

We will here, however, confine ourselves to the work in connection with the Ringedals Lake. The first stage of this work, carried out in 1912-1913, was the construction of a dam bringing the water-level at Ringedals Lake up to 446-metre line. The former original water-level of the lake was 438.5 metres above sea-level, but the water was withdrawn into the tunnels at the bottom of the lake, or at 418-metre line, in order to increase the storage capacity. Now there is in course of completion the raising of this dam by 17 metres, which will bring the water-level at Ringedals Lake up to 465 metres. The surface-level of the lake will be about 47 m. (154 ft. 2 in.) above the intake into the tunnels. The storage capacity has thus been enormously increased, and is now 293 million cub. m., which, added to that of the Berso Lake, brings the aggregate to 350 million cub. m. (12,360 million cub. ft.). The water flow from both reservoirs is anticipated to be 24 to 25 cub. m. (847 to 883 cub ft.) per second.

The Ringedals dam is built across a comparatively narrow ridge, extending across the valley and originally retaining the water in the lake. As the location of the dam was thus determined by natural conditions it was not possible to give it any curvature in the horizontal plane, and consequently the section is, perhaps, greater than might otherwise have been the case; the strata, very good, firm granite, assisted greatly towards the task of the designer. A plan of the dam is given in Fig. 2, and sections are shown in Figs. 3 to 6, page 369. Fig. 19, on page 278, shows the dam in course of construction, and affords a general idea of the configuration of the country forming the water-providing area. The spillway is seen in this view at the near end of the dam. The total length of the dam is 500 m. (1640 ft.), including the spillway, which is 100 metres long, and is on the 464-metre level. As will be seen on the plan, Fig. 2, the dam extends for a considerable distance into the rock on each side; this accounts for the difference in height of the sections; the maximum height of the dam is 33 m. (108 ft. 3 in.), the width at the top throughout is 4 m. (13 ft. 1 in.), while the maximum depth at the foundation level is 21.5 m. (70 ft. 6½ in.). The first part of the dam was built entirely of stone masonry, the schiess found in close proximity to the works being sound and cheaply got. For the face rich cement mortar was used, while the rear slope consists of dry masonry. The new part of the dam, which increases its height from the 446-metre to the 465-metre level—by 55 ft. 10 in.—is mainly of concrete. The sections show clearly the method of construction. The dam has a facing of granite masonry built in cement mortar, behind which is a layer 1 metre thick of concrete, in the proportion of 1 : 2½ : 3, while behind this again, for a further thickness of 1.30 m. (4 ft. 3 in.) the proportions are reduced to 1 : 3 : 6. In this there is incorporated, for draining the dam, 3-in. pipes, laid from the top and discharging into a tunnel 1 metre broad and 1.8 metres high, extending from end to end of the dam. Behind this drainage layer there is a further layer, 1 metre thick, of concrete in the proportions of 1 : 3 : 4½. The superior concrete in this particular layer was decided upon in order to prevent drainage-water from reaching the rear wall. This latter part is built up of concrete in the proportion of 1 : 5 : 6, with large boulder plums carefully placed in the concrete, so that each is completely surrounded. The rear face, it will be seen, is curved at a radius of 23.50 metres, but the greater part is on a slope of 1.55 : 1, reduced near the toe to 1.439 : 1. The back face is built of masonry in cement. The total amount of material in the dam when finished will be 80,000 cubic metres.

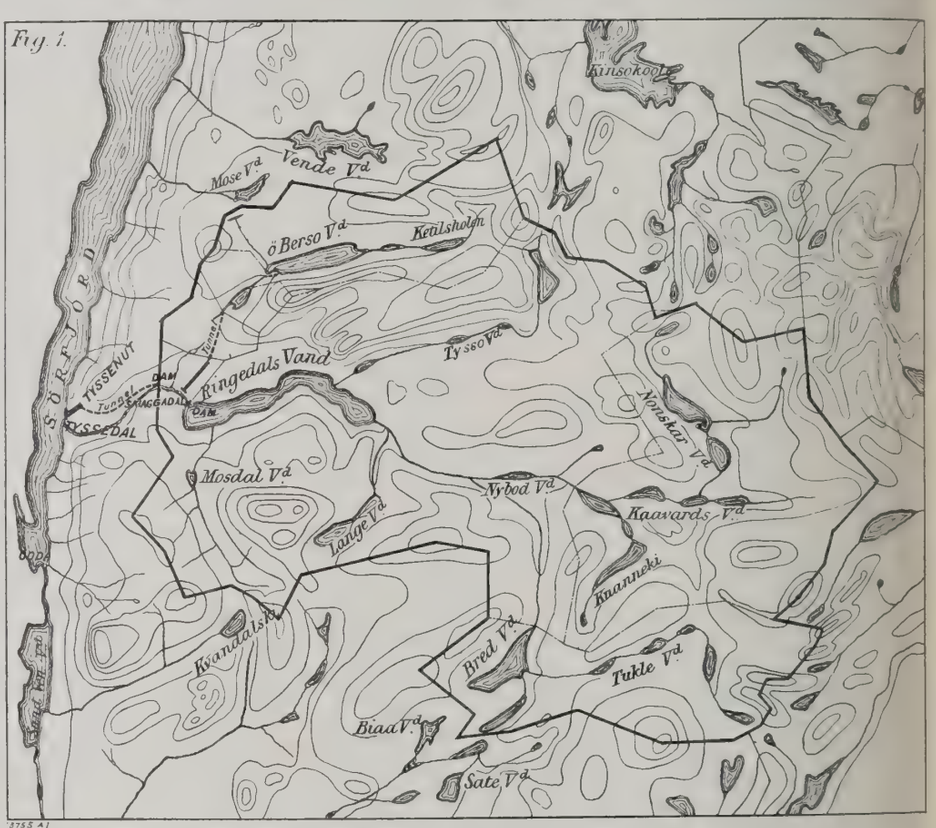


Fig. 1. Drainage Area for the Electric Power-Station at Tyssedal.

The intake for the tunnels is shown in Figs. 6 to 8. Originally there was only one intake and one tunnel, the latter 3430 metres long, with a cross-sectional area of 9 sq. metres. This conveyed the water to a distributing basin located on the slope below the Tyssenut, a mountain range about 1000 metres high, rising steeply from the Sörfjord, and towering over the power-station, as shown in Fig. 20, page 278. From thence the water is conveyed through pipe-lines to the power-station below. The water supply from the drainage area proved to be considerably greater than was estimated, while the loss of head in the tunnel was higher than calculated. The distributing basin thus proved to be of rather small dimensions. The new tunnel, being cut parallel to the old one, is of the same cross-sectional area, as shown in Fig. 9. A new intake had to be built in connection with this tunnel. The distributing basin at the further end of the tunnel and at the top of the pipe-line, however, has been considerably enlarged, as shown in the detail drawings, Figs. 10 to 13, page 270. The excavated chamber at the distributing basin is about 25 m. (82 ft. 3 in.) long, 11 m. (36 ft. 1 in.) wide and 13 m. (42 ft. 8 in.) high. Through two openings cut in the rock, as shown in Figs. 10 to 12, this new chamber is connected with the old distributing basin, from which all the pipe-lines emerge. The same figures show the topmost anchorage of the pipe-lines, and the sluice-gate with the building overhead for operating these sluices. The details of the valves at the entrance to the tunnels and at the entrance to the pipe-lines follow generally the arrangements originally adopted and described in our article in volume lxxxvii., so that we may depart from this part of the subject by saying that the regulating dam at Ringedals Lake and the other extensions described have been carried out from plans prepared at the Hydraulic Bureau of Mr. Johann Kinck, Christiania.

Two new pipe-lines have been laid from the distribution basin in supplement to the two which constitute the first section of the undertaking. The new pipe-lines are of steel. Two of the pipes supply seven 4620-horse-power turbines, and were constructed by Messrs. Thyssen and Co., of Mulheim a/d Ruhr. The line has a total length of 730 m. (2395 ft.). The diameter inside varies: the section at the intake is 1200 mm. (47.2 in.), at the central part 1050 mm. (41.3 in.), and at the lower part 950 mm. (37.14 in.). The plates of which the tubes are made vary from 7 mm. to 23 mm. (0.28 in. to 0.91 in.) in thickness; the upper section is riveted and the lower section welded. The general configuration of the pipe-line is shown in Fig. 14. These two pipe-lines terminate in a distribution pipe 38 m. (124 ft. 8 in.) long, forming at the power-station a loop, from which branches run to each turbine. The other two pipe-lines, which supply five 13,500-horse-power turbines, were

THE MANUFACTURE OF CALCIUM CARBIDE AND NITROGEN PRODUCTS; 13,500-HORSE-POWER PELTON WHEEL AND ELECTRIC GENERATOR AT TYSSEDAL POWER-STATION.

CONSTRUCTED BY MESSRS. ESCHER WYSS AND CO., ZURICH, AND MESSRS. SIEMENS AND SCHUCKERT, BERLIN.

(*For Description, see Page 267.*)

Fig. 23.

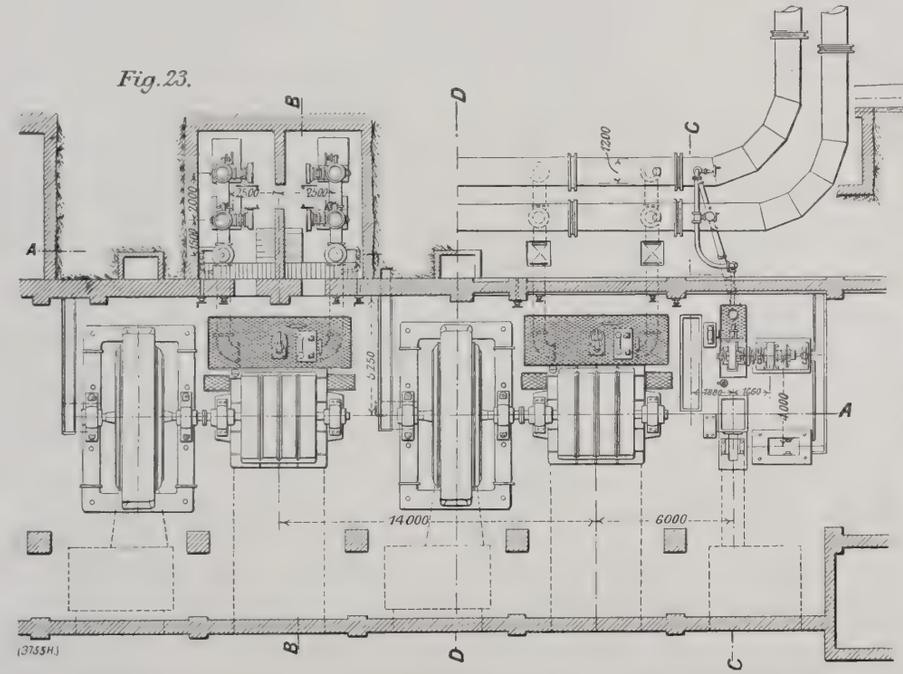


Fig. 24. SECTION A.A.

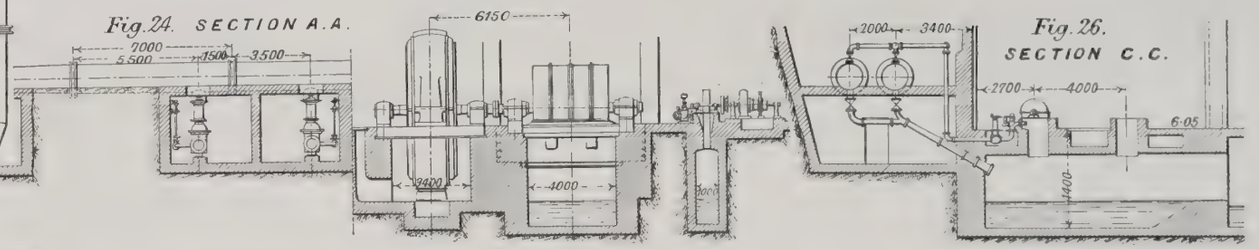


Fig. 25. SECTION B B

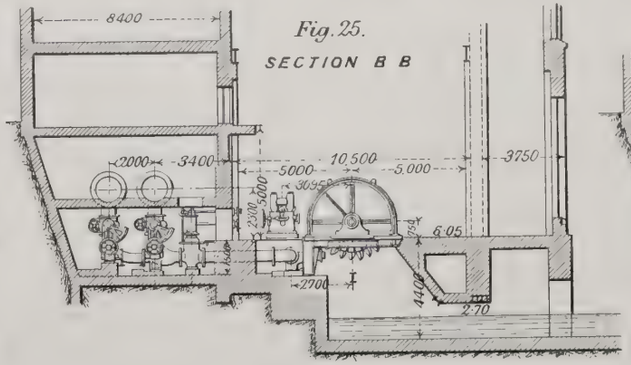


Fig. 26. SECTION C.C.

Fig. 27. SECTION. D D.

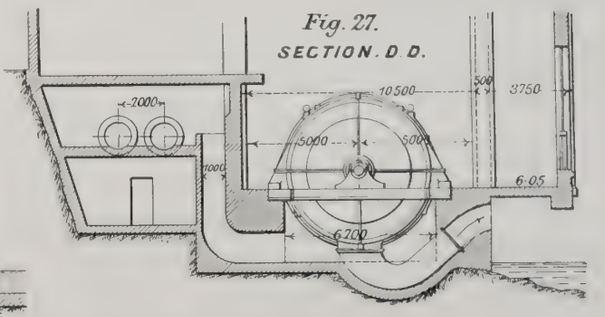


Fig. 28.

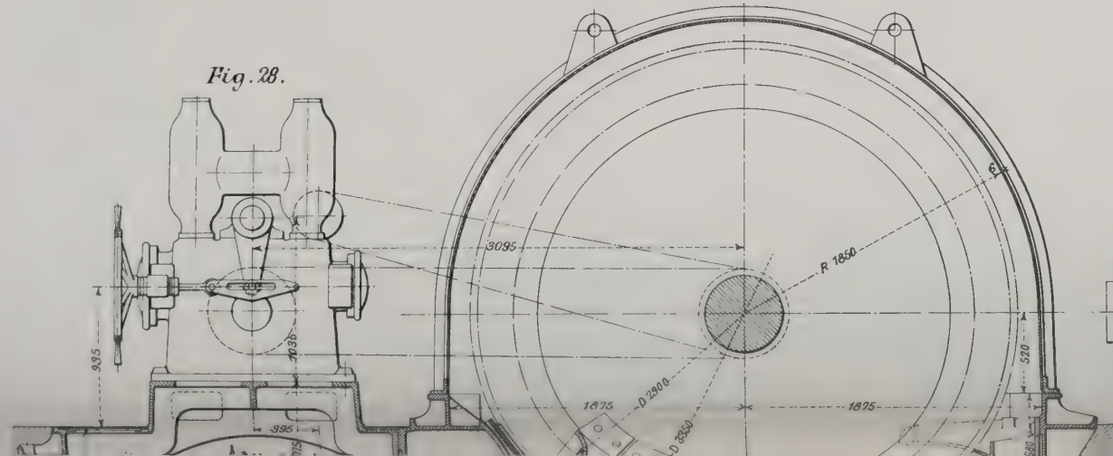
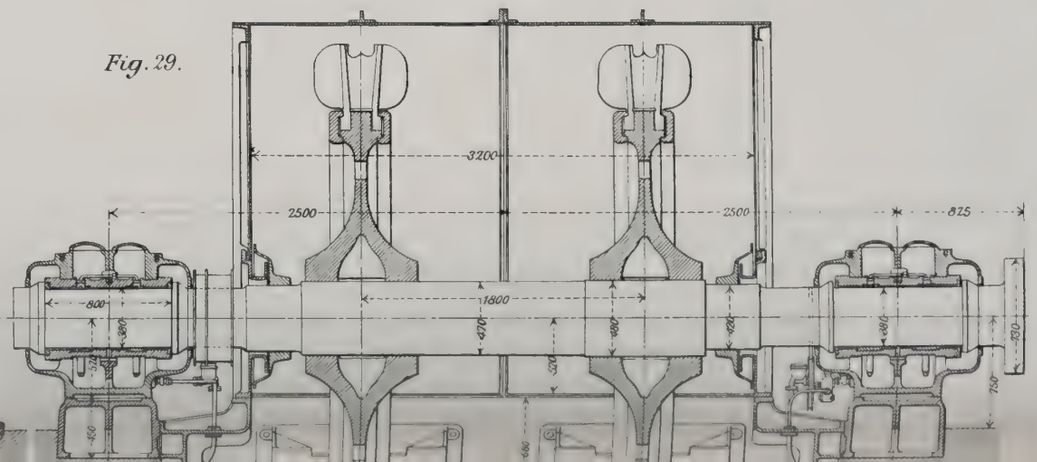
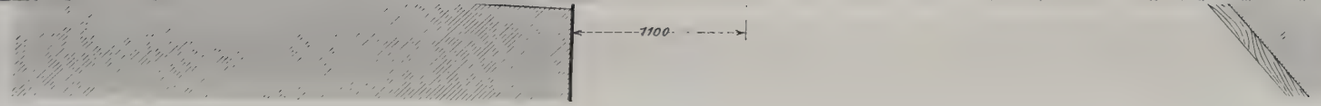


Fig. 29.

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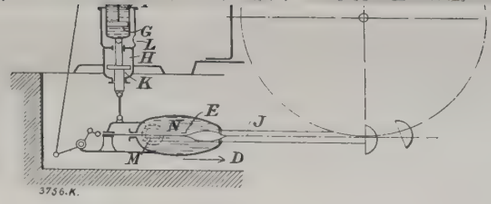
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Fig. 30.

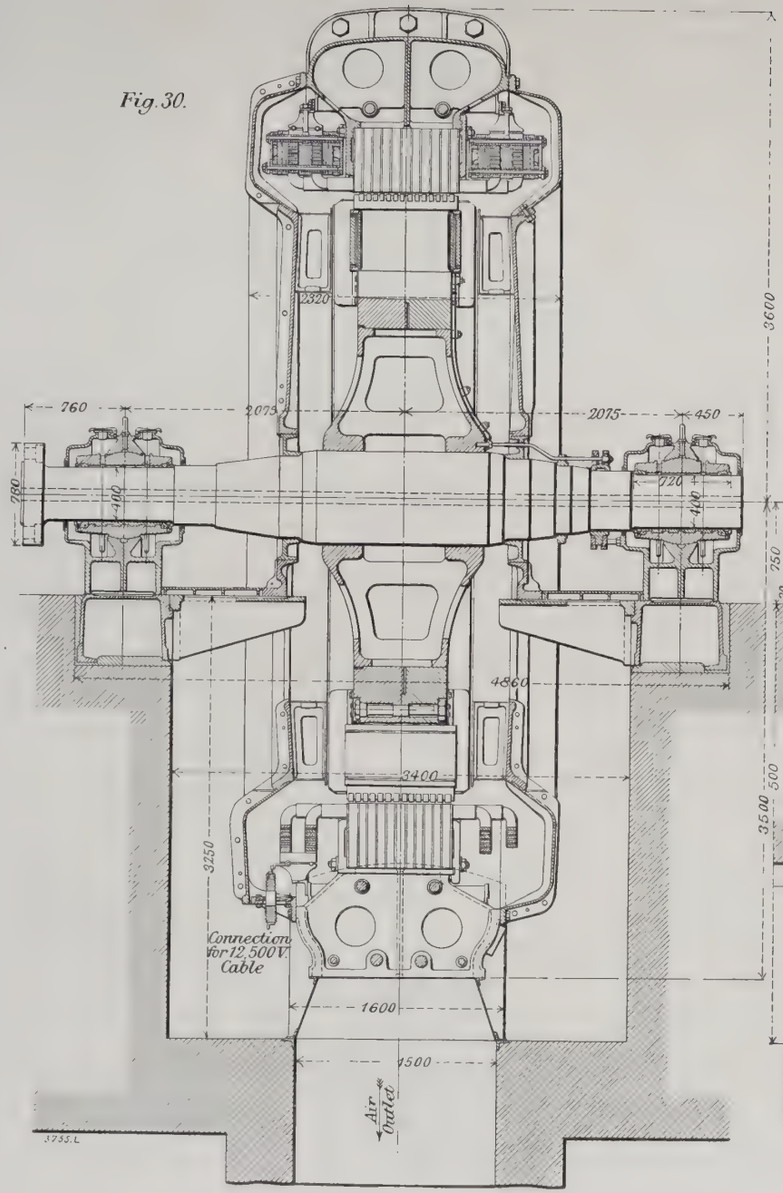
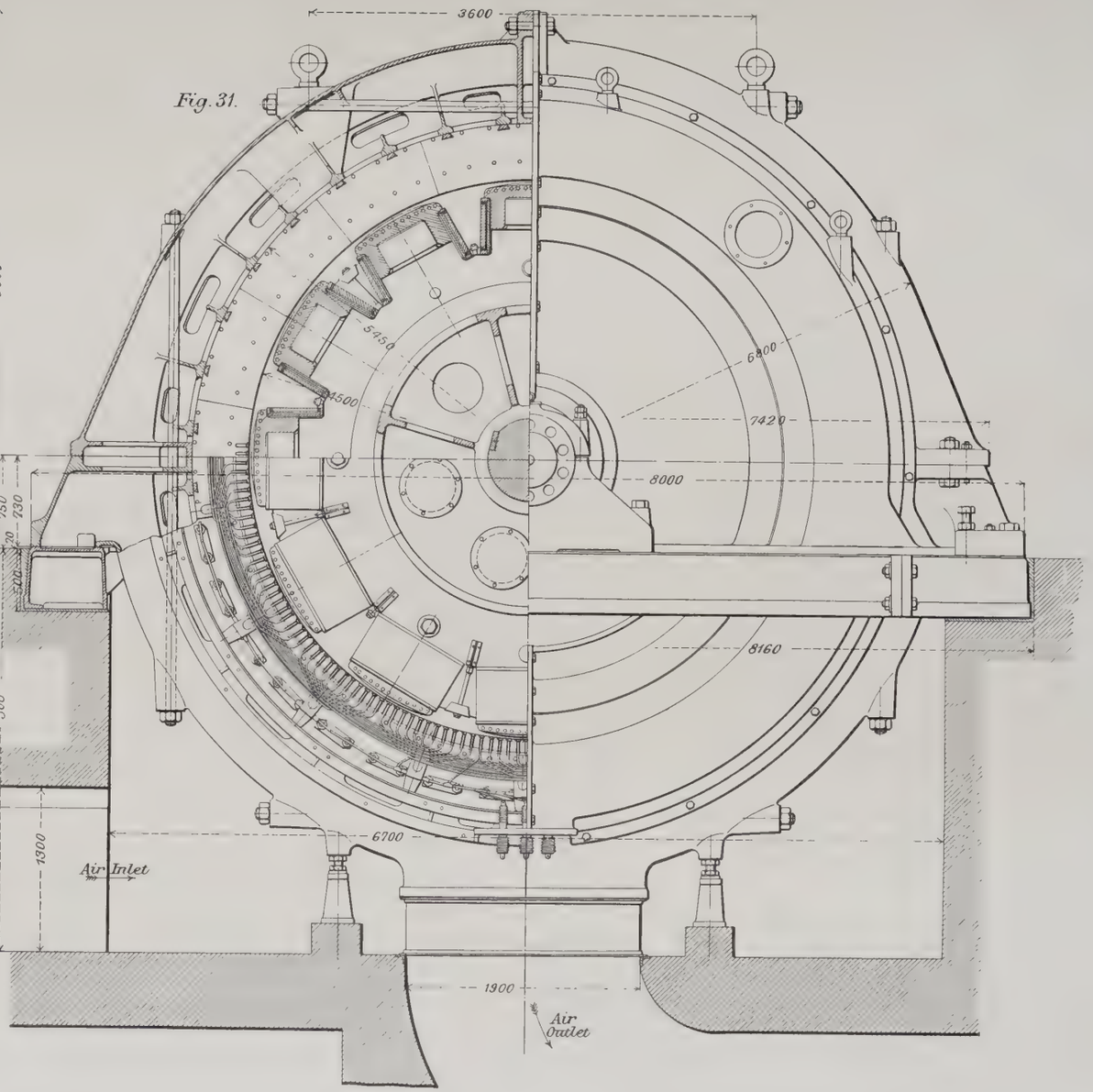

2320
760
2075
2075
450
780
400
720
410
4860
3400
3250
Connection for 12,500 V. Cable
1600
4500
Air Outlet
3755.L

Fig. 31.


3600
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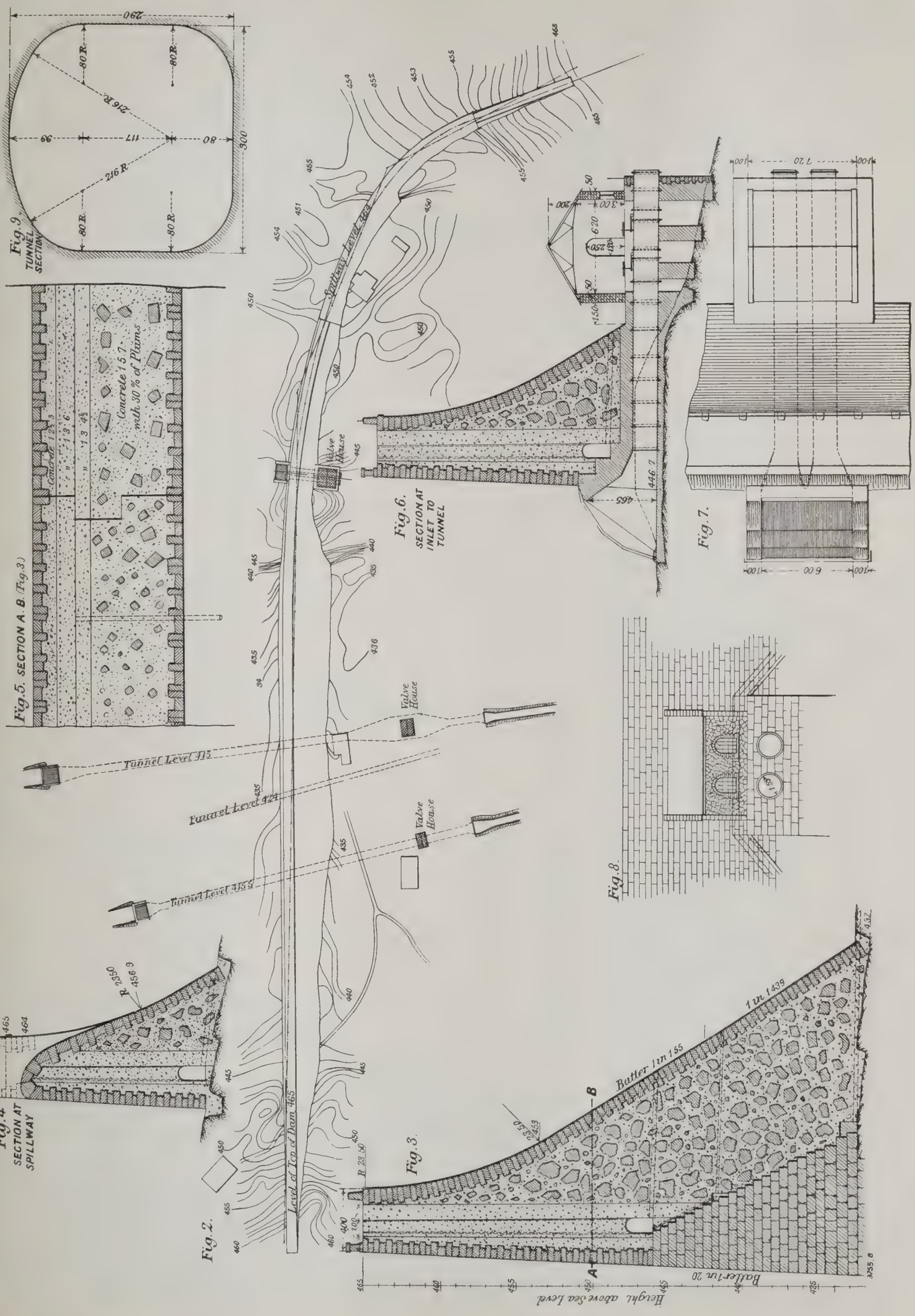


Fig. 9. TUNNEL SECTION
Fig. 5. SECTION A. B. (Fig. 3)
Fig. 6. SECTION AT INLET TO TUNNEL
Fig. 7.
Fig. 8.
Fig. 4. SECTION AT SPILLWAY
Fig. 2.
Fig. 3.
Spillway Level 452
Valve House
Tunnel Level 413
Tunnel Level 424
Tunnel Level 435.9
Level of Top of Dam 465
Batter 1 in 1.55
Batter 1 in 1.439
Batter 1 in 20
Height above Sea Level

manufactured by A.G. Gustav Kuntze, Worms-on-the-Rhine. They are of the same length, but the diameters are 1500, 1350, 1200 millimetres, while the thickness of the plates used is from 9 mm. to 35 mm. One of the pipe-lines is welded throughout, and the other line is partly riveted and partly welded. The distributing pipes at the power-station in this case are 60 m. (196 ft. 10 in.) long, and run parallel to the station. Each of the four pipe-lines is provided with an automatic flap-valve, mounted in the intake basin, with gate-valves a little further down. The pipes are buried in concrete anchoring blocks at various points down the mountain slope, and at each anchoring point there is an expansion joint. The pipes were tested before leaving the manufacturers' works at a pressure of 50 per cent. above the normal. Fig. 20, page 278, gives a perspective view of the pipe-line from the distributing basin to the power-station.

The power-station is illustrated in elevation, plan, and section, Figs. 16 to 18, page 271, and two interior views are given on Figs. 21 and 22, page 278. The last section to be built—that to the left of Figs. 16 and 17—is now completed. The central part of the station has a length of 82 m. (269 ft. 0.39 in.), and a width of 14.12 m. (46 ft. 3 in.), while the two wings are 47 m. (154 ft. 3 in.) long and 10.5 m. (34 ft. 6 in.) wide. To the rear there is a four-storey building accommodating the switch-gear. This latter building is 82 m. (269 ft. 0.39 in.) long and 8.27 m. (27 ft. 1½ in.) wide. The general construction of the building, with the height of floors, &c., is shown in the cross-section, Fig. 18; and this, with the dimensions given, affords a clear indication of the immense extent of the power-station, although it seems so small in the view given in Fig. 20.

The first installation at the power-station was of about 32,000 horse-power in seven units, each of 4620 horse-power. Later there were added five units, each of 13,500 horse-power, while the latest additions are two units, each of 16,000 horse-power. The supply-pipe for this extension has diameters of 1700 mm., 1500 mm., and 1250 mm. In addition there are four electric units of 240 horse-power for excitation. The 4620-horse-power machines are driven by Pelton turbines, with horizontal axles, constructed by Messrs. Escher Wyss and Co., Limited, of Zurich. The normal load is 4620 horse-power at 375 revolutions per minute, the water consumption being 1200 litres (42.3 cub. ft.) per second. The turbines are equipped with automatic speed and pressure-regulators. The diameter of the running wheels is 2475 mm. (8 ft. 1½ in.) over the outside edge of the buckets, while the distance between bearings is 2300 mm. (7 ft. 6½ in.) centres. These turbines are coupled direct to three-phase alternating-current generators, constructed by the Allmänna Svenska Elektriska Aktiebolaget, Västeras, Sweden. These generators are rated when working 375 revolutions per minute at 4400 electrical horse-power, at a power factor of 0.8, which is equivalent to 4100 k.v.a. at 12,500 volts, at a periodicity of 25. Each of the seven units is guaranteed to take 25 per cent. overload. The stator of the alternators has an outside diameter of 3450 mm. (11 ft. 4 in.), and the distance between bearings is 2500 mm. (8 ft. 2½ in.) centres.

Two of the 13,500-horse-power turbines were constructed by Messrs. Escher Wyss and Co. They are Pelton wheels similar to those previously mentioned, but have two running wheels, each operated from one nozzle. The general arrangement of these units in the power-station is shown in Figs. 22 to 27, on Plate XXI. In these views are seen the two distribution pipes, into which flows the water from the pipe-lines with the arrangement of the valves for controlling the supply to the turbines, the relative position of the Pelton water-wheels to the electric generators, and the discharge into the tail-race. The distributing lines are equipped with hand-operated throttles and hydraulically-operated gate-valves.

The Pelton wheels, with their nozzles, for the 13,500-horse-power sets, are illustrated in Figs. 28 and 29, on Plate XXI. The outside diameter of each running wheel is 3350 mm. (11 ft.), and the distance between the centres of shaft bearings is 5000 mm. (16 ft. 5 in.). The full-load speed is 250 revolutions, and the consumption of water at this output is 3350 litres (116.6 cub. ft.) per second. The maximum variation of speed when suddenly dropping from full load is 9 per cent., while the maximum rise of pressure in the up-line is 12 per cent. The turbines have oil-pressure regulators and movable nozzles. The chief feature, apart from the great size, is the arrangement of the nozzle, and the method of its control under excess water pressure. This is clearly shown diagrammatically in Fig. 28, on Plate XXI.

The shaft A is directly and rigidly connected up to the servomotor of an ordinary speed-governor. The water is discharged through the nozzle N, forming the jet J, which impinges upon the buckets of the runner-wheel. Each jet generates 6750 brake horse-power, and each turbine unit is pro-

Fig. 10.

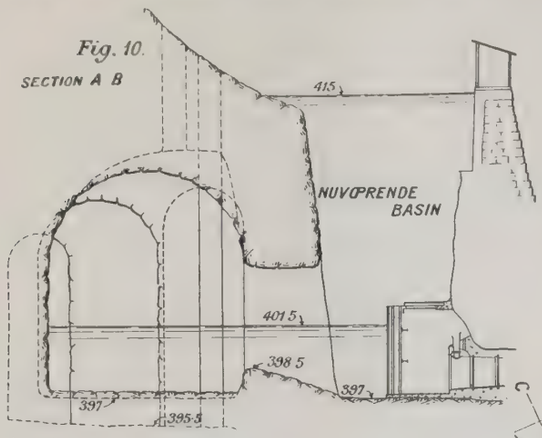


Fig. 11. SECTION C-D-E-F

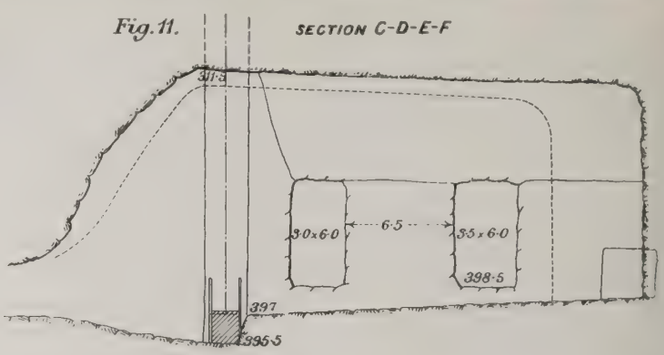


Fig. 12.

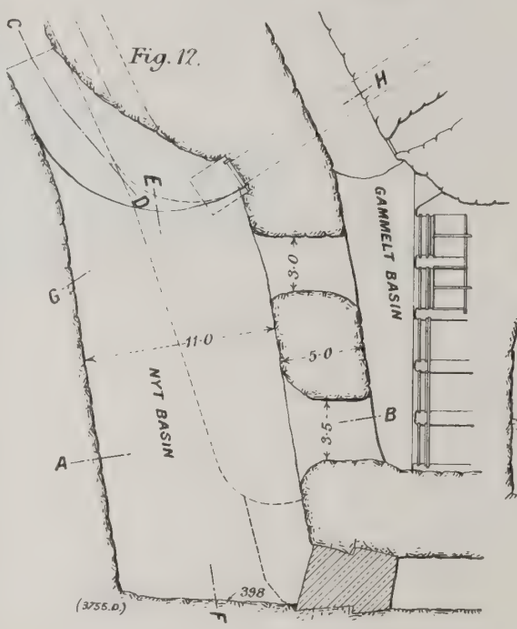


Fig. 13. SECTION G H

Fig. 14.

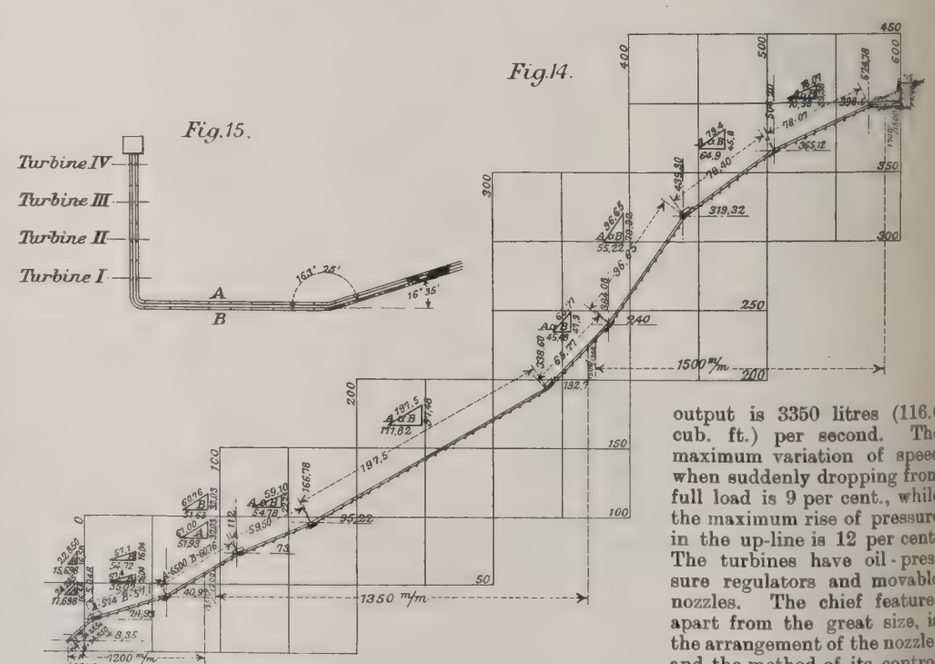


Fig. 15.

vided with two jets and two runner-wheels. Under ordinary circumstances the nozzle is stationary, and the needle opens or closes the nozzle, respectively reducing or increasing the jet in accordance with the power required as controlled by the speed-governor. This turbine is, however, also provided with a so-called "deflecting nozzle," designed in such a way that the nozzle, and thereby also the jet under special circumstances, may deflect from the range of the runner-wheel, in this way preventing a portion or the whole of the jet from reaching the buckets or from generating power. This deflecting nozzle is operated in the following way:—Should a great amount of power suddenly be thrown off, the speed-governor tends to shut off the water supply, or to move the lever B upwards in the direction of the arrow C. If the design were such as to allow this sudden closing of the needle, the inertia of the water-column would cause such great and dangerous pressure to rise as might eventually result in the breaking of the pipe-line. The deflecting nozzle prevents this occurrence in an effective way. If a sudden movement of the lever B occurs, as mentioned above, the oil contained in the dashpot F, being unable to pass rapidly through the hole of the piston G, causes the dashpot to be raised, thereby providing an opening for the pressure water in chamber H to escape through L. As a result the pressure existing in the chamber H is reduced so that the pressure in the chamber K becomes predominant, causing the nozzle or the jet to be deflected from the wheel, thereby reducing the power generated by the water in exact relation to the stroke of the governor. In consequence of this deflection of the nozzle no movement of the needle relative to the nozzle is caused, consequently the same amount of water is discharged and there is no reason for any pressure rise whatever.

In the meantime the oil passes through the diaphragm of the dashpot, causing the same to lower, thereby shutting off the discharge of the water from chamber H. The pressure here is again increased to its normal figure, and in consequence the nozzle slowly and gradually moves back to its original position. Meanwhile the relay of the governor remains in the same position, and by this redeflection of the nozzle, therefore, the position of the needle relative to the nozzle is gradually altered, reducing the water discharge until the nozzle has reached its original horizontal position. The hole of the diaphragm may be varied, and thus the time required for the movement of the deflection and redeflection may be controlled; in other words, it is possible to control the rise of pressure within certain limits.

The two three-phase generators are also illustrated on Plate XXI., Figs. 30 and 31. These electric generators, built by the Siemens-Schuckert Works, Berlin, are each direct-coupled to the water-turbines just described. The electric generators develop 12,000 kilovolt-amperes, at a working pressure of 12,500 volts, 25 periods. The net weight of the complete machine is about 165 tons, that of the rotating portion, with shaft, about 56 tons. In order to facilitate transport, the stator and base-plate were made in four pieces, and no part was made to weigh more than 40 tons. The stator-casing is of cast iron, of box-shaped section. The active iron core of the stator carrying the main winding is built up in the usual way of segment-shaped stampings, paper-insulated from one another, and arranged to break joint. Air-passages are provided for cooling. The stampings are held together by heavy end-plates and a large number of insulated bolts. The teeth of the open slotted laminations are strengthened at their front surfaces by grooved end-plates, to prevent vibration under the influence of the alternating magnetic field.

Fig. 16.

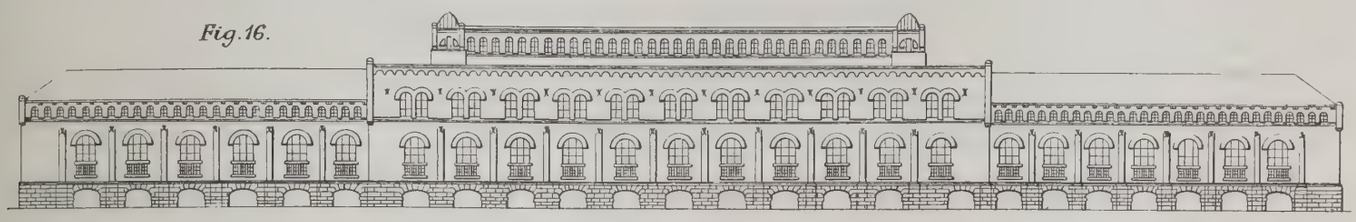


Fig. 17.

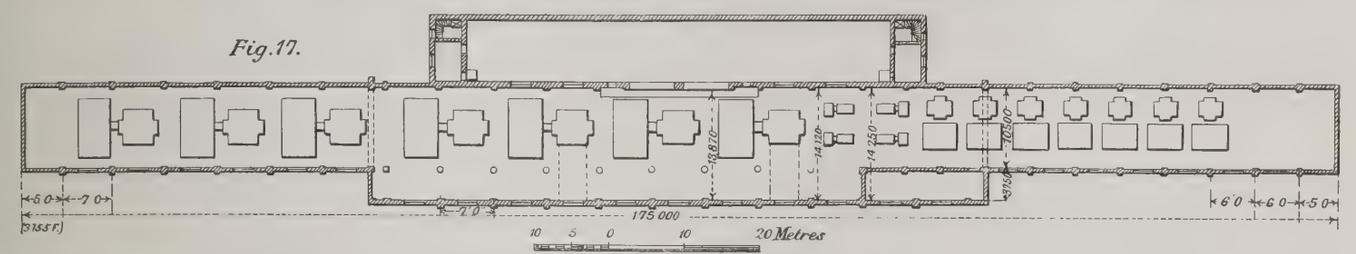
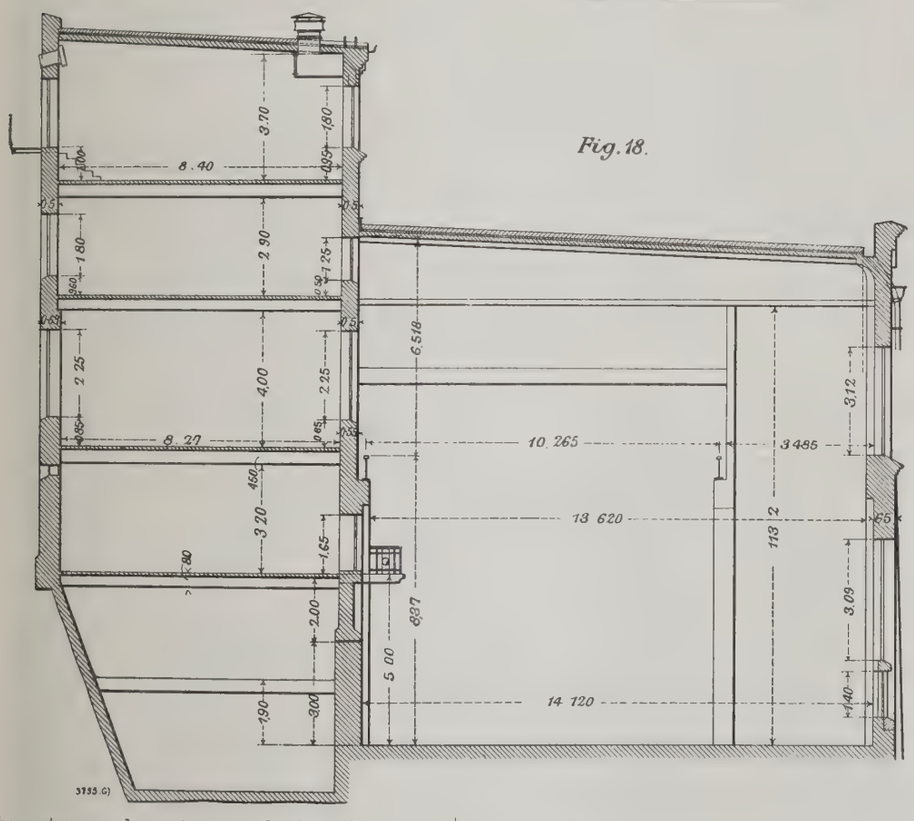


Fig. 18.



The stator is form-wound, the coils being insulated from the iron core with mica. To avoid trouble owing to short-circuit effects in the system, following lightning strokes or damage to the mains, the coils are provided with special holding-down bolts. The ends of the windings are connected up to a terminal plate at the lower part of the stator, from which the current is led to the bus-bar through bare copper connections fixed on insulators in a cableway.

The machines are self-ventilating. In order that the cooling effect be thorough, and with a view to give the current of air through the machine a determined path, the stators are completely closed in by end shields. The completely covered-in upper portion is provided with an air-duct, through which dry air, free from dust, is admitted to the top part of the machine, whence it is drawn through side openings provided in the stator, distributed throughout the machine, and exhausted into the atmosphere through an exhaust duct at the lower part of the stator.

The rotors, as is generally the case with three-phase generators driven by water-turbines, had to be designed with a view to meet an increase in speed of 1.8 times the normal corresponding to a maximum of 450 revolutions per minute. In order to comply with this condition, the usual method of fixing the poles to the rotor-spider by means of screws or dove-tails, had to be departed from and a new device adopted. A spider of cast steel has been provided, on which a magnet rim has been shrunk, the shrinkage being larger in extent than the expansion of the rotor, due to centrifugal force at the highest speed. The magnet rim is also a steel casting, the pole cores being cast with it; it is made in two rings, half of the magnet cores being in each ring. The pole-shoes are steel castings, of rectangular shape, screwed on the pole cores, in which they are securely held by set-screws. In order to prevent eddy currents, laminations are fitted on the outer surface of the pole-shoes.

The pole winding consists of flat copper strips paper-insulated. The bare copper coming directly under the action of the ventilating air, a good cooling effect on the pole-winding is thus produced. The winding is made on specially-cast bobbins, and is insulated against the iron by impregnated press-spahn. The separate windings of the magnet are pressed down under high pressure in the direction of the pole axis, and are held in place by an end flange welded on the bobbins to prevent all

shifting. The connections between the separate pole-windings are held by radial supporting bolts screwed in the magnet rim. The slip-rings for supplying the exciting current are of hard bronze carried on, and insulated from, a supporting spider. The current supply to the slip-rings is by carbon brushes carried on spring brush-holders in the usual way.

The shafts are of Siemens-Martin steel, forged and hollow throughout their whole length. The rotor is shrunk on its shaft, on which it is further secured by two keys. The shafts are of ample dimensions, the highest speed required being much below the critical. The bearings are divided horizontally; the brasses are of cast-iron lined with white metal and are water-cooled, and adjustable for wear. Ring lubrication is provided.

When the rotors were built up, they were tested at the Siemens-Schuckert Works at the maximum speed at which they will run in service—*i.e.*, 400 revolutions per minute. No centrifugal expansion was found during these tests. The trials showed an efficiency of 96.3 per cent., which, as will be seen, exceeded the guaranteed efficiency—*i.e.*, 95 5 per cent. at 9600 kw. at 0 8 power factor.

In our next article we shall illustrate and describe the later and still larger sets added to the station—those of 16,000 horse-power.

(*To be continued.*)

LITERATURE.

Flight without Formulæ: Simple Discussions on the Mechanics of the Aeroplane. By Commandant Duchêne. Translated from the French by John H. Ledeboer, B.A. London: Longmans, Green and Co. [Price 7s. 6d. net.]

To be perfectly candid, it must be admitted that we took up this book with some amount of prejudice. An attempt to employ mathematical reasoning without the assistance of mathematical notation is usually a failure. By such a course a most valuable asset is neglected and a very treacherous ally courted. It is perfectly true, of course, that every mathematical formula can be translated into words, but the effort to apprehend the thought conveyed often demands a greater strain than the original formula, and has not the advantage of showing the steps by which the result has been attained. At a very early stage we met with the following sentence, which may serve to illustrate the point, for we will undertake to say that few will grasp its meaning at first reading:—"By virtue of this property, a cambered plane may be regarded as possessing an imaginary chord, if the expression be allowed, inclined at a negative angle (that is, in the direction opposed to the ordinary angle of incidence) to the chord of the profile of the plane viewed in section." The clause, "if the expression be allowed," presumably refers to the term "cambered plane," and certainly, for those whose definition of a "plane" is that given by Euclid, the term does introduce some difficulty, and we can well understand that from this description of a cambered plane many would turn away disappointed, feeling that these things were too hard for simple laymen. But the difficulties are mainly at the beginning, and we soon begin to take great interest in watching the ingenuity of the author in escaping the pitfalls and dangers awaiting those who attempt to popularise rigid dynamics. Common-sense and sound judgment will carry a man a long way, but he may find himself assenting to propositions, the whole of whose conditions have not been explained. In the range of aerodynamics there are problems whose solution is only possible because terms have been neglected, or restricting conditions have been introduced that make the purely theoretical conclusions only available within certain definite limits. The special character of such approximations usually forms no part of the stock-in-trade of the popular writer. He is limited to the broad demonstrated facts, but Commandant Duchêne is neither disingenuous nor superficial. He allows us to see behind the scenes, and is not afraid to point out where the indications of theory are contradicted by the results of experience. Moreover, and this is a very excellent feature, he makes judicious and adequate use of illustrations and graphs. Some of these latter, in which curves are cut in two points, are most instructive and will repay very attentive study. Similarly, experiments with cork, cardboard, and needles, &c., raise a number of problems that lend profound interest to the inquiry. Those who have had perseverance to overcome the earlier chapters will find the latter part of the book very attractive. The author has attacked a difficult subject in a difficult way, but he has availed himself of various devices of an informative kind that compensate for the loss of exactness due to want of mathematical notation, and has succeeded in making his pages both lucid and interesting.

As a general rule, there are several simple but important points connected with velocity, and the power required for horizontal flight under varying conditions, that have not been correctly apprehended by the public. These relations and others between the weight of the aeroplane, the area exposed, and "the angle of incidence," need to be very correctly apprehended, and the author, in the first three chapters, has very wisely insisted on the importance of these elementary points. When these initial difficulties are clearly apprehended, the fact that an aeroplane of given weight, area, and angle of incidence, can fly horizontally only at one definite speed, becomes almost an axiom, but from want of distinct apprehension of first principles, that matter is frequently misunderstood. A simple deduction, or corollary, to this proposition leads to the first difficulty, and, perhaps, to the first difference of opinion between experts. Seeing that there are only two means of increasing the speed of an aeroplane, either to reduce the lift coefficient or to increase the loading per square metre, the question arises which is the more economical. Makers have decided in favour of increasing the load, pilots rather incline to the opposite view. The French authorities have made their decision with the result that their military aeroplanes are loaded up to 40 kg. per square metre, and even higher. The important fact to notice is, that there are evidently limits in both directions, and consequently to the maximum speed attainable. In a note the translator states that a speed of 212 km. per hour has been achieved in an official trial with a machine weighing 450 kg., and only 7 square metres area, or 64 kg. per metre. This implies a lift coefficient so exceedingly small as to suggest some inaccuracy in the measurement, or possibly an uncertainty in the wind factor. This result will, of course, not be confused with the maximum mechanical efficiency, depending on the motive power employed. The factor of efficiency is continally increasing with experience and the introduction of novel devices. In 1910 it was stated that on an average aeroplane, 1 horse-power was required to transport 250 kg. at 1 metre per second. Now the efficiency is so increased that 300 kg. are transported at the same rate per horse-power.

The next two chapters are devoted to the explanation of problems connected with power plant, but as the treatise deals with the mechanical principles of flight, no description of aviation motors is attempted. The theory of the propeller raises some difficult points connected with the forward travel and the amount of "slip," that are neither simple of themselves, and do not permit of being simply presented. An adequate treatment of this section by rigorous theory is not yet possible, and the author admits that the plan adopted of comparing a propeller to a screw can only explain the results obtained from experiment in an incomplete fashion. The most effective form to give the propeller, in order to secure the maximum effect when applied to a particular class of aeroplane, is not yet settled, and can only be decided by experiment. The indications of theory must be considered as general guides, and cannot be strictly followed in practice. This does not mean that mathematics speaks with an uncertain sound, but that in the problem solved, conditions are present that differ from those that obtain in practice. On the other hand, experiment is not altogether satisfactory. The conditions of actual flight are not reproduced when measuring the thrust exerted by a propeller turning at a definite speed without forward motion. The result is made more difficult of interpretation if the complete power plant is used, because the power developed by an internal-combustion engine varies with the speed of rotation. The author states that a propeller of a given diameter, driven by a given expenditure of power, exerts the maximum static thrust if its pitch ratio is in the neighbourhood of 0.65, but that in flight the highest efficiency is obtained with a propeller of pitch ratio slightly greater than unity. There must be some relation between the diameter of the propeller and the pitch ratio in which the effect attains a maximum value; but it does not follow that this relation will remain unaltered at all speeds, or that a relation suitable to one class of aeroplane will prove equally effective when applied to another class. A very instructive diagram is given, showing the effect on speed, and necessarily rising-capacity, resulting from change in pitch ratio, keeping the same motor and the number of revolutions constant. With a pitch ratio of 0.5 an aeroplane could not maintain horizontal flight, since there is no contact between the power-plant curve and the aeroplane curve. When the pitch ratio is increased to 0.54, there is contact at one point and horizontal flight becomes possible, but at only one speed, and without any margin. As the pitch ratio increases, the flying speed increases rapidly. On the other hand, when a pitch ratio reaches 0.9, or possibly unity, there is no advantage in further increase. In some forms of propeller a pitch ratio greater than unity has been used, but at present, in French construction at least, the tendency is to reduce the diameter of the propeller and to use a moderate pitch ratio.

The remaining chapters are devoted to the consideration of stability problems, and will be useful to those who want an elementary notion of the conditions under which equilibrium can be maintained; but the successful removal of the difficulties in the way of securing stability has passed beyond the stage discussed here. Historically these chapters are very interesting, showing the gradual evolution of the aeroplane as we know it. We may trace the introduction of the tail and the reasons for it, together with the modifications it has undergone in common with other material parts. The treatment of the general problem of stability is, however, piecemeal and on a different plane to that adopted by such authorities as Professor Bryan. We have already referred to the excellent use the author has made of experiments with paper gliders. To those unaccustomed to the more severe mathematical representation of problems, the diagrams and models will be found very instructive by illustrating the kind of problems that have to be solved. These, however, may prove a little misleading by unduly emphasising particular points. The author is inclined to insist on the importance of building an aeroplane with wings forming an inverted dihedral angle, but such an arrangement, if effectual, is only a particular case of a general problem. The successful efforts of Lieutenant Dunne and Mr. Handley Page are not referred to in the text, and the work of English design, as also that accomplished in our aircraft factories, might have had more attention. Up to a certain point the author has been very successful, but there are indications that the results collected will soon require very considerable extension.

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(1) *Hand-Book on the Steam-Engine, with Special Reference to Small and Medium-Sized Engines.* By Herman Haeder. Translated by H. H. P. Powles. Fourth English Edition, Revised and Enlarged. London: Crosby Lockwood. [Price 7s. 6d. net.]

(2) *Les Machines à Vapeur.* By F. Cordier. Paris: Octave Doin et Fils. [Price 5 francs.]

(1) "In the present condition of the markets, makers must not occupy too much time in calculations or mathematical research, but collecting results from actual practice, must note them in a convenient form. . . . The present work aims at showing the results of practical experience. Letterpress has been reduced as much as possible to allow of the introduction of numerous tables and drawings, these being the language of technical people." So says the author in his preface, and the book is quite in keeping with his intention. The outstanding merit of the work is brevity of treatment and absence of speculation. We note, by the way, that the revision of the present edition has not included any reference to the central exhaust type of engine, commonly called Uniflow, which has during recent years attracted much attention.

(2) The book by Commandant Cordier is of a different type, and constitutes one of the volumes of the scientific encyclopædia projected by Doin et Fils. It is a readable book, with illustrations from the best English, French, German, and Belgian practice, as well as apt references to, and cullings from, recent technical journals. Like most encyclopædia articles, it is more suited for the intro-

duction of the mature and somewhat robust mind to the subject, than for the guidance of the beginner or the reference of the expert.

BOOKS RECEIVED.

Modern Practice in Mining. Vol. III. *Methods of Working Coal.* By R. A. S. REDMAYNE, K.C.B., M.Sc., M. Inst. C.E., M.I. Mech. E. London: Longmans, Green and Co. [Price 6s. 6d. net.]

The War Traders. By GEORGE HERBERT PERRIS. London: The Chancery Lane Press. [Price 1s. net.]

Philosophie des Structures dans l'Architecture et dans l'Art de l'Ingénieur. Par FÉLIX CARDELLACH. Traduit de l'Espagnol par LÉON JAUSSELY. Paris: H. Dunod et E. Pinat. [Price 7.50 francs.]

An Elementary Treatment of the Theory of Spinning-Tops and Gyroscopic Motion. By HAROLD CRABTREE, M.A. Second Edition. London, New York, Bombay, Calcutta, and Madras: Longmans, Green and Co. [Price 7s. 6d. net.]

United States Department of Labour. Bureau of Labour Statistics. Bulletin No. 122. *Employment of Women in Power Laundries in Milwaukee.* No. 124. *Conciliation and Arbitration in the Building Trades of Greater New York.* No. 128. *Wages and Hours of Labour in the Cotton, Woollen, and Silk Industries, 1890 to 1912.* No. 129. *Wages and Hours of Labour in the Lumber, Mill-Work, and Furniture Industries, 1890 to 1912.* No. 132. *Retail Prices, 1890 to 1912.* Washington: Government Printing Office.

Department of Commerce. Statistical Abstract of the United States, 1913. Washington: Government Printing Office.

United States Bureau of Mines. Bulletin No. 57. *Safety and Efficiency in Mine-Tunnelling.* By DAVID W. BRUNTON and JOHN A. DAVIS. Bulletin No. 67. *Electric Furnaces for Making Iron and Steel.* By DORSEY A. LYON and ROBERT M. KEENY. Bulletin No. 79. *Abstracts of Current Decisions on Mines and Mining, March to December, 1913.* Bulletin No. 82. *International Conference of Mine-Experiment Stations, Pittsburg, Pa., September 14-21, 1912.* Compiled by GEORGE S. RICE. Washington: Government Printing Office.

A Manual of Mechanical Drawing. By JOHN HANDLEY DALE. Cambridge: University Press. [Price 3s. net.]

Flight without Formulæ: Simple Discussions on the Mechanics of the Aeroplane. By COMMANDANT DUCHÊNE. Translated from the French by JOHN H. LEDEBOER, B.A. London: Longmans, Green and Co. [Price 7s. 6d. net.]

Vorlesungen über Wasserkraftmaschinen. Von Dr.-Phil., Dr.-Ing. R. CAMERER. Leipsig and Berlin: Wilhelm Engelmann. [Price 23 marks; bound 25 marks.]

British Rainfall, 1913. On the Distribution of Rain in Space and Time over the British Isles during the Year 1913. Compiled, under the direction of HUGH ROBERT MILL, Director of the British Rainfall Organisation, by ROBERT COCKBURN MOSSMAN, Acting Editor, and CARLE SALTER, Assistant Editor. London: Edward Stanford. [Price 10s.]

Proceedings of the Incorporated Municipal Association. 1914. London: Wyman and Sons, Limited. [Price 5s.]

Report of the International Commission to Inquire into the Causes and Conduct of the Balkan Wars. Washington, D.C.: Carnegie Endowment for International Peace.

Methods of Machine-Shop Work, for Apprentices and Students in Technical and Trade Schools. By FREDERICK A. HALSEY. London: McGraw-Hill Book Company, Inc. [Price 10s. 6d. net.]

Mathematics for the Practical Engineer. By CHARLES H. BROMLEY and HENRY R. COBLEIGH. London: McGraw-Hill Book Company, Inc. [Price 8s. 4d. net.]

Fuel Economy and CO_2 Recorders. By A. R. MAUJER and CHARLES H. BROMLEY. London: McGraw-Hill Book Company, Inc. [Price 6s. 3d. net.]

Preliminary Machine-Drawing Course. By C. E. HANDY, A.R.C.S., Wh. Sc. London: Longmans, Green and Co. [Price 1s.]

Royaume de Belgique. Ministère de l'Industrie et du Travail. Office du Travail. Annuaire de la Législation du Travail, 1912. Tome Premier et Tome Second. Brussels: Albert Dewit. [Price, Vol. I., 6 francs; Vol. II., 3 francs.]

Royaume de Belgique. Ministère de l'Industrie et du Travail. Office du Travail et Inspection de l'Industrie. Groupe III. *Industries de la Construction Mécanique.* Tome IV. Fasicule B. Brussels: J. Lebégue et Cie.

THE SOUTH-WESTERN POLYTECHNIC.—The South-Western Polytechnic, Manresa-road, Chelsea, will reopen on September 28 for day classes, and on September 21 for evening classes. The engineering courses include lectures in electrical and mechanical engineering, physics, chemistry and mathematics, and practical instruction in the fully-equipped laboratories of the institute. Students are prepared by recognised teachers of the University of London for the B.Sc. degree in engineering of the university, for the examinations for admission to the various engineering societies, and the examinations of the City and Guilds of London Institute. The evening courses include, besides the engineering courses as above, classes in electrical wiring, building construction, and other trade subjects. Arrangements have been made for placing students, who have passed satisfactorily through the three years day course, in positions with large engineering firms. Hitherto such firms have offered more vacancies than the institute has been able to fill with its students. The prospectus may be obtained, post free, for 4d.

"THE COLLAPSE OF SHORT TUBES."

TO THE EDITOR OF ENGINEERING.

SIR,—An article on "The Collapse of Short Tubes," published in the issue of ENGINEERING for August 14, refers to a recent paper by Mr. G. Cook, and tends to give the impression that in that paper curves obtained from experiments are compared with the corresponding results of my theoretical investigations. May I be allowed to point out that this is not the case? The curves which Mr. Cook has given for comparison with his experimental results are in every case rectangular hyperbolas, representing a relationship between length and collapsing pressure which has been suggested by Fairbairn and by Professor Carman on experimental grounds, but which has no basis in analysis. Mr. Cook's results show that this relationship does not very accurately represent the facts.

Assuming, however, that a curve of this form is to be adopted for purposes of design, we want rules which will enable us to construct the particular hyperbola corresponding to any given values of thickness and diameter. The hyperbola will be determined if we know the length of tube for which it gives the same value of the collapsing pressure as Professor Carman's formula for very long tubes, and the discovery of a general expression for this "critical length" is a problem which Mr. Cook has endeavoured to solve. His results show that Professor Carman's estimate,

$$\text{Critical length} = 6 \times \text{diameter},$$

is not of general application, but that within the scope of his experiments the critical length is closely represented by the formula:—

$$L = 1.73\sqrt{\frac{d^3}{t}}.$$

An equation of the same form is obtainable from analysis, which to this extent may be regarded as satisfactory. I have discussed the point more fully in a paper which I hope to publish shortly in the *Philosophical Magazine.* In the present state of our knowledge regarding non-elastic strain, it is useless to hope for a theoretical relationship between pressure and length which shall agree closely with experimental results.

I am, Sir, yours faithfully,

R. V. SOUTHWELL.

Bracondale, Norwich, August 21, 1914.

BOILER TRIALS.

TO THE EDITOR OF ENGINEERING.

Sir,—Having had a good deal to do with the running of boiler trials to ascertain commercial efficiencies, I was much interested in your article on "The Conduct of Boiler and Steam-Engine Trials," in your issue of August 14. Might I be allowed to make some suggestions through your columns which I think might be of interest?

The accurate calculating of coal consumption is a difficulty which everyone who has been in charge of trials must have appreciated, and the possibilities of error are considerable. For instance, an error of 1 in. in estimating the thickness of fires would mean, in a Lancashire boiler with 36 sq. ft. of grate surface, an error in the coal consumption of $2.5 \times 36 = 90$ lb., using the formula given in your article for slack. Suppose the boiler is burning 15 lb. of coal per square foot of grate surface per hour = 540 lb. per hour, then the percentage error in a four hours' trial would be 90 in 2160 = 4.16 per cent.

An idea recently occurred to me which, unfortunately, I have no opportunity of testing for myself at present, but some of your readers who have opportunities might think it worthy of a trial.

The rule I have always adopted in running guarantee trials with my patent draught regulator is to start the trials with the fires made up to working thickness after cleaning, and burned bright. I have had the fires levelled with the rake (I scarcely see the need of a special tool for this), and have then, in conjunction with the owner's representative, "sighted" the height of the top of the fire above the dead-plate with a batten held across the door. In this way I have always reckoned on being able to estimate within 1 in.

My idea for achieving greater accuracy in the measurement of coal consumption is as follows:—When the fires are burned bright, ready to start the trials, the whole of the fire could be raked out rapidly into a suitable receptacle placed on a portable weighing-machine, the weight noted, and the fire then shovelled back. In this way the weight of the fire could be ascertained, practically speaking, exactly—*i.e.*, within a few pounds—at the beginning and end of the trial.

This idea will probably meet with adverse criticism, and perhaps ridicule, if it is published. But I have survived a good deal of both, like most inventors, and I have sufficient practical experience to state fearlessly that this idea is perfectly feasible, and to prophesy confidently that sooner or later it will be adopted in some form or other.

The inaccuracy, not always unintentional, of the results of coal-consumption trials is notorious, and the opportunities for trickery which they afford are unfortunately plentiful. The result is that boiler-owners, generally speaking, have little confidence in guarantees which can only be established by properly-conducted trials. A traveller who can talk glibly about a fancy-shaped fire-bar which "acts like a Bunsen burner," or something equally probable, is more likely to get an order than an engineer who offers something with a definite guarantee on a no-saving no-payment basis, but who wishes to run trials to satisfy himself and his prospective client as to the exact percentage of saving. Any regularisation of trials which would lead to more reliable results being obtained would be a boon to both engineers and steam-users, and would help to conquer the existing feeling of distrust which is so serious an obstacle to the adoption of some improvements, while it unfortunately aids those who trade in articles to which properly-conducted trials would deal a death-blow.

It would be interesting to know how the constants 2.5 and 1.7 in the formula for corrections for differences in thickness of fuel have been arrived at, and why a formula should be suggested for such a very simple calculation. Ordinary Welsh steam coal weighs green at least 50 lb. per cub. ft. Coke weighs on an average about 32 lb. per cub. ft. Coal on a burning fire is somewhere between these two figures, the "where" depending on the stage of combustion which it has reached. The constant 1.7 assumes a weight of 20.4 lb. per cub. ft., which appears to me impossible. The constant 2.5 assumes a weight of 30 lb. per cub. ft., less than the average weight of coke, which appears improbable.

Yours truly,

CHARLES THOMSON.

Lintley, Greenlaw, N.B., August 26, 1914.

MARKING LABORATORY EQUIPMENT.

TO THE EDITOR OF ENGINEERING.

SIR,—I have the honour to ask you whether you could favour me with any information that you may have regarding means adopted by similar institutions to this for marking the miscellaneous equipment of a technical college. The equipment, of course, would include articles in metal, timber, glass, and paper, and all would require to be marked with letters and figures of a size dependent upon the size of the article.

Possibly you may know of institutions where the system of marking articles is complete. In that case might I ask either that you be so good as to inform me concerning them, or that you make them aware of our object in writing to you, and on our behalf solicit replies from them.

Bespeaking your favourable consideration of this request,

I have the honour to be, Sir, your obedient servant,

R. RIDDELL,

Deputy Superintendent of Technical Education.

Central Technical College, Brisbane, June 30, 1914.

WAR MAPS.—A further series of war maps has been issued by Messrs. Edward Stanford, Limited, of 12, 13, and 14, Long Acre, W.C. Of these, the largest, 38 in. by 28 in. (exclusive of margins), shows the whole of Belgium and the part of France adjoining the boundary between the two countries, in addition to the greater portion of the western frontier of Germany. A second map, measuring 33 in. by 23½ in., shows the western provinces of Germany, a portion of Belgium and Denmark, and the whole of Holland. The third map covers the area bounded by the west of Iceland on the one side and the Russo German frontier on the other. In the north and south direction the map extends from Vienna to a little north of the Gulf of Finland. In view of the well-earned reputation of the publishers, it is unnecessary to say that the maps are excellently engraved, accurate and full.

DIRECTORY OF BRITISH ENGINEERS.—We have received from the British Engineers' Association, 32, Victoria-street, Westminster, S.W., an advance copy of the second edition of the official directory of that Association. Among the members of this Association are nearly 250 British engineering firms, and the directory gives a complete alphabetical list of these firms with their full postal addresses. The remainder of the directory is occupied by a classified list of the productions of these firms, including all kinds of engineering plant and accessories. The list is very complete, and has apparently been compiled with much more care than is usually bestowed on publications of this class. We have, however, one improvement to suggest for future editions, and that is that the telegraphic addresses of the firms might be included, as well as their postal addresses, as doubtless the directory will give rise to many inquiries from abroad. In its present form, however, it is an extremely useful publication, and its issue at the present time is particularly opportune.

COMPETITION WITH GERMANY AND AUSTRIA-HUNGARY.—Inquiries have been received at the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C., from a large number of firms in all parts of the United Kingdom for the names of manufacturers or purchasers of various classes of goods which have been previously obtained from, or sold to, Germany and Austria-Hungary. Among the articles respecting which inquiries have been received from would-be purchasers are the following:—Paraffin-lamp chimneys; bored-wood brush stocks; lumineux ribbons and crinoline trimmings; metal glove-fasteners; 22-carat gold-leaf for bookbinders' use; numbering, dating, and perforating-machines; heat-resisting glasses and globes; glass wool; metal frames and other materials for ladies' hand-bags; compressed asbestos-fibre jointing; stay fittings and broche cloths and spiral springs for corset manufacturers; millinery ornaments, similar to Gablonz ware, in mother-of-pearl, galalith, and glass; aluminium powder; coppered iron-wire for chair-springs. Inquiries have been received from manufacturers for purchasers of the following articles:—Crayons; bandages—knitted tubular; bottles (glass) for chemists and doctors; cameos; card clothing for textile industry; electrical fittings, &c.; Christmas cards; fancy goods; gloves and chamois leather; electrical hair dyes; electrical massage vibrators; cheap leatherette papers; gold lace; glazed presspahn. Persons interested in any of the above-mentioned articles are invited to write to the Director of the Commercial Intelligence Branch, with a view to being placed in communication with the inquirers.

OVAL CHUCK FOR WOOD TURNING.

CONSTRUCTED BY MESSRS. A. RANSOME AND CO, LIMITED, ENGINEERS, NEWARK-ON-TRENT.

Fig. 1.

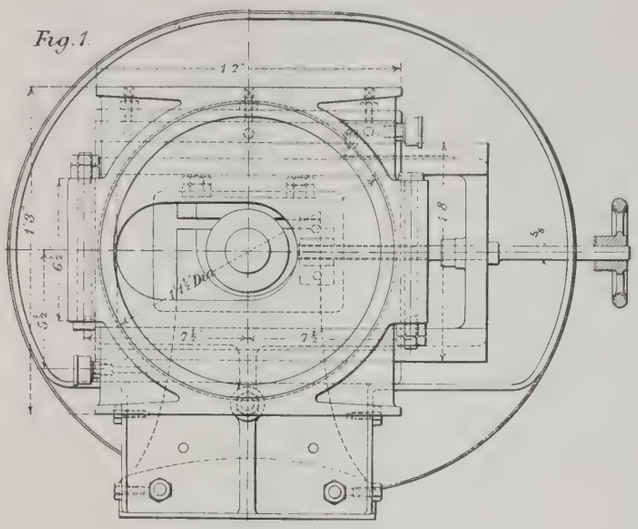


Fig. 3.

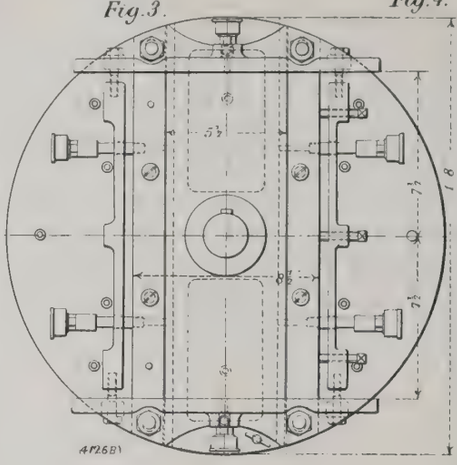


Fig. 4.

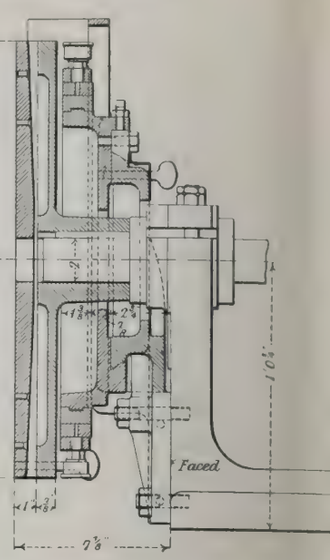
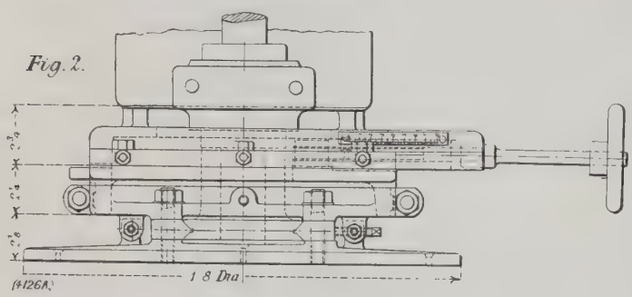


Fig. 2.



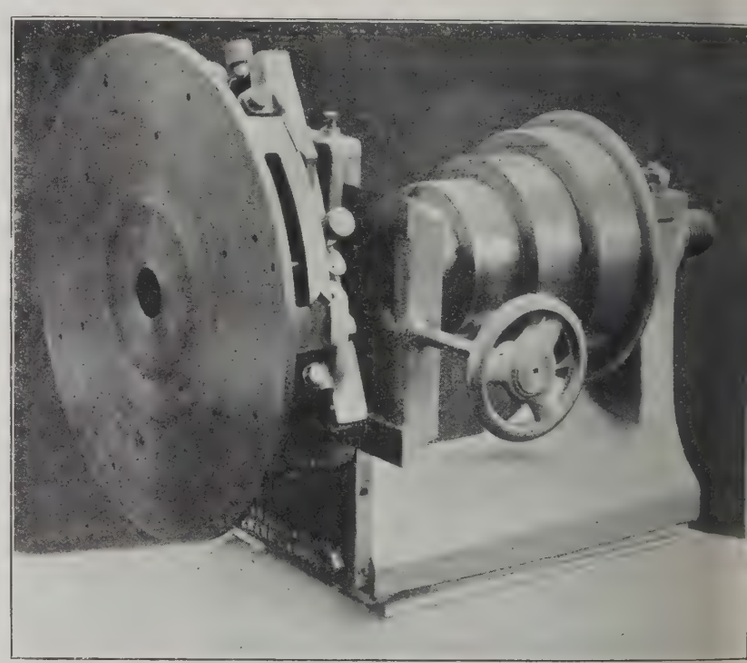


Fig. 5.

Although the use of oval chucks on wood-turning lathes is by no means novel, it is rare that one so large as that illustrated on this page, and recently made by Messrs. A. Ransome and Co., Limited, of Newark-on-Trent, is employed. The chuck in question is fitted to the back of the headstock of a 12-in. centre lathe, and has a 20-in.-diameter face-plate, to which can be fitted a large wooden face-plate of any required diameter. To the back of this face-plate is fitted two steel V-slides (Figs. 1 and 2), working in corresponding V's planed on the edge of a rectangular plate attached to the end of the lathe mandrel (Fig. 4), the slides causing the plate to revolve with it.

Two guide-bars are also fitted to the back of the face-plate at right angles to the V-strips. These guide-bars rest on the planed faces of a gun-metal sheave revolving round a circular track. The circular track is mounted on a slide fitted to the headstock, and by means of a screw (Fig. 1) can be brought exactly concentric with the lathe-mandrel when a circle is formed, or may be set eccentric to the mandrel when an oval is formed, the differences between a major and minor axes depending upon the amount of eccentricity of the circular plate.

The chuck illustrated (Fig. 5) is capable of turning ovals of any proportions up to 8-in. difference between the major and minor axes, and has been specially designed for turning ovals on small wooden bedstead ends, up to 18 in. across the major axis of the ellipse. Special care has been taken in the lubrication of the various slides, all of which are provided with setting-up screws for taking up any play or wear.

An engraved scale (Fig. 2) is provided, with index pointer, to enable the chuck to be adjusted exactly to any required amount, and a wrought-iron guard is fitted over the chuck to protect the operator.

CONTINUOUS PHOTO-PRINTING MACHINE.

We illustrate on the opposite page a continuous photo-printing machine, used in conjunction with an automatic washing and drying-machine, both of which were designed and constructed by the C. F. Pease Company, of 166, W. Adams-street, Chicago, Illinois, U.S.A., and are sold under the trade name "Peerless." With these machines a single operator can print, wash, and dry 100 linear yards of blue prints per hour, during which time the apparatus consumes 7 units of electrical energy, 60 gallons of water, and 50 cub. ft. of gas. It is, of course, quite possible to use the machine for part of the time only if such a large output is not required. The operator's time can then be occupied in other ways, and the working costs correspondingly reduced. Prints can also be made on separate sheets of sensitised paper, instead of in continuous rolls, if desired.

Fig. 1 is a front view of the machines, and Fig. 2 is a side view, showing the course of the paper through the apparatus. The table from which the tracings are fed into the machine will be seen in Fig. 1, and beneath it are two horizontal spindles which carry rolls of sensitised paper of different widths. The tracings and paper are carried upwards over a cylindrical segment of thick plate-glass by means of an endless canvas belt, best seen in Fig. 2. Springs are provided to keep the belt tight, so as to ensure good contact, and side travel of the belt is prevented by a special device. The belt is driven by a small electric-motor, the speed of which is controlled by a rheostat placed on the right-hand side of the machine; both motor and rheostat are clearly shown in Fig. 1. By means of the rheostat the speed of the paper can be varied from 4 in. per minute, which allows sufficient exposure for the slowest negatives and black-line prints, up to 6 ft. per minute. The exposed paper can be examined immediately it has passed the glass segment, so that the speed can be adjusted to give the right exposure before any prints have been spoilt. In front of the glass is a bank of five arc-lamps, of the enclosed type, fitted with aluminium reflectors. Each lamp is separately wired and controlled by switches, which are enclosed in a metal box on the left-hand side of the machine, as shown in Fig. 2. The number of lamps employed can thus be varied according to the width of paper being used. The motor-switches are also enclosed in the same box, and all the wiring is encased in steel tubing. A small electric fan, of the pedestal type, is mounted on top of the switch-box. This fan, which can be distinguished in Fig. 2, drives a current of air in a transverse direction through the machine, in order to carry away the heat from the lamps Fig. 3 shows how easily accessible the lamps are for trimming and cleaning, and also illustrates how they may be turned back to facilitate these operations.

After printing, the tracings are delivered into an enamelled-iron trough in front of the machine, so that the operator can remove them without changing his position. This trough, which can be seen in Fig. 1, also serves to catch the exposed sensitive paper if the printing-machine is used independently of the washing and drying equipment, as is often the case. Usually, however, the exposed paper passes over a roller at the top of the printing-machine, and thence to the washing and drying-machine, as shown in Fig. 2. This part of the apparatus is driven, by means of chains and sprocket-wheels, from the motor of the printing-machine, and in it the paper is first washed by a spray of pure water, and afterwards treated by a weak solution of potassium bichromate. This solution is contained in a galvanised tank placed in the base of the machine, and clearly visible in Fig. 2. From this tank the solution is circulated by a small rotary pump, driven by an electric motor, having a vertical shaft, and delivered on to the paper through a flexible pipe; an inspection of Fig. 2 will make the whole arrangement clear. After a further washing with pure water the paper passes upwards in front of the drying device, over a roller at the top, and down at the back of the machine. Here it passes through a system

CONTINUOUS PHOTO-PRINTING MACHINE.

CONSTRUCTED BY THE C. F. PEASE COMPANY, ENGINEERS, CHICAGO, ILLS., U.S.A.

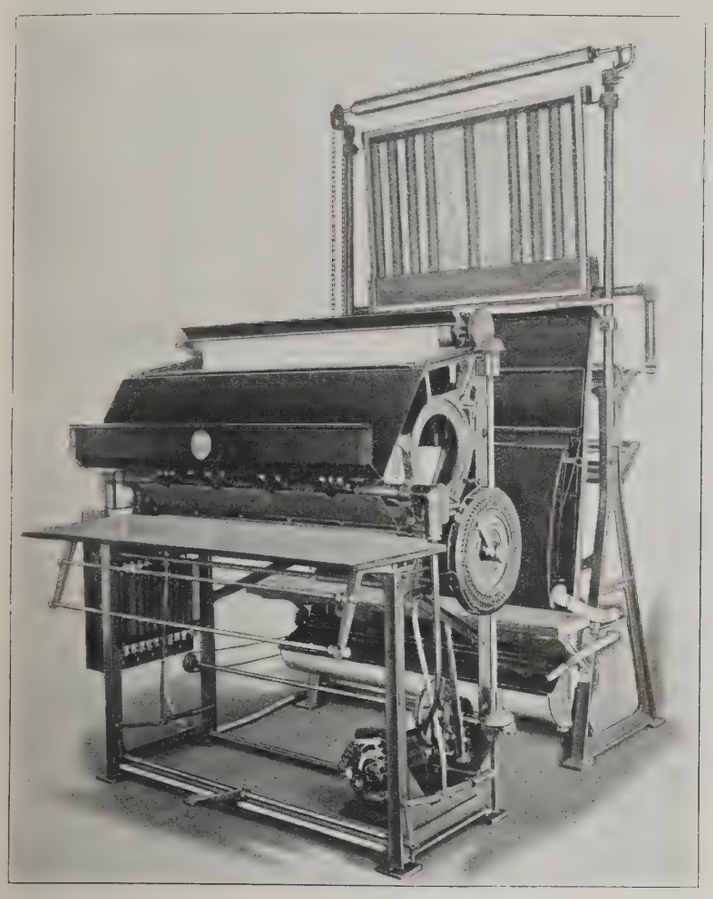


Fig. 1.

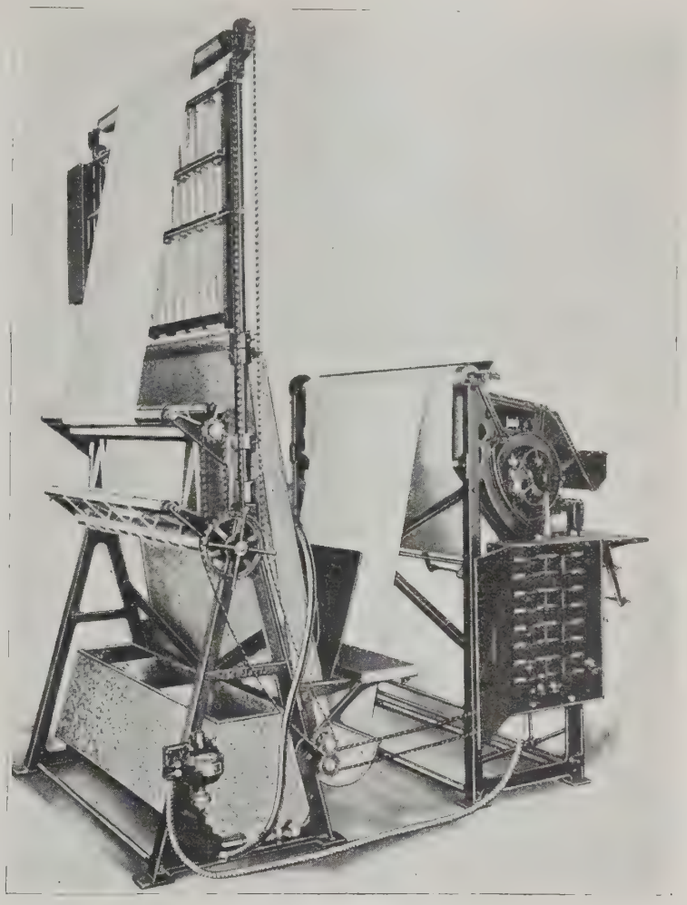


Fig. 2.

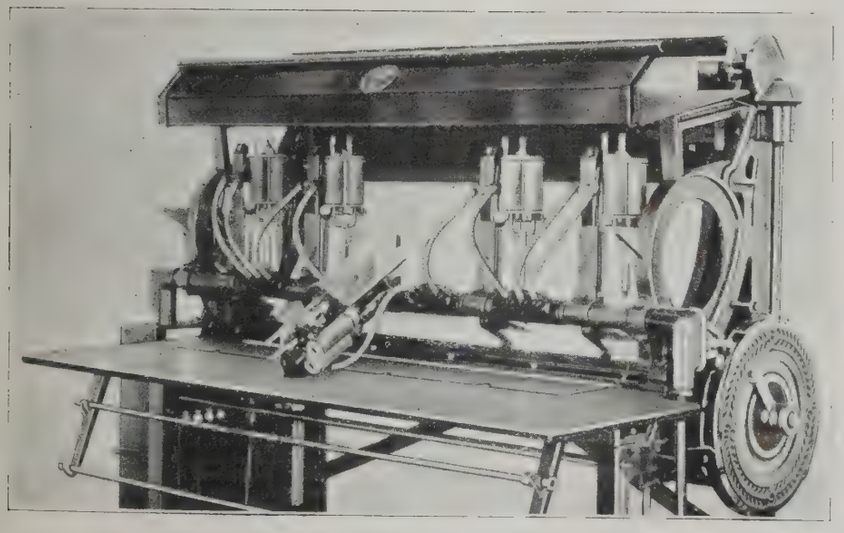


Fig. 3.

of rollers, the object of which is to remove wrinkles, and finally the finished prints are wound on to another roller. They have then only to be cut up for use. The drying apparatus, shown in Fig. 1, consists of a number of Bunsen gas-burners; but Fig. 2 illustrates an equipment in which the drying is effected by electrically-heated resistance wires. The energy consumed for this purpose is about 8 kw.

When the apparatus is not in use, it is desirable to keep it threaded up with a strip of waste paper extending from the feeding-table of the printing-machine to the last roller of the washing and drying-machine. After a run is finished, this strip of paper, or leader as it is called, is placed on one of the spindles under the feeding-table, the sensitised paper is cut off a few inches beyond the last tracing, and the end is pasted on to the end of the leader. The machine is allowed to run until all the prints have been wound up on the last roller, and the leader extends from one end of the apparatus to the other, thus leaving it all ready for starting up at any moment; a considerable quantity of sensitised paper is obviously saved by this precaution.

The floor space occupied by the whole apparatus is about 5 ft. 6 in. by 6 ft. 6 in. It is said to be noiseless in action, and to work cleanly, so that it can be placed in the most convenient position in the drawing-office or tracing-room. The machines, which can be used for all kinds of photo-printing work, are made in various sizes to suit large or small engineering works, or commercial photo-printing establishments.

The Swedish State Railways.—According to a report handed to the Government by the Board of the Swedish State Railways, the receipts for last year amounted to 88,693,266 kr., in addition to which there were State grants for new railways, &c., amounting to 19,257,400 kr. The expenditure was 66,867,363 kr., leaving a surplus on the working of 21,825,903 kr. The railways, rolling-stock, &c., were estimated at the end of the year at the aggregate sum of 614,704,643 kr. (18 kr. = 1*l.*).

The Institute of Metals.—In consequence of the war it has been found impossible to hold the autumn meeting of the Institute at Portsmouth this year, and all the Institute's arrangements in connection with the proposed meeting are cancelled. Instead of the previously announced meeting a statutory meeting of members of the Institute will be held at the offices, Caxton House, Westminster, at 4.30 p.m., on Thursday, September 10, when formal business only (including the election of new members) will be transacted. No papers will be read or discussed at this meeting, but members are invited to communicate their discussion of the following papers in writing for publication in the next issue of the Journal:—1. Captain N. T. Belaiew, on "The Widmanstätten Structure in Various Alloys and Metals." 2. Dr. G. D. Bengough, M.A., and Mr. D. Hanson, M.Sc., on "Tensile Tests on Copper at High Temperatures." 3. Mr. O. F. Hudson, M.Sc., on "The Critical Point at 460 deg. Cent. in Zinc-Copper Alloys." 4. Mr. F. Johnson, M.Sc., on "A Note on the Annealing of Brass." 5. Mr. R. K. Morcom, on "The Deposition of Metals by the Spraying Process." 6. Mr. J. Phelps, M.A., on "The Effect of Hydrogen on the Annealing of Gold." 7. Mr. A. Philip, B.Sc., A.R.S.M., on "A Contribution to the History of Corrosion. Part III. Coke, Condenser Tubes and Corrosion." 8. "Mr. S. W. Smith, B.Sc., A.R.S.M., on "The Surface Tension of Molten Metals" 9. Mr. W. E. Thorneycroft, B.Sc., and Professor T. Turner, M.Sc., on "The Behaviour of Copper-Zinc Alloys when Heated in a Vacuum." The Council hope that the papers will be fully discussed by the members in this way, so that the Journal may not suffer from the abandonment of the Portsmouth meeting, which is unavoidable in the existing circumstances.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, August 12.

If only the present status of the steel industry were taken into account there would be occasion for despondency. Present disturbances abroad dominate the situation. Enough time has elapsed since the rendering of the inter-State commerce decision to observe its discouraging effects. The roads west of Pittsburg benefit in the higher classes of freight; the roads east do not, except to the extent of their penetration into the western territory. The Standard Oil Company, the United States Steel Corporation, the United Fruit Company, and other large transporters of ocean freight are taking vigorous measures to place their fleets in commission for Atlantic transport services. Exporting interests in all lines are grappling with this inviting problem. The cutting off of the supply of ferro-manganese threatens seriously. Two Dunbar furnaces will blow in. Heavy inquiries for steel are already arriving from the Pacific Coast for supplies which heretofore were largely filled in Europe. At present the export and import business in steel products is at a standstill. Many concerns have withdrawn quotations on all finished material; others have advanced an additional dollar on near-by deliveries. Everything is unsettled. Consumers of steel are waiting to see. Railroad orders have not developed as was hoped. The tendency is to a greater price firmness, in view of a heavier export demand when it is safe. The wheat-belt railroads are crowded with traffic. Cotton roads see trouble, as exports are stopped. Measures are being taken to finance the crop to save the planters. The whole steel situation has suddenly assumed new aspects, not necessarily grave.

National Service.—As the result of a circular sent by the Council to the members of the Institution of Electrical Engineers, the Council have now the names of a large number of electrical engineers who offer their services (subject to various periods of notice) to fill vacancies in connection with the public services, electric-power stations, tramways, railways, &c. These names have been classified by means of index-cards under various headings, and are at the disposal of such undertakings should any of the men's services be required.

The Special Fire Service Force.—The Special Fire Service Force, which is being formed by the British Fire-Prevention Committee, may shortly require the following for service in connection with the protection of Government establishments, stores outside the London area, and for other national purposes. Eighteen steam fire-engines with gear (horse-drawn or motor, with or without mechanics); twelve manual fire-engines or hose-vans; twelve landaulette motor-cars (with or without drivers). Offers to loan the above should be addressed, with full particulars in writing, to 8, Waterloo-place, London, S.W.

Contracts.—The National Time Recorder Company, 5, Blackfriars-road, S.E., inform us that they have just received a repeat order from the Price's Patent Candle Company, Limited, for thirty of their model B patent check-action time-recording machines. They have also recently supplied repeat orders to the General Electric Company, Limited, making ten machines in all, and have just completed an installation of thirteen of these time-recording machines in Russia for the Vienna-Warsaw Railway.—The Edison and Swan Company, Limited, inform us that they are supplying to H.M.S. Tiger a quantity of Admiralty-pattern quartzalite radiators.

Truro City Water Supply.—In connection with the water supply of the City of Truro, it has been decided to substitute Candy mechanical filters for the present open sand filters. At the seventy-second half-yearly meeting of the Truro Water Company, held on the 1st inst., the directors reported that the further installation of Candy filters would soon be in operation, and that the cost of working the new filters would be considerably less than the expenses attendant on the sand-beds, while the capital cost of the Candy filters was much below the heavy expenditure that would have been incurred by the construction of the additional sand-beds necessary for giving an adequate supply of properly filtered water.

The Royal Sanitary Institute.—The fifty-eighth course of lectures and demonstrations for sanitary officers will take place from September to December. The course comprises the following:—Four lectures on elementary physics and chemistry in relation to water, soil, air and ventilation, and meteorology. Twenty-one lectures on public health statutes; the practical duties of a sanitary inspector; municipal hygiene or hygiene of communities, including prevention and abatement of nuisances, sanitary defects in and about buildings, and their remedies, water supplies, sanitary appliances, drainage, refuse removal and disposal, offensive trades, disinfection; building construction in its sanitary relations, local physical conditions, measurement and drawing plans to scale. Inspections and demonstrations are arranged in connection with the lectures, and include visits to disinfecting stations, &c. There will be also seven lectures on meat and food inspection, including taking of samples of water, food, and drugs for analysis. Practical demonstrations of meat inspection will be given. Full particulars can be obtained at the offices of the Institute, 90, Buckingham Palace-road, London, S.W.

NEW SOUTH WALES.

The following information given in the monthly statistical bulletin for May last, issued by the Government of New South Wales, will be found interesting:—Agricultural production: The preliminary results of the final compilation of the crop returns show that the yield of wheat during the 1913-14 season was 38,029,082 bushels from 3,205,695 acres, equal to an average of 11.9 bushels per acre. The ploughing season was exceptionally favourable over most of the State, rains having occurred at frequent intervals over the wheat belt, thus enabling farmers for several months to proceed with ploughing and seeding operations without serious interruption. The area under wheat last year was increased considerably, and exceeded the total area under all crops for 1912-13. The grain area alone was 974,181 acres in excess of that cropped during the previous year. An opportune rainfall during October was responsible for the high production of grain, which is the highest reached so far in any of the States. The area under all crops was 4,572,800 acres, which includes about 3800 acres double cropped, and exhibits an increase of 831,974 acres, as compared with the total cultivation for the previous year. Dairying production: Although expansion was recorded in respect to butter and cheese production, dry weather in portions of the coastal districts somewhat restricted the output of dairy products. The quantity of butter made during 1913 was 77,666,394 lb., or 1,056,866 lb. more than during the previous year. The output of cheese amounted to 6,236,962 lb, and exhibits a satisfactory increase when compared with the production during 1912, when 5,454,685 lb. were produced. The increase was doubtless due to the enhanced price of this commodity, and dairymen, in order to secure the benefit of the rise in prices, devoted a larger proportion of milk to the production of cheese instead of butter. Stock returns: The preliminary stock returns show that the number of sheep in the State at the end of 1913 was 39,842,518, as compared with 39,044,502 at the close of 1912. The lambing, although much in advance of the previous year's results, was not so satisfactory as could be desired, owing to the protracted dry weather and absence of suitable pasturage in some parts of the State during the earlier portion of the season. The returns of cattle and swine exhibit decreases of 204,033 and 5491 respectively, but horses increased by about 30,000. Gold production: The gold yield during May was 7977 oz. crude, equal to 5994 oz. fine, valued at 25,459*l.*, and showed a decrease of 4310 oz. fine, and 18,310*l.* in value, compared with May of last year. The value of gold produced during the five months was 218,423*l.*, and showed a decrease of 7606 oz. fine, and of 32,304*l.* in value, over the figures for the corresponding period of last year.

The Resistance of Steel Conductor-Rails.—At a time when railway electrification is so much to the fore, the British Standard Specification No. 68, on "A Method of Specifying the Resistance of Steel Conductor-Rails," is opportune. Work on this question was commenced in March, 1913, and after a conference had been called, the Sectional Electrical Committee of the Engineering Standards Committee drew up and passed this specification. The Sectional Committee embraced representatives of eight of the leading railways interested in electrification, of tramways, and of consulting engineering firms, Dr. R. T. Glazebrook acting as chairman. The method suggested consists in specifying the resistance of a steel conductor-rail in michroms, reduced to the equivalent value of the resistance of a 100-lb. steel rail at 60 deg. Fahr. The report gives the necessary reduction factors, formulæ, &c., to enable the resistance to be reduced to this base. The price of the report is 10*s.* 8*d.*, and it may be obtained either from the offices of the Committee, 28, Victoria-street, Westminster, or from Messrs. Crosby Lockwood and Son, Stationers' Hall-court, E.C.

The Australian Navy.—The Royal Australian Navy comprises the battleship Australia (built by Messrs. John Brown and Co., Limited), having a displacement of 19,200 tons; the second-class protected cruiser Melbourne (built by Messrs. Cammell Laird and Co., Limited), having a displacement of 5600 tons; the second-class protected cruiser Sydney (built by the London and Glasgow Engineering and Shipbuilding Company, Limited), and a sister ship of the Melbourne; the second-class protected cruiser Brisbane (built at the Commonwealth Dockyard, Cockatoo Island, Sydney), a sister ship to the Melbourne; the second-class protected cruiser Encounter, lent by the Lords of the Admiralty for training purposes, and having a displacement of 5880 tons; the ocean-going torpedo-destroyer Parramatta, having a displacement of 700 tons; the Yarra and the Warrego, sister ships to the Parramatta; and the Derwent, the Swan, and the Torrens, three further sister ships to the Parramatta (built at the Commonwealth Dockyard, Cockatoo Island, Sydney); the submarine A E 1 (built by Messrs. Vickers, Limited), having a displacement of 800 tons; and the A E 2 (built by Messrs. Vickers, Limited), a sister-ship to the A E 1. The battle cruiser Australia is fitted with turbine engines, giving her a speed of 26 knots; she is 578 ft. long by 79 ft. 6 in. beam, and she carries 24 guns and two 21-in. submarine lance torpedo tubes. The Melbourne is fitted with turbine engines giving her a speed of 26 knots; she is 430 ft. long by 48 ft. 6 in. beam, and she carries 12 guns and two 21-in. lance torpedo tubes. The second-class protected cruiser Brisbane is expected to be delivered in February, 1915. The torpedo-boat destroyers Parramatta, Yarra and Warrego are each 245 ft. long by 24 ft. 3 in. beam; they each carry four guns and three 8-in. lance torpedo tubes.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was quiet, and Cleveland warrants were easier. The turnover consisted of one lot at 52*s.* 9*d.* twenty-two days, and closing sellers quoted 52*s.* 8*d.* cash and 52*s.* 11*d.* one month, with buyers naming 1*d.* less. In the afternoon the market was nominally steady, and 2000 tons of Cleveland warrants were done at 52*s.* 9*d.* eighteen days, and 53*s.* November 6. At the close sellers quoted 52*s.* 9*d.* cash and 53*s.* one month, but buyers only named 52*s.* 6½*d.* and 52*s.* 9*d.* respectively. On Friday morning the market was weak, and only one lot of Cleveland warrants changed hands at 52*s.* 6*d.* cash, with sellers over at 52*s.* 7*d.* cash and 52*s.* 10*d.* one month. The afternoon session was quite idle, and Cleveland warrants were the turn easier, with sellers at 52*s.* 6½*d.* cash and 52*s.* 9½*d.* one month. A decided decline took place in Cleveland warrants on Monday morning, and the closing quotations were 10½*d.* under those of Friday. The business amounted to 6000 tons at from 51*s.* 9*d.* to 51*s.* 7½*d.* cash, and from 52*s.* 3*d.* to 52*s.* one month, with sellers over at 51*s.* 8*d.* cash and 51*s.* 11*d.* one month. In the afternoon there was nothing doing, and the price of Cleveland warrants showed a slight improvement at 51*s.* 10½*d.* cash, 52*s.* 1½*d.* one month, and 52*s.* 6*d.* three months' sellers. On Tuesday morning the tone was easier, but again there were no dealings, and sellers of Cleveland warrants quoted 51*s.* 9*d.* cash, 52*s.* one month, and 52*s.* 6*d.* three months. The afternoon session was dull and quiet, and the turnover consisted of one lot of Cleveland warrants at 52*s.* three months. The closing prices were 51*s.* 7½*d.* cash and 51*s.* 10½*d.* one month sellers. When the market opened to-day (Wednesday) there was an absence of demand for Cleveland warrants, and prices were quoted down to 51*s.* 4½*d.* cash, and 51*s.* 7½*d.* one month, sellers. Buyers named 51*s.* and 51*s.* 3*d.* respectively. In the afternoon there was no change, and business was again at a standstill. Sellers of Cleveland warrants quoted the same prices as in the morning, but also named the three months' position at 52*s.*, while buyers quoted 50*s.* 11*d.* cash, and 51*s.* 2*d.* one month.

Sulphate of Ammonia.—The difficulty arising through the restricted sailings at the present time has not yet been fully surmounted, but things are gradually settling down, and before long shipping will be very nearly in full swing again. The demand for sulphate of ammonia has been of a restricted nature of late, and the current price for prompt lots is now round 10*l.* 15*s.* per ton. As to forward lots, there is some difference of opinion between buyers and sellers, with the result that little is being fixed up.

Scotch Steel Trade.—Business in the Scotch steel trade has been rather a serious problem to the different managements for a long time back, and the newer phase is also one requiring careful handling. During the past week the outlook has improved considerably, as shipping facilities are more favourable, but heavier freights and increased costs for raw material are all against buyers, who are still somewhat backward to fix up contracts. Over the week prices have remained steady, with the result that some are more inclined to place orders, but each lot is arranged on its own merits, and producers are giving preference to contracts which promise early specifications. The latter are scarce for plates, both on home and export account, but are likely to show some improvement before long. Black-sheet makers are fairly well supplied with orders for the heavier gauges, but makers of sectional material, while moderately well off, could be doing with more orders. The mails from abroad are bringing in very satisfactory inquiries and orders from markets which have remained loyal to the Scotch makers, and those which in recent years purchased large quantities of steel material from the Continent will now require to pass their business here or else to America. The steel industry has once again got an opportunity of asserting itself in an unmistakable manner, and whether this unfortunate war lasts for a long or a short period, it is quite certain that it will be a long time before the German maker will be in a position to offer his manufactures abroad. Under the circumstances it is to be hoped that the home material will by that time have secured so firm a hold that it will continue to keep these markets.

Malleable-Iron Trade.—The condition of affairs in the malleable-iron trade of the West of Scotland is most satisfactory, and makers are very busy. Raw material causes a little trouble, as so much of it, for steel bars, formerly came from the Continent, but the difficulty is being overcome, and the outlook is promising very well indeed. Prices are unchanged, and are based on 7*l.* 12*s.* 6*d.* per ton, less 5 per cent., for "crown" bars.

Scotch Pig-Iron Trade.—The Scotch pig-iron trade is moving along rather quietly, as the horizon is still somewhat clouded. The demand has not been excessive, and a little storing is reported, but with confidence returning the outlook is improving, and a better inquiry is anticipated shortly. The shipping trade is dull, but with the prospect of cargo vessels securing a safe voyage on the main trade routes there is now more inclination to undertake outstanding orders. Furnaces in full blast number 55, as against 88 at this time last year. Prices are the turn easier, and the following may be taken as the market quotations for makers' (No. 1) iron:—Clyde, 69*s.* 6*d.*; Calder, Gartsherrie, Summerlee and Shotts, 70*s.*; and Langloan, 72*s.* (all shipped at Glasgow); Glengarnock (at Ardrossan), 71*s.*; and Carron (at Grangemouth), 70*s.* 6*d.*

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The hard steam-coal market is one of considerable difficulty. There are large stocks accumulating both at pits and at ports. It will take many weeks of normal shipping to relieve the congestion. The industrial demand does not do much to relieve the situation, for, apart from the armament factories, few works are taking supplies of any quantity. Many pits are only working two and three days per week, but stocks are still accumulating. Prices are easier. There has been a slight reduction on pre-war quotations. The demand for house-coal is on a smaller scale, but there is still good business to be done in the best hand-picked qualities. The shortage of wagons, however, is limiting output, and some collieries are in arrears with orders. The lower-grade qualities are the weak spot, slight reductions failing to bring forth much business. The orders at local dépôts are only for small tonnages; there is a falling off in country orders; and, compared with previous years, the London dépôts are not taking their usual quantities. Deliveries on contract account in gas-fuels are steadily maintained. Many works are apparently laying in stocks so as not to be affected by any transit delays that may arise. Slacks are in lesser demand, but there is no attempt to force the market in view of reduced output at the collieries. There is also a reduced output in washed smalls, but these are being readily taken and the price is firm. Blast-furnace coke has hardened. Quotations:—Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. to 13s.; Derbyshire best brights, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 10s. 3d. to 11s. 3d.; small nuts, 9s. to 10s.; Yorkshire hards, 10s. to 11s.; Derbyshire hards, 10s. to 11s.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.; smalls, 2s. to 3s.

Iron and Steel.—There has been a revival in the South Yorkshire iron and steel industries. Unemployment is not so bad as was at first anticipated, and discounting the armament houses, which are naturally working at top speed just now, the number of firms who are in full working order is considerable. The lack of Continental supplies has caused something of a run on locally-produced raw materials, and the immediate effect has been a rapid rise in prices If the demand continues at its present magnitude, as seems very likely, there will be room for a more reasonable tone in these quotations, as otherwise any all-round benefit that might be derived from Continental inactivity will be nullified by the high initial cost of working material. The current official quotations are:—West Coast hematite, 79s. 6d.; East Coast hematite, 77s 3d.; Lincolnshire foundry, 60s. 8d.; Lincolnshire forge, 59s. 8d.; Derbyshire foundry, 59s. 3d.; Derbyshire forge, 56s. Soft billets are quoted at 6*l.*, hard billets at 6*l.* 10s., Bessemer acid billets at 8*l.*, and Siemens acid billets at 8*l.* 15s. to 9*l.* Hoops are 30s. dearer. In the more finished departments much is expected from the diversion of trade that is now being discussed. There are already large orders for tools and implement parts to hand, and it is expected that these will be followed by orders which will benefit nearly the whole of the steel industry. The chief sufferers are those who had no other source, either for raw materials or for finished goods, than the Continent; but firms who were already in touch with the colonial and foreign markets not now affected by the war are pushing home their advantage to the full. There are few, if any, houses in this district who are not in a position to undertake a good part of the previous Continental output of rods, sheets, iron and steel bars, steel wire, twist-drills, high-speed steel, and implement and machinery parts. The cutting off of German supplies of finished products has also not been without effect on the home market, and there are many orders from sources where competition has hitherto been keenly felt.

THE LATE LORD MERTHYR OF SENGHENYDD.—We regret to have to announce the death, which occurred at Newbury yesterday (Thursday) morning, of the Right Hon. Lord Merthyr of Senghenydd. The deceased, William Thomas Lewis, was the first Baron of Senghenydd, having been created in 1911. He was born at Merthyr-Tydvil, on August 5, 1837. The above sad news reached us as we were going to press, and we reserve a notice on the late Baron's life for our next issue.

JAPANESE SPELTER.—H.M. Vice-Consul at Osaka (Mr. O. White) reports that the Mitsui Bussan Kaisha recently made a trial shipment of 10 tons of spelter to the United Kingdom, though it seems scarcely probable that the Japanese zinc companies are yet in a position to compete on the European market. It is reported that the Amagasaki Works, backed by the Fujita Company, the Miike Works, and by Mitsui and Co., have come to an agreement to work sales in combination. The output of the Amagasaki Works is estimated at 400 tons a month, and of the Miike Works at 150 tons a month. The latter works are said to be contemplating extensions which will bring their output up to 500 tons per month. In that event the total annual output would be nearly 11,000 tons for the two works. The supply of zinc would then, perhaps, be greater than the demand in Japan, and in order to keep up prices there it would be necessary to export the surplus. Accordingly, it seems probable that the present shipment has been made in order to get expert opinion on the Japanese product as a guide to future policy. It was reported in the local Press that a similar shipment of zinc had been made to Rotterdam, but H.M. Vice-Consul is unable to confirm the statement.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The pig-iron market is in an unsettled state. European troubles continue to occupy the attention of most commercial men, and business is on a very limited scale. Traders act with the greatest caution, and, as a rule, will not commit themselves beyond small transactions for early delivery. Certain financial obstacles may shortly be overcome, and, as a result, resumption of trade with many firms abroad may follow, but the dangers of the North Sea are fully realised, and, until an assurance of safety can be given, few vessels are likely to go out. Quotations are not easily fixed. Values of Cleveland pig are falling, due largely to decline in warrant prices, caused by nervous holders selling out, but hematite quotations, though very irregular, show a marked upward tendency. A hematite furnace has been put out at the works of Messrs. Whitwell and Co. Second hands are now offering No. 3 g.m.b. Cleveland pig at 51s. 6d., and, in fact, are rather pressing sales at that figure, whilst No. 1 is 54s.; No. 4 foundry and No. 4 forge, each 51s. 3d.; and mottled and white iron, each 50s. 9d. Makers are prepared to sell at very little above the foregoing quotations. Though some merchants have sold, and are understood to be still prepared to sell, small lots of Nos. 1, 2, and 3 East Coast hematite pig at 68s. for early delivery, makers will not name below 70s., and some producers ask 72s. 6d., and even more. There is little or nothing passing in foreign ore. Some consumers are said to be rather short of supplies, and boats are not easily secured. One or two cargoes originally intended for other countries have been diverted here since the outbreak of war, and sold on the basis of 20s. 6d. ex-ship Tees for best Rubio, which is the recognised market basis. Coke is still scarce and dear. Consumers consider market rates much too high, but sellers continue to take a very firm stand, and for average quality of Durham blast-furnace bee-hive coke, delivered at Tees-side works, from 18s. to 18s. 6d. is asked.

Shipments and Stocks of Pig-Iron.—Shipments of pig-iron from the Tees are on a very limited scale, practically all oversea deliveries being suspended, and what cargoes are being despatched are to coastwise customers. Arrangements, however, are being made for deliveries to certain places abroad. To date this month the pig-iron shipments are returned at 15,510 tons, as compared with 47,435 tons to the same date last month, and 73,394 tons for the corresponding part of August last year. Stocks of pig are accumulating. What iron is held by makers at their own yards is not ascertainable, but it must now be considerable. The stock of No. 3 Cleveland pig in the public warrant stores here stands at 93,009 tons, 10,757 tons having been added since the beginning of the month.

Manufactured Iron and Steel.—Producers of nearly all descriptions of manufactured iron and steel are fully employed, and have good order-books. Particularly is this the case with manufacturers of shipbuilding material and of joists, but most of the output is for home customers, and with foreign buying at a standstill works cannot be kept in full swing for very long. Arrangements are in progress for some deliveries to the Far East. Hopes are entertained that an Australian order in the market for 30,000 tons of steel rails will come to this district. The galvanised sheet department of Messrs. Dorman, Long and Co., which has been closed owing to short supplies of spelter, is to be reopened on Monday next. Men are this week being restarted at the Newport Wire Works of Messrs. Richard Hill and Co. The following are the principal market quotations:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 5s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 7*l.* 10s.; iron ship-rivets, 9*l.*; steel bars, 6*l.* 15s.; steel ship-plates, 7*l.*; steel ship-angles, 6*l.* 15s.; steel boiler-plates, 8*l.*; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 15s.; heavy steel rails, 6*l.* 15s.; and galvanised corrugated sheets, 13*l.* 10s. to 14*l.* 10s.—sheets less 4 per cent., f.o.b.; rails net, f.o.b.; and all other descriptions less the usual 2½ per cent., f.o.b.

INCOMPETENT FOREIGN CRITICISM.—The extraordinary superficiality of the observations of many visitors to our shores is strikingly illustrated by the following extract from an American monthly journal devoted exclusively to railway work. A writer in the current issue of that paper states that in this country "many of the cars, or coaches, as they are called, are now constructed with a corridor running along one side of the car. The original inventor no doubt intended that these corridors should connect with each other, and so permit the passengers to pass from car to car if they so desired. It was a vain thought. It naturally happens that in the vicissitudes of travel the cars are frequently turned end for end, and the corridor is of little or no service, one car having the corridor at the right side, while the adjoining car will likely have the corridor at the left side, and the accidental coming together all one way at the same time never happens, except when the royal family is taking a jaunt, which seems happening all the time; but as nobody else is allowed to ride on the same train as their royal highnesses, the advantage is not visible to the common people." It must, we think, have been a very uncommon person who found the vestibule connections between our corridor coaches invisible, and an equally uncommon person who did not ascertain that the fact of a corridor being on the right or left-hand side of a vehicle made no difference whatever in the facilities for intercommunication between adjoining corridors.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has shown little special activity, but there has, at the same time, been a strong Continental demand, especially from Italy and France; on the other hand, outputs have been checked by many miners having joined the army. The best qualities have been taken up by the Admiralty. Under all the circumstances, the market has shown strength, and sellers have, in some cases, somewhat advanced their terms; smalls have also been steady. Household coal has exhibited little change. The best secondary large steam coal has made 19s. to 20s.; other secondary descriptions have brought 18s. to 18s. 9d; best bunker smalls, 8s. to 8s. 6d.; and cargo smalls, 5s. to 7s. per ton. The best household coal has been quoted at 19s. to 20s.; good households have made 17s. to 18s.; No. 2 Rhondda large has realised 12s. 6d. to 13s. 6d.; and No. 2 smalls, 6s. to 7s. per ton. Patent fuel has been taken at 19s. 6d. to 20s. 6d. per ton. Special foundry coke has made 27s. 6d. to 30s.; good foundry coke, 21s. to 24s.; and furnace coke, 18s. to 20s. per ton. As regards iron ore, Rubio has brought 20s. to 21s. per ton upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Steel and Tin Plates.—Cessation of imports from the Continent has stiffened steel prices to the extent of 10s. per ton. Reports from branches, however, show that works are expecting to close down; only firms concerned in the manufacture of armaments are likely to be fully employed. The tin-plate trade suffers from the closing of the European markets and difficulties attending exports.

Unemployment Diminishing.—Unemployment appears to be diminishing at Swansea. Many of the tin-plate and fuel works are re-starting. A leading manufacturer of tin-plates considers that the war will put a stop for a time to the dumping of steel bars from Germany, and will increase activity in British steel trades.

Welsh Coal for Italy.—The administration of the Italian State Railways has arranged with representatives of collieries producing ordinary steam coal and Monmouthshire large for the supply of considerable additional quantities during August and September. Next to the British Admiralty, Italy is about the largest consumer of Welsh coal.

Mannesmann Tubes.—The Mannesmann Tube concerns at Swansea and Newport are said to be the largest industries started in Great Britain with German capital; but the capital is becoming more British every day. There are similar Mannesmann works in several Continental countries. Both British and German companies export largely to the Colonies, and it seems probable that British companies will do more business in future. Much the same is expected with regard to electrical machinery.

A Four Years' Strike.—After a dispute which has continued for about four years at the Gelli Steam Colliery (Messrs. Cory Brothers) on the question of the price-list, work is expected to be resumed shortly. The matter was dealt with recently at a meeting of the local Conciliation Board; and in consequence of the decision then reached, Mr. D. Watts Morgan, miners' agent, addressed a meeting at the Ystrad library, and explained the position of affairs. Eventually a resolution was passed agreeing to accept the terms offered, conditionally upon their being confirmed by the district meeting of the South Wales Miners' Federation.

Restrictions Withdrawn.—The removal of restrictions on the export of patent fuel and tin-plates has given great satisfaction. The Atlantic Patent Fuel Works will now be restarted, while the Graigola, already partly employed, are likely to increase their operations.

MECHANICAL TRANSPORT FACILITIES.—Owing to a number of motor vehicles having been claimed by the Government for war purposes, many firms find themselves in a difficulty in effecting delivery of their goods. Other firms, on the contrary, find their trade so much affected that they cannot keep their vans in full work. To remedy these difficulties the Commercial Motor-Users' Association, of 83, Pall Mall, London, S.W., and the Imperial Motor Transport Council, of 173, Fleet-street, London, are making arrangements of the nature of an exchange by which such difficulties may be reduced or entirely abolished. The Commercial Motor-Users' Association is also compiling a list of petrol-driven lorries which their owners would place at the disposal of the Territorial Force County Associations for use in this country in case of necessity, and also of drivers and mechanics who are prepared to offer their services in a similar manner.

THE TRADE OF CANTON FOR 1913.—The following note is taken from *The London and China Telegraph* on the trade of Canton for 1913:—There have been no important developments in local industries. As a result of the quasi-monopoly established in their favour by the embargo on the export of limestone mentioned in the 1912 report, which was successfully maintained until the end of the year, the Canton cement works have had a very profitable year. The receipts of the Canton Electric Company have almost doubled during 1913. They were, however, in the depreciated bank-notes, and actually some 35 to 40 per cent. must be written off. The same applies to the receipts of the Chinese section of the Canton-Kowloon Railway, which also show a very large increase. A paper mill has been started at Kongmoon, at the mouth of the West River. The capital (300,000 dols.) is entirely Chinese, and there is a chief engineer in charge. The output at the end of the year was about 15 tons a week.

CALCIUM CARBIDE AND NITROGEN PRODUCTS; ELECTRIC POWER-STATION AT TYSSEDAL, NORWAY.

(*For Description, see Page* 267.)

FIG. 19. DAM AT RINGEDALS LAKE.

FIG. 20. PIPE-LINES AND POWER-STATION AT TYSSEDAL.

FIG. 21. GENERAL VIEW IN POWER-STATION.

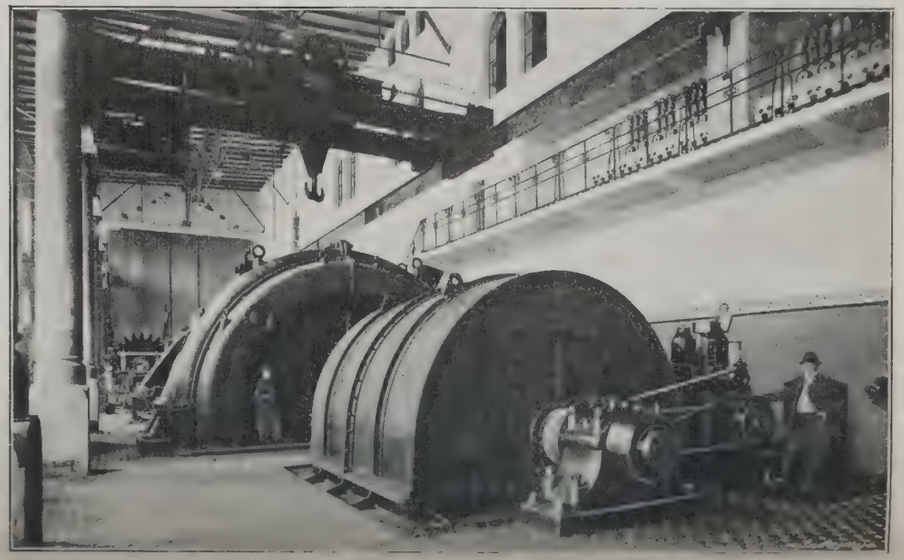


FIG. 22. A 13,500 WATER TURBO-ELECTRIC SET.

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With a Two-Page Plate of the MANUFACTURE OF CALCIUM CARBIDE AND NITROGEN PRODUCTS; 13,500-HORSE-POWER PELTON WHEEL AND ELECTRIC GENERATOR AT TYSSEDAL POWER-STATION.

NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to some Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, AUGUST 28, 1914.

THE ENGINEER AND THE MAP OF THE WORLD.

THE one certainty regarding the result of the present war is that the map of the world will be greatly altered. The changes will concern the boundary lines of different nationalities, and will therefore be political. Even although the engineer has exercised great influence in providing the munitions of war which have so greatly assisted in the accomplishments which will inevitably lead to such changes, our purpose in writing now on the subject is rather to point to the material alterations in the map of the world resulting directly from the work of the engineer. By his agency land is converted into water and water into land. Rivers regularised and deepened, and artificial canals, affect the extent to which water-borne traffic can penetrate into the interior of countries. Railways, roads, and tramways have in other cases superseded rivers. Railways and roads are constructed, and traverse bridges across straits, whereby islands become ostensibly part of the mainland. Waterways are cut through isthmuses to connect oceans. By afforestation and deforestation vast changes are also made on the face of the earth, and, through these and other agencies, influence is exerted on the climatic conditions, whereby the land is made more or less fruitful, the temperature being affected and the degree of moisture in the air altered. The health of districts is, by the same media, improved directly, while the advent of the engineer in many parts of the world brings in its train the scientist, with his investigation and work to combat fatal diseases, such as malaria, yellow-fever, and the like. One has but to remember the improvement in the health conditions of Ismailia and at Panama to realise the immense consequence following the presence of the bacteriologist in association with the engineer. Mountains, deserts, and rivers have had their significance minimised by the advance of engineering. Mountains have been pierced, rivers bridged, deserts watered by irrigation, and forests removed or planted. Following tree-planting comes ploughing and harrowing and harvesting, and the desert blossoms like the rose. Industrial communities arise to meet the needs of the agricultural workers, and these again bring railways and other changes. Indeed, the practical every-day facts of the map take on a new meaning, owing to the advance of modern science. The term miles, for instance, has not the same significance as under the older forms of transport. To-day distances must be measured rather by the time necessary to get from point to point. Again, even such island empires as Britain and Japan may lose their isolation if tunnels are made, and submarine and aerial ships become tenable, for ordinary commerce.

In view of the war there is appropriateness in the suggestion of lack of finality in the work of those concerned with the political changes on the map of the world as compared with the continuous and permanent influence exerted by the engineer on geography. The presidential address, delivered to the Geographical Section of the British Association by Sir Charles P. Lucas, K.C.B., K.C.M.G., although prepared without any conception of the present international crisis, had an appositeness which is peculiarly impressive, as it deals with man as a geographical agency. It dealt with man's work in such departments of activity as irrigation, land reclamation, reservoir building, afforestation, &c. The damming of the Nile at Assouan, making a lake 65 square miles in area, with its immense practical, if not also political, advantage to the Soudan and Egyptian deserts, was referred to by Sir Charles Lucas. There was also indicated the corresponding irrigation work in India, which, in 1903, watered something like 68,750 square miles, a larger area than England and Wales together. Sir William Willcocks' work now in progress on the Euphrates and the Tigris, for irrigating nearly 19,000 square miles, at once rises to memory in this connection, while 4000 square miles of the plains between the White and Blue Nile are to be watered artificially for cotton culture by the construction of a dam, and of a 100-mile canal south of Khartoum. In Australia, again, great work is being done to the same end. Already the works completed and in process of construction irrigate over 600 square miles in Victoria alone; but when the whole water supply of the State is utilised, more like 6000 square miles will be irrigated. The Burren-juck scheme, in New South Wales, will irrigate, in the first instance, not far short of 500 square miles, but may eventually be made available for six times that area. In the Algerian Sahara desert nearly 22,000 square miles have been reclaimed with water from artesian wells. These facts show what has been done, and give confidence in the belief that still greater achievements will effect still more extensive changes on the face of the earth. By tree barriers in the sand dunes, whereby the moisture of the soil is preserved, fine crops of durum wheat, it was further pointed out by Sir Charles, are got without a drop of rain from seed time to harvest. In the Landes of Gascony 3600 square miles of sandy waste have thus been planted with trees. The influences of all such works to assist agriculture is not only direct, but there is a great indirect gain; a consequence is the settlement of a population more or less extensive, due not only to the winning of the produce of the land irrigated, but to the creation of railways and factories for meeting the needs of the people. In this way, as the stories of Canada, South Africa, and Australia testify, great communities are built up, and new nations grow steadily in prosperity.

The map has also been changed by great reservoirs for the water supply of cities—Thirlmere, Vyrnwy, Loch Katrine, and those for Birmingham are cases in point. In the last session of Parliament there was vigorous opposition to the flooding of one of the historic districts of Scotland further to augment the water supply to the city of Glasgow. Abroad there are many similar instances, the most recent being the formation of a great dam on the Murrumbidgee River for New South Wales, to make a lake 41 miles long, and the Catskill Reservoirs for the supply of New York, recently fully illustrated and described in ENGINEERING. In his address, Sir Charles Lucas referred also to the importance of natural waterways, the Clyde, the Tyne, and other such streams, on whose banks there have been created great factories to produce articles for export through the waters of such rivers to the farther ends of the earth.

In the reclamation of land the engineer has exercised an equally great influence on the map. That the engineer in such work has greatly affected geography is proved by the example of London alone, since the Metropolis is built partly on marshy land. Some City names, indeed, prove this, notably Moorfields and Finsbury (or Fensbury). With the work begun in the sixteenth century that part of the City has been recovered from the marsh lands. Pimlico is largely built on piles, and in the region now occupied by Belgrave-square snipe-shooting was a sport three or four generations ago. The names of the Strand and Fleet-street also carry their significance. Even in new countries there are analagous cases. Harbours, such as that at Wellington, in New Zealand, have been partly reclaimed from the sea. Sir Charles Lucas also referred to the work done in the Lincolnshire Fens, where land variously estimated in extent from 800 to 1200 square miles has been recovered or improved. Another instance of reclamation at home is to be found on the famous Romney Marsh, in Kent. Abroad one of the most extensive cases is that in the Netherlands, where there has been a constant change between land and water area; the Dutch people have steadily worked towards reclamation, and even at the present time the progress of the scheme for draining the Zuyder Zee proves the far-sighted policy of the Government. The scheme is to be carried out in thirty-three years at a cost of nearly 16,000,000*l.*, and will result in an addition of 815 square miles of land to the kingdom, 750 miles of which will be fertile, while at the same time a much-needed fresh-water lake, with an area of 557 square miles, will be formed and will be fed by one of the mouths of the Rhine. Between the

Elbe and Scheldt more than 2000 square miles have been reclaimed from river and sea in the past three hundred years.

Touching upon afforestation, Sir Charles Lucas did well to point out, as did Mr. G. B. Marsh fifty years before him, that man has too long forgotten that the earth was given him for usufruct alone, not for consumption, still less for profligate waste. The sweeping away of great forests—a practice even more pursued to-day than ever before—is undoubtedly the eating up of capital. Apart altogether from the value of the timber, trees give shelter against the wind, store water, prevent inundation, and preserve and enrich the soil. It is true that experience in the South of France has proved that the pasturing of sheep is as great a destroyer of forests as man, because they break the soil and expose the roots, so that rainstorms and floods sweep away the soil. This may easily be remedied, but the cutting away of the timber without replanting of trees is reprehensible. It has been suggested that, in view of the possible degree of unemployment in this country consequent on the present unsettled state of affairs, the British Government might utilise the occasion for carrying into effect the afforestation scheme approved by a recent commission of inquiry—a point not enforced by Sir Charles Lucas. This proposal, it will be remembered, aimed at the planting annually of 150,000 acres of suitable land, and the result might probably be a valuable source of revenue ultimately for the Government. It is thought this would afford temporary employment to men out of work and not suited for the army, while permanently many men could be utilised directly in connection with the forests and indirectly with the subsidiary industries. The Commissioners estimated that the annual cost would be two millions sterling, and each year there would be an increasing deficit in working operations for the next forty years Then revenue would be derivable. From this date onwards the Commissioners estimated that the deficit would steadily decrease, until in eighty years there would be, from nine million acres of forest then existent, a net revenue of 17,500,000*l*. The scheme thus expressed is seductive, but the figures are only estimates. That we are deficient in forest lands is shown by the fact that the proportion to the total area of the country is 5.3 per cent., as compared with 32.6 per cent. in Austria, 17.3 per cent. in Belgium, and 17 per cent. in France. At present, under the auspices of Birmingham University, and under the presidency of Sir Oliver Lodge, the Midlands Reafforestation Association is planting the pit-mounds and ash-quarries of the Black Country with trees which will resist smoke and bad air—alders, willows, poplars—carrying out their work, a report says, under a combination of difficulties not to be found in any other country. Thus, apart from the direct gain in the growth of timber, the work of afforestation confers great indirect advantages, and serves further to prove that from first to last the engineer is exercising an important influence on the map of the world, as well as upon the significance of geographical terms. Sir Charles Lucas has done well once more to direct attention to these important considerations.

BRITISH PATENTS AND FOREIGN PATENTEES.

The state of war which exists at the present time between this country and Germany and Austria-Hungary has brought about a condition of affairs never contemplated by the law-makers of the several countries, and not considered by those who had industrial property in the form of patents, designs, and trade-marks to protect and work.

In this country there are laws relating to the protection of inventions and the registration of designs and trade-marks. Austria-Hungary and Germany have laws to the same ends. The German law governing the patenting of inventions and the protection afforded a patentee are often the subject of criticism and comparison with our own law and the protection afforded thereby. In most cases, the criticism and comparison are in disparagement of the law obtaining in this country. As to whether the criticism be just or unjust we are not at the moment concerned ; we wish rather to consider the position of those alien enemies, both within and without our realm, who have taken advantage of the benefits and advantages of our law and have obtained protection for their inventions, designs and trade marks in this country. The number of British patents granted annually to Germans and Austrians is very large. In the last annual report issued by the Comptroller-General of Patents, the numbers were as follow :—

Total number of patents granted	...	16,154
Number granted to Britons	...	8,263
Number granted to Germans	...	2,606

From the latest particulars as to the number of patents granted annually in Germany it would seem that of 13,080 patents granted in one year, 8831 were granted to Germans and only 749 to Britons. It will thus be seen that the percentages are very different.

A cry is raised periodically as to the hardships that are caused to British labour by foreign patentees who work their inventions abroad, to the benefit of their own labour markets, and import, free of duty, their products into this country. At the same time, protests are issued and resolutions passed against the equitable decision of Lord (then Mr. Justice) Parker in the well-known case *in re* Hatschek, comment on which we have made on more than one occasion.

Now we are confronted with the proposal that all patents granted in this country to alien enemies should be forthwith revoked. In other words, that the property in this country of our enemies should, as it were, be thrown into the street, so that all who pass by may appropriate whatever they fancy. The proposition seems attractive, but there is, as we have pointed out, a large patent property in Germany which belongs to British inventors. If we revoke all the patents belonging to the subjects of the States with which we are at war, we must expect that the Governments of those States will act in a similar manner as regards the patents held by us. Our gain would then be a good deal counterbalanced.

The Government do not propose any drastic measures, but have taken certain steps for the protection of British trade, and to that end have passed an Act (Patents, Designs, and Trade Marks (Temporary Rules) Act, 1914) amending the Patents and Designs Act, 1907, and the Trade Marks Act, 1905, in a certain manner, and have taken power to make rules and to do such things as they think expedient for avoiding or suspending, in whole or in part, any patent or licence granted to, and the registration of any trade mark the proprietor whereof is, a subject of any State at war with His Majesty. The Board of Trade has set up the necessary machinery to carry out the Act, and has issued rules from which it appears that they may, on the application of any person, and subject to such terms and conditions, if any, as they may think fit, order the avoidance or suspension of the rights of patent and registers of trade-marks of aliens. The Board, before granting any such application, may require to be satisfied on three points.

The first point of which the Board will require to be satisfied is that the patentee, licensee, or proprietor is the subject of a State at war with His Majesty. This point looks very simple and easy of proof, but when the time comes, it may raise difficulties that are not apparent to those who are not well posted as to the preparations of our enemies. The Board of Trade will no doubt rule—and, indeed, we think they must do so—that the person appearing on the Register as patentee, licensee, or proprietor, must be regarded as such, and not a third party who may subsequently appear.

The second point requiring proof is that the person applying intends to manufacture, or cause to be manufactured, the patented article, or to carry on, or cause to be carried on, the patented process, or intends to manufacture, or cause to be manufactured, the goods or any of them in respect of which the trade mark is granted. We cannot say what sort of proof the Board will require on this point, but it, and the third point, are evidently intended to prevent applications under the Act by persons who have no interest and are acting more or less as common informers.

The third point on which the Board will require to be satisfied is that it is in the general interests of the country or of a section of the community or of a trade, that such article should be manufactured, or such process carried on, or the registration of the trade mark avoided or suspended.

The Act and Rules made under the new Act are only to continue in force during the continuance of the present state of war in Europe and for a period of six months thereafter. This provision raises an interesting question. Are patents, designs, and trade-marks to be avoided or suspended for not longer than six months after the termination of the war, and then to be automatically restored, or is the avoidance or suspension to be irrevocable? Evidently the latter is not to be the case, for the Board of Trade have powers to revoke any avoidance or suspension at any time in their absolute discretion. The matter appears to us to be in a state of confusion, and the Government have evidently found it to be so, for the President of the Board of Trade introduced a Bill on Tuesday night into the House of Commons to amend the Patents Act they passed only a few days ago. The President in his introductory remarks explained that the new Act was not as clear as it might have been. The new Bill is not available at the moment of writing, but if it merely proposes to take further powers to deal with patents, designs, and trade-marks for the term of the war, it will be of little value. It would not be worth anyone's while to go to the expense of laying down machinery and plant for the establishment of a new manufacture if he is to be liable to be stopped six months after the expiration of the war, or if he may then be called on by the foreign patentees to pay an unknown royalty in order to continue the manufacture or the process he had established. Of course much will naturally depend upon the terms to be obtained at the end of the war. If we conquer "all along the line" our Government may make any terms it likes.

The Act and Rules have been drafted to meet circumstances that might arise ; they have not been drafted, as we have heard and seen it assumed, as an engine of destruction against the industrial property of our enemies. We may be sure that the Board of Trade will act fairly and honourably, and will vigorously discourage applications by persons who are not in a position to prove the requirements mentioned above. It is to be hoped, on the other hand, that our enemies will deal fairly and honourably in regard to British patent property in their States.

ALKALI WORKS IN 1913.

The report just issued by the Chief Inspector of Alkali, &c., works, is the fiftieth of the series. The field covered in the reports is now of vast extent, the &c. including undertakings of the most varied type, from gas works to metal-smelting industries and cement making. In fact, out of 1327 works now registered in England, Ireland, and Wales, under the Act, only 70 are, strictly speaking, alkali works, and whilst the number registered under the latter title have decreased by three in the period covered by the report, there has been an increase of 25 in the registered works otherwise classed. The number of works registered in Scotland is now 167. In all 54 more processes are now under inspection than in 1912. The increase is largely due to the greater attention now being paid to the utilisation of by-products, particularly ammonia and tar.

It appears from the reports of the district inspectors that a fairly high state of efficiency has been attained in the matter of preventing escapes of acid into the air and in checking other similar nuisances. Part of the improvement has been due to the continued replacement of hand labour by mechanical devices, although there has in cases been a certain amount of trouble with these at the outset. Proprietors are in the main anxious to meet the requirements of the inspectors, who, for their part, give all the help they can when the source of accidental and temporary nuisances is to be sought out and remedied. In not a small proportion of the cases of infraction of the Acts, the factory proprietors had started a new process in ignorance that this process should be registered, and back fees have accordingly been accepted in lieu of taking proceedings. In no case was it necessary to institute prosecutions for the undue escape of noxious gases or failure to adopt the best preventive measures.

In the alkali and wet-process copper works, the percentage of hydrochloric acid in the chimney gases has averaged 0.076 grains per cub. ft., and the inspector reports a slight but continuous increase in the ratio of the acid condensed to the acid generated, which now amounts to 98.81 per cent. Some trouble has arisen from the neglect of workmen operating salt-cake plant to cover a hot fresh-drawn charge with a little cold salt cake. In the case of copper works, it is reported that the adoption of mechanical furnaces for calcining burnt

pyrites has been considerably extended. These mechanical furnaces lead to a more uniform production of the acid gases, which much facilitates their condensation and collection.

In cement works, the two main difficulties are the production of black smoke and of dust, but a very great improvement has been effected under both heads during the past few years. This is in part attributable to the extended use of the rotary kiln and a better knowledge as to its best proportions and methods of operation. Although the number of old-type kilns is diminishing, the greater output of the horizontal rotaries more than makes good the deficit.

At smelting works further improvement has been made in preventing the escape of metallic fume, and in reducing the percentage of acid discharged in chimney gases. In this latter connection the problem is said to be difficult, but is being met in one case by putting up plant to make sulphuric acid from these gases. The legal limit to the SO_3 in gases discharged into the atmosphere is 4 grains per cub. ft. In general it is much below this figure, the average for the sulphuric acid works inspected during the year being 1.182 grains. It is noted, however, that occasionally escapes of more than the legal limit do occur temporarily, but the manufacturers make every effort to restore the normal condition of working as quickly as possible, so that prosecution has been unnecessary. The increasing manufacture of sulphate of ammonia is leading to an increased demand for the acid. An intensive system of production has accordingly been developed by which more acid is obtained per unit of chamber space. This necessitates greater care and supervision, the consequence of which has been that the increased production has actually led to a diminution of nuisance. An interesting automatic appliance is being fitted in some districts under the name of "nitrophor" to control the flow of nitric acid into the Glover tower. In this device advantage is taken of the fact that there is a rapid change of temperature in the leading chamber of the sulphuric-acid plant when the process is not working smoothly. By electrical means this change of temperature is utilised to cause an increased supply of nitric acid into the system.

In addition to acid made by the lead-chamber process, much is now manufactured by catalytic or contact processes, which are particularly advantageous, when a highly-concentrated acid is required as the final product. For concentrating weak acid silica wire is, in some cases, used for the evaporating vessels. As already mentioned, the legal limit of pollution is 4 grains of SO_3 per cub. ft. of escaping gases. In one case, however, which was investigated during the year, nuisance arose, although the proportion of SO_3 was less than $\frac{1}{2}$ grain per cub. ft. The complaint was obviated by turning the gases into a chimney, further diluting them, and discharging them at a higher level.

Amongst the processes capable of being particularly offensive is that of making chemical manures. The increasing adoption of mechanical methods of removing the hot superphosphate is, however, noted as improving much the general condition of works engaged in this manufacture, whilst abolishing a particularly trying form of hand labour. The very large quantity of manures imported is very noteworthy, in view of the fact that but 24 per cent. of our own output of sulphate of ammonia is used at home, the remainder being exported. In 1913 the imports of guano amounted to 25,548 tons, of mineral phosphates to 539,016 tons, and of nitrate of soda to 140,926 tons. On the other hand, we exported 325,000 tons of ammonium sulphate, retaining for domestic use only 97,000 tons. A new manure which is competing for the favour of the farmer is cyanamide, of which the output last year was 266,000 tons. None of it appears to be produced in this country, the manufacture being localised in places where water power is readily available. The biggest producer is the North-Western Cyanamide Company.

An increasing proportion of the sulphate of ammonia produced is derived from coke-ovens, which, out of a total of 432,618 tons, contributed 133,816 tons in 1913, the corresponding output of gas works being 182,180. Shale distilleries stand next with an output of 63,061 tons. The so-called direct process is finding increased favour. In this the hot-oven gases are passed direct into the sulphuric acid. A semi-direct process is also widely adopted, in which the gases are cooled to extract the tar, and then heated with sulphuric acid.

In the old indirect process the ammoniacal liquors collected had to be distilled, a highly noxious spent liquor being one of the by-products. By the direct process, no such liquors are formed, and in the semi-direct process the amount produced is halved. It is worthy of note that producers of the Mond type now furnish 11 3 per cent. of the total make of sulphate of ammonia. At many small gas works very indifferent methods are employed to recover this valuable by-product. The amount retrieved should, the report states, amount to 25 lb. to 30 lb. per ton of coal carbonised. Owing to the use of inefficient washers, badly-constructed stills, and the like, serious losses of ammonia arise, however, at many of these small works.

A considerable proportion of the report is taken up with a discussion of the action of sulphuretted hydrogen on hydrated oxide of iron. The oxide as used in purifiers is, of course, not pure, and the inspector estimates its "efficiency" by determining the maximum volume of H_2S which the oxide is capable of absorbing, as compared with that absorbed by an equal weight of pure ferric hydrate. The efficiency thus found is always less than unity, generally considerably so, pointing to the presence in the commercial oxide of inactive components of iron. It is pointed out that if the ferric hydrate is ignited, it cannot be re-hydrated, and is very sluggish in its action on sulphuretted hydrogen. It will, however, absorb the latter, and become completely sulphided if the time of exposure be sufficiently prolonged. The sulphide thus formed is, however, very dense and hard, and can only be re-oxidised with great difficulty.

The report states that the tin-plate trade was somewhat slack during 1913. The methods used to prevent the escape of muriatic acid are said to be satisfactory in general, but trouble has arisen in the treatment of the "scruff" periodically removed from the tinning-pots. This contains chloride of zinc, and, when heated, as used to be the practice, in small reverberatory furnaces with low chimneys, there was an evolution of dense white fumes consisting of the oxides and chlorides of tin and zinc with much free hydrochloric acid. This was not only destructive to vegetation near the works but the fumes extended to a considerable distance as a dense white fog. The nuisance was abated by connecting the flue to high boiler chimneys. In this way not only were the noxious gases diluted, but there was a deposit of fume in the flues.

This, being rich in oxide of tin, was valuable commercially. Too often, however, the flues are insufficiently large, so that there is a considerable loss of tin. One firm has adopted the plan of washing the whole of the scruff for almost a week in boiling water, which dissolves out the chlorides. The washed scruff thus freed can be furnaced at a low temperature with good yields and practically no escape of metallic compounds up the chimney.

One curious case of an excess of acid in the discharge from alkali works is noted in the report. The acid content was found frequently to verge on the legal limit, and at times to exceed it. A careful examination of the arches and pot settings showed no leakage, and heavily grouting the arches failed to remedy the trouble. This was finally traced to the use of a coal containing an exceptional amount of chlorine, so that the fuel gases themselves carried a considerable amount of HCl into the chimney.

Tar works are rapidly increasing in number, owing to the demand for road-binding purposes. To fit the tar for this end the removal of the "water" is necessary. This water is properly a gas liquor, and much nuisance may arise unless proper steps are taken to condense the noxious vapours given off. It appears, however, that some surveyors are unwilling to pay the extra price demanded for "boiled" tar, preferring to do the boiling themselves, although, as both are often under the control of the same local authority, the cost is merely a matter of account. When the surveyor does his own boiling in the open street the vapours given off are not condensed, and a nuisance is created. It is, however, impossible under the Act to register and inspect these itinerant tar-boilers.

Zinc works have been inspected and reported on since 1892. The trouble here arises mainly from zinc fume, which is liable to be produced unless the condensation of the zinc vapour is effected within certain somewhat narrow limits of temperature, and without too great a dilution with other gases. This zinc fume is very difficult to collect, and if discharged into the air may occasion widespread nuisance. The trouble is aggravated, the inspector states, when zinc residues containing chloride are under treatment, and in such cases improvement has been slow. The present policy is to prevent the formation of fume rather than its subsequent escape into the atmosphere. With the co-operation of owners, a number of experiments directed to this end have been carried out at various works; but though marked improvement has been effected in cases, it has been found that no single system is of general applicability.

COLONIAL AND FOREIGN MARKETS.

At the Royal Agricultural Society's Show at Shrewsbury we came across this claim:—"More '———' engines sold to British farmers last year than any other three manufacturers combined." While much attention had evidently not been devoted to the wording of this notice, it was clear that the market had been studied, even if we allow that the statement may have been somewhat exaggerated. The engines in question were United States products, and though for the moment our minds are not centred particularly on trade competition with that country, we may as well recognise what, in some cases at least, leads to success. No one could well visit the machinery section at the Shrewsbury Show without being struck with the extraordinary number of the firms now making small petrol or paraffin engines suitable for all sorts of farm work. Equally noticeable, too, were the workmanship, design, and finish of those staged by English manufacturers, a very favourable impression of their quality being general. Even discounting something for special "show" finish, they were for the most part superior to the foreign-made engines, and it was very gratifying to hear at one stall that one model was "going like hot cakes," or that of another "five hundred had been sold lately in the New Zealand market," and so on. The claim above referred to, however, reveals another side to the picture. Our trade may be good, but it does not follow that it is all that it might be for an exporting country of our engineering standing.

Why should one foreign firm sell so many small-power engines to British farmers? The answer in the particular case under notice is fairly plain. These engines are unattractive to the engineer, but they are not sold to engineers. They are easily run, and are extremely cheap—two qualities which, above all others, commend them to the farmer, who is an amateur as regards machinery. It is almost certain that a large number of this particular make contributed to the 21,191 oil and petrol-engines imported into Canada in ten recent months from the United States. In the same period only 174 British engines were imported. There must be reasons for this disparity. This American trade in Canada has increased by leaps and bounds, but little has been effected by Great Britain. The British maker has a 12½ per cent. tariff reduction in his favour, and yet his share of this young and vigorous business is inconsiderable. He is, it is true, at some disadvantage in the matter of freight and the cost of stouter packing, but these can scarcely be decisive factors; for, since the tariff revision of the United States, we understand that Germany has been able to obtain a footing in the internal-combustion engine business in that country, despite a 20 per cent. tariff.

It is probable that our limited success is to be explained by the fact that we have not suited our goods and methods of selling to the market. Canada partakes in some respects of what we here are almost inclined to regard as the reckless progressiveness of the United States. In both countries long life is sacrificed to cheapness in order that the benefit of present use may be had though funds may be low, and also that advantage may be taken later of an improved model or of some new method. The bulk of the small English engines at the Agricultural Show were not on these lines at all. They were substantial little things, well finished, and probably, for their type, economical in fuel. We do not wish to advocate rough work and poor design, but it must be recognised that one of the last persons anywhere in the world to lay out capital is the farmer. Cheapness in first cost looms very large in his somewhat limited range of vision. In this more often than not he is perfectly right. Much of the machinery in which he invests his capital is in actual use on

very few days in the year. By far the greater part of the time it is standing idle, and though not "eating its head off," is certainly not improving, while interest on first cost is all the while adding up. The knowledge of this influences his other purchases. Though a small engine may be put to a variety of uses, for a considerable portion of its time it will be idle. First cost then becomes increasingly important, and fuel costs less so, since, work or no work, standing charges on capital have to be met. For the amount of work done, a small economy of fuel is not important, if gained through any refinement of design which increases cost of construction. That this fact is being recognised here we gather from the number of makers turning their attention to a simple type of two-cycle engine. Little engines of this class have practically nothing to go wrong; they are reversible, and their simple construction, attractive in itself, is favourable to an attractive price. It is not the "sound job" in the eyes of the engineer that is the primary necessity. The judge in the case does not keep his eye on specification clauses relating to bronze bearings, accurate workmanship, refinement of governing, &c. He probably knows little or nothing of such points.

It is necessary, moreover, not only to turn out a suitable model, even, perhaps, at the expense of a little British dignity, at a price which will ensure a market. It is just as necessary to let that price be known. When so many foreign firms do successful business in small plant, in spite of having published their prices, there can be no object in always listing things "prices on application," unless it be to conceal the fact that ours do not compare favourably with those of our competitors. When a possible purchaser has become interested, either through a personal agent or through trade literature, he should be given every incentive to decide there and then. It is no use firing his imagination with glowing descriptions of the usefulness of some appliance if he is to be left to cool down pending the arrival of letters by mail from a distance. If the prices of one maker are available, but those of another can only be had on application, the order is given for the machine whose price is approximately known, or the matter drops. This is often the case abroad.

There are plenty of countries where the market needs to be studied just as much as that in Canada. Australia has many of the characteristics of the Canadian market, but in South Africa a rather more conservative spirit seems, from some reports, to reign. Perhaps the nearer proximity and relationship to the Old World has some influence. Whatever the cause, in internal-combustion engines for farm work something a little better than the American product is called for, though no fault is found with the American design—only with the workmanship and material. Again, countries like Egypt, Japan, and China, only lately roused from the lethargy of centuries, are inclined to flatter themselves that they are rapidly becoming "Europeanised" when they purchase even the most shoddy examples of western civilisation. It is depressing to see the pride with which these people often contemplate some purchase of most execrable workmanship, if it comes to them as the product of a Western nation. In this they are not necessarily to blame. It is with them a matter of low cost or not at all. The fellah of Egypt, or the peasant or artisan of China and Japan, is a person of very small means. If these can be met by suitable prices, such buyers offer at once a large field. If not, the native will pursue the ways of his forefathers. In these countries Germany has latterly been rapidly increasing her hardware trade. She has done this largely by concentrating her attention first on price, giving the best quality possible under the circumstances. Her business in China has been done by responsible Chinese-speaking representatives, instead of by agents acting through a compradore. In other markets she has been equally alive to the advantages of efficient and aggressive representation coupled with as great responsibility as possible, consistent with sound policy.

We have dealt above chiefly with the question of internal-combustion engines for farm and other uses. Germany's export trade in internal-combustion engines of all classes amounted, in 1912, to 1,472,000*l*. Of prime movers, in combination with, or without, other plant, she exported 2,826,000*l*. worth in that year. It is not only in this trade, however, that she has made great headway of late years. Her exports of industrial tools and agricultural implements in 1912 amounted to 4,184,000*l*., showing in nearly every market an appreciable advance. In some she seemed to be losing a little ground, as, for instance, in ploughs, in Russia, where the home product is coming into favour. She has, however, been able to accommodate her manufactures successfully to a large number of countries, and by means of long credit, where necessary, has built up a considerable business. In most industrial implements and tools Russia and France have proved her largest purchasers, Russia taking, for instance, 519,650*l*. worth in 1912, and France 269,050*l*. worth. In internal-combustion engines likewise these two countries were good buyers. The former bought engines to the amount of 452,000*l*., and the latter to the sum of 117,000*l*. We may quote the following figures of exports from Germany to Russia to show the extent of recent trade between these countries:—Screw-spanners, wrenches, &c., 44,000*l*.; blocks and tackle, 44,500*l*.; screw-vices, anvils, &c., 10,150*l*.; saw-blades, 102,000*l*.; cutting tools, shears, &c., 168,000*l*., and so on. Of spades, hoes, &c., Germany exported to Russia to the amount of 22,900*l*.; of cultivators, rakes, &c., 88,000*l*.; and of ploughs, 337,000*l*. While Germany exported to Russia only a small quantity of scythes, &c., Austria-Hungary sent there implements of this class to the amount of 141,000*l*. The exports of Germany in these classes are considerable to other countries, and two recent memoranda, to be had free from the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, E.C., will be found to give many interesting figures, bearing on the engineering hardware trades.

In view of the reputation British engineering products have always enjoyed in Russia, it should not be difficult to regain some of the business there in the near future. Reports from many sources suggest that, although we have been for many years in the habit of making innumerable things purely for foreign markets, we have latterly not shown the enterprise exhibited by others in meeting the changing needs of these, or the demands in new fields. As the Board of Trade points out, it is not a question of selling something we already make, but in most cases of making something answering to particular demands. Some markets are characterised by a progressiveness which is always on the look out for handy novelties; in others a conservative spirit exists, and what is wanted is the native implement in improved material, or with some small modification. Whatever the future may bring with it, it is not to be expected that Germany will not make every effort to regain those of her foreign markets which are now jeopardised. Neither must it be imagined that we are always the best able to step into the gap. Provided expansion proves feasible under the present trying circumstances, there are certainly markets near by which we should be in a position to command, while in others further afield we shall continue in friendly rivalry with such countries as the United States. As the latter are developing internally so rapidly, in proportion more of their energy must be expended in that direction than is the case with us. By adapting ourselves to the demand, and with enterprising selling, we ought to secure a very material share of the business to be done to fill the gap in the world's trade. The fact must not be lost sight of, however, that present conditions will seriously curtail the purchasing power of the world for some while ahead. If the immediate response to canvassing new markets is not of the most promising, manufacturers should not be disappointed, but should make sure that they are taking such steps now as will lay the field freely open to them as soon as the revival comes.

HARBOUR CONSTRUCTION AT FRANKFORT-ON-MAIN.

Although Frankfort only holds the sixth place amongst Germany's fifty-three Rhine harbours (amongst which Frankfort is generally reckoned), this city decided upon harbour construction on a very large scale, the aggregate calculated cost of the new east harbour, when completed, amounting to 57,420,000 marks (2,871,000*l*.), of which 20,016,000 marks (1,000,800*l*.) were estimated for the acquirement of the necessary land, and 37,404,000 marks (1,870,200*l*.) for the actual construction. The former figure, however, has been considerably exceeded, the land purchases for the east harbour at the end of the year 1911 having entailed an expenditure of 26,196,505 marks (1,309,800*l*.) for an area of 3,975,600 sq. m. (4,770,000 square yards).

Frankfort, though counted amongst the Rhine harbours, as is also Offenbach, lies, as its name implies, on the Main, which river drains an area of 27,600 sq. km. (10,650 square miles). The canalisation of this latter river between Frankfort and the Rhine presented some difficulties, there being an insufficient depth of water and a considerable fall on this section of the river. At one time it was contemplated to construct an independent canal between Frankfort and Mayence, but this plan was abandoned, and the Prussian State undertook the work of making the Main navigable for large vessels. This was accomplished by the construction of six weirs, which deal with an aggregate fall of 10·4 metres over a distance of 33 km. (34 ft. 2 in. in 20½ miles). The regulation, which entailed an expenditure of some 5,500,000 marks (275,000*l*.), allows of the passage of vessels of 2½ metres (8 ft. 3 in.) draught and 1000 tons capacity, and a further weir has been constructed above Frankfort, so as to make Offenbach also accessible for Rhine craft.

When the weirs which regulate the flow of the River Main are rendered inoperative by ice or repairs, this waterway is no longer navigable for Rhine craft; during these interruptions of the traffic a safe harbour must be provided for the vessels in question, allowing them to enter even at the lowest water level. When the Frankfort west harbour (Fig. 1) was built, the city undertook that it should be made to comply with these requirements, and although no such undertaking exists for the new, east harbour (Fig. 2), large portions of it will offer the same advantages to shipping.

As the Rhine traffic represents some 90 per cent. of Frankfort's shipping trade, it was not only necessary to keep the new harbour below the Offenbach weir at the same level as the west harbour, in order not to burden the traffic with the passing of an additional lock, but it was also advisable to make the lower, or west, harbour cover as large an area as possible and to direct the commercial and transit traffic to this portion. The arrangement compels vessels coming from the Upper Main to pass the Offenbach weir so as to get into the lower harbour, but this traffic is of no great importance comparatively, and need hardly be reckoned with as far as the commercial dock basin is concerned—*i.e.*, the northern basin of the lower, or west, harbour. Should this traffic, contrary to what is expected, materially increase in the future, accommodation in the way of quays and warehouses will be provided in the upper, or east, harbour (Fig. 2), at the present time in course of construction. As far as the industrial dock basins are concerned—that is, the southern basin of the west harbour and the two west-to-end basins of the east harbour—the question of height of water level was immaterial.

The basin below the entrance to the lower, or west, harbour (Fig. 2) is simply a portion of the river which has been widened out and deepened; it is about 500 metres long and 55 metres (180 ft.) broad, exclusive of the fairway, so that a water area of some 2.8 hectares (7 acres) is available. The entrances to both the upper and the lower basins of the west harbour are such that ice-drift and silting are not to be feared; the direction tends down stream, the angle with the direction of the stream being 45 deg. as far as the entrance to the lower basin is concerned, and 60 deg. for the upper one, where the water-borne traffic is smaller. It is not customary to make the width of the entrance less than four ships' breadth; the entrance to the upper basin is therefore 50 metres wide, that of the lower 60 m. (196 ft.), so as to gain quay accommodation on the one side of the coal quay. The bridge across the lower entrance has a single span of 91 m. (298 ft.), so as to avoid piers in the waterway. The lower portion of the bridge is 8.20 m. (26 ft. 11 in.) above highest navigable water level.

The entrance to the lower harbour first leads into an outer basin of triangular shape, from which branch off the commercial dock basin and the lower industrial dock basin. This outer triangular basin not only serves as a waiting place, and the means of establishing connection between the two dock basins just referred to, but it is also used for turning vessels; its dimensions are such that there can be inscribed in it a circle of 150 metres diameter—that is, 65 metres more than the length of the largest Rhine vessels, which is 85 m. (279 ft.).

The commercial dock basin, the more northerly of the two lower, or west, ones, is straight, and

about 1230 m. (4050 ft.) in length ; the breadth, on account of the high value of the land, is only 75 m. (246 ft.). This breadth allows of two vessels along each quay, and room being left in the middle for two vessels passing each other, each with half a ship's breadth at either side, which makes 7½ ships' breadth, all told, of 10 metres.

The installation for timber traffic and storage consists of an open landing-stage and a closed-in timber-pond, both located south of the inner, or east, harbour ; the former is at the entrance of the timber-pond, and outside the floating traffic. In other words, the timber-pond forms a continuation of the landing-stage.

Four dock basins are intended for industrial purposes—viz., the industrial basin in the lower, or west, harbour, the basin which forms the entrance to the east, or upper, harbour, and the two parallel basins in the upper harbour ; the first of these has a length of 1290 m. (4250 ft.). The cross basin in the upper harbour is 740 m. (2427 ft.) long and connects with the inlet ; this basin leads into the two straight basins, respectively 620 m. and 745 m. (2034 ft. and 2444 ft.) long. The breadth of the industrial harbours does not require to be so large, and is fixed at 40 m. and 50 m. (131 ft. and 164 ft.).

The water areas available for shipping are as given in the adjoining column.

	Sq. Metres.
River	46,250
West, or lower, harbour—	
Outer basin and commercial basin ...	124,280
Lower industrial basin	65,730
East, or upper, harbour—	
Cross basin	61,400
Parallel basins	55,350
Landing-stage	27,250
Timber-pond	79,500
	459,760 =
	542,000 square yards.

The harbour as enlarged, Fig. 2, will provide an aggregate wharf accommodation of 14,133 m. (8.7 miles) in length. Including 5 km. (3.1 miles) of old shore accommodation, Frankfort will thus have about 20 km. (12.5 miles) of wharf accommodation available. For comparison's sake, the aggregate wharf accommodation is given for the following towns: —

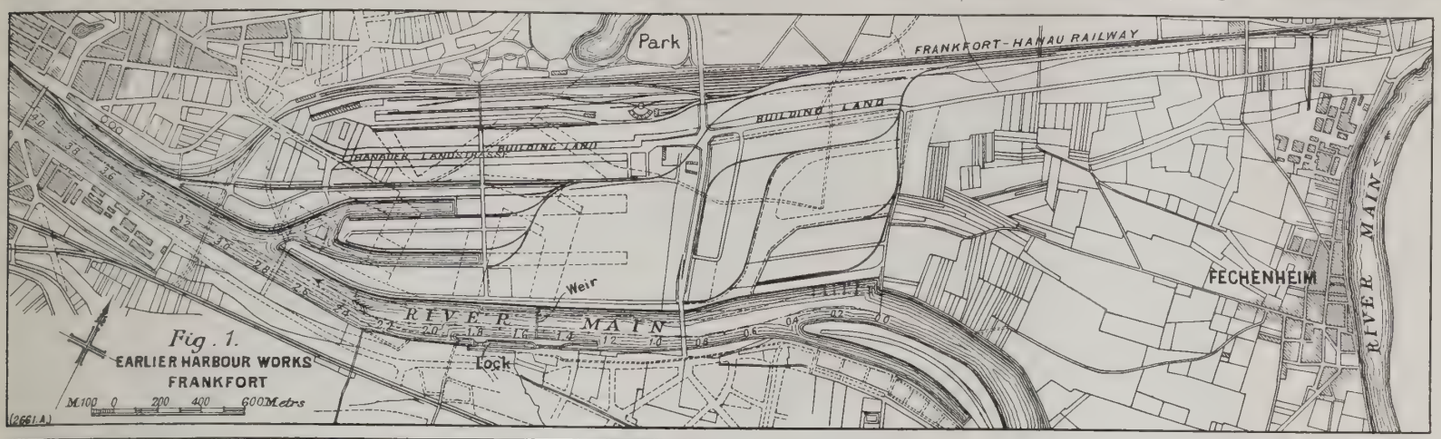


Fig. 1. EARLIER HARBOUR WORKS FRANKFORT

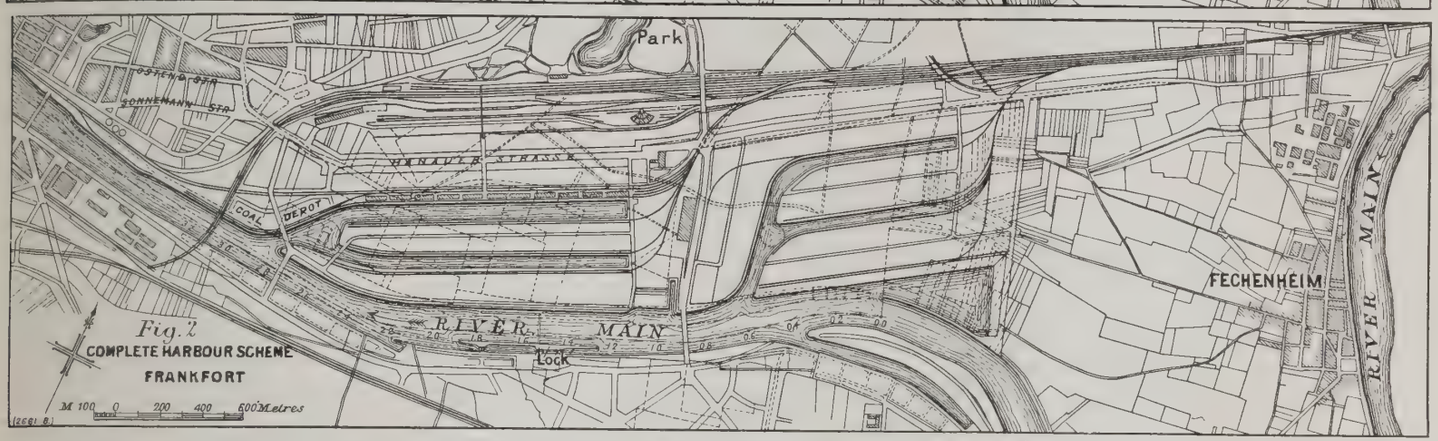
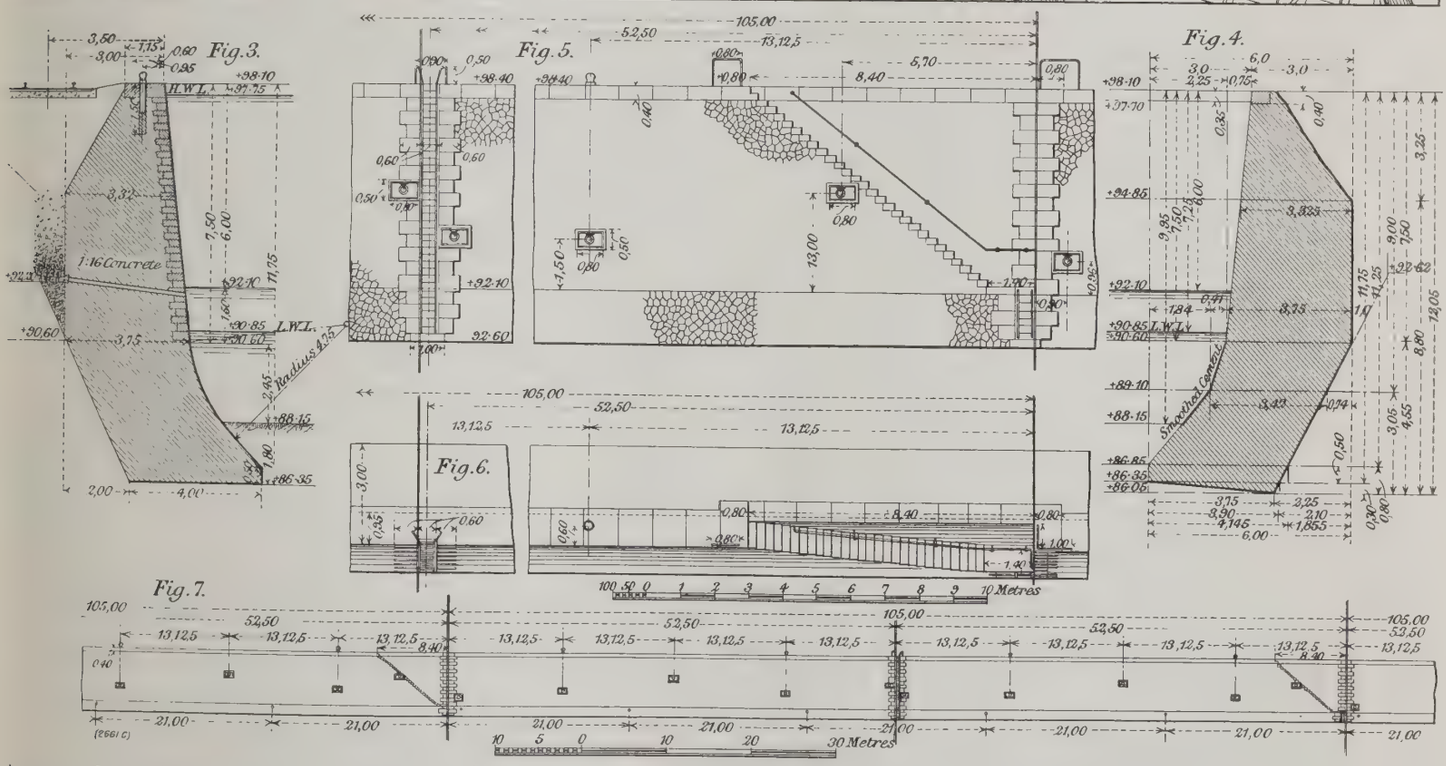


Fig. 2. COMPLETE HARBOUR SCHEME FRANKFORT



	Km.	(Miles.)
Düsseldorf	10.0	(6.25)
Maience	11.5	(7.15)
Mannheim	33.0	(21.00)
Rheinanhafen	12.1	(7.45)
Ludwigshafen	12.3	(7.45)
Strasburg	13.1	(8.10)

The Main is regulated so as to be navigable for vessels of 2.30 m. (7 ft. 7 in.) draught, which, with a margin of 0.20 m. (8 in.), makes a depth of 2.50 m. (8 ft. 3 in.) in the channel. This depth also suffices in the river harbour, whilst in the inner dock basins it has been increased to 2.70 m. (8 ft. 10 in.). All quay and other structural foundations, however, have been laid so deep that they will allow of the depth of the harbour being increased to 3 m. (9 ft. 10 in.) should this be deemed expedient. The renewal of the water in the east harbour basins is effected by ground springs, the bottom being sand; the inflow of fresh water is further increased by the position of the basins parallel with the river, and by the location of the entrance. In addition, the weir at Offenbach causes a pressure, which drives the ground-water up into the lower, or west, harbour. The subterranean inflow of water does not suffice to protect the water in the harbour from impurities and the deposit of mud, so that dredging will be necessary every second or third year. In the lower harbour the necessary flushing process can be brought about by flushing canals from the Offenbach weir, above which the water-level generally is some 2.10 m. (6 ft. 11 in.) higher than in the lower harbour.

The quay walls at the entrances to the dock-basins and at the sides of the latter are nearly vertical, two profiles being used, the depth of water being lower in the river harbour than in the inner basins. The construction of the walls is such that the vessels can get as near as possible to the shore and the cranes. The general construction is shown in Figs. 3 to 7; the foundations and the entire walls are made of concrete, the wall on the outer side being coated with basalt, and the crown finished with granite blocks. There are steps at varying distances, and ladders between them, so that, at least, a set of steps or a ladder corresponds with each ship's length. Both steps and ladders are in the quay wall thickness (Figs. 5 to 7).

The condition of the bottom was ascertained through thirty-nine borings and test-shafts, and was found to be favourable; the excavation, moreover, afforded a sufficiency of clean, sharp sand for concrete, &c. Below the sand is a layer of marl, the thickness of which the borings did not wholly penetrate. The bottom of the harbour at all parts cuts into this layer.

Ample quay accommodation has been provided for. The commercial and transit quay along the north side of the commercial dock basin is 1230 m. (4035 ft.) long; first comes a quay roadway of 15.15 m. (50 ft.) wide, then a space 31.75 m. (103 ft.) wide, for sheds, &c., which adjoins another roadway of 13.10 m. (43 ft.) in width, making a total of 60 m. (196 ft.). Along the shore run three lines of rails at a distance of 5 m. (16 ft.) between centres. The southern set of rails is intended for direct transit to and from ship, the northern for the traffic with the warehouses and sheds. This arrangement not only simplifies and concentrates the railway traffic, but it leaves the back of the buildings free for wagon and other traffic landwards. The roadway is paved, and the cranes can deal with all kinds of traffic. The space allotted to warehouses allows of buildings 28 m. (92 ft) in depth, and there is room for eleven such warehouses, each 90 m. (295 ft.) long, with an intermediate passage of 15 m. (about 50 ft.). These warehouses, located, as shown in Fig. 2, to the north of the commercial dock basin, in the outer, or west harbour, are being built gradually according to requirement.

The coal quay, west of the one just referred to, has a length of 850 m. (2788 ft.) along the fore harbour, past the entrance and along the river bank; it is arranged in the same way as the former, with some minor modifications as regards the tracks. The sites for storing coal are 80 m. (262 ft.) in width, and they are covered with a 30-cm. (11 in.) layer of rammed clay. Ample accommodation is also provided in all other portions of the harbour.

For industrial purposes two sites are reserved adjoining both the lower and the upper, or west, harbour, and measuring 25 and 39 hectares (61 and 96 acres), the latter being especially intended to serve as a purely industrial site. All told there are seven different strips of land, which are all dealt with in the same way as regards access by water, railway, and roadway. The roadways are parallel, and slope slightly towards the shore. The sites are either for sale or hire; up to April 1, 1912, there were sold 347,767 sq. m. (417,320 square yards), at an aggregate price of 9,156,760 marks (457,800*l.*); up to the same date there were let, in addition, 244,656 sq. m. (293,580 square yards), representing a rental of 308,870 marks (15,440*l.*), which latter sum at 4 per cent. represents a capital of 7,720,750 marks (386,000*l.*). Considerable additional areas, which do not directly adjoin the water, but are conveniently located as regards the harbour, are also reserved for industrial purposes.

The aggregate area set aside for the new upper, or east, harbour amounts to 3,476,000 square metres, or about 350 hectares (865 acres). Of this total, 68,600 sq. m. (82,300 square yards) are in existing roadways and railways, included in the harbour, and 228,600 sq. m. (274,320 square yards) are existing shore and water areas, leaving an actual balance of 3,178,800 sq. m. (3,814,000 square yards). Of this total, water areas and quay walls, &c., account for 14.4 per cent.; streets and railways for 29.3 per cent., the area for "useful purposes" thus amounting to 56.3 per cent. of the total, which far exceeds that of Mannheim, Strasburg, Düsseldorf, Cologne, &c.

The railway communications, as well as the connection of the new harbour with the town, are on the same comprehensive basis as the rest, and some very important structures also in the way of bridge-building are already more or less advanced. The bridges and viaducts come under two heads—the bridging of the streets and railways and the bridges over the Main and the harbour basins. The former group includes the carrying of the new East Station, Sachsenhausen Railway, and the track for the local connecting line over the Hanau road. This bridge is an iron construction 30 m. (98 ft.) in width.

The second and more important group of bridges comprises two large structures. The main bridge at Offenbach, to establish a direct road connection between Frankfort and Offenbach, will be built at the joint expense of these two communities. This bridge has five spans—three over the river and one on each side; the latter are 28½ m. (93 ft.), those across the stream 51 m., 66 m., and 51 m. (167 ft., 216 ft., and 167 ft.) in the clear. This construction permits of the adoption of massive arches of concrete, with stone facing, which from every point of view is considered the most desirable system. The concrete foundations of the bridge were designed 5 m. (16 ft.) longer than necessary, so as to allow of subsequent widening. The second main bridge was designed to form, with the bridging of the entrance to the lower harbour and the coal-storage sites, a continuous bridge line, which, from a constructive point of view, can be divided into four sections. The main bridge proper comprises three spans, a central one 89 m. (292 ft.) in the clear, flanked on either side with one of 56½ m. (185 ft.). The bridge over the harbour entrance has to span a similar width, whereas the bridging of the coal-storage site will take the shape of a viaduct on solid arches.

The plan for the construction of the new Frankfort harbour stipulated for the work being undertaken in two different sections. The first section (Fig. 1) has recently been completed and opened for traffic. The second section is gradually being proceeded with.

Although the plant for loading and discharging vessels and otherwise handling goods cannot in importance vie with the installations at the Duisberg-Ruhrort Harbour, which boasts the largest internal harbour traffic in the world, the Frankfort harbour authorities have expressed their determination to make their harbour as efficient and complete as possible. The traffic of the Frankfort Harbour in 1911 amounted to an aggregate of 1,990,248 tons, against 1,840,704 tons in 1910.

NOTES.

Important Salvage Work in Sweden.

Some five or six months ago the Swedish ironclad Tapperheten ran aground at Norbadan, in the Stockholm Skärgard. The first attempt to get her off failed, and fears were at one time entertained that it would be almost impossible to save the ship. Early in July the Naval Department, however, was able to announce that the Tapperheten had floated at 1.35 P.M., and was being towed to Sandhamn. During the last few days prior to this great activity had prevailed on board and around the Tapperheten, in connection with bringing into position and fastening the various pontoons, getting ready for the pumping, &c. The sea was somewhat turbulent, so the salvage steamer Poseidon was placed so as to serve as a breakwater. The pumping was carried on both fore and aft, so that the ship could rise from the bottom on an even keel, after which she was to be towed aft, so that the pontoons could pass through the channels which had been blasted in the rocks. This part of the work was by no means a small matter. Prior to the final pumping the tightening of the ship's bottom had been effected as well as possible. On the day the pumping was to have commenced, the sea was broken, with a strong wind from the north-east. During the early part of the afternoon the pumping was commenced, first slowly, emptying the upper and smaller compartments. By degrees more pumps and hose were brought into action, and towards evening the two salvage steamers Helios and Herakles had altogether 5400 ft. of 5 in. hose in use. During the early night the Tapperheten rose 3 in., and by 8.30 in the following morning the stern had risen nearly 4 ft., and a couple of hours later she was just afloat, so much as to begin to move. But after moving 4 ft. the vessel stopped, a chain from one of the pontoons having caught in the rugged bottom, in addition to which one of the weak spots in the bottom had got dangerously near a rock. However, additional pumping and very careful towing overcame the difficulty. On her way to Sandhamn the Tapperheten only took in 600 tons of water in the hour, which the salvage steamers' pumps easily could dispose of. The ship remained some time at Sandhamn so as to be further repaired before being towed to Stockholm.

Colour-Blindness.

During recent years the subject of colour-blindness has received much attention, especially in relation to men working on railways and on ships. Engine-drivers and ships' officers are now subjected to examinations as regards their sight, both in respect to its strength and also to the power of discriminating between different coloured lights. Many tests have been devised by means of wools and coloured counters by which the sight of such people can be tested. It has now been found that colour-blindness is always inherited, and that a man whose ancestry is free from it never exhibits it. Curiously, as was explained by Professor William Bateson, in his presidential address, delivered before the British Association at Sydney on the 21st inst., colour-blindness is always inherited through the mother, and never through the father. There appears to be no instance in which a colour-blind father has transmitted his defect to his children except in connection with a mother, who was a transmitter. It does not follow, however, that the mother herself need be colour-blind, but she must have inherited the power of transmitting this defect from the ancestor. Some, probably all, the daughters of a colour-blind father inherit the power of transmitting the defect, although they themselves may not be colour-blind, and, as a rule, they transmit it to about one-half of their offspring of both sexes. The sons who inherit colour-blindness are, of course, colour-blind, but they do not themselves transmit it; it is the inheriting daughters who become the transmitters to the next generation. These facts ought to be of considerable assistance in the future to those who are responsible for investigating the eyesight of engine drivers and officers of ships, provided that they are able to carry their investigations back through at least a couple of generations in the family. If it can be shown that two generations are free from colour-blindness there is at least very good reason for supposing that the third generation will also be free.

Trade in Railway Material.

In pursuance of their scheme for assisting British manufacturers to capture new markets under the prevailing favourable conditions, the Commercial Intelligence Branch of the Board of Trade have issued a return giving particulars of Germany's export trade in railway wheels, tyres and axles. In 1912 the total value of these exports to all destinations was 1,377,000*l.*, the two most important customers being Italy and Australia, which took 275,000*l.* and 199,000*l.* worth respectively. Next on the list are Canada with 90,000*l.*, Japan with

88,000*l.*, Brazil with 63,000*l.*, China with 62,000*l.*, and British India with 60,000*l.* worth. The United Kingdom and France each spent 40,000*l.* with Germany for the class of goods we are referring to, while Spain's purchases amounted to only 1000*l.* less. To the Dutch East Indies Germany exported these manufactures to the value of 32,000*l.*, and for Denmark the figure was 28,000*l.*, while Argentina, Chili, Norway, Egypt, Turkey and Portugal, each took quantities ranging from 10,000*l.* to 16,000*l.* in value. The above-mentioned countries, in the aggregate, account for 1,095,000*l.* worth of goods, which is 80 per cent. of Germany's total exports of this class of railway material. In 1913 Great Britain exported similar goods valued at 1,210,000*l.* to the above-mentioned markets, so that our trade for that year exceeded that of Germany for the preceding year by about 13 per cent. Nevertheless, the figures show that our exports might be very considerably increased. Great Britain and her colonies and dependencies alone took 402,000*l.* worth of German productions, which is just over 29 per cent. of the total in 1913. There is but little doubt that a determined effort on the part of our manufacturers would secure much of this trade in future. Up to the present Germany has taken the bulk of the trade in the markets above specified, excepting British India and Argentina, so that it should also be possible greatly to extend our exports to Canada, Australia, Scandinavia, Southern Europe (especially Italy and France), the Dutch East Indies, China, Japan, and Brazil. These are the markets to which British manufacturers should especially direct their energies. Some very useful particulars as to the special requirements of some of these markets, and some data of tenders recently obtained from, and of contracts let to, German firms, are given in the pamphlet, and further information in the possession of the Board of Trade can be obtained by British firms. A careful study of these particulars, followed by an energetic and judicious scheme of propagandism, cannot fail greatly to benefit the British steel industry.

INDUSTRIAL NOTES.

It is being realised that there may be much slack time in several branches of industry. The Welsh slate quarries, for example, are affected by the war, and a notice has been posted up in the Penrhyn Quarry stating that:—"Owing to the state of war now prevailing throughout Europe the demand for slate will certainly diminish, and perhaps cease for a time. Therefore, after the termination of the present quarry month, the length of time worked week by week will be governed largely by the outlook, though every endeavour will be made to provide as much employment as possible. Until further notice the usual monthly lettings and the terms of employment of men cannot be guaranteed for any specific time."

At the Dinorwic Quarries, Llanberis, also, the property of Sir Charles Assheton Smith, Bart., the following notice is posted: "Owing to the stagnation in the slate trade, brought about by the European war, the letting of the 'bargains' at the Dinorwic Quarry, commencing on the 17th inst., will be for two weeks only, and not for four weeks as previously; at the expiration of the two weeks referred to—viz., on September 4, short time may have to be resorted to, but should the trade of the country improve by that date the usual full time will be continued."

We are informed that about 3000 men are affected at the Dinorwic Quarry, and almost as many at the Penrhyn Quarry.

The effect of the war upon the Northumberland miners, says the *Newcastle Daily Chronicle*, is illustrated by the pays that are to be drawn at several of the northern collieries this week-end. Dudley, Burradon, Hazlerigg, and Seaton Delaval which, amongst others, are paid weekly, have only one shift to draw, while Seaton Burn has none. West Cramlington, Shankhouse, Hartford, Cramlington Ann Pit, and the Cramlington Lamb Pit have two shifts each to draw for their fortnight's pay, while Seghill Colliery has nine shifts to draw. Seaton Burn has only worked two shifts since the war started, and was idle all last week and this week.

But means will gradually be forthcoming for counteracting slack trade in different ways, and, as an instance, we may state that the Development Commissioners are circularising the county councils asking whether, with a view to developing cultivation, and at the same time providing immediate employment, the councils would be prepared to consider at once, in consultation with the agricultural college for the province, whether arrangements can be made to acquire on reasonable terms and reclaim for cultivation any areas of land which are at present waste and uncultivated. They suggest that in consultation with the colleges the councils should formulate schemes for the acquisition and reclamation of any such land which may be available on reasonable terms.

The Development Commissioners are prepared in principle, and within the limits of the funds available, to recommend advances either to county councils or to agricultural colleges for the execution of approved schemes, the proceeds to be paid to the Development Fund. In the case of suitable land which the owner may be willing to put temporarily at the disposal of the council or college, the Commissioners suggest that when the improvement has been completed the owner should pay the value of the improvement as fixed by agreement, or by arbitration if necessary, such payment to be made either in a lump sum or by instalments over a series of years.

The selection of projects for final approval and execution must be governed largely by subsequent information as to the amount of unemployment and the districts where it is likely to be most severe.

The last quarterly report of the Ship Constructors' and Shipwrights' Association has a patriotic address to the members, concluding: "The disturbing influences due to the war will undoubtedly cause unemployment, will dislocate our food supply, and seriously cripple the whole structure of industry. . As trade unionists, and part of the great industrial movement, we must be absolutely united together, to assist our less fortunate brothers to look after the women and children."

The Dock Labour Joint Committee have given notice that they are prepared to grant temporary registration tallies for carters, warehousemen, checkers, and members of similar trades, who have been thrown out of work in Liverpool. These tallies will enable the holders to seek work as dock labourers (on ship and quay) and as coal-heavers until December 31, 1914. The tallies can be obtained by personal application at the dock clearing-houses. The men are advised to register in the area where they are most likely to obtain employment, and applicants should obtain a note of recommendation from their union or an employer.

We are informed that a conference of trade-union leaders representing all industries was held on Monday last at Unity House, under the chairmanship of Mr. Arthur Henderson, M.P., with a view to consider the position of trade unions in consequence of the war. It was decided that an immediate effort should be made to end all existing trade disputes and to prevent any points of difficulty arising during the war; the Government, also, was requested to use its influence with employers so that whenever possible there might be brought about a complete cessation of overtime. The Government was further requested to take into consideration the serious position in which trade unions must inevitably be placed if compelled to use their funds to make provision for unemployment during the war, and to take steps by the provision of an appropriate grant to subsidise the unions or to give the necessary assistance through relief committees, thus enabling all working-class citizens to obtain uniform assistance, and enabling the unions to continue the payment of sick, superannuation, and similar benefits. A deputation was appointed to lay the proposals before the Government, and all trade unionists were urged to contribute liberally to the National Relief Fund.

It is stated in the *Industrial World*, Pittsburg, that whilst the steel industry in the Western States of America showed a disposition to prepare for a suddenly accelerated demand for steel products, as a direct result of European hostilities and the prostration of all European industry, the Eastern mills, were severely affected by the financial embarrassments on the Atlantic seaboard; being more completely dependent on ocean transportation, they were betraying a disposition to proceed with caution. Inability to get ready money was given as the reason why the Bethlehem Steel Company was adopting a retrenchment policy. About 2000 workmen, mostly labourers, were discharged at the Bethlehem Works on the 4th inst., due to the fact "that the company felt constrained at this time, on account of the uncertainty in commercial conditions occasioned by the general state of war throughout Europe, and the continued depressed business conditions at home, to inaugurate a retrenchment policy." This retrenchment policy, adds our contemporary, was to extend to all subsidiary concerns—*i.e.*, the Fall River Shipbuilding Company, Quincey, Mass.; Harlan and Hollingsworth, Wilmington, Del., and Bath, Maine. Owing to the failure of the company to obtain any of the work called for under this year's Army Appropriation Bill, it was likely that the No. 4 machine-shop at Bethlehem may have to close down, throwing several hundred expert machinists out of work. The one particularly hopeful feature was the large naval programme authorised by Congress; the company hoped to receive a large share of the armour-plate and other contracts.

We read in the *Australian Record* that the danger of a strike of builders' labourers on the railway works in Victoria has been averted by a decision of the Railway Commissioners to meet the demands of the men in regard to extra pay. It is stated authoritatively that the Commissioners have practically agreed to concede the rate of wage laid down by the Wages Board award—from 8s. 8d. to 10s. 8d. per day—to the following men:—Scaffolders, hod-carriers, plasterers' labourers, concrete-packers, and tackle hands. These men are at present paid from 8s. to 9s. per day, and it is understood that the Commissioners propose to increase their pay to the Wages Board rate. The wages of general handy men will not be altered, as the Commissioners are said to hold that they should not receive any advance on rates paid to other generally handy men in the department's employ. The new rates of wage will come into operation forthwith. Owing to the proposed increases of pay it is stated that the expenditure on railway electrification work will be considerably increased. Without making detailed investigations, it is understood that at least 7000*l.* will be needed to meet the additional outlay, and it may be that this amount will be doubled.

The same journal reports that Mr. Justice a'Beckett, in delivering his decision in respect of the appeal of the master masons against a determination of the Wages Board for the industry, fixed the following rates of pay for the stone-masons in Victoria:—

Carvers in marble or stone, 1s. 10½d. an hour; monumental carvers in marble or stone, 1s. 9d.; carvers' assistants, 1s. 8d.; letter-cutters in marble and stone, 1s. 7d.; letter-cutters in granite, 1s. 7½d.; stone-cutters for monumental purposes, 1s. 5½d.; stone-cutters for street kerbing, 1s. 4½d.; planing-machine workers, 1s. 6d.; other stone-cutters, 1s. 7d.; slate-cutters, 1s. 4½d. (granite-cutters are to be paid 2d. an hour in addition to the above rates, unless certain tools are provided by the employers, when the extra rate is to be a ½d. per hour); polishers, 1s. 3½d.; carborundum workers, 1s. 3½d.; labourers, including persons setting saws, fixing, and rubbing moulding work, 1s. 2½d. Apprentices and improvers are to have an increase of 2s. 6d. per week for the earlier years, and 5s. a week for the fourth, fifth, and sixth years. The determination came into force at the end of June last.

Messrs. Vickers, Limited, have posted a notice at their naval construction works on Barrow Island, stating that the directors will pay weekly to the wives, families, and other dependents of their employees who have been called up to serve in the present war, an allowance similar to that paid by the Government by way of separation allowance.

We are informed that, in answer to a request from the French Government to be allowed to take over all or part of the machinery at their dépôt at Asnières, near Paris, Messrs. J. Rhodes and Sons, Grove Works, Wakefield, at once gave their consent. It is not known yet what machines have been requisitioned, but the firm have instructed their French manager to place everything at the dépôt at the disposal of the Government. There is a large stock of machines of all kinds, and the probability is that those taken over will be used for the making of shells and cartridges.

Australian Areas.—The Commonwealth of Australia has a gross area of 2,974,581 square miles. This total is made up as follows:—Victoria, 87,884 square miles; New South Wales, 309,472 square miles; Queensland, 670,500 square miles; South Australia, 380,070 square Western Australia, 975,920 square miles; Tasmania, 26,215 square miles; and territories, 524,520 square miles.

British Standard Specification for Salt-Glazed-Ware Pipes.—A specification (No. 65) of particular interest to sanitary engineers and architects has just been published by the Engineering Standards Committee. It deals with stoneware sewer and drain pipes. The Committee was urged to take this up some time ago, and the Institution of Municipal and County Engineers laid a draft specification before the Committee. After a conference of users and manufacturers in 1911, a sectional committee was appointed under the chairmanship of Sir M. Fitzmaurice, C.M.G. The question of putting forward a standard socket, likely to produce better alignment in unskilled hands than the form in general use, was considered, but it was found desirable only to specify the minimum mean thickness and minimum internal depth and jointing space. The specification divides pipes into two classes—viz.:—British standard pipes, of which only a percentage made are tested hydraulically, and British tested pipes, of which all are tested. The points dealt with include the absorption test, limits of deviation from thickness, diameter, straightness, &c. The report may be obtained, at the price of 5s. 2d., from the offices of the Committee, 28, Victoria-street, Westminster, or from Messrs. Crosby Lockwood and Son, Stationers' Hall-court, E.C.

PHOTOGRAPHY AND THE TESTING OF MATERIALS.*

By Professor W. E. Dalby, F.R.S., M. Inst. C.E.

Photography plays an increasingly important part in connection with the testing of materials. Apparatus for getting a photographic record of the structure of a metal is part of the equipment of a modern testing laboratory. The examination of metallic structure by means of the microscope developed from the study of the structure of meteoric irons, and quoting from an article by Roberts-Austen, "there can be no question that in the main it was originated by Dr. H. C. Sorby, who, in 1864, gave the British Association an account of his work at the Bath meeting." Martens, of Charlottenburg, Osmond, Roberts-Austen, Merrett, Stead, and Arnold, and many other workers, have developed the methods whose names are too well known to need any mention in this brief paper. The recent work of Dr. Rosenhain, whom Australia sent to England, is familiar to us all. The papers of the Alloys Research Committee in the Proceedings of the Institution of Mechanical Engineers are profusely illustrated by photo-micrographs of the structure of irons, steels and alloys. The examination of structure by the aid of the microscope has become in recent years an established method, and many mysterious fractures yield their secret to the microscope. A metal specimen is prepared for microscopic examination by carefully polishing the surface, after which it is treated with an etching fluid which acts differentially on the individual elements of the structure and so produces a pattern which, by the aid of the microscope, reveals the inner architecture. The photographic apparatus, by means of which a permanent record of the etched surface is obtained, need not be described here, as there are several well-known forms of it on the market. A few photographs of etched surfaces have been taken to illustrate the application of the method. Incidentally the photographs show the main styles of

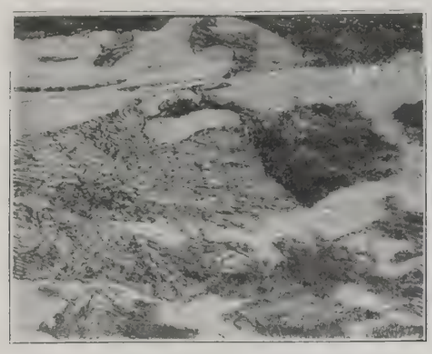


Fig. 1.—0.66 C. steel cooled from 1000 deg. C. Pearlite + ferrite × 695.

Fig. 2.—0.66 C. steel quenched in water from 1000 deg. C. Martensite.

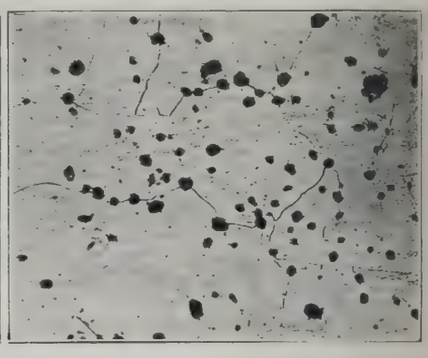


Fig. 3.—Case-hardened iron No. 36. Centre of bar showing ferrite and slag. Cross-section × 260.

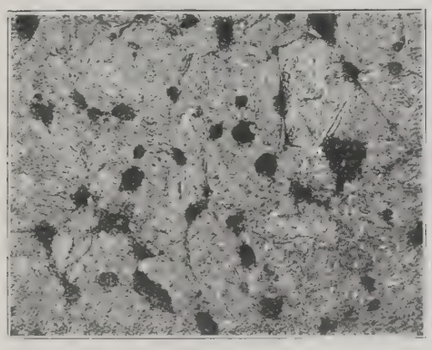


Fig. 4.—Case-hardened iron No. 36. Case-hardened area, martensite + slag. Cross-section × 260.

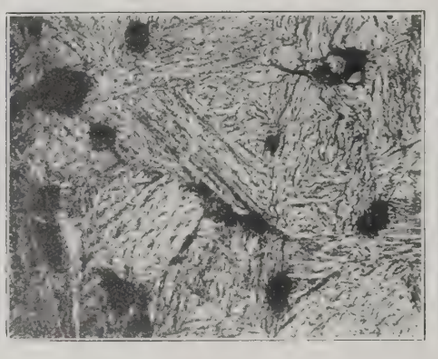


Fig. 5.—Case-hardened iron No. 36. Case-hardened area, martensite + slag. Cross-section × 695.

Fig. 6.—Case-hardened iron No. 36. Case-hardened area, martensite + slag. Cross-section × 695.

Fig. 7.—Case-hardened iron No. 36. Case-hardened area, martensite, slag, and cracks between slag-holes. Cross-section × 695.

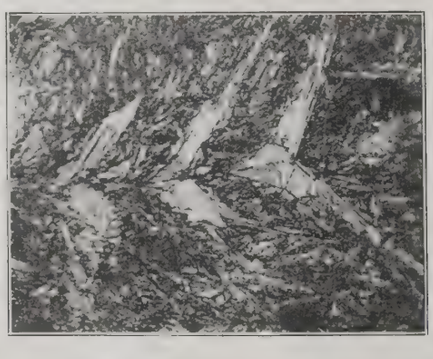


Fig. 8.—Case-hardened iron No. 36. Case-hardened area near surface, martensite with well-developed austenite. Cross-section × 695.

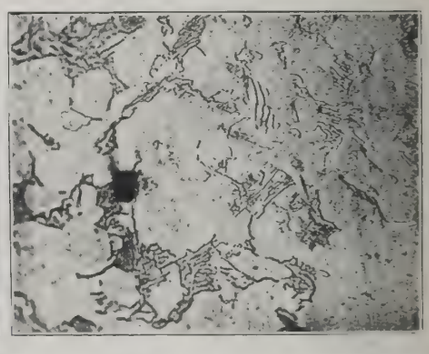


Fig. 9.—Case-hardened iron cooled slowly from 900 deg. C. Cross-section × 695. Taken at a point well within the boundary of the hardened iron about 0.2 in. from outside surface. Ferrite + traces of pearlite.

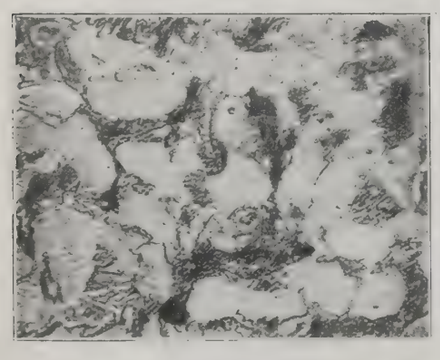


Fig. 10.—Case-hardened iron, annealed rom 900 deg. C. Ferrite + pearlite. Cross-section × 695.

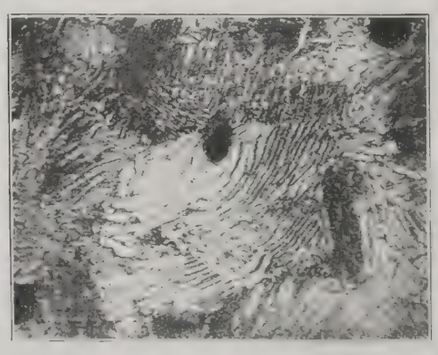


Fig. 11.—Case-hardened iron annealed from 900 deg. C. Mostly pearlite. Cross-section × 695.

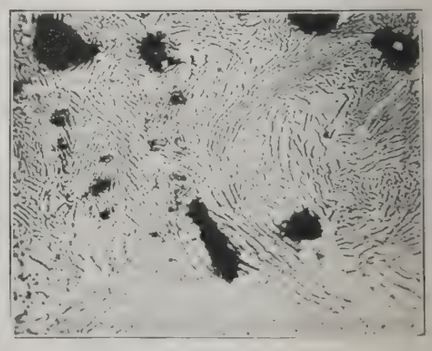


Fig. 12.—Case-hardened iron annealed from 900 deg. C. Pearlite. Longitudinal section × 695.

* Paper read before Section G of the British Association in Australia, August, 1914.

crystalline architecture met with in iron and steel. It is well known that if a piece of steel containing 0.9 per cent. of carbon is cooled slowly, the elements finally build themselves into a structure called pearlite, from its resemblance to the laminated structure of mother-of-pearl. Pearlite consists of alternate layers of cementite, or iron carbide, and ferrite. The granular structure may be produced by very slow cooling.

If more than 0.9 per cent. of carbon is present in the steel, crystals of cementite are distributed through the pearlite.

If less than 0.9 per cent. of carbon is present, crystals of ferrite are distributed through the pearlite.

Fig. 1 shows the structure of a piece of 0.66 carbon steel which has been cooled slowly, and it shows ferrite distributed through the pearlite.

Another slide exhibited shows a section in which the carbon is slightly above 0.9 per cent. The cementite is seen surrounding the general pearlite structure.

The building of these formations requires time. If the steel is suddenly quenched from about 900 deg. Cent., the materials from which the structures are formed are found in the state in which it builds itself at that temperature. The sudden quenching prevents material change in the style of the building. Martensite is formed in this.

Fig. 2 shows the structure of 0.66 carbon steel after quenching from about 1000 deg. Cent.

The effect of the carbon content on the style of the structure can be easily shown by using a specimen of case-hardened iron. In the process of case-hardening carbon penetrates inwards, and along the line of penetration the carbon content varies from a maximum at the surface to nothing at a point below the surface, the depth of which depends upon the time during which the iron has been subjected to the case-hardening process. Hence the structure corresponding to a graded carbon content can be passed under review in the microscope. Photographs have been taken at typical points, and the slides about to be shown have been made from these photographs. All the photographs show the slag or cinder which is found in manufactured iron.

The photographs are divided into two groups—namely, those related to the structural state, found after sudden quenching in water from a temperature of about 900 deg. Cent., and those which relate to the structure found after annealing from 900 deg. Cent.

The characteristic structure in the first state are martensite and austenite.

The characteristic structures of the annealed state are pearlite, cementite, and ferrite.

States produced by rapid quenching :—

Fig. 3.—Centre of bar showing crystals of iron with slag interspersed. × 260.

Fig. 4.—Case-hardened area. Martensite. × 260.

Fig. 5.—Case-hardened area. Martensite. × 695.

Fig. 6.—Case-hardened area. Martensite. Slag. × 695.

Fig. 7.—Case-hardened area. Martensite. Slag. Cracks. × 695.

Fig. 13.—Case-hardened iron annealed from 900 deg. C. Longitudinal section × 695 near surface. Cementite + pearlite.

Fig. 8.—Case-hardened area. Near surface. Austenite. Martensite. × 695.

States produced by slow cooling :—

Fig. 9.—Annealed. Centre. Ferrite. Traces of pearlite. × 695.

Fig. 10.—Annealed. Increased proportion of pearlite. × 695.

Fig. 11.—Annealed. Mostly pearlite. × 695.

Fig. 12.—Annealed. Mostly pearlite. × 695.

Fig. 13.—Annealed. Pearlite. Cementite. × 695.

These photographs sufficiently illustrate the way in which photography can be applied to the examination of the structure of a metal.

The ultimate test of the quality of a material is, however, the direct practical test applied by the engineer—namely, the breaking of a sample in order to find how much load it will carry, and at the same time to measure how much the sample extends before fracture. This test does not reveal the secrets of inner structure, but it does, though in a drastic fashion, establish the quality of the material in a way which enables it to be wrought into a design with confidence or justifies its rejection from the work altogether.

The author, in the year 1909, designed an instrument which brought this mechanical process of testing within the range of photography, and, notwithstanding the difficulty that the instrument must stand the shock of the fracture of every specimen broken in it. The delicacy of the recording mechanism is in a measure its own protection, because where the mass is negligibly small the forces caused by a shock are negligibly small. The complete story of the load on the specimen, and the extension which the load produces starting from zero and ending with the load producing fracture, is written by a spot of light on a photographic plate. The record ends at the instant of fracture, because when this takes place the parts of the instrument under stress recover their normal unstressed state so rapidly that the spot of light moves over the plate so swiftly that no record is left which will appear when the plate is developed. Thus the load actually on the specimen at the instant of fracture is definitely recorded. Load-extension curves are commonly obtained by means of the pencil-and-drum apparatus usually supplied with testing-machines. The load-extension curves obtained by means of the instrument are free from the effects of pencil friction, and the inertia of the beam and refinements of form and details of relation are brought out on the curves, which are quite lost unless these causes of error are eliminated. The instrument, in combination with the microscope, opens out a promising field of research. The details of the instrument have been described in the Proceedings of the Royal Society, A., Vol. lxxxvi., 1912, and need only brief reference here.

Two bars are placed in series between the grips of a testing-machine. The lower bar is the specimen to be broken ; the upper bar is proportioned so that the load which breaks a specimen produces a stress on the upper bar well within its elastic limit. The extension of the upper bar is thus proportional to the load on both the bars. This extension is used as a measure of the load on both the bars. The upper bar carries a metal box, in which are placed two mirrors free to turn about axes at right angles, and a source of light which is reflected successively from the mirrors on to a focussing-screen of a camera, also carried by the metal box. An extensometer attached to the lower bar which is to be broken tilts one of the mirrors through an angle which is proportional to the extension of the specimen. The upper bar tilts the second mirror through an angle which is proportional to its extension, and therefore proportional to the load on the two bars. The spot of light therefore describes a curve, the co-ordinates of which are the load and the extension of the lower specimen.

Slides are on view illustrating the general construction of the apparatus. (See ENGINEERING, vol. xciii., page 781).

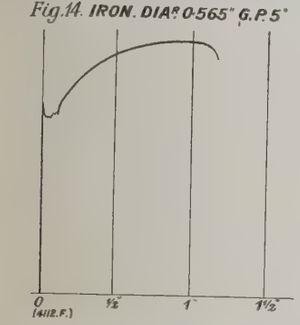
A series of records of iron, steel, and alloys are also exhibited. The records are not photographs of the plates taken from the apparatus, but the actual plates themselves. The records were, in fact, taken on a plate of the standard lantern size, and were afterwards bound up with a cover-glass.

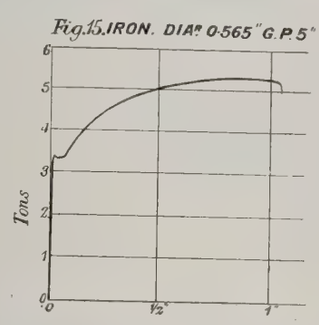
Fig. 14 shows the diagram of a piece of iron just as it was obtained in the apparatus.

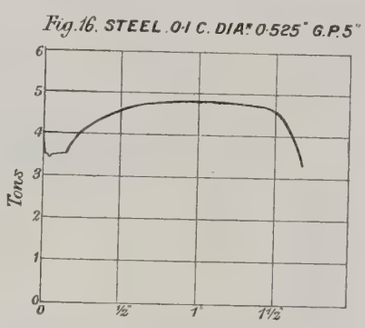
Fig. 15 shows a slide in which the load-scale is reproduced by photography on the cover-glass. This is bound up with the record of the break, and gives a completely calibrated diagram.

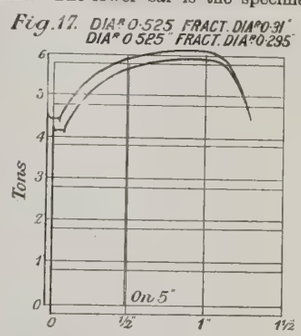
Fig. 16 is a record of a 0.1 carbon-steel bar, bound up with calibrated cover-glass.

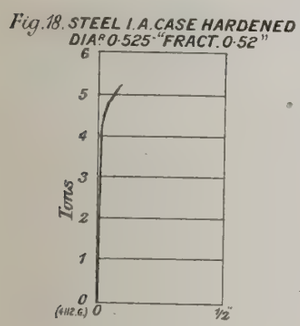
Fig. 17 shows a pair of records bound together. After the first record was taken, the plate was accidentally broken. Many weeks later a second record was taken of the same material with a different instrument, arranged in an entirely different way in the machine with a different extensometer. In fact, all the mechanical elements in the testing plant were different. The record is such an exact reproduction of the original record that they are bound together, and serve to illustrate the accuracy of

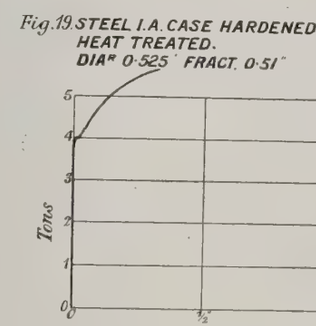


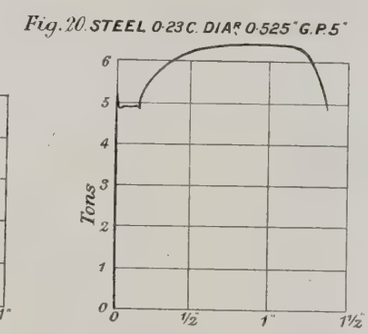


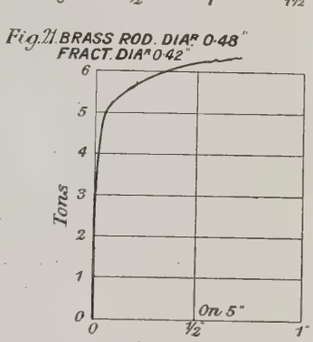


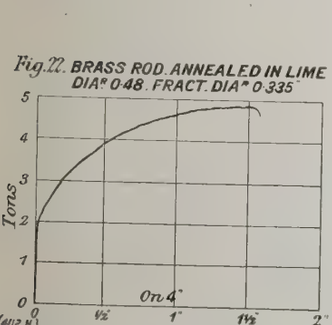


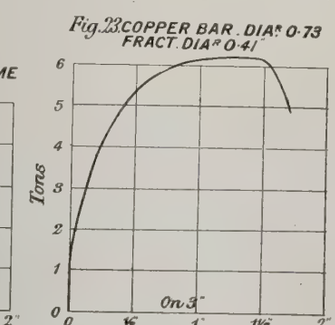


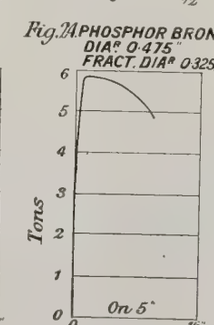












the testing plant. The second specimen did not extend quite so much, otherwise the records are identical.

Figs. 18 and 19 show the effect of case-hardening the steel, the diagram from which is shown in Fig. 17. It will be seen how shortly the case-hardened specimen breaks off when tested after case-hardening in the usual way. The diagram in Fig. 19 shows that subsequent annealing restores a measure of ductility. Fig. 20 is a diagram from 0.23 carbon steel. Fig. 21 a diagram of brass rod tested from the bar. Fig. 22 a diagram of a specimen of this brass rod after annealing in lime. Fig. 23 is a diagram of a sample cut from a copper bar. Fig. 24 a diagram from a rod of phosphor bronze.

In conclusion, I may just refer to the remarkable way in which our President has used photography and polarised light to reveal the state of stress produced in specimens of transparent xylonite by the application of determined loading. From the records so obtained, the corresponding state of stress may be inferred in conditions which are quite outside the range of mathematical analysis. He himself is to give you an account of his researches by means of these methods.

This brief paper illustrates the wide field of research which the use of photography has made possible to the engineer, and the aid which methods explained and illustrated in the paper are able to give in connection with many important practical questions of engineering design.

GASEOUS EXPLOSIONS.

Seventh Report of the Committee, consisting of Dr. Dugald Clerk (Chairman), Professor Dalby (Secretary), and Professors W. A. Bone, F. W. Burstall, H. L. Callendar, E. G. Coker, H. B. Dixon, Drs. R. T. Glazebrook and J. A. Harker, Colonel H. C. L. Holden, Professors B. Hopkinson and J. E. Petavel, Captain H. Riall Sankey, Professors A. Smithells and W. Watson, Mr. D. L. Chapman and Mr. H. E. Wimperis.*

The decease of the Chairman, Sir William Preece, was reported to the committee in December last, when a letter of condolence was sent to the family. Sir William Preece had associated himself intimately with the investigations carried out by the committee, and contributed an interesting "Note on the Kinetic Theory of Gases." As Chairman he did much to help forward the important work on which the committee is engaged, both by his valuable suggestions and by his tactfulness and resource. His loss is not only deeply deplored, but felt to be a personal one by every member of the committee.

The Vice-Chairman, Dr. Dugald Clerk, was unanimously elected Chairman.

The committee met three times during the session 1913-14, at the City and Guilds (Engineering) College, Exhibition-road, London, S.W. The following notes were presented and discussed :—

Note 32, by Professor Dalby, on "Suction Temperatures," directly measured and deductions therefrom, together with a summary of a series of seventeen experiments made at the City and Guilds (Engineering) College on a Crossley gas-engine with a cylinder 7 in. in diameter, stroke 14 in.. and with a compression ratio of 4.8.

Note 33, by Mr. H. E. Wimperis, on "Thermal Efficiency."

Note 34, by Professor E. G. Coker and Mr. W. A. Scoble, on "Temperature Distribution in the Cylinder of a Gas-Engine."

Note 35, by Professor W. Watson, on "The Spectroscopic Study of the Combustion of Air-Petrol Mixtures."

The object of Note 32 was to show how the suction temperature varied with the speed, with the jacket temperature, and with the mixture. The records given in the note relate to trials Nos. 72 to 90. The data were obtained by a research student of the City and Guilds (Engineering) College, Mr. Limbourne, working under the supervision of Professor Dalby. A table included in the note shows the variation in the suction temperatures, and a set of curves, also included, gives the temperatures of the working mixture; these indicate how the direct knowledge of the suction temperature can be applied to determine the temperatures at other parts of the cycle.

In Note 33 Mr. Wimperis discusses the thermal efficiency of an engine using as the working agent a standard gas referred to in the first report of the committee, and using in his calculations the values of the internal energy defined by the curve in Fig. 6 of that report. [Engineering, September 11, 1908.]

In Note 34 Professor Coker describes the method of measuring the cyclical temperature in a gas-engine cylinder used by him at the Technical College, Finsbury, and gives the results of some recent experiments. Curves are included showing the temperature of the explosive charge, together with tables of the actual temperatures at various points in the cycle. A full description of the thermo-couple used in these experiments is given in the note.

In connection with Note 35, Professor Watson showed a series of photographs of the spectrum of the light given by the burning charge in the cylinder of a petrol-engine. The results show that the gases in the cylinder continue to emit light giving a line spectrum for a considerable time after the chemical changes are generally assumed to have been completed. Before proceeding to consider the work carried out during the current session, it has been thought advisable to give a brief summary of the previous reports of the committee.

Summary of Previous Reports.—The first report [Engineering, September 11 and 25, 1908] is devoted mainly to the specific heats of gases at high temperatures. The experiments of Wiedemann, Regnault, Holborn, and Henning are analysed and discussed, and a curve is given showing the energy of CO_2, steam, and air in terms of the temperature Centigrade. The experiments of Dr. Dugald Clerk are described, and the results obtained compared with the constant-pressure experiments mentioned above. The closed vessel experiments of Mallard, Le Chatelier and Langen are analysed and the results plotted and discussed. The report ends with the discussion of thermal equilibrium, chemical equilibrium, the motion of a gas, and the measurement of temperature. A curve is given showing the internal energy of a gas-engine mixture in terms of the temperature. There is an appendix by Professor Callendar on "The Deviation of Actual Gases from the Ideal State," and on "Experimental Errors in the Determination of their Specific Heats."

The second report [Engineering, September 3, 1909] is mainly devoted to the specific heat of gases at high temperatures. Regnault's results at low temperatures are discussed in the light of Mr. Swann's experiments, which were communicated to the committee by Professor Callendar. The committee definitely adopted Mr. Swann's values for air and for CO_2 as given below :—

Volumetric heat of air at 100 deg. Cent. is 19.8 ft.-lb. per cub. ft., measured at 0 deg. Cent. and 760 mm.
Volumetric heat of CO_2 at 20 deg. Cent. is 27.4 ft.-lb. per cub. ft., and at 100 deg. Cent. is 30.7 ft.-lb. per cub. ft., measured at 0 deg. Cent. and 760 mm.

The results of the experiments made by Dr. Dugald Clerk, with the object of determining the volumetric heat of air at high temperature, are given in the report, together with a description of Professor Hopkinson's experiments on the compression of air in a gas-engine cylinder.

Dr. Watson's researches on the efficiency of a petrol motor are included in the report. Dr. Watson made a simultaneous measurement of the quantities of air and petrol taken into the engine, and of the chemical composition of the exhaust gas. The point brought out was that the ratio of hydrogen to carbon in the exhaust gas was greater than the ratio of hydrogen to carbon in the petrol used. Additional evidence of this discrepancy is furnished by some experiments of Professor Hopkinson, and the experiments of Hopkinson and Watson are in agreement. The report concludes with an account of the experiments on radiation carried out by Professor Hopkinson. There are two appendices: one relating to Regnault's corrections in connection with the determination of the specific heat of air, and the other relating to Deville's experiments on the dissociation of gases, by Dr. Harker.

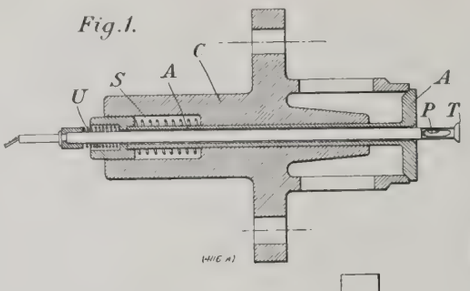
The third report [Engineering, September 9, 16, and 30, 1910] is devoted mainly to radiation from gases. A brief history of the subject is given, together with a record of the experiments of Professor Hopkinson and of Professor Callendar. The report discusses the direct effect of radiation on the efficiency of internal-combustion motors, the amount of radiation from flames, and the molecular theory of radiation from gases, as well as the question of the transparency of flames to their own radiation. There is an appendix on the radiation of flames by Professor Callendar, giving some account of experiments made with a Méker burner; a second appendix on the radiation in a gaseous explosion by Professor Hopkinson; and a third appendix which contains abstracts from various papers relating to the application of heat radiation from luminous flames to Siemens' regenerating furnaces.

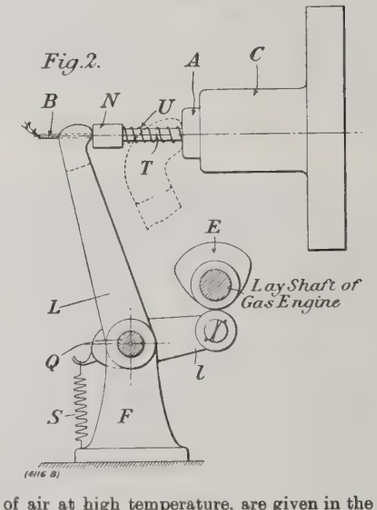
The fourth report merely notes the number of meetings held during the year, and states that, partly owing to the breakdown of apparatus and partly to the demands made upon the time of the various investigators, only two notes were read; consequently it was decided that the work then on hand should be included in the report for the following year.

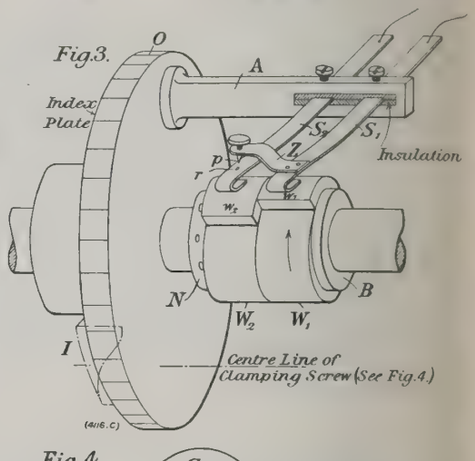
The fifth report [Engineering, November 8, 1912] continues the discussion of the effect of radiation, and is devoted mainly to the consideration of the factors which determine the heat flow from the gas to the walls of the cylinder. The remarkable effect of turbulence on the rate of combustion is first mentioned in this report. Particulars of Dr. Dugald Clerk's experiments are given, and these experiments definitely establish the fact that, but for turbulence, the speed at which modern internal-combustion engines are run would be impossible. Professor Hopkinson's experiments, in which a fan was placed inside a closed vessel and the rates of combustion observed with the fan at rest and in motion, are recorded in the report, and confirm Dr. Clerk's results.

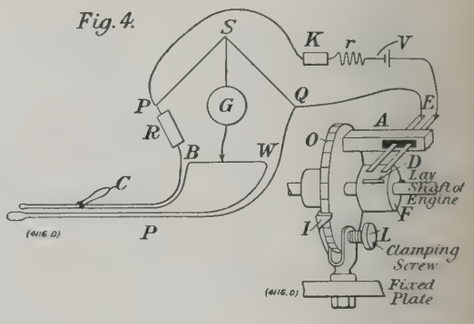
In the sixth report, the resignation of Dr. Dugald Clerk and Professor Hopkinson from the joint secretaryship of the committee is reported. Dr. Clerk consented, however, to act as vice-chairman, and Professor Dalby was appointed secretary.

The committee allocated the whole of the grant to the secretary for the purpose of providing him with a permanent research assistant to carry on the work. It was stated that Professor Dalby and Dr. Clerk were engaged on the design of an experimental plant to be placed in the new laboratory of the City and Guilds (Engineering) College. [Engineering, September 19, 1913.]









Six notes, relating chiefly to heat flow, temperature, and leakage, are briefly summarised.

Object of Present Report.—The following report is devoted partly to the special consideration of temperature measurements and subjects arising therefrom, and partly to the illustration of the use which can be made of the data obtained by the committee.

Methods of Measuring Temperature of the Charge in a Gas-Engine Cylinder under Working Conditions.—One of the problems requiring solution was the direct measurement of the temperature of the working agent in the cylinder while the engine was running under ordinary working conditions. The difficulty of making this measurement arises from the fact that during the explosion of the charge in the engine cylinder the temperature is sometimes higher than that of the melting-point of platinum, or of the couples which can be put in the cylinder to make the measurement.

In Note 32 is described a method devised by Professors Callendar and Dalby,* which, for the first time, enabled direct observation of the suction temperature to be made while the engine was working not only under normal conditions, but under special conditions, during which the richest possible mixture was used and the temperature reached at explosion was considerably higher than that occurring in practice. The thermometer itself consists of a piece of platinum wire about 0.7 in. long and $\frac{1}{1000}$ in. in diameter, arranged with compensating leads. It is placed in a thermometer-valve which is inserted through the spindle of the admission-valve in the manner shown in Fig. 1, in which P is the platinum thermometer and T is the head of the thermometer-valve which is inserted centrally in the admission-valve A. The spring S

* Presented to Section G of the British Association in Australia, August, 1914.

* Proceedings of the Royal Society, A., vol. lxxx., 1907.

serves to close the admission-valve, and the spring U serves to close the thermometer-valve. The main casting C carrying these valves is bolted to the engine in the ordinary way. A separate cam is mounted on the half-time shaft to operate the central thermometer-valve, and the complete arrangement is shown in Fig. 2, where E is the cam; *l* and L are levers keyed to the supplementary shaft Q which is carried on the casting F; the spring S maintains contact between the end of the lever *l* and the cam. The end of the thermometer with the leads projecting is shown at B. The lever L is in contact with the nut N on the thermometer-valve. The cam is so designed that during the explosion period the valve is closed, and the thermometer therefore screened from the action of the gas. In this way the thermometer is withdrawn just before the end of compression, so that at this critical period of the cycle there is nothing in the nature of a protuberance to cause pre-ignition. When the platinum thermometer is exposed in the cylinder and connected to the Wheatstone bridge and galvanometer on which the indications are received, the circuit is made by a contact-maker on the crank-shaft when the crank passes through an assigned crank-angle, and is broken by the contact-maker when the crank passes through a second assigned crank-angle a little greater than the first, so that the electrical measuring device is in operation during 5 deg., 10 deg., or 15 deg., as the case may be. This contact-maker is a very important part of the electrical equipment used in connection with these temperature measurements, as it enables a definite make and a definite break to be made in the electrical circuit, and, in addition, enables the time between the make and break to be adjusted with accuracy.

The contact-maker, Fig. 3, consists of a brass bush B keyed to a lay-shaft of the engine, and carrying two fibre washers or cams W_1 and W_2 which can be clamped in any relative angular position against the flange of the bush by the nut N. A radial step is made in step to each washer, and the surface gradually rises from the bottom of the step to the normal circular surface of the washer. The reflex ends of the stiff springs S_1 and S_2 rest on the fibre cams. A projection Z carrying a platinum-pointed screw *p* is riveted to one of the springs, and the screw *p* is adjusted so that its point is just clear of the platinum rivet in the other spring when both springs are riding on the circular surfaces of their respective cams. Contact is made when the rotation of the lay-shaft in the direction of the arrow brings the radial step w_1 of the cam W_1 under the spring S_1, thereby allowing it to fall down the step, thus bringing *p* and *i* together. Contact is broken when the radial step of the cam W_2 reaches the spring S_2, thereby allowing the second spring to fall down the step. The epoch and duration of contact are readily adjusted by adjusting the angular positions of the cams relatively to the bush, and also with regard to one another. The distances between the springs and the platinum contacts and the steps are exaggerated in the diagram in order to make the principle of the apparatus clear. The percussion form of contact with platinum points is found to give definite and certain results. The contacts keep clean, and no trouble of any kind is experienced with them. The general arrangement of the electrical connections is shown in Fig. 4. In this figure, P S, Q S are the equal ratio arms of the Wheatstone bridge. The galvanometer G is connected to the point S and to the sliding contact on the bridge-wire B W. The thermometer and its leads P are connected on one side of the bridge-wire, and the compensator C and the balancing resistance R on the other. The battery circuit includes a mercury reversing key K, an adjustable resistance *r*, and a storage-cell V; and the battery is connected to the bridge at the points P and Q, and to the brushes of the periodic contact-maker at E. The brushes E are carried by an insulated arm A bolted to a divided disc O riding loosely on the lay-shaft of the engine, and capable of being clamped in any position by the screw L. The index I shows the crank-angle corresponding to the middle point of the contact when the insulated copper strip D carried in the fibre bush F passes under the brushes.

The temperature is measured, therefore, during a particular crank-angle determined by the setting of the contact-maker. This can be set, while the engine is running, to determine the make and break at any assigned crank-angle in the revolution. It was usually set so that the interval between the make and break was 5 deg. or 10 deg. In this manner the mean temperature over a small crank-angle can be measured at any point in the cycle, except only during the period of the explosions, when the thermometer is withdrawn from the cylinder. But although there is this possibility with the method, it is desirable to measure the temperature at a point on the cycle where the rate of change of temperature is at a minimum. This point occurs just after the closing of the suction-valve. The great advantage of making the measurement at this point is that the thermometer is exposed to the incoming charge during the whole of the suction stroke, and therefore the thermometer-valve tends to assume the temperature of the charge; consequently the temperature which the small wire is set to measure does not differ greatly from the temperature of the metal in which it is mounted. This condition tends to minimise the errors of measurement. At any other point in the cycle the rate of change of temperature is greater, and the error of the measurements, therefore, is likely to be greater owing to the lag of the thermometer. On the expansion stroke, for example, the temperature may vary as much as 150 deg. during the movement of the piston through one-tenth of the stroke. Just after the closing of the suction-valve, the variation of temperature during the movement of the piston through one-tenth of the stroke is only about 20 deg.

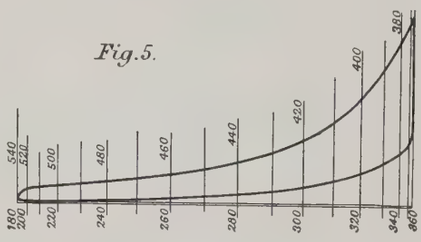
Having found the temperature at one point in the cycle, the temperature at any other point can be calculated by using the charge itself as the thermometric agent. The characteristic equation of the charge is $\frac{PV}{T}$ = a constant. If, therefore, from the indicator diagram taken at the time the temperature was measured, the corresponding pressure and volume are measured, then the temperature at any other point of the cycle can be calculated by the aid of this constant, and the pressure and volume scaled from the indicator diagram, allowance being made for chemical contraction of the charge after explosion. It is necessary to have accurate indicator diagrams from which to measure the pressure and volume for this purpose, and this has led to the development of an optical indicator.

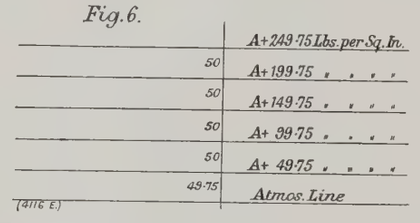
Example of the Application of the Method to an Engine Trial (72) *at the City and Guilds* (*Engineering*) *College.*—The general procedure in making temperature measurements by this method, and with an improved optical indicator devised by Professor Dalby and Dr. Watson, may be illustrated by data obtained during a trial made at the City and Guilds (Engineering) College by Professor Dalby last year, a full report of which will be found in Note 32 communicated to the Committee.

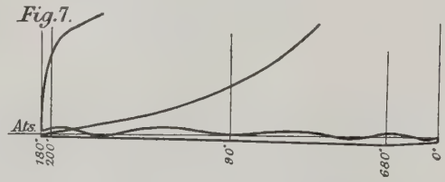
Indicator Diagrams.—In each trial two indicator diagrams were taken—namely, a complete diagram showing the pressure and volume during the whole cycle; and a diagram taken with a thin disc stopped down so as to give on a large scale the portion of the diagram during the pumping stroke. The diagrams are in general calibrated *in situ*.

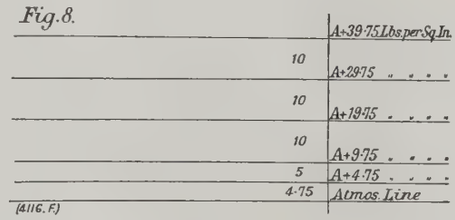
In carrying out a series of experiments, however, it was found that the scale was so constant that it was unnecessary to calibrate each diagram separately. The scale was therefore made for the two discs used, and was checked from time to time. A pair of typical diagrams taken during trial No. 72, together with the scales, are shown in Figs. 5, 6, 7, and 8. The following data relate to trial No. 72:—

Mixture, 6·88 air to 1 gas by volume; jacket temperature, 29.5; temperature measured at crank-angle 200







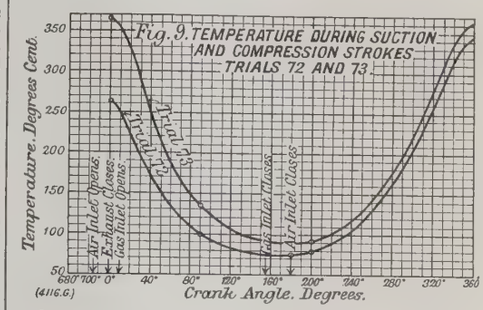


deg., 77 deg. Cent.; pressure measured from the diagram at 200 deg. crank-angle, 14.7 per sq. in.; volume measured at this point, 0.3872 cub. ft.; speed, 106 revolutions per minute. The gas constant for the charge is therefore $\frac{PV}{T} = 0.01616$.

This constant may now be used to calculate the temperature at any point along the compression curve, since at a point where the pressure is P and the volume V the temperature is:—

$$T = \frac{PV}{0.01616}$$

Fig. 9 shows temperature-curves for the compression stroke calculated in this way, both for trials 72 and 73. Trial 73 was run at about 200 revolutions per minute. The constant, however, cannot be applied during the whole cycle, because, although the weight of the charge remains the same, assuming that there is no leak, yet the volume corresponding to this weight is slightly different after the explosion has taken place owing to the contraction due to the chemical rearrangement of the constituents. The chemical contraction is calculated from the analyses of the gases. In the gas used in the experiments referred to the contraction amounted to 3.14 per cent. The effect of this is to change the gas constant for all points along the expansion-curve from 0.01616 to 0.01565. The curve, Fig. 10, shows the temperatures calculated along the expansion-curves for trials 72 and 73. When applying this method of taking the temperatures the governor should be put out of action, so that there shall be no change in the rate of the supply of gas which will produce a disturbance of the temperature in the cycle. Any disturbance produced in a particular



cycle causes a temperature wave through a long series of succeeding cycles. In practice the gas-engine can be run without any difficulty without the governor if the engine is coupled to a generator, because the generator automatically settles down to the speed corresponding to the power applied to it, and by regulating the resistance of the armature or the fields, or both, the desired speed can be maintained for long periods. A special switchboard and a resistance-board have been designed for the engine at the City and Guilds (Engineering) College, for the purpose of controlling the generator.

Method of Measuring the Temperature of the Charge by Means of a Thermo-Couple.—The second method of measuring the temperature of the charge in the cylinder is by means of a couple. This method has been developed by Dr. Coker and Mr. Scoble at the Technical College, Finsbury. It was found that alloys of platinum with rhodium and iridium respectively were able to withstand the temperature of explosion near the walls of the cylinder for some hours, or even days, when made into thermo-couples $\frac{5}{10,000}$ in. to $\frac{8}{10,000}$ in. thick, provided the engine was not overloaded. The actual temperature measurement is made by observing the change in the electromotive force produced in this couple by a change in temperature. The small changes on the electromotive force produced by a couple of this kind can be measured with great accuracy on the bridge described below. The general relation between electromotive force and temperature found for one of the couples used is

$$E \text{ (microvolts)} = -174 + 7.6075\,T - 0.001673\,T^2.$$

The general arrangement of the apparatus is shown in Fig. 11. The battery B and resistances R_1 and R_2 are arranged in circuit, so that the fall of potential between the extreme points of a bridge-wire, B W, can be adjusted to 1 millivolt. This is tested by the electromotive force of a cadmium cell, C, which can be opposed to the battery electromotive force by means of the upper key, K_1, an allowance for the known temperature variation of the electromotive force of the standard cell used being made by an adjustable contact-maker, D. The thermo-couple, H, has one lead connected to the lower key, K_2, and the other set to a set of resistances, S, in the main circuit, each of which gives a difference of potential of 1 millivolt when the adjustments are correct. During an observation, therefore, the battery electromotive force opposes that of the couple, and the readings of the bridge-wire and step resistance, taken together, measure the electromotive force of the couple when the galvanometer, G, shows a balance. The scale of the bridge-wire is graduated to read to 10 microvolts, and single microvolts may be read by estimation. The majority of the observations were taken when using a D'Arsonval galvanometer, giving, on a scale distant 110 cm., a deflection of 560 mm. for 1 microvolt. The contact-maker used with this apparatus is one devised by Professors Callendar and Dalby, which has already been described and illustrated in Fig. 3.

Suction Temperature.—Direct measurements of the suction temperature were made at the City and Guilds (Engineering) College during the session 1912-13 on a Crossley gas-engine, with a cylinder 7 in. in diameter, stroke 14 in., and with a compression ratio of 4.8. The object of the experiment was to show how the suction temperature varied with the speed, with the jacket temperature, and with the mixture.

The apparatus with which the measurement was made has been already described above. The results of the experiments are shown by the curves, Fig. 12. It is proposed to repeat these experiments on engines of more modern type and with higher compression ratios as soon as the development of the new laboratories at the College renders it possible to do so.

The Cyclical Variation of the Temperature of the Charge in a Gas-Engine Cylinder.—An example has already been given of the method of determining the cyclical variation of the temperature of the charge in a particular experiment, deducing it from the temperature measured at a point on the compression curve in combination with accurate indicator diagrams. The experiment was made at the City and Guilds (Engineering) Col-

lege on the gas-engine already referred to. The engine is not of recent construction, and therefore the compression ratio—viz., 4.8—is low compared with the ratios of gas-engines of more modern construction. Dr. Coker and Mr. Scoble have measured the cyclical variation of temperature on a more modern engine constructed by the National Gas-Engine Company in 1907. This engine has a cylinder 7 in. in diameter, and a stroke of 15 in. The maximum volume occupied by the charge is 5.8 times the minimum volume. The method adopted was to measure directly by means of a platinum couple the temperature at various points along the compression curve and along part of the expansion curve; but the highest temperature had still to be measured by using the charge itself as a gas-thermometer. A value of $\frac{P V}{T}$ is selected from a point on the expansion stroke, and the constant so found is used to calculate the higher temperatures. In this method it is unnecessary to make any calculation regarding the chemical contraction before and after the explosion, because the temperature is measured after the explosion; but the rate of change of temperature at the point where the temperature is measured is very great, and therefore, in comparing the two methods, it is necessary to choose between a temperature measured when the rate of change is great, with a corresponding lag and no correction for chemical contraction, as against a method of measuring the temperature when the rate of change is a minimum—viz., just after the closing of the suction-valve, and allowing for chemical contraction. With suitable precautions, both methods can be made to give consistent results.

The curve in Fig. 13 shows the temperature cycle in a gas-engine cylinder determined by Dr. Coker and Mr. Scoble when the ratio of air to gas was 7.35 to 1. The jacket temperature was 35.6 deg. Cent., and the highest temperature calculated was 1836 deg. Cent.

Temperature Cycle of Gas Charge.—Conditions.

Curve Number.	I.H.P.	Ratio of Air to Gas.	Jacket Outlet Temperature.
			deg. C.
1	10.24	7.35/1	35.6
2	9.96	7.08/1	37.2
3	10.11	7.13/1	81.4
4	10.36	6.71/1	40.6
5	10.36	5.66/1	52.8
6	9.74	6.64/1	43.7

Application of the Work of the Committee to Practical Problems.—The application of the work of the committee to practical problems can be illustrated in connection with the calculation of the heat exchanged between the working agent and the walls of a gas-engine cylinder.

First Law of Thermodynamics and the quantities necessary to apply it to determine heat lost or gained by the working charge during a change of state.—Let A (Fig. 14) be a point on the pressure-volume diagram representing the state of a working agent with regard to its pressure and volume. Let the state change along the path A B, so that B represents the state after the change. Then

$$\left.\begin{array}{l}\text{The heat received by the working agent from its external environment during the change of state from A to B} = Q\end{array}\right\} = \left\{\begin{array}{l}\text{Mass of charge}\end{array}\right\} \times \left\{\begin{array}{l}\text{The change of its internal energy per pound}\end{array}\right\} + \left\{\begin{array}{l}\text{The work done by the agent on its environment}\end{array}\right\} \quad (1)$$

That is, reckoning in thermal units,

$$Q = M (E_B - E_A) + \frac{Z}{J} \quad . \quad . \quad . \quad (2)$$

In which Q is measured in pound calories.

M is the mass of the charge in pounds.

E_B is the internal energy of the charge in its final state.

E_A is the internal energy of the charge in its initial state.

Z is the work done by the agent on its environment measured in foot-pounds.

J = 1400.

Earlier it was assumed that the specific heat of the gas used in the gas-engine cylinder was constant, and that the change of internal energy was determined by the change of temperature only. With this assumption the first term on the right-hand side of the equation was reckoned by merely multiplying the specific heat into the change of temperature corresponding to the change of state from A to B, the mass of the charge M being calculated from the general relation,

$$M = \frac{P V}{c T} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

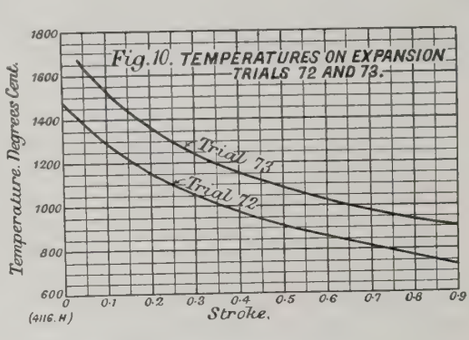
corresponding values of P, V and T being taken from any point on the path where they could be determined. It is known, however, that the specific heat is variable, and the committee began their work by reviewing all the available experimental data in connection with the subject. Several members of the committee were themselves carrying out researches in relation to this problem at the same time.

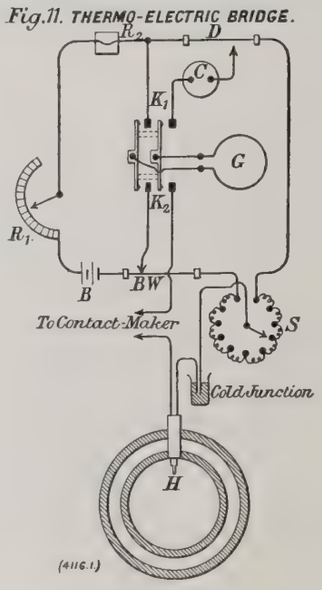
Data Found to Enable this Determination to be Made.—The aim of the committee was to ascertain the true value of the specific heat at constant volume, K_v, or, to put it in another way, to ascertain the relation between the internal energy of the gas and its temperature. In dealing with gas-engine problems it is more convenient to combine equations (1) and (2) into a single expression, in which the specific heat is given not in terms of the unit of mass, but in terms of the unit of volume at standard pressure and temperature. Substituting in equation (3) for the standard pressure 1 atmosphere, for the standard temperature 273 deg. Cent. absolute, and for the gas constant $c = 96$, it will be found that the weight of a cubic foot of the working agent at standard temperature and pressure is 0.081 lb., and therefore in terms of foot-pounds, and still assuming that the specific heat at constant volume is constant, equation (2) becomes—

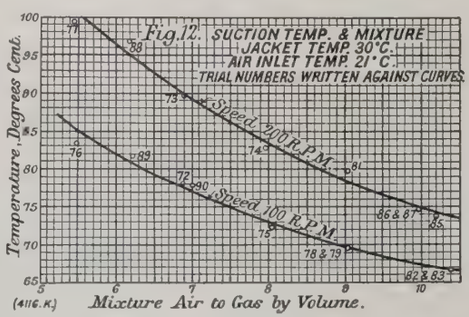
$$J Q = 0.081 J K_v (\text{change of temperature}) + Z.$$

The quantity $0.081 J K_v$ represents the change of internal energy in foot-pounds per degree change of temperature per cubic foot as measured at standard temperature and pressure. When K_v is variable and is a known function of T, say $\phi(T)$, the term becomes

$$0.081 J \int_{T_1}^{T_2} \phi(T)\, d T.$$







Values of this expression in which the lower limit T_1 is 0 deg. Cent. can be read off the curve given in Fig. 15, which is taken from the first report.

To use this curve to find the internal energy corresponding to a given state-point it is necessary to measure the pressure P and volume V from a P V diagram, and also to determine the absolute temperature T. The corresponding volume at standard temperature and pressure is then calculated from the equation—

$$V_o = \frac{V P T_o}{T P_o}.$$

This calculated value of V_o when multiplied by the internal energy, as given by the curve for the temperature T, gives the internal energy of the gas corresponding to the given state-point.

Symbolically let

E_A = internal energy corresponding to the position of a state-point A,

V_{AO} = the corresponding volume measured at A reduced to standard temperature and pressure, and

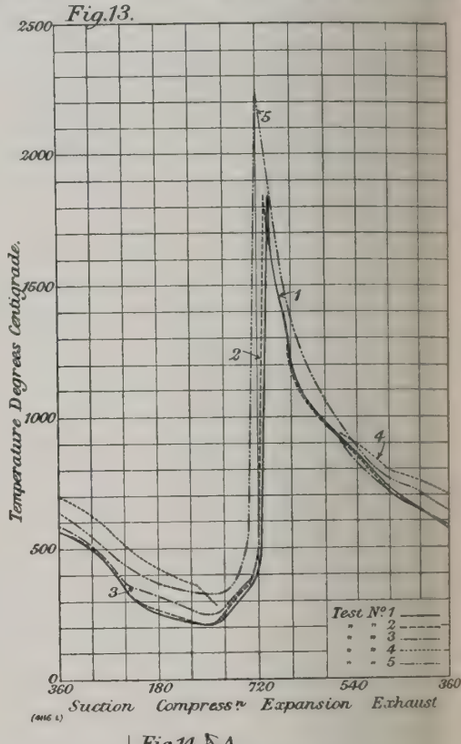
Y_t = the ordinate of the curve measured at the temperature corresponding to the temperature of the state-point, then

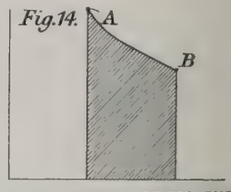
$$E_{AO} = V_{AO} Y_t$$

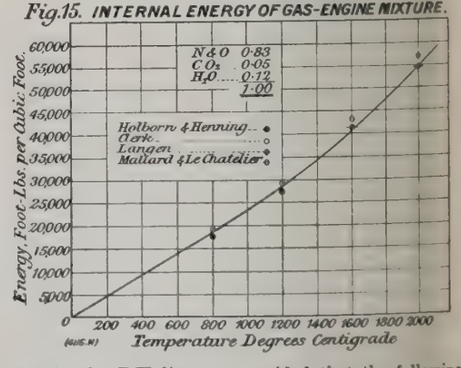
The position of the points A and B on the P V diagram gives no indication of the temperature at A or B. If the temperature at one of the points, however, is known, then the temperature at the second point can be calculated from the relation

$$\frac{P_A V_A}{T_A} = \frac{P_B V_B}{T_B} \quad . \quad . \quad . \quad (4)$$

This relation expresses the characteristic equation for gases, and is quite independent of the specific heat of the gases concerned. It applies to all positions of the state-point in the P V diagram, provided that the following two conditions are satisfied :—







Condition 1. That there is no change in density of the gas, such as may be produced by some change in its chemical constitution.

Condition 2. That the weight of the working agent during the change of state from A to B is constant.

It is fundamentally important, therefore, to be able to measure by direct observation the temperature corresponding to at least one position of the state-point in the diagram, because by means of this temperature and the relation expressed in equation (4) the temperature corresponding to any other position of the state-point in the diagram can be calculated, providing always that the conditions 1 and 2 are not violated during the change of state. If the first condition is violated, there is a small change of volume caused by chemical action as the state-point moves from A to B; and in order to calculate the magnitude of this change it is necessary to have a chemical analysis of the gas before and after chemical action. When these analyses are known, a correction

can be made, and equation (4) can still be applied to calculate the temperature. This kind of action has to be reckoned with—for example, if the state-point A is on the compression-curve of a gas-engine and the state-point B is on the expansion-curve.

The earlier part of this report shows that the committee have given a good deal of consideration to the subject of the direct measurement of temperature, and that individual members have worked at the problem successfully. Examples have been given earlier in the report of methods which have been applied and are being used in the researches which are now being carried out. This example shows how the equation (4) is used to calculate the temperature for different positions of the state-point B from observations of a single temperature. The single temperature which it is most useful to know is the suction-temperature, and this may be defined as the temperature of the charge in the cylinder just after the admission-valve is closed. There is then a definite weight of charge in the cylinder at a definite pressure and volume, and at a definite temperature. Allowing for the chemical contraction, equation (4) can be applied along the expansion-curve.

The committee have examined into the question of leak of charge, and have come to the conclusion that in most cases in a modern engine it is a negligible amount when proper precautions are taken. These considerations show how important the suction temperature is in combination with the indicator diagram, as from this temperature, and the pressure and volume given by the diagram, the state of the working agent all through the cycle can be determined, at least approximately. The values of the suction temperature for a particular engine are exhibited in Fig. 12 above, and a diagram of the kind would be useful in connection with any internal-combustion motor. To resume, it can now be assumed that it is possible to fix a temperature for one particular position of the state-point A, and then the temperature at the end of the change of state B, if not observed, can be calculated. With a knowledge of those temperatures the internal energy of the working agent can be read off from the curve, Fig. 15, and then the first term on the right side of the equation—viz.,

$$E_B - E_A = \text{change of internal energy}$$

is determined.

The value of the second term on the right side of equation (1) is merely the value of the shaded area under the path AB expressed in foot-pounds. Consequently, from a pressure-volume diagram giving the initial and final conditions of the working agent and the path of the state-point in between, together with the temperature corresponding to one position of the state-point, the right side of the equation can be determined and the heat gained or lost by the working agent during the change can therefore be computed. If there is no gain or loss of heat the work done is done at the expense of the internal energy of the working agent itself. One of the main objects of the committee has been to extend our knowledge of the physical constants of the gases by the careful examination of methods, apparatus, and results of various investigators, including members of the committee, and change of state of the working charge in a gas-engine can now be followed with a degree of accuracy which hitherto has been impossible.

A diagram from an actual gas-engine shows the P V changes during the whole of the four-stroke cycle, but the method explained above can only be applied to determine the heat exchanges during that part of the cycle when the weight of charge enclosed in the cylinder is constant—*i.e.*, during the period between the closing of the suction-valve and the opening of the exhaust-valve. There is no difficulty in applying the method practically to a change of state along the compression-curve, because the conditions 1 and 2 above are fulfilled. There is no chemical change, and the weight of charge is constant. Applying the method to the analysis of the expansion-curve, however, there is difficulty. The left side of equation (1), Q, gives the heat gained or lost by the gas during a change of state. Q includes the heat gained by combustion as well as the heat gained or lost from outside, so that it must be written :—

$$Q = O + C,$$

where O represents the heat gained or lost to the outside, and C represents the heat produced by combustion during the change. The difficulty is to separate these two during a change of state along the expansion-line. It is probable that combustion is not quite complete at the point of maximum pressure; in fact, some combustion may be going on right up to the point at which the exhaust valve opens. If, therefore, two points are taken on the expansion-curve, and this method of analysis is applied, neglecting O, the heat loss determined will obviously be too great.

An analysis of the diagram by this method will be found in Dr. Clerk's Gustave Canet lecture, and need not, therefore, be further pursued [ENGINEERING, July 4 and 11, 1913.] Attention may be specially drawn to the curves in Fig. 12, which show the results of trials made for the purpose of ascertaining the relationship between the suction temperature and the strength of the mixture used, and on the speed. When the mixture is 9 parts of air and 1 part of gas by volume, the suction temperature is about 70 deg. Cent. at a speed of 100 revolutions per minute. At 200 revolutions per minute the suction temperature is increased to 78½ deg. Cent. At the constant speed of 200 revolutions per minute the temperature gradually increases as the mixture becomes richer; with a 10 to 1 mixture the temperature is 75 deg. Cent., and this increases to 96½ deg. Cent. with a 6 to 1 mixture. At the lower speed the change in temperature is almost as great for a corresponding change in the mixture—namely, from 67½ deg. Cent. to 82 deg. Cent. With a modern engine using a higher compression, it is probable that the temperatures would be generally higher. Fig. 13 shows the cyclical variation of temperature as determined by Dr. Coker on a more modern engine, and the suction temperatures given by him are of the order of 200 deg. Cent. Dr. Coker explains this high suction temperature as being partly due to the retention of hot gas and partly due to the long exhaust pipe which was used.

Dalby and Callendar's experiments have shown that when using rich mixtures the maximum temperature in the cylinder is probably about 2000 deg. Cent., and these results have been confirmed by Coker and Scoble. For the mixtures used in ordinary working conditions the experiments of Dalby, Callendar, Coker and Scobel show that the temperature is about 1800 deg. Cent. It is hoped to continue the experiments on temperature measurements when engines of more modern construction have been installed in the new engine laboratory of the City and Guilds (Engineering) College. The concentration of research on the accurate measurement of temperature is a necessary step towards a more certain knowledge of the specific heat of gases at high temperatures; and the vital importance of this subject is indicated by the brief explanation given above of the method by which the determination of heat exchange between the working charge and the walls of the cylinder can be made. So far the committee have only been able to present the curves given in Fig. 15 as representing the most reliable data available. The practical use to which the curve can be put is illustrated by using the data given by it to find the efficiency of an engine working on the Otto cycle without loss of heat, assuming that the mixture used is that specified near the curve in Fig. 15, this mixture being very much nearer the actual mixture used in a gas-engine than air.

Thermal Efficiency.

$\frac{1}{r}$	Efficiency calculated from the Curve and for the Mixture given in Fig. 13.	Efficiency of the Air Standard.
⅓	0.187	0.242
⅜	0.273	0.356
¼	0.337	0.426
⅕	0.384	0.475

The committee are of opinion that they can usefully continue their work by organising research on the lines which have been foreshadowed in this report. The committee recommend, therefore, that they be again reappointed, and that, in view of the expensive nature of the research and the organisation involved, the sum of 100*l.* be granted to them.

VICTORIAN RIVERS.—The Murray, which forms the northern boundary of Victoria, is the largest river in Australia. Its total length is 1520 miles, for 1200 of which it flows along the Victorian borders. Several rivers in the north-west of Victoria have no outlet, and are gradually lost in the absorbent tertiary flat country through which they pass. The principal Victorian rivers are the following :—Avoca, 170 miles in length; Broken, 110 miles; Broken Creek, 120 miles; Glenelg, 290 miles (falls into Discovery Bay); Goulburn, 345 miles (joins the Murray near Echuca); Hopkins, 170 miles (falls into the sea at Warrnambool); Latrobe, 145 miles (falls into Lake Wellington); Loddon, 210 miles (falls into the Murray); Macallister, 100 miles (falls into the Thomson); Mitta Mitta, 167 miles (joins the Murray); Mount Emu Creek, 165 miles (falls into the Hopkins); Mount Hope Creek, 120 miles (falls into Kow Swamp); Murray, 1200 miles; Ovens, 132 miles (joins the Murray); Pyramid Creek, 140 miles (falls into the Loddon); Snowy, 103 miles (falls into the sea); Tambo, 120 miles (falls into Lake King); Thomson, 110 miles (falls into the Latrobe); Wannon, 145 miles (falls into the Glenelg); Wimmera, 190 miles (falls into Lake Hindmarsh); and Yarra Yarra, 150 miles (falls into Hobson's Bay).

THE LATE MR. ALFRED DOWSON.—We regret to have to record the death, which occurred on the 14th inst., at Fleet, Hants, of Mr. Alfred Dowson, civil engineer, formerly of Westminster. Mr. Dowson was sixty-eight years of age. For nearly a quarter of a century he was actively engaged in the design and construction of engineering works on the sea coast, including piers and landing stages at New Brighton, Hunstanton, Redcar, Cleethorpes, Wallasey, and St. Anne's-on-the-Sea. He was also consulted on the improvement of the harbour of St. Heliers, Jersey, and much of the work subsequently carried out followed the lines he had advocated. Mr. Dowson had made a thorough study of coast erosion; he constructed breakwaters and other coast-defence works at various parts of our sea shore, eventually bringing out a novel system of open groynes, which he patented, and applied with much success at the mouth of the River Ribble, in Lancashire, and at Brighton. In 1870, on the passing of the Tramway Acts, he carried out several tramway schemes in this country and in India. In conjunction with his brother, Mr. J. Emerson Dowson, he published, in 1875, a treatise on "The Construction of Tramways." Mr. Alfred Dowson ultimately gave up his sea work, with a view to act as engineer to his brother's well-known Dowson Economic Gas-Power Company, subsequently taking charge, until his retirement in 1908, of the company's works at Basingstoke. The deceased was greatly interested in sanitation problems, and was for many years a Fellow of the Royal Sanitary Institute. He also took a keen interest in the movement to preserve our commons and open spaces, and for several years he acted as honorary surveyor to the Reading branch of the Commons Preservation Society.

FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Morocco: H.M. Chargé d'Affaires at Tangier reports that tenders are invited by the Moroccan Adjudications Commission for the construction of a second section 17.7 km. (about 11 miles) long, of the road from Salé to Kenitra. The estimated value of the contract is 307,679 francs (about 12,300*l.*), and a deposit of 5000 francs (about 200*l.*) is required to qualify any tender. Tenders, on the proper form, accompanied by certificates of competency, will be received by M. le Président de la Commission Générales des Adjudications et des Marchés, Dar En-Niabs, Tangier, up to 11 a.m., on October 3. The contractor must elect domicile in the neighbourhood of the works.

Mexico: The *Diario* notifies that a fifty-two years' concession has been granted to Señores Alberto Barberis and Ciro Castillo Corzo for the construction and working of a railway in the State of Chiapas, starting from a convenient point between the stations of La Aurora and Tonalá on the Pan-American Railway, and passing through the town of Tuxtla Gutierrez to the left bank of the River Grijalva. A branch line will run from the junction with the Pan-American Railway to the Pacific Coast. The concessionaire must complete at least 50 km. (about 31 miles) in each of the first five years, and the whole undertaking must be finished within a period of eight years. Free importation of materials required in connection with the work is allowed for a period of five years.

Brazil: The *Diario Official* contains a decree, No. 11.008, of July 22, approving the plans and estimate of 7,566,966 milreis (about 504,460*l.*) for the construction of 43 miles of the Brusque section of the Santa Catharina Railway.

Ecuador: With reference to the concession for the construction of a railway from Huigra to Cuenca, granted to the firm of Messrs. Orenstein and Koppel, of Berlin, the *Registro Oficial*, Quito, publishes the text of a decree containing regulations governing the construction of the line. The *Registro Oficial* also notifies that a concession has been granted to Señor Edmundo Catefort for the construction of a railway between Quito and Bahia de Caráquez. The concessionaire engages to form a company with a capital of 1,000,000*l.*, the Ecuadorian Government guaranteeing interest on the revenue up to 6 per cent. per annum on that amount.

MINING MACHINERY.—The value of the mining machinery exported from the United Kingdom in July was 62,377*l.*, as compared with 123,356*l.* in July, 1913, and 62,228*l.* in July, 1912. British South Africa figured in these totals for 22,710*l.*, 42,765*l.*, and 29,017*l.* respectively. In the seven months ended with July 31, this year, mining machinery was exported to the value of 527,331*l.*, as compared with 661,826*l.* and 509,436*l.*

THE CAPE COD CANAL.—On July 29 the Cape Cod Canal was opened for commerce. This canal is a tide level connection between Buzzard's Bay and Cape Cod Bay, on the coast of Massachusetts. It is 8½ miles long from shore to shore, but with approach-channels, ultimately giving throughout 30-ft. depth of water, its length is 13 miles. It has a minimum bottom width of 100 ft., with 200 ft. at passing-places. It has been cut by dredgers through gravel. The canal is situated on the sea route between New York and Boston, between which cities 25 million tons of shipping are estimated to pass annually. Both passenger and freight traffic are very heavy. From its exposed nature the sea passage round Cape Cod has constantly proved a source of danger to shipping, while in addition to affording enhanced safety, the new route reduces the sea passage by no less than 138 miles if the outside route round the Nantucket Light is taken, or by 70 miles on the Pollock Rip Channel route. The canal has been constructed by private enterprise at a cost of 12 million dollars. It is crossed by sundry roads and railways, the most important piece of bridgework being for the New York, New Haven, and Hartford Railroad, which is taken over the waterway by an electrically-operated bascule bridge.

RIMS FOR MOTOR-VEHICLE TYRES.—The Engineering Standards Committee have issued an interim report on rim diameters for solid tyres for motor-vehicles. Six nominal sizes have been accepted by the tyre and commercial vehicle sections of the Society of Motor Manufacturers and Traders, and these sizes have been submitted to a sub-committee of the Engineering Standards Committee, and will be recommended by them to the main committee for adoption as British standards. The diameters selected are 670 mm., 720 mm., 741 mm., 771 mm., 850 mm., and 881 mm., and it is believed that these dimensions will provide suitable standards, and will enable the largest number of existing moulds to be used without alteration. The sub-committee recommend that the rims should be provided with slots in the flanges to facilitate the removal of the tyres, and that suitable supporting pads should be provided where a continuous inturned flange is not used. They also consider that a reasonable lead should be provided on the outer edge of the rim to facilitate the pressing on of the tyre. The question of specifying suitable tolerances to be allowed on the standard rim diameters is under consideration, and this, together with other recommendations in connection with solid tyres, will be presented to the main committee for publication at a later date.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

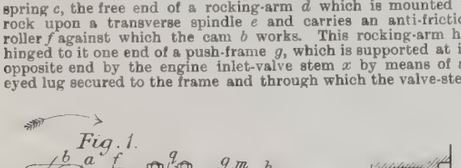
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

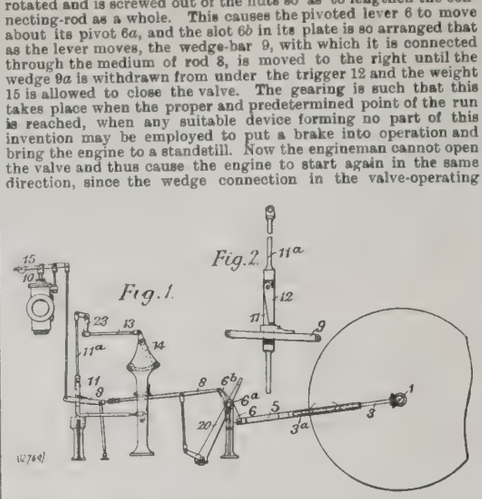
8667/14. E. E. Bentall, and G. C. Bingham, Maldon. Internal-Combustion Engines. [2 *Figs.*] May 15, 1913.—This invention has for its object valve-gear for internal-combustion engines, wherein the inlet-valve is operated through the medium of hit-and-miss mechanism from a half-speed spindle in such a manner as to automatically control the speed of the engine and to permit of it being varied as required. Inlet-valve gear, according to this invention, comprises a reciprocating frame operated from a half-speed shaft of the engine, a slide mounted in said frame and adapted to engage the stem of the engine inlet-valve, and hit-and-miss mechanism which is controlled by the velocity of the frame during its forward movement to lock said frame to the slide or to allow the one to move independently of the other as the engine speed varies, and consists of a combined inclined surface and stop on the frame, a hinged finger-piece on the slide, and a spring which normally holds said finger-piece to engage the combined inclined surface and stop. The half-speed shaft *a* carries a cam *b* which operates, against the action of a spring *c*, the free end of a rocking-arm *d* which is mounted to rock upon a transverse spindle *e* and carries an anti-friction roller *f* against which the cam *b* works. This rocking-arm has hinged to it one end of a push-frame *g*, which is supported at its opposite end by the engine inlet-valve stem *x* by means of an eyed lug secured to the frame and through which the valve-stem



works. The push-frame *g* has arranged to slide in it a slide *h*, which is held in its normal position by a spring *k*, and is fitted with an extension or lug *l* which engages and operates the inlet-valve stem when the slide is caused to travel with the frame. This slide has hinged or pivoted to it a finger-piece *m* which swings in a vertical plane and is normally held by a spring *n* against a cam surface on the frame. The lower end of this spring *n* rests on one end of a lever *o*, which is pivoted to a fixed plate *p*, and has its opposite end arranged to move over and engage a serrated segmental projecting rib on the plate, so that the lever may be adjusted to any position desired to vary the tension of the spring. The cam surface on the frame *g* comprises a combined curved surface and stop *q*, and against this the finger-piece *m* works in such a manner that it will slide over the curved surface and engage the stop when the engine is running at normal speed, but when it exceeds this speed the finger-piece will be thrown by the curved surface downwards to such an extent as to allow it to pass the stop so that the slide will not be forced to travel with the frame, and consequently the inlet-valve stem will not be operated as it normally is when the slide travels with the frame. The force with which the finger-piece is thrown downwards, and consequently the extent of its downward movement, depends upon the speed of the engine and the tension of the spring *n*, so that by varying the latter the former may be varied as desired. (*Sealed July* 30, 1914.)

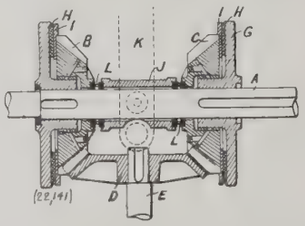
LIFTING AND HAULING APPLIANCES.

12,764/13. The Butterley Company, Ltd., Butterley, and C. E. Drabble, Ripley. Winding-Engines. [4 *Figs.*] June 2, 1913.—This invention relates to winding-engines or the like, and its object is to provide means for automatically controlling and regulating the working of such engines, whether steam or electrically driven, to prevent over or under-running; the apparatus being operated from any revolving shaft of the engine and causing the steam valve to be closed at any predetermined point of the run through the medium of a wedge-bar and trigger being inserted in the valve-operating linkage. The shaft 1 of the engine, or some shaft rotated thereby, is connected with another shaft 3 whose end is screw-threaded at 3*a* for some distance and works in nuts 4 carried by a rod 5 which forms a continuation of the threaded shaft. The whole thus forms a connecting-rod capable of being lengthened or shortened according as the screw-threaded shaft is screwed out of or into the nuts. The other end of this extensible connecting-rod is connected with one end of a lever 6, which is fulcrumed at 6*a*; this lever may be in the form of a plate having a specially-curved slot 6*b* therein. In the slot works a pin carried by the end of a rod 8, whose other end is attached to a wedge-bar 9, which forms a link or connection with the valve-spindle 10. The wedge-bar 9 passes through a bridle 11 in which is pivoted a trigger 12 operated through the medium of the connecting-rod 11*a*, bell-crank 23 and rod 13 from the starting-lever 14. Now, assuming the engine to be stopped and a run about to commence, the parts 9, 9*a*, 11, 11*a* and 12 of the valve-operating linkage are in the positions shown, the steam-valve spindle 10 and weight 15 can now be raised by the starting-lever 14 being moved from right to left and the engine then commences to rotate. At the same time the screwed shaft 3*a* is rotated and is screwed out of the nuts so as to lengthen the connecting-rod as a whole. This causes the pivoted lever 6 to move about its pivot 6*a*, and the slot 6*b* in its plate is so arranged that as the lever moves, the wedge-bar 9, with which it is connected through the medium of rod 8, is moved to the right until the wedge 9*a* is withdrawn from under the trigger 12 and the weight 15 is allowed to close the valve. The gearing is such that this takes place when the proper and predetermined point of the run is reached, when any suitable device forming no part of this invention may be employed to put a brake into operation and bring the engine to a standstill. Now the engineman cannot open the valve and thus cause the engine to start again in the same direction, since the wedge connection in the valve-operating



linkage is withdrawn, as described above. On operating the engine-reversing lever 20, however, from right to left, the pin which works in the slot 6*b* in the plate part of the pivoted lever 6 is moved to the other end of the slot, and the latter is so arranged that this brings the wedge connection back into its initial position. The engine is now ready for another run, but in the reverse direction, so that the threaded shaft will rotate in the other direction and shorten the extensible connecting-rod, thus returning the pivoted lever to its original position when the wedge connection will again have been withdrawn and the engine is stopped as before. On again actuating the engine-reversing lever the pin carried on the end of rod 8 will be moved to the other end of the slot, the wedge connection will be re-inserted in place and the parts will be as they were initially. (*Accepted May* 20, 1914.)

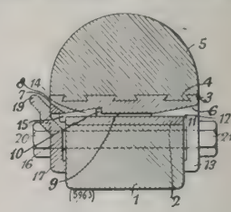
22,141/13. Babcock and Wilcox, Limited, and F. W. Hollick, London. Cranes. [1 *Fig.*] October 1, 1913.—This invention consists in the application to cranes of reversing gearing, including a friction clutch comprising discs fixed on the reversing shaft, the hubs of which discs carry the reversing bevels, said discs being fitted with plane annular facings for frictional contact with plane annular facings on the bevels. A practically constant coefficient of friction between the contacting surfaces of such a clutch is obtainable without the necessity for lubrication, while risk of seizing or jamming, on the one hand, and of involuntary slipping, on the other hand, is avoided. As shown, running loose on the driving shaft A, are two toothed bevel-wheels B, C adapted to mesh, as usual, with one bevel-wheel D secured on he driven shaft E. The two bevel-wheels B, C are



also loosely mounted on the hubs of two friction-discs F, G keyed to the driving shaft, one adjacent to the bevel gear B, and one adjacent to the bevel gear C. The inner face of each disc F, G has a plane annular facing H of ferodo (a material composed of asbestos and other non-inflammable constituents) or similar substance, while the bevel-wheels B, C are provided with co-operating plane annular metal facings I nearly contacting with the facings H on the discs. A sliding sleeve J, operated by the usual clutch lever K, is fitted on the shaft A between the bevel-gears, and is adapted to act thereon through the intermediary of thrust bearings L so as to press one or the other of the bevel-gears B or C into frictional contact with its frictional disc F or G, so that the reversing shaft may be driven in one direction or the other. (*Sealed July* 30, 1914.)

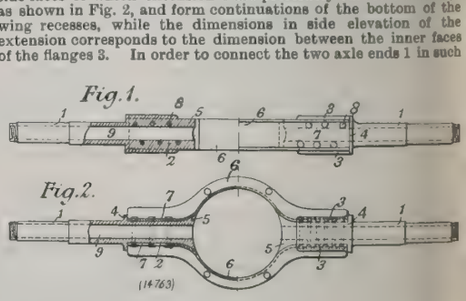
MOTOR ROAD VEHICLES.

5963/14. P. B. Bosworth, Akron, U.S.A. Wheel Rims. [1 *Fig.*] March 9, 1914.—This invention belongs to that class of tyre-holding rims known as demountable, and embodies a novel construction by which the tyre may be quickly and fixedly mounted on the wheel rim, and demounted therefrom, and which will hold the tyre securely against independent movement while mounted on the wheel. The invention consists in the combination with a vehicle wheel of a pair of wedge-shaped rings positioned on the periphery thereof, one of the said wedge-shaped rings being provided with an inwardly-projecting flange for preventing its lateral movement, a tyre-carrying rim provided on its inner face with a pair of inclined faces adapted to seat on the inclined faces of the wedge-shaped rings, and a clamping-ring secured to the side of the wheel and provided with a portion engaging the side of the tyre-carrying rim for shifting it laterally to cause snug engagement between the rim and the outer faces of the wedge-shaped rings. 1 and 2 denote respectively the felly and felly-band of an ordinary wheel constructed in accordance with the well-known standard now adopted by manufacturers for carrying elastic tyres. Surrounding the felly-band 2 is an outer band 3, which is preferably provided with corrugations or dovetailed grooves 4 for use in assisting in holding a tyre 5 in position thereon. The cross-sectional configuration of the tyre aside from the portion which is secured to the band 3 is immaterial. The inner face of the band 3 along one of its lateral faces is provided with an inclined face 6, and at another point with an inclined face 7, preferably, although not necessarily, spaced inwardly from the lateral face 8 of the band 3. The normally inner face 9 of the band 3 is united with the inclined face 7, by a shoulder 10. Mounted on the outer face of the felly-band 2 is a broken retaining-ring 11 provided with a laterally-projecting wedge-shaped flange 12, the outer face of which is inclined, and with the inner face thereof fashioned to rest on the outer face of the felly-band 2. This member 11 is also provided with an inwardly-extending flange 13 provided with apertures. On the outer face of the felly-band 2 is a second broken ring or annulus 14, the outer face of which is inclined and fashioned to engage the inclined face 7 of the band 3, and with the inner face thereof cylindrical to seat on the outer face of the band 2. The broken ring 14 is also provided at one side with an inwardly-extending lip or flange 15. The ring 14 and the outer portion 12 of the member 11 are approximately wedge-shaped in cross-section. Positioned against the side plate of the felly 1 is an annularly-formed clamping-ring 16, provided with an inwardly-extending flange 17, which rests against the side of the felly, and is further provided with an outwardly-extending portion 18, which is adapted to bear laterally against the side 8 of the band 3 of the tyre. Extending outwardly from this portion is a laterally outwardly-inclined flange 19. The inwardly-extending flange 17 of the member 16 is provided with apertures arranged in transverse-registering relation with respect to the apertures in the flange 13 of the member 11, and the felly 1 is also provided with a series of transverse apertures. Extending in these registering apertures are bolts 20 provided with nuts 21, the function of which is to draw



the clamping-ring 16 inwardly towards the felly, and also, at the same time, to shift the band or ring 3 of the tyre laterally for firmly seating it. In setting up a wheel of this description, the member 11 is positioned on the felly-band 2 and the tyre with the member 14 seated in the frusto-conically-formed groove formed by the face 7 with one side thereof resting against the shoulder 10, and the two are slid laterally on to the felly-band 2 until the inclined face 6 of the band 3 rests on the inclined face of the portion 21 of the member 11. During this operation, or immediately thereafter, the member 14 is forced laterally in the direction of the member 11 until the inwardly-extending lip or flange 15 thereof engages the side of the felly-band 2. The clamping-ring 16 is then positioned and the bolts 20 passed through the apertures in this ring, the felly, and the member 11, and the nuts 21 are placed on their threaded ends. As the nuts 21 are drawn up, they tend to force the member 11 inwardly towards the side of the felly, and this movement causes the inclined outer faces of the portion 12 and the ring 14 to engage the inclined faces 6 and 7 of the ring 3. At the same time, the lateral movement of the member 16 causes the face 18 thereof to force the ring 3 laterally towards the member 11, causing the inclined faces 6 and 7 of the ring 3 to contract the members 11 and 14 to firmly lock them in position. (*Sealed July* 30, 1914.)

14,763/13. H. M. Butler, Leeds. Road-Vehicles. [9 *Figs.*] June 26, 1913.—The present invention has for its object to provide an improved construction of built-up hind axle of the kind comprising two tubular wheel-carrying axle ends connected by channel-section members, the latter being so shaped as to provide a substantial space midway or about midway between the opposite tubular axle ends. According to this invention, the ends of each channel-section member, which ends are, as hitherto suggested, straightened to lie upon flattened portions of the axle ends, are either constructed with flanges which overhang and lie above and below the inner end of each tubular axle end, or the axle ends may be formed with flanges to lie above and below the faces of the channel-section members. The axle ends 1 are each formed of a tubular member, the outer end of which is of circular section to constitute the barrel upon which the hub of the wheel rotates, while the inner end is formed with what is hereafter termed a wing 2, of somewhat oblong form in cross-section. The vertical sides of the wing 2 are recessed in the direction of its length, by means of which there are formed on the two opposite sides outwardly-extending upper and lower flanges 3, the ends of the recesses next to the barrel being closed by laterally-extending flanges 4. The wing 2 extends beyond the flanges 3, the vertical side faces of which extension 5 are preferably curved outwardly, as shown in Fig. 2, and form continuations of the bottom of the wing recesses, while the dimensions in side elevation of the extension corresponds to the dimension between the inner faces of the flanges 3. In order to connect the two axle ends 1 in such



a manner as to leave a substantial space about midway of the axle when complete, the ends are connected by two channel section members or bridge-pieces 6, arranged so that the backs of the members 6 face each other. The opposite ends of these members 6 are formed with a straight portion 7 to lie flush against the wing 2 between the flanges 3, the straight ends being connected by outwardly-curved or otherwise bent portions, so that when the two members are placed in position on and connecting the axle ends, there shall be left in plan a space enclosed by a substantially annular frame (see Fig. 2). The members 6 are also formed so as to lie against the curved portions of the extension 5. The ends of the members 6, when the axle is built up, bear against the laterally-extending flanges 4, and the flanges 3 on the wings overlie the outer faces of the flanges of the channel-section members 6, and the dimensions of the wing 2 of each tubular member or axle end 1 and the dimensions of the sections 6 must be such as to allow of the bolts or rivets such as 8 being passed through the channel-section members 6 and the wings 2 to secure the members to the wings, without the rivets extending into the bore 9 of the axle ends. When the members 6 have been secured in position by the rivets 8 on the axle ends 1, the flanges 3 on the wings are caulked down cold on to the outer faces of the said members 6. The flanges of the outwardly-curved or bent portion of the members 6 may be formed with bolt-holes to receive bolts, by which a gear-box is connected to the members, or other means may be employed for connecting the gear-box thereto. (*Sealed July* 30, 1914.

NOTES ON THE RELATION BETWEEN RAINFALL AND YIELD.

By D. HALTON THOMSON, M.A. (Cantab.), Assoc. M. Inst. C.E.

IT is unfortunate that practically the only systematic gauging of rivers and streams maintained in this country is in connection with existing works, and whenever new schemes are projected in hitherto unappropriated drainage areas, the only available data on which to base their design are the records of rain-gauges in the locality or in neighbouring watersheds. There is no need, therefore, to emphasise the importance of establishing as accurately as possible the general relation between annual rainfall and yield in areas where the two sets of observations have been simultaneously carried out for a period of years.

A common method of ascertaining this relation is to plot the annual yield against the rainfall of the corresponding period, and to draw amongst the points thus obtained a curve—usually a straight line—from which a simple formula in fair accordance with the facts can be deduced. Dr. H. Lapworth* has pointed out that the annual evaporation (E), including all losses in inches in any drainage area, may be denoted by :—

$$E = C + a R \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where

R = annual rainfall in inches.
C = a constant.
a = a coefficient peculiar to each watershed.

The annual yield (Y) in inches is then represented by the straight-line equation :—

$$Y = R - E = (1 - a) R - C \quad . \quad . \quad (2)$$

The points as plotted above, however, usually distribute themselves in so haphazard a manner that it is probable no two individuals would derive the same values for the constants a and C from the same data. The reasons for this irregularity are not far to seek, and fall under the following heads :—

1. The observations themselves may not be reasonably accurate.

2. The physical conditions of the drainage area vary from year to year.

3. The time-distribution of the yield differs from that of the rainfall.

Now there must be an appreciable probable error in applying the observations to the purpose in view, however carefully the readings themselves are made. The rainfall may be derived from the records of only a few gauges, or even one gauge, so placed as not to be fairly representative of the drainage area ; or the yield may be calculated from a weir-gauge the rating of which is open to question. In areas containing reservoirs it is possible to determine the yield only by taking into consideration a number of variables, such as compensation water, overflow, draught to supply, and change in reservoir-level, any or each of which may be a source of error. Sometimes only the main feeders are gauged, a rough estimate being made to account for the smaller contributories. The mere construction of a reservoir, if it forms a large proportion of the total collecting area, appreciably affects the natural yield by introducing a factor which did not previously exist—namely, evaporation from its water surface. Indeed, the most fruitful source of discrepancy is perhaps due to the changes of conditions which inevitably take place in the course of time and tend to break the continuity of the observations.

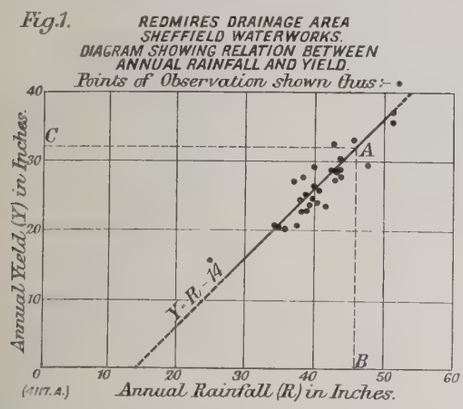
Assuming, however, that the records are reliable, the relation between rainfall and yield would be representable by a single curve only, if all the physical conditions of the drainage area, apart from the actual total annual rainfall, remained constant from year to year. In fact, only certain of these conditions—such as area and shape of the drainage area, its topography, geology, condition of surface, and natural storage capacity—are constant ; others—such as time-distribution and intensity of rainfall, temperature, direction and intensity of wind and saturation—are continually changing. But even were it feasible, which it is not, to form an equation allowing individually for each of these factors, it would be so unwieldy as to be useless. A formula such as (2), which represents the yield as a simple function of the rainfall, is for practical purposes undoubtedly preferable, even if it is theoretically illogical.

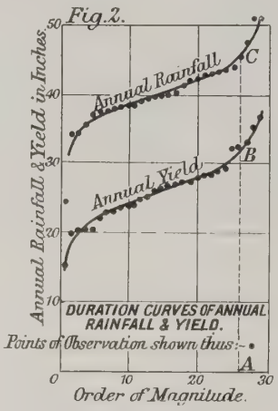
The third source of discrepancy lies partly in the fact that the yield lags behind the rainfall ; they are therefore not comparable in every respect over one and the same period. The importance of this lag depends upon the type of watershed under consideration ; in impervious and sparsely vegetated areas the whole of the discharge passes away very quickly, but in large retentive drainage areas the lag may be very pronounced. Many engineers have recognised its significance, and for the purposes of records terminate their water-year when the discharge is usually low—namely, in the late summer or early autumn, instead of on the last day of the calendar year—in order to prevent the normal flood season from being split up into two portions, and to credit as large a part of the annual discharge as possible to the rainfall of its origin. Experience shows, however, that the correlation of observations arranged in this manner is not sensibly improved.

Were it possible to estimate the lag, if only approximately, another method suggests itself. The rainfall of any year might be compared with the yield of the year ending later by the amount of the lag. The question then arises, What is meant by the lag? It might be defined, for instance, as the average time between the commencement of a rain-spell and that of a rise in discharge, or between the heaviest part of the rain-spell and the peak of the flood-wave. But even were some such assumptions adopted, and apart from any difficulties in determining their numerical values, the problem of correlation is not thereby solved, for a drainage area not only has a retarding, but also an equalising, effect upon its discharge. The yield not only lags ; its time-distribution is totally different from that of the rainfall.

The flow of a stream consists essentially of a series of freshets following one another at intervals in accordance with the occurrence of the rainfall from which they are derived. The rate of rise, the height of the flood-peak, and the rate of fall of each individual freshet depend upon the intensity of the rainfall and the physical characteristics of the drainage area. The main mass of the flood-wave usually follows quickly on the rainfall, but weeks and months may pass before the whole of the flow due to that fall has drained off. With most streams in temperate countries the tail-end of a freshet is replenished by its successor long before the channel runs dry, so that the discharge at a given moment may be composed of water originating from a number of entirely independent rain spells. It follows, therefore, that the discharge of any one year is derived only in part from the rainfall of that year, the remainder arising from the rains of the period which, if the drainage area is very retentive, may extend back many months and even more than a year. Also part of the rainfall of that year is not discharged until the following year, and therefore cannot affect the yield of the year in which it occurs. This overlapping of the annual yield would be of no importance were the magnitude and distribution of the rainfall similar year by year, since the undischarged surpluses at the end of each would be similar and so counterbalance one another so far as the annual totals were concerned. In reality, of course, the rainfall varies very considerably, so that this surplus at the end of a wet year will be greater than at the end of a dry year. Other conditions being unchanged, therefore, the yield of a wet year following a dry year will bear a less than normal proportion to the rainfall, since it will include only a small surplus from that dry year ; and, conversely, the yield of a dry year following a wet year will bear a greater than normal proportion to the rainfall, since it will include a large surplus from that wet year. Even a year of no rainfall, to take an extreme case, would produce a yield derived from the undischarged surplus of the preceding year. Thus, in view of the foregoing considerations, the discharge of a given year cannot be expected to compare without qualification with the rainfall of that year.

When, however, a number of consecutive annual observations is available—say, twenty or more, the more the better—some assistance may be gained by regarding the problem from another point of view. Rainfall is a physical phenomenon which varies from year to year, according to some ill-understood law ; over a short period these fluctuations appear to be fortuitous, but a long period evinces the fact that those years, the fall in which is in the neighbourhood of the average, occur most frequently, whilst the greater the deviation from the average, both in excess and in defect, the more rare is their recurrence. The longer the period of observations available the more marked and regular is this frequency relation. Similarly, the annual yield, since it is derived from the rainfall, varies accordingly to a frequency relation, the form of which, however, will differ from that of the rainfall, since the discharge is equalised by the drainage area and subject to certain losses. If, then, the annual rainfall and yield be taken separately, and the approximate frequency law which a long series of each would ultimately assume be capable of determination, the two phenomena may be correlated on the assumption that the rainfall of a given frequency produces a yield of the same frequency. By this means all considerations of time-lag and





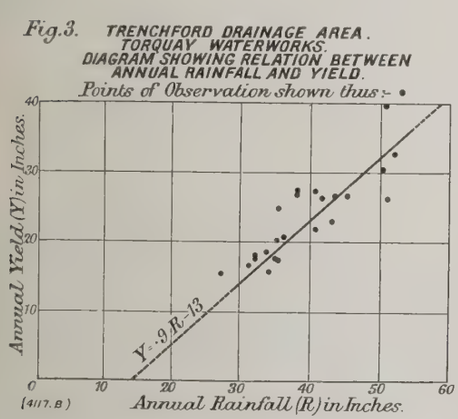


Fig.3.
TRENCHFORD DRAINAGE AREA.
TORQUAY WATERWORKS.
DIAGRAM SHOWING RELATION BETWEEN ANNUAL RAINFALL AND YIELD.
Points of Observation shown thus :- •
Annual Yield (Y) in Inches.
Annual Rainfall (R) in Inches.
Y = 9 R - 13
(4117.B.)

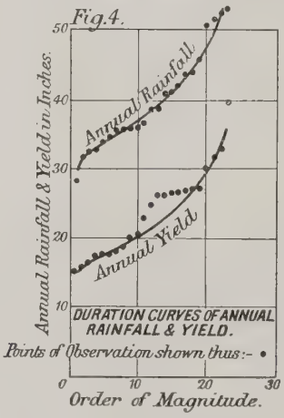


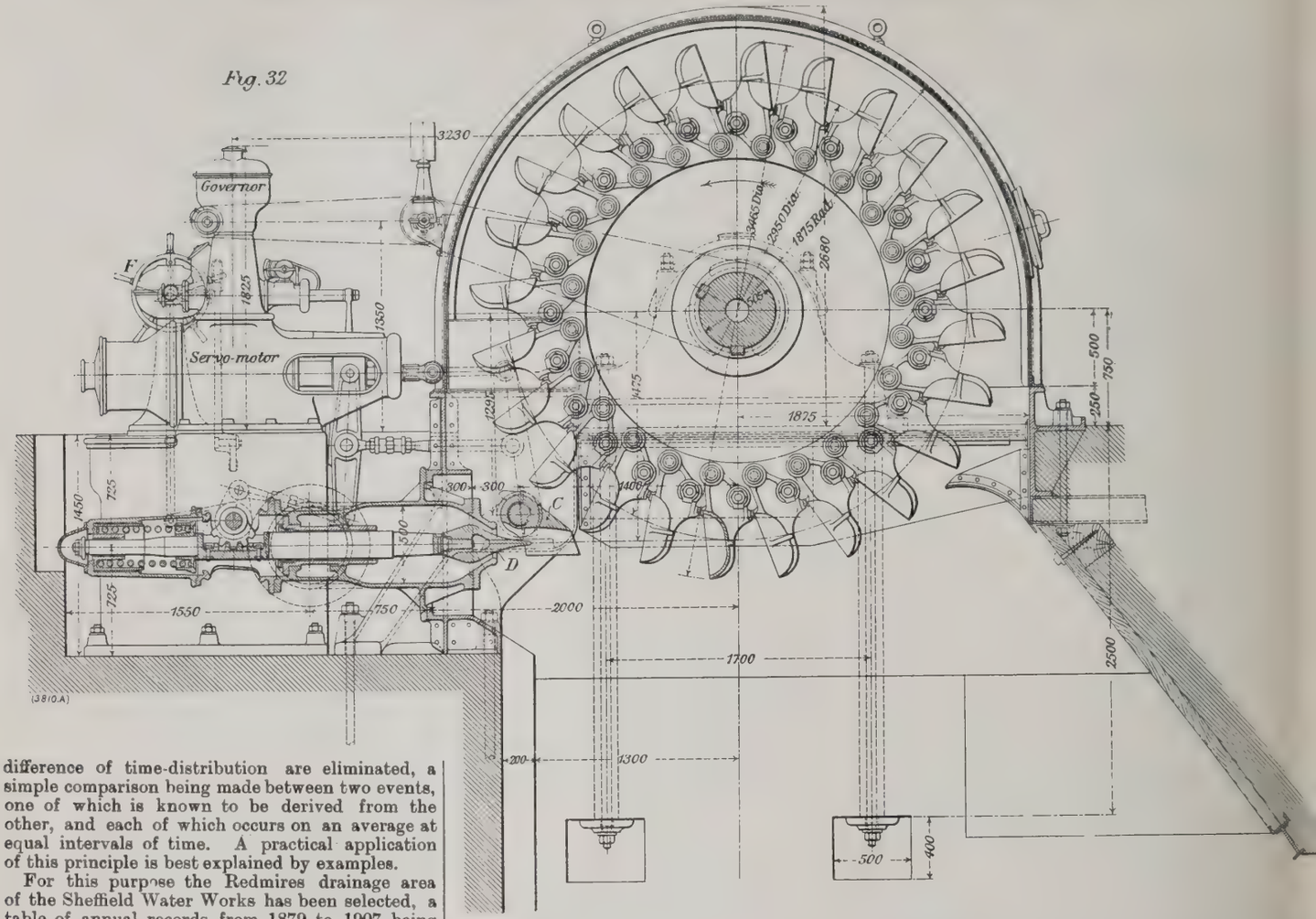
Fig.4.
Annual Rainfall & Yield in Inches.
Annual Rainfall
Annual Yield
DURATION CURVES OF ANNUAL RAINFALL & YIELD.
Points of Observation shown thus :- •
Order of Magnitude.

* Transactions of the Association of Water Engineers. Vol. xv, page 181.

16,000-H.-P. PELTON WHEEL AT THE TYSSEDAL POWER-STATION, NORWAY.

CONSTRUCTED BY MESSRS. PICCARD, PICTET AND CO., ENGINEERS, GENEVA.

Fig. 32



difference of time-distribution are eliminated, a simple comparison being made between two events, one of which is known to be derived from the other, and each of which occurs on an average at equal intervals of time. A practical application of this principle is best explained by examples.

For this purpose the Redmires drainage area of the Sheffield Water Works has been selected, a table of annual records from 1879 to 1907 being given by Mr. L. S. M. Marsh, in the Proceedings of the Institution of Civil Engineers, vol. clxxxi., page 10. Its area is about 5000 acres. From this table each yield is plotted in Fig. 1, page 293, as a black dot against the rainfall of the corresponding year. The distribution of these dots is markedly irregular, and the straight line which would best represent them is not readily determined by eye. Now, in order to apply the principle of equal frequency enunciated above, the two sets of observations should be plotted in order of magnitude, as in Fig. 2. It is immaterial that the years in each set do not appear in the same order. The horizontal scale then measures the number of years out of the total (in this case 29) during which a rainfall or yield of given magnitude is equalled or exceeded; in other words, the points lie approximately on duration curves, and smooth lines drawn among them by freehand, as shown, would represent very fairly the form these curves would take were an indefinitely long series of observations available. When more than, say, twenty years' record can be utilised, the points usually lie in a fairly regular manner, and the smooth lines through them may be drawn with some degree of confidence. The points where any ordinate, such as A B C, cuts the duration curves, represent the rainfall and yield occurring on an average with equal frequency. The rainfall A C and the yield A B may therefore be transferred to Fig. 1, and used as the co-ordinates of a point on the required straight line. A series of points thus transferred from the duration curves will be found to lie on a straight line, or very nearly so, among the points of observation, and from this a formula for the watershed based on equation (2) can be calculated. In the Redmires drainage area the constant C = 14 and a = zero, so that equations (1) and (2) become :—

$$E = 14,$$

and

$$Y = R - 14.$$

or, in words, the annual evaporation is 14 in. whatever the rainfall.

In further illustration, the formula for the Trenchford drainage area (961 acres) of the Torquay Water Works has been calculated. The records from 1887 to 1909 are given by Mr. Samuel C. Chapman in the Transactions of the Association of Water Engineers, vol. xv., page 153. The diagrams, Figs. 3 and 4, page 293, are worked out in a precisely similar manner to those for the Redmires drainage area. In this case the constants are C = 13, a = 0.1, so that equations (1) and (2) become :—

$$E = 0.1\,R + 13,$$

and

$$Y = 0.9\,R - 13.$$

In this case the annual evaporation is not independent of, but increases slightly with, the rainfall.

CALCIUM CARBIDE AND NITROGEN PRODUCTS.

(*Continued from page 272.*)

Continuing our article on the manufacture of calcium carbide and nitrogen products, we give on the present and opposite pages further illustrations of the powerful turbo-generators which provide the electricity for the various chemical reactions involved in the process, as carried out at the works at Odda, on the Hardanger Fjord, Norway. The three latest turbine sets furnished by Messrs. Piccard, Pictet and Co., of Geneva, are also on the Pelton system. Two of the machines have two, and one machine a single running wheel, which run at 250 revolutions per minute. Each set with two wheels is of 16,000 horse-power.

The two running wheels are at a distance of 2 m. (6 ft. $6\frac{11}{16}$ in.) from each other between centres, and are enclosed in a common casing built up of plates. They each receive the impulse of a jet having a diameter of 161 mm. (6.3 in.) at full load. Each of the two nozzles is supplied by a separate set of piping, fitted with an hydraulically-operated valve. The piping is connected to two mains, as described in the previous article. The turbine-shaft, 505 mm. (19.8 in.) in diameter at the part where it is fitted in the wheel-boss, is carried in two bearings with spherical seatings, one 420 mm. (16.5 in.) and the other 320 mm. (12.6 in.) in diameter, this latter provided with strong annular thrusts for maintaining the wheels in the axis of the jets. The bearings are supplied with oil circulation by a small pump, one for each bearing. The oil in the tank is cooled by the water leaving the wheels.

Each wheel has an over-all diameter of 3.465 m. (11 ft. $4\frac{1}{2}$ in.), and is fitted with twenty-four buckets cast in steel, held on a steel disc, also cast, the method of fixation being on Messrs. Piccard, Pictet and Co.'s patent system. In this, each bucket is made with two stay-lugs; these grip the outside ring of the disc, and the bucket is thus astride the disc (Fig. 33). Fastening is obtained by means of two bolts (marked A in Fig. 33), which run through the disc and lugs; the bolts are made slightly conical and engage steel split bushes (marked B), which are machined over their whole length and are made inside with the same taper as the bolts, whilst they are cylindrical on their outside surface, the hole in the disc in which they are fitted being cylindrical also. The bushes are tightened in the hole cut in the disc, and this prevents all loosening of the bucket under the shock it receives from the water-jet at each revolution of the wheel. The holes in the disc being cylindrical and bored on templates with those in the lugs of the buckets, the buckets are interchangeable and can easily be replaced.

The turbines are fitted with the patent method of double automatic governing, based upon the combined action of two different systems, one acting by modification of the flow, and the other by modification of the turbine efficiency, both being combined in one and the same governor. Governing by modification of the turbine efficiency is obtained by means of a tipping device (marked C in

16,000-H.-P. PELTON WHEEL AT THE TYSSEDAL POWER-STATION, NORWAY.

CONSTRUCTED BY MESSRS. PICCARD, PICTET AND CO., ENGINEERS, GENEVA.

Fig. 33.

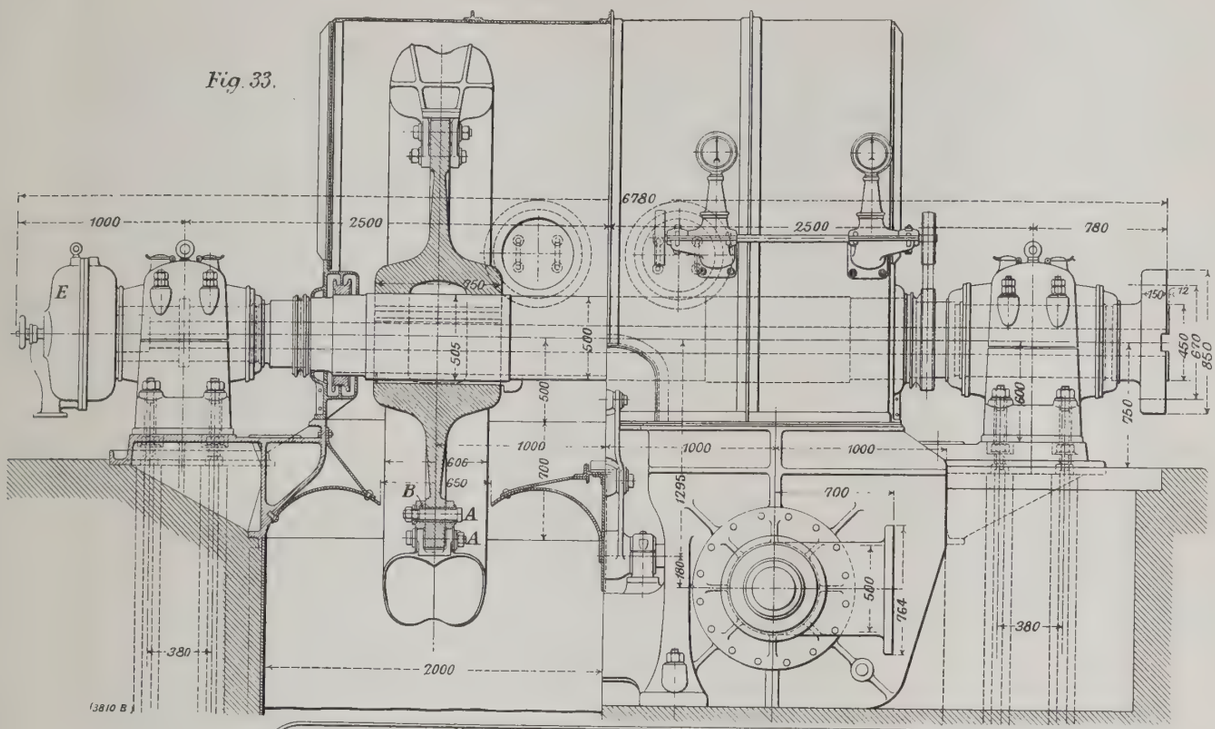


Fig. 34.

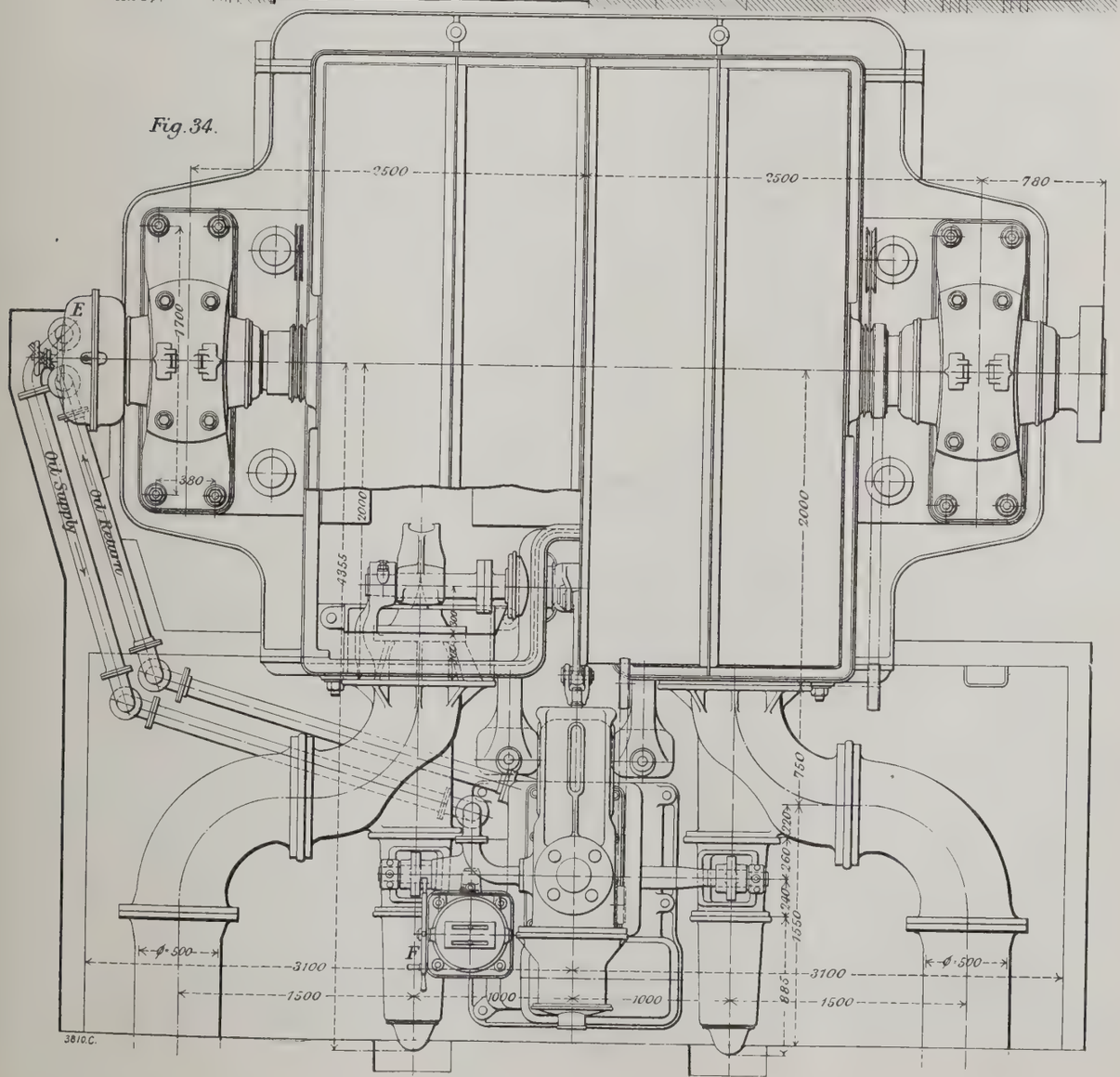


Fig. 32), placed directly at the outlet of the injector on the path of the jet for deviating the latter. Governing by modification of the flow is obtained by means of a needle (marked D in Fig. 32), which is displaced in the direction of the jet axis inside the nozzle-pipe. The tipping device acts very rapidly and gives an excellent governing of the speed without the aid of any revolving masses, whilst the needle acts slowly on the flow, thus preventing all danger through water-hammering in the main. Although both the tipping device and the needle are operated by the same governor, their action is not simultaneous ; the former first deviates the jet, then the needle moves slowly forward in the nozzle-pipe until the flow corresponds with the load for the time being, the tipping device meanwhile returning backwards under the action of the governor. But this return of the device is connected to the motion of the needle, so that gradually as this latter advances, the tipping device rises not to its former position, but to a position tangent to the new jet, the diameter of which has decreased. When the load on the turbine increases, the needle travels backwards under the action of the governor, and at the same time the tipping device rises, and maintains, whatever be the load on the turbine, its position tangent to the jet. The necessary oil under pressure for working the relays is supplied by a pump (marked E in Fig. 33), one for each governor, and placed at the end of the turbine shaft. These pumps are rotary multiple-piston pumps, of strong design, without gearing or valves. They work smoothly, and the multiplicity of the pistons ensures great regularity in their output, an important condition for a governor-pump.

The governor with its relay is located between the two nozzle-pipes ; the tachometer is driven by a belt. This tachometer, though of strong type, is of great sensitiveness, since it contains no joints liable to cause friction, the weights being suspended by flexible steel strips. The governor is provided with a device for varying the speed of the turbine within certain limits, so as to give it the required speed when connecting it up with another set. Another arrangement allows of modifying statism at will—*i.e.*, the difference between the speed under full load and that empty ; this can be done whilst the governor is working. The needles can also be disconnected from the automatic governing device and worked by hand by means of gearing (marked F in Fig. 32) fitted to a column in close proximity to the governor.

The three-phase generators, which are directly coupled to these turbines, were made by the British Westinghouse Company, Manchester. They are designed for an output of 9600 kw. at a power-factor of 0.8, equivalent to 12,000 k.v.a. at 12,000 volts, 25 periods per second. The rotor consists of a solid hub with two steel rings, into which are dovetailed the pole-pieces with pole-shoes. The stator consists of four parts, and has an inside diameter of 3810 mm. (12 ft. 6 in.). The outside diameter of the machine is 5946 mm. (17 ft. 6 in.), and the distance between bearings is 4115 mm. (13 ft. 6 in.) centres. The machines are totally enclosed and furnished with air channels, as described in connection with the Siemens-Schuckert generators illustrated in the previous article.

The magnetising current for the above-mentioned generators is supplied by four turbine-driven exciters. These units were built by the firms furnishing the alternating-current units. The exciter units are also run by Pelton turbines with automatic needle regulation for the speed, but they have no arrangement for regulating the pressure. The capacity of the turbines is 250 horse-power at 750 revolutions per minute, and the water consumption is 64 litres per second. The 110-volt direct-current generators coupled to these turbines have a capacity of 220 electrical horse-power at 750 revolutions per minute. The units are guaranteed for an overload of 80 per cent. above the normal rate.

The switch gear is very complete, and contains all apparatus required for the safe and efficient operation of the modern power plant. The present switch-gear is located in a four-storey building. It was furnished and installed during 1911-1912 by the British Westinghouse Company, of Manchester, and has proved to be very satisfactory. It may be specially mentioned that the automatic oil circuit-breakers have handled a number of severe short-circuits without showing any signs of distress.

The 12,500-volt transmission lines are brought out through the rear wall from the fourth floor of the switch-gear building. The lines to the carbide factories at Odda, situated about 3 miles from the electric generating station, are carried on two rows of steel masts, each row taking two lines. Each line consists of three aluminium cables, with a cross-section of 450 sq. mm. (6.975 sq. in.). The lines are carried along the shore of the Sörfjord, where for some distance the mountains rise almost vertically to a height of more than 1000 metres, and where avalanches of snow and stone are frequent. In order to protect the lines it was found necessary to cut a tunnel about 1200 m. (3936 ft.) long through the mountain. In addition to the overhead conductors there are also two iron-armoured lead-covered treble-conductor copper cables, each conductor having a cross-section of 120 sq. mm. (1.86 sq. in.), which convey power direct to the cyanamide works. With the transformation of the current to suit the requirements of the calcium carbide and cyanamide works we shall deal when describing these works in the succeeding articles.

(*To be continued.*)

LITERATURE.

Les Pierres Précieuses. Par JEAN ESCARD. Paris: H. Dunod and E. Pinat. [Price 30 francs.]

IT is curious to note that France, commonly regarded as the home of luxury and of refined ornament, has long been without an adequate treatise on gems and precious stones. A large literature exists in other countries, from which we can learn how stones have been employed in art and industry, but for thirty years France has not contributed to this subject. The present volume, however, makes amends, covering so large a field that it is difficult to do justice to its comprehensiveness. For the gem can be viewed in many aspects, some of them far removed from the conventional lines of ornament and decoration. The peculiar qualities of hardness and durability demanded of precious stones make them invaluable in some industrial operations ; the action of light on others gives them ready employment in optics and physical research ; in presence of these larger interests, the skill of the lapidary and the art of the jeweller occupy a position of secondary importance.

With the variety and extended application of precious stones, with the possible synthetic reproduction, and with the continual addition of strange and often uncouth names to our catalogues as fresh discoveries are announced, it becomes necessary to review definitions and to ask what constitutes a precious stone? Definitions are always difficult, and when fashion is the arbiter science is at a disadvantage. But in no case would chemical analysis or optical examination decide the question. Oxides, aluminates, silicates, and many other combinations are all represented, so that we have to do not with a natural family, but with artificial groupings. To be a precious stone from the popular point of view a mineral must possess a number of qualifications, but the greatest of these is rarity. It must be transparent and of a fine water—that is, very limpid. It should have a strong, clear colour, devoid of nuances or half-tones, though there are exceptions. The mineral must be very brilliant, a quality that depends upon the optical properties of dispersion and refraction. This last is again a function of density : therefore precious stones are heavy. Further, it must be hard, so as to take and hold a fine polish. The more a stone unites these qualities in a high degree, the higher place it will hold in popular estimation, always provided its rarity makes it difficult to obtain. There are, however, minerals which are neither limpid, nor clear, nor dense, nor hard, and yet have a high place in the hierarchy of valued gems. Such are the opal and labradorite, whose iridescent reflections make their chief charm ; the former especially owes its beauty to the warm reflections that play about in its semi-transparency. The turquoise is opaque, but its beautiful delicate blue colour appeals to the popular taste. Market price is little guide in decisions, for this is controlled by many vague factors. For instance, the topaz, after having been highly esteemed, is to-day utterly *démodé* ; on the other hand, artistic workmanship will give to "fancy stones," *pierres de fantaisie*, a high, if temporary, value. Among these will be reckoned beautiful varieties of quartz, jaspar, agate, feldspar, &c., that by reason of the variety of brilliance and polish to which they are susceptible lend themselves admirably to the graver's tool for the treatment of artistic subjects. Some of these are as yet little known and their qualities inadequately appreciated. It is one of the merits of Mr. Escard's work that he treats these lesser known varieties in considerable detail. This is in some measure due to the fact that many of the minerals suitable for lapidary work are from Madagascar, and have been the product of French exploration. Here may be found the beautiful rose-coloured quartz that is known by several names—tourmalines that run through the whole possible gamut of colours. There are reds of all shades, vieing with the ruby in pure red, and sometimes tinged with violet, or fading away to the most delicate rose ; there are greens and blues, some browns with now and then a smoky tint, some golden-yellows, and one of dazzling gold. Here the colours are uniform in the same crystal, there they alternate to form harmonious blendings. One does not know what to admire most—the delicacy and perfection of the form, the multiplicity and brilliancy of the faces, or the variety and richness of the colours.

With material so varied in its nature and appealing to so many interests, the author has a large field to explore. He traces the part jewels have played in the ancient history of the Egyptian, Greek, and Roman people. Alas, for the credit of human nature, he shows that the most ancient traditions prove that the art of imitating the costly gem has been practised from the time when it was first appreciated and utilised as a personal adornment. The Egyptians, it is to be feared, had as little sense of morality as of chivalry. In the early days, men monopolised the jewels for their own decoration, they were too precious to be wasted on the weaker sex. But as gems became more common, mean men treated their wives to the cheaper kinds, and when the first chemists had learned the art of producing a colourable imitation—and that they very soon did—the wives had to accept the miserable forgery. Later in time, Pliny instructed his world how to decide between true and false stones, and there seems to have been no age when deception was not practised on the ignorant and vain. The author sketches the history of many well-known stones, but it would have extended his volume to unwieldy dimensions to tell of the crime and guilt for which these precious gems have been responsible.

Two chapters are devoted to the discussion of the characteristic properties and peculiarities presented by precious stones generally. The more interesting portions refer to the modification of colour caused by the action of radioactive substances and by X rays. Sir William Crookes has taught us much of the behaviour of diamonds when submitted to these conditions, and also of the phenomena of fluorescence and luminescence. Some of this information is reproduced here, but as we think, without sufficient acknowledgement. The matter, however, is very well summarised, and the facts are clearly stated. It is otherwise when treating of that vexed question, the genesis of the diamond. English chemists and geologists are practically ignored, but what is of more importance is that the rival theories in favour of an aqueous or igneous origin are not clearly outlined. Naturally, reference is made to the meteoric theory, that would persuade us that diamonds are the gift of heaven conveyed to earth in meteoric showers. Such an origin appeals powerfully to the imagination, but though it is certain that diamonds have been extracted from meteoric masses, it may be questioned whether the meteors are the product "du démantèlement d'astres plus ou moins rapprochés de nous." Similarly there is no proof that a particular meteor in which a diamond was found embedded constituted the true matrix of the diamond. If from some catastrophe a portion of our gemmiferous beds, so well described by the author, was ejected into space and arrived on another planet, we know that such a conclusion would be unfounded. Whatever ingenuity is brought to bear upon this problem of genesis, it remains a puzzle. It is even doubtful if we are entitled to say that in some vague and undefined manner carbon, existing deep down in the interna regions of the earth, submitted to high temperatur and great pressure, has been changed from its blac and uninviting appearance to the most beautifu gem which ever saw the light of day. But in som such form that theory finds general acceptance.

A more varied and not less interesting class of gems is that in which the base is either quartz or silica. Among the former are placed the chalcedony, agate, and opals ; in the second, the feldspars and complex silicates. The aluminates, which include the ruby, sapphire, and varieties of spinel, make another important group, while the garnets, tourmalines and beryls form another convenient division. The great number of stones described is quite bewildering, and the popular nomenclature might be revised with advantage. A sufficient description of each is given, and the illustrations of these sections, as elsewhere in the volume, are excellent and admirably supplement the text.

Pearl, coral, and amber can hardly be called precious stones, but their description necessarily finds a place here. The pearl fishery is a large industry, and the trade in imitation pearls possibly still larger. The discovery of X rays has found a new sphere of usefulness in the pearl fishery, since by their aid it is possible to see clearly the position and shape of the pearl secreted within the oyster. Those that show well-developed pearls are opened at once, and the gems extracted. Where smaller pearls are detected, the oyster is placed in tanks and given the opportunity of increasing them, and when no pearl is visible the oyster is returned to the sea. It is claimed that the introduction of radiography has introduced a very decided economy. The presence of the fly in the amber can be detected without any such aid, but when found increases the value of the specimen considerably. The trade in amber amounts to about 8,000,000 francs annually, and that in coral to about one-fourth of that amount.

A true industry, and one that has gained a fair footing in France, is the fabrication of artificial stones, both by synthesis and by a process of reconstruction. In the first case, the problem is to unite the materials of which a stone is composed in such a manner that the product shall possess all the properties of the true stone, whether physical, chemical, optical, or crystalographic, so perfectly that no test can detect any difference from the natural mineral. In this way Moissan has reproduced the diamond, Ebelmen the spinel, Fremy and Feil the ruby and sapphire, and other successes might be recorded. So far as is known, the process of synthesis approaches the formation of the mineral in the depths of the earth. Reconstruction is quite a different process. That consists in pulverising natural stones that are faulty or useless, and reuniting the powder by fusion at a high temperature. By this means solid and transparent masses are produced that can be cut like natural stones, and externally have the same appearance. They are distinguished by the expert by the absence of crystalline texture and the special form of minute gaseous bubbles formed internally. These reconstructed stones are, however, much prized as jewels; they have the composition, the brilliancy, and the hardness of natural stones. The author, who is evidently well acquainted with the whole process of manufacture, or of manipulation of precious stones, as practised in France, where the industry has its home, discusses the future of the diamond in a hopeful manner. He is fully conscious of the difficulties in the details of manufacture, but confidently believes that the process is sound, and that in the future artificial diamonds of several carats weight will be at the command of the jeweller. But to produce artificial diamonds, large in size and perfect in transparency, will be so expensive, that no depreciation in the value of the natural gem is to be feared. Notwithstanding the progress in manufacture by synthesis, for a long time to come the market is likely to be flooded with imitations, more or less worthless, and therefore the author does well to conclude with a chapter on the processes of imitation and the methods of detection. But even when armed with these instructions, one should mistrust his powers to detect a fraud, for long and skilful training in the art of deception has produced such adepts that the successful unmasking of an imposture can only be accomplished by those who have acquired equal knowledge and experience.

The Wonders of Wireless Telegraphy, explained in Simple Terms for the Non-Technical Reader. By J. A. FLEMING, M.A., D.Sc., F.R.S. London : Society for Promoting Christian Knowledge. [Price 3s. 6d. net.]

WHEN the nicely-adjusted apparatus of the laboratory had demonstrated the possibility of dispensing with metallic conductors for the transmission of telegraphic signals, and it became evident that future progress demanded the erection of engineering plant on a large scale, Mr. Marconi, whose name is so honourably connected with the development of wireless telegraphy on a commercial basis, invited the co-operation of Professor Fleming in erecting a power plant for the production and emission of electric waves on a scale hitherto unprecedented. This was but a little more than a dozen years ago, but was before Poldhu had become historical, before electro-magnetic waves had flashed across the Atlantic, and when the modest equipment of a 25-horse-power oil-engine and an alternator capable of producing a low-frequency alternating current at a pressure of 2000 volts was regarded as an imposing installation. Dr. Fleming was thus present at the birth of commercial radiotelegraphy, he has watched over its rapid growth, and his ingenuity and experience have contributed not a little to its progress and development. He is therefore in an admirable position to recount its history, to tell what it has accomplished, and to indicate its hopes and prospects in the future.

Unfortunately, the plan of his book limits the thoroughness of the treatment. Professor Fleming has extended his well-known elementary work on "Waves and Ripples in Air and Water" to embrace electro-magnetic waves in ether, and the method pursued in that work has to some extent decided the arrangement of this book. Consequently the description of the wonders of wireless telegraphy is delayed, pending the setting forth of some physical principles that do not affect the mechanical results. Further, the author has been so closely connected with Marconi that the work of this eminent physicist figures so prominently as to allow insufficient room for the adequate display of the achievement of others who have worked not less indefatigably, but without so complete a recognition. Nevertheless, we doubt if Marconi's great merit is sufficiently emphasised. It is owing to him more than to any other that wireless telegraphy has been placed on a commercial basis and become a great factor in trade and industry. To take the great step involved in passing from the working of laboratory experiments at small cost, to the construction of the apparatus on the large scale necessary for the interchange of messages on a commercial footing, required the skill of the financier as much as the ability of the physicist. To inspire the confidence in the public that was necessary to float a company needed an enthusiast. To perceive the advantage that would result from this addition to our resources demanded the intuition of a prophet. History will probably demonstrate that we are more indebted to Marconi for the strength of his convictions than for the ingenuity of his mechanical inventions.

There is no necessity to describe with any completeness the scientific contents of the book. In six chapters Professor Fleming sketches the main characteristics of electric oscillations and electric waves : the construction and utilisation of apparatus for the transmission and reception of signals ; the results of practical application with the peculiarities that have been encountered and the explanations offered. In these successive chapters, the author is certain to express, lucidly and picturesquely, the fundamental principles that make radiotelegraphy possible. Wide experience provides him with a great wealth of graphic illustration and enables him to draw instructive analogies from other departments of physics that assist the unscientific reader in following, or imagining, the processes that cannot be made evident to the senses. It goes without saying that none of these aids will be wanting, and nothing omitted that will assist the student in grappling with unfamiliar conceptions. In undertaking this task of illuminating the dark places of experimental science the author renders a very essential service. He instructs those who are intelligently interested in the details of a new discovery and its application. He addresses himself entirely to an unspecialised public, and should be readily understood by any receptive mind after diligent attention. Such an amount of attention will be well rewarded, for the wonder of radiotelegraphy lies rather in the method than in the fact of accomplishment. Those who are content simply to marvel at the successful transmission of signals over thousands of miles, or the conveyance of articulate speech over hundreds, only very inadequately comprehend the magnitude of the achievement that excites their admiration. To see it in its proper proportion, some effort must be made to apprehend the mental processes involved in the patient unravelling of recondite phenomena ; the scientific imagination exercised in the contrivance of experiment and the interpretation of results ; and the acuteness of reasoning everywhere practised.

No guide more competent than the author could conduct us through the mazy intricacies of the many problems connected with practical radiotelegraphy, or better discriminate between the many specious speculations and hasty conclusions that new applications bring in their train. In few branches of mechanical science is there greater opportunity to err in misconceiving the results of isolated experiment on a small laboratory scale, conducted under favourable conditions and able supervision, as necessarily directly applicable to the regular conduct of telegraphic communication for commercial purposes at all times and under all conditions. Accuracy and reliability are the qualities that are of the utmost importance. Even efficiency in the technical sense —that is, economy in utilising power for a particular end—is subsidiary to certainty of operation. On practical grounds, therefore, we would willingly have listened to Professor Fleming on some points of technical interest in the method of generating radioelectric waves, a topic that is now exercising electrical engineers. Mechanical methods are pressing hard on those of the spark and arc, and great changes are possible in the equipment of the radiotelegraphic station of the future. The author raises our curiosity in the possibilities of future development without satisfying it, and though the general prospect, seen dimly through uncertain mists, looks very inviting, such a hand-book may not be the place to discuss the salient features too closely.

BOOKS RECEIVED.

All the World's Aircraft. Founded and edited by FRED. T. JANE. Sixth year of issue. London : Sampson Low, Marston and Co., Limited.

Commercial Year-Book of the Birmingham Chamber of Commerce, with Trade Index. Compiled under the authority of the Chamber, and edited by the Secretary, G. HENRY WRIGHT, F.C.I.S. With an Introduction by the President, H. W. SAMBIDGE, J.P. Derby, Leeds, and London : Bemrose and Sons, Limited.

The Petroleum Year-Book, 1914. Compiled and arranged by SYDNEY H. NORTH. London : Wilkinson Brothers, Limited. [Price 5s net.]

History and Romance of the Petroleum Industry. By J. D. HENRY. In three or more volumes. Vol. I. London : Published by the Author, 4, London-Wall Buildings. [Price 10s. net.]

The Journal of the Institute of Metals. Vol. XI. Edited by G. SHAW SCOTT, M.Sc., Secretary. London : Published by the Institute.

Link Motions, Valve-Gears, and Valve-Setting. By FRED. H. COLOM. Third Edition, revised and enlarged. New York : The Norman W. Henley Publishing Company. [Price 50 cents.]

United States Geological Survey : Department of the Interior. Professional Papers. Shorter Contributions to General Geology. No. 90-A. *Geology of the Pitchblende Ores of Colorado.* By EDSON S. BASTIN. No. 90-B. *Erosion and Sedimentation in Chesapeake Bay around the Mouth of Choptank River.* By J. FRED. HUNTER. No. 85-D. *The Jurassic Flora of Cape Lisburne, Alaska.* By F. H. KNOWLTON No. 85-E. *Resins in Paleozoic Plants and in Coals of High Rank.* By DAVID WHITE. Washington : Government Printing Office.

United States Geological Survey : Department of the Interior. Professional Papers. No. 69. *The Earthquakes at Yakulat Bay, Alaska, in September,* 1899. By RALPH S. TARR and LAWRENCE MARTIN. With a Preface by G. K GILBERT. No. 74. *Geology and Ore Deposits of the Butte District, Montana.* By WALTER HARVEY WEED. No. 81. *Cretaceous Deposits of the Eastern Gulf Region and Species of Exogyra from the Eastern Gulf Region and the Carolinas.* By LLOYD WILLIAM STEPHENSON. No. 82. *The Geology of Long Island, New York.* By MYRON L. FULLER. No. 84. *The Upper Cretaceous and Eocene Floras of South Carolina and Georgia.* By EDWARD WILBUR BERRY. Washington : Government Printing Office.

Monthly Statement of Coal-Mine Fatalities in the United States : March, 1914. By ALBERT H. FAY. Washington : Government Printing Office.

United States, Department of the Interior : Bureau of Mines. Technical Papers. No. 59. *Fires in Lake Superior Iron-Mines.* By EDWIN HIGGINS. No. 67. *Mine Signboards.* By EDWIN HIGGINS and EDWARD STEIDLE. No. 68 *Draining Wells in Oklahoma by the Mud-Laden Fluid Method.* By A. G. HEGGEM and J. A POLLARD. Washington : Government Printing Office.

United States Geological Survey : Department of the Interior. Bulletins. No 580-A. *The Darwin Silver-Lead Mining District, California.* By ADOLPH KNOPF. No. 580-B. *Notes on the Unaweep Copper District, Colorado.* By B. S. BUTLER. No. 580-C. *Some Cerusite Deposits in Custer County, Colorado* By J. FRED. HUNTER. Washington : Government Printing Office.

PORTABLE LEAD-MELTING FURNACE FOR JOINTS OF CAST-IRON PIPES.

CONSTRUCTED BY MESSRS. GEORGE GREEN AND CO., ENGINEERS, KEIGHLEY.

Fig. 1.

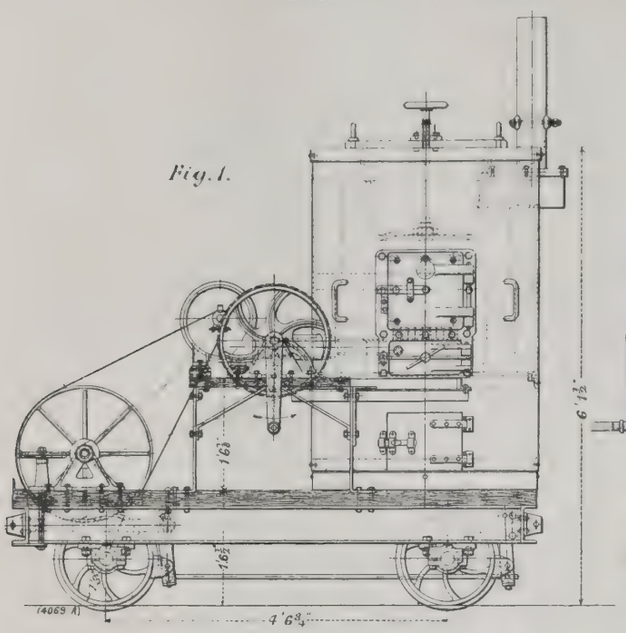


Fig. 2.

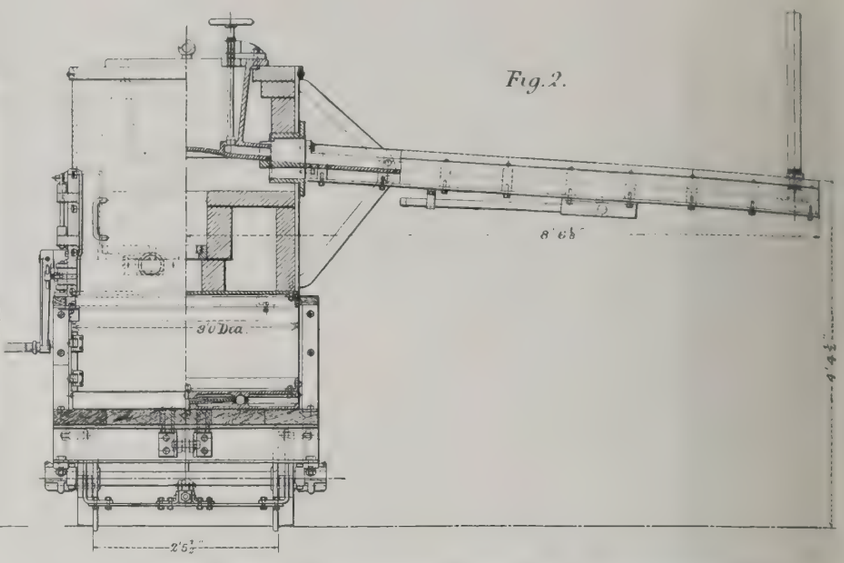
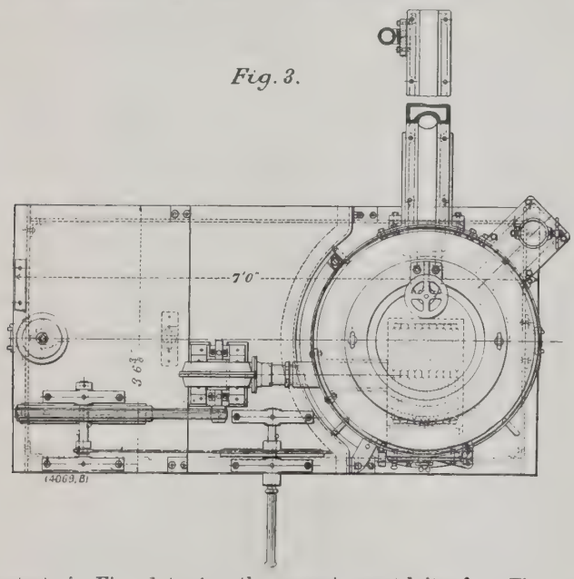


Fig. 3.



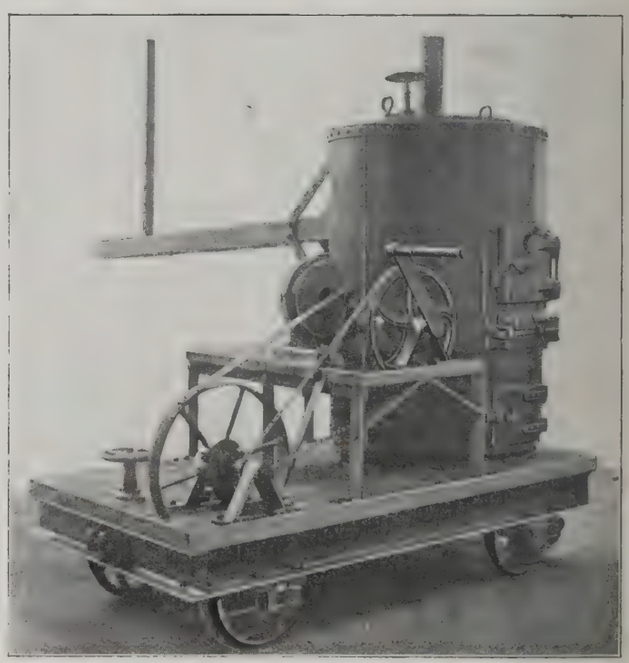


FIG. 4

WE illustrate in Figs. 1 to 4 on the present page a portable lead-melting furnace for pouring the joints of cast-iron water-mains. It is built by Messrs. George Green and Co., engineers, Keighley, and consists of one of their improved soft-metal melting furnaces, lined with firebrick and mounted upon a ball-bearing turntable (see Figs. 2 and 3) on a steel bogie. The bogie is carried on cast-steel wheels with improved dust-proof roller bearings, and fitted, as shown in Fig. 1, with a hand-screw brake, which acts on all four wheels. The furnace is designed for burning ordinary gas-coke fuel, forced draught being used, the fan being driven by hand by means of the transmission device shown in our illustration. One man can easily produce sufficient blast for the melting. The melting-pot, which can be seen in Figs. 1 and 2, and in plan in Fig. 3, is of cast iron, a screw stopper-plug provided with a hand-wheel regulates and cuts off the flow of molten metal. Owing to its length, the pouring-spout is heated with hot blast, with a view to keep the molten lead fluid whilst pouring; a damper is provided in the smoke-pipe for regulating the current of hot blast to suit the requirements. A chamber at the bottom of the furnace shell, underneath the furnace proper, serves as a store for coke. The furnace we illustrate has been designed for the pouring of lead joints on 50-in. diameter pipes; the capacity of the melting-pot is 10 cwt. of molten lead. The design can be varied to suit special requirements.

CUTTING-OFF MACHINES FOR PIPES.

THE illustrations on page 299 show two machines, designed and constructed by Messrs. Charles Winn and Co., of Granville-street, Birmingham, for rapidly cutting off lengths of iron and steel pipes, electric conduits, &c. The machine illustrated in Fig. 1 is capable of working on pipes up to 4 in. bore, while that shown in Fig. 2 takes in pipes up to 2 in. bore. The details illustrated in Figs. 3 to 9 belong to the smaller machine, and the following description refers particularly to this, though it may be taken as applying generally to the larger machine as well. What differences there are between the two machines can easily be seen by comparing Figs. 1 and 2.

The frame and headstock are cast in one piece, as can be seen in Figs. 1 and 2, and they are strongly ribbed to ensure rigidity; the gibs are of strong section, to withstand rough usage, and wide apart to resist the torsion of the saddle. The machine is driven by a three-speed cone-pulley carried directly behind the headstock, and power is transmitted to the spindle by machine-cut gearing, protected by guards as shown. The drive has been made sufficiently powerful to allow full advantage to be taken of modern high-speed steel-cutting tools. The headstock bearings are of ample proportions, and are adjustable for wear, and the spindle, which is hollow, is fitted with a thrust-collar at the front end and with locking-rings at the back end to take up end play; it is also provided with a bush-holder at the back end, into which bushes of various sizes are fitted to support the outer ends of long tubes. Figs. 3 to 6 illustrate details of the headstock and of the firm's patent quick-grip chuck, which is probably the most interesting part of the machine, and adds largely to its efficiency. The chuck, which is of the four-jaw self-centring type, is opened and closed while the machine is in motion by means of the capstan levers, prominently shown in Figs. 1 and 2, and an examination of Figs. 3 and 5 will show how this is accomplished. It will be seen that the capstan head is keyed to a short shaft, at the other end of which is a pinion *a* which engages with a geared segment on the Y-shaped lever *b*. The upper ends of this lever fit into a groove in the outer part of the chuck, so that by turning the capstan levers in a clockwise direction the outer part of the chuck is moved longitudinally from left to right. This movement forces the jaws inwards, since their outer ends rest on the conical inner surface of the outer ring of the chuck, as shown in Fig. 3, and the jaws thus grip the pipe tightly; to release them, the capstan levers are turned in the opposite direction, thus allowing the jaws to be moved outwards by the flat springs shown in Fig. 6. To adjust the jaws to take pipes of different sizes, it is only necessary to slack back two nuts and turn the outer ring of the chuck about its axis. The jaws rest on eccentric cam surfaces formed on the chuck-ring, so that they move radially inwards or outwards, according to the direction in which the chuck-ring is turned; the arrangement is clearly shown in Fig. 6. The adjustment that can be effected in this way is about one-third of the total capacity of the chuck, but further adjustment can be obtained by changing the jaws, an operation which can be very

CUTTING-OFF MACHINES FOR PIPES.

CONSTRUCTED BY MESSRS. CHARLES WINN AND CO., ENGINEERS, BIRMINGHAM.

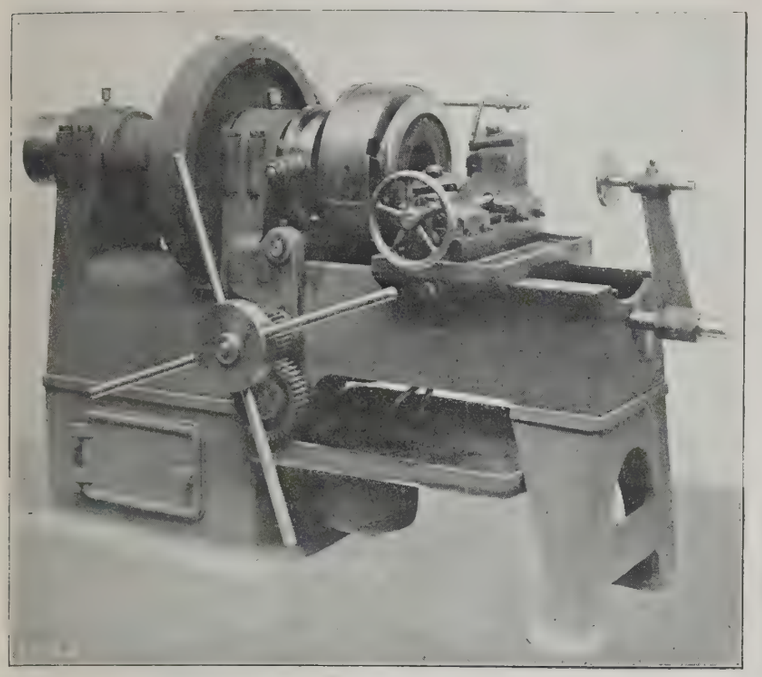


FIG. 1.

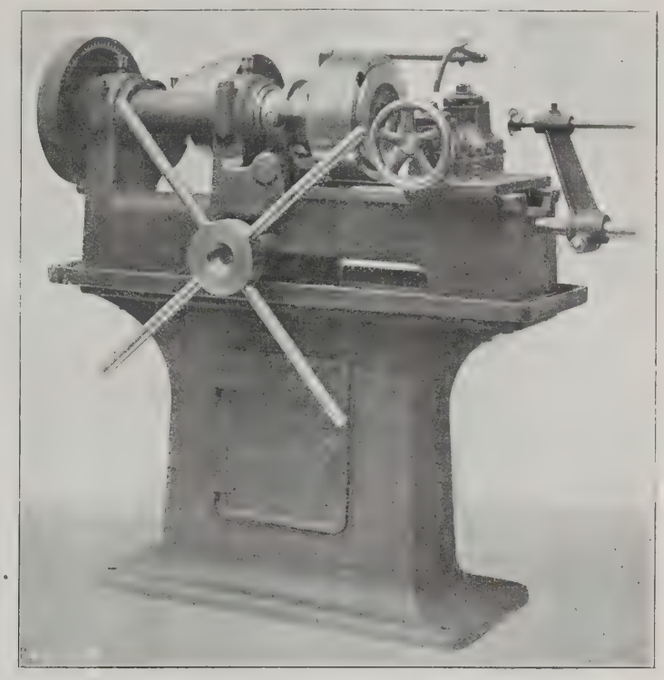
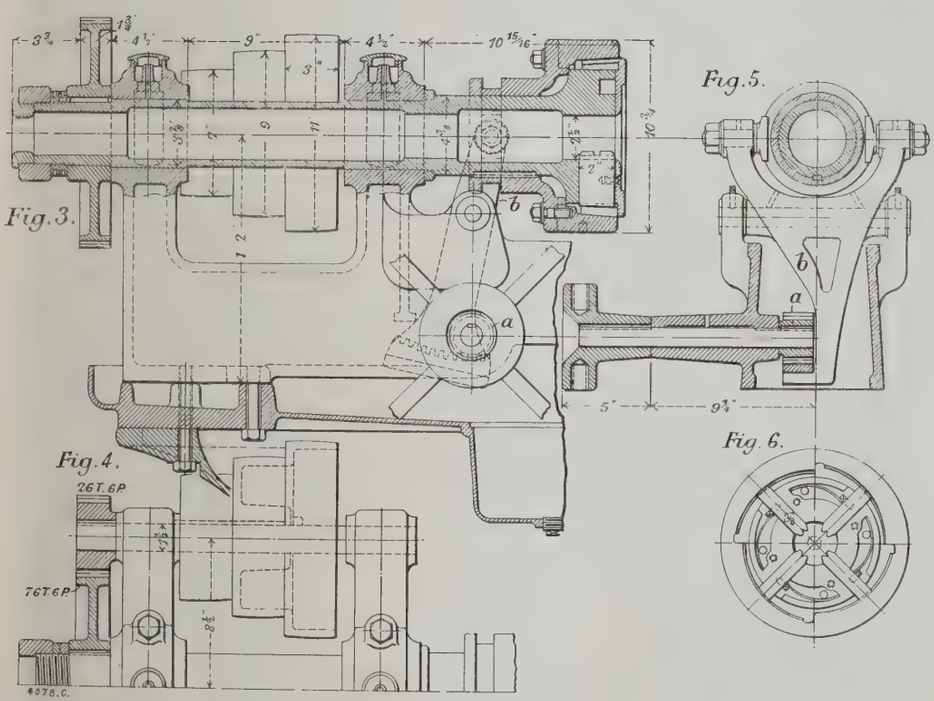
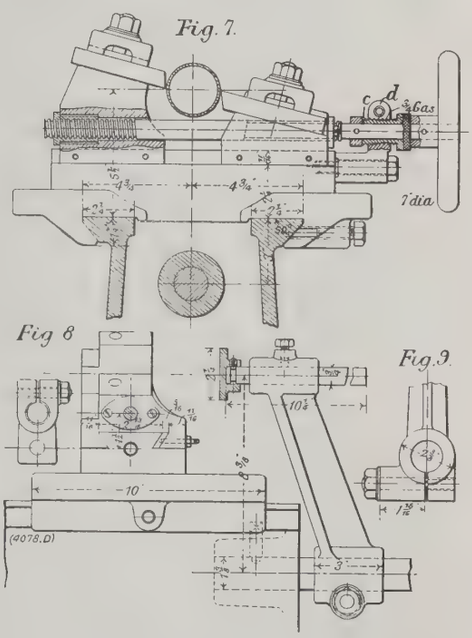


FIG. 2.





easily carried out without removing any part of the chuck.

Details of the saddle and slide are illustrated in Figs. 7 and 8. It will be seen that the saddle is fitted with two tool-rests set at an angle, so that the cutting-tools may be of the simplest possible form. The tools are each arranged to absorb the thrust of the other, and to clear themselves in cutting, thus permitting high cutting speeds. They are fed into the work by means of a hand-wheel and screw, the latter being cut with right and left-handed threads, which work in renewable gun-metal nuts fitted into the rests, as shown in Fig. 7. The same figure also shows the means adopted to equalise the cutting of the two tools. For this purpose, the screw *c*, working in the fixed nut *d*, is provided, and, by turning the knurled head of this screw, the required adjustment can be effected.

The machines are fitted with an adjustable length-stop, which can be seen in Figs. 1 and 2, and is shown in detail in Figs. 8 and 9; it can be swung out of the way when it is required to cut a long pipe. They are also provided with a rotary-gear pump to supply a continuous stream of lubricant to the cutting-tools, and with a tray having a reservoir and strainer to collect the used lubricant and swarf.

With these machines a piece of 1-in. gas pipe can be cut off in 5 seconds and a 2-in. gas pipe in 12 seconds. The machines are made in smaller and larger sizes than those illustrated, the larger machines being capable of cutting pipes up to 8-in. bore.

VICTORIAN EXPENDITURE. — The skill and integrity with which the finances of Victoria have been controlled has been productive of the best results. The great bulk of the Victorian Government loans was raised for the prosecution of reproductive public works; and these works not only secured fairly remunerative employment for the Victorian working classes, but the harbours and railways which were brought into operation gave a valuable and sustained stimulus to all departments of Victorian trade and industry. The skill with which the loans of Victoria were financed had also the effect of enabling the Victorian Government to raise capital at reasonable rates; and it is not a little satisfactory to add that while European securities have been greatly affected by the recent course of European history, Antipodean investments have hardly suffered at all. In 1855 the average rate of interest on Victorian loans was 6 per cent. In 1860 it still stood at 5.99 per cent.; but in 1870 there was a decline to 5.78 per cent.; in 1880 to 5.01 per cent.; in 1890 to 3.99 per cent.; and in 1900 to 3.83 per cent. In 1910 a further reduction to 3.56 per cent. had been secured, and in 1911 and 1912 the average was only 3.54 per cent. In 1855 the outstanding public loans of Victoria amounted to 480,000*l.*; in 1860, to 5,118,100*l.*; in 1870, to 11,924,800*l.*; in 1880, to 20,056,600*l.*; in 1890, to 41,377,693*l.*; in 1900, to 48,774,885*l.*; and in 1910, to 55,501,725*l.* In 1911 a total of 57,933,764*l.* was attained; and in 1912 this aggregate was further carried to 60,712,216*l.* The effect of the severe economy practised in the matter of interest was that, notwithstanding the great increase of the debt and the very considerable expenditure incurred for useful public works, the annual charge for interest only stood in 1912 at 2,150,748*l.*, or a debt of 44*l.* 17s. 7d. per head of the population, the annual charge for interest per head being 1*l.* 11s. 10d. Victorian finance is certainly a credit to Victorian administration. Notwithstanding the lightness of Victorian indebtedness *per capita*, stocks and debentures had been purchased and cancelled at the close of June, 1912, to the extent of 1,356,489*l.*

INDUSTRIAL NOTES.

THE report recently issued by the Royal Commission on Mining in South Africa states that the coal deposits in South Africa are numerous, but comparatively undeveloped. In 1913 the total output only amounted to 8,800,000 tons, valued at about 2,200,000*l.* The value of the output in diamonds in the Union of South Africa was 11,389,000*l.* in 1913, and in the same year the gold output from the Transvaal was valued at 37,400,000*l.* In regard to cost of production in the gold mines of the Witwatersrand it is said that by calculating the working capacity of two Europeans as equal to that of three natives, it is estimated that if natives at their present cost per shift—viz., 3s. 2d. per head—had to be replaced by Europeans at 10s.—and this appeared to be the minimum wage at which Europeans could live in the Transvaal—out of the fifty-two producing mines for which figures were available, twenty-six would cease to make a profit. If the white labourers replacing natives were paid at the rate of 12s. 6d., about the current rate in Western Australia, where living is cheaper, out of the fifty-two mines, thirty-five would cease to make a profit. The average cost of native labour, 3s. 2d. per shift, includes the cost of food, recruiting and compound expenses, in addition to money wages. In 1913 the value of gold recovered per ton of ore, reckoned at the rate of 4*l.* 4s. 11½d. per fine ounce, was 27s. 9d., in which sum the working costs per ton of ore were 17s. 11d., and the average gross working profit per ton of ore 9s. 10d.

The total amount paid in salaries and wages by the Rand gold-mines was 13,600,000*l.* in 1912, and 12,900,000*l.* in 1913. The average wage of the white employee, excluding the technical and clerical staff, was 316*l.* per year. That of the native was 30*l.* If to this latter sum there be added 10*l.* for housing the native and for the rations he receives, the white man, who is employed almost wholly in supervision, will be seen to receive about eight times as much in wage as the native, who does the manual work. The Economic Commission has found that, when allowance is made for the cost of living, the Witwatersrand workman is better off, in a monetary sense, than the workman in Australia and America, and much better off than the workman in Europe.

We are informed that employment in the engineering trades in the Manchester district is expected to become almost normal in a week or so. The improvement is due to the demand for skilled labour in the establishments making naval guns and munitions of war, the reopening of machine-making shops, and the receiving of large orders which, but for the war, would have been placed in Germany.

The sixtieth quarterly report for June last, issued by the General Federation of Trade Unions, gives the balance-sheet for the quarter ended June 30 last, which shows a membership of 985,344, and an excess of income over expenditure of 10,372*l.* 11s.

The same quarterly report states that the question of how the war is going to affect trade unions is being asked on every side. The answer can only be arrived at when one knows how the trade unions are going to face the situation. It goes without saying that there will be a greatly increased volume of unemployment, and the trade unions paying unemployment benefit are sure to be faced with serious difficulties. Some unions will have a fair percentage of members in employment during the whole of the war, and these members will manifest both their common-sense and their patriotism by maintaining, or even increasing, their normal contributions. The problem of retaining the effective membership of the workless members will be serious. Where Reservists or Territorials have been mobilised steps should be taken, not only to retain intact their membership, but to keep in touch with them. Another really important matter is the setting aside of funds for the sole purpose of securing the continued existence of the union and the carrying on of its work.

A meeting convened by the Wholesale Textile Association was held in London on Wednesday, the 26th ult., when it was stated that, in Germany, when a manufacturer obtained an order he could go to a commercial bank and get an advance to the amount of 60 per cent. of the value of the order. That enabled him both to buy raw material and to pay wages while he was carrying out the work. English banks, on the other hand, immediately asked for securities or personal guarantees. The result was that the small manufacturer in this country had no chance. It was decided to ask the Chancellor of the Exchequer to encourage existing banks to grant the necessary facilities, or else to found a commercial bank on the German model. Sir George Pragnell, chairman of the Wholesale Textile Association, remarked that in the movement to capture the trade of Germany and Austria they had so far only touched the fringe of the matter.

In a pamphlet, No. 124, issued by the United States Department of Labour we find it stated that no data are obtainable giving accurate information as to wages and membership in unions prior to 1906. A few unions have complete records of membership, but on account of the many independent or dual unions that have been connected with the general arbitration plan it is impossible to show the precise increase in membership of a large number of unions. Again, it must be understood that the question of jurisdiction and amalgamation has had a very marked influence on membership.

It is for this reason that it is impossible to show the number of men receiving increased wages, but in considering the skilled crafts as a whole the increase in 1913 over that paid in 1906 was approximately 6.5 per cent., while the unskilled occupations showed an increase of about 5.5 per cent.

In the skilled occupations the greatest increase in wage rates for 1913 over 1906 was received by the boiler-makers, 1.50 dols. per day, or from 3.50 dols. to 5 dols. per day. The smallest increase was 20 cents, received by the carpenters and structural and ornamental iron-workers, or from 4.80 dols. to 5 dols. The house-shorers, considered a semi-skilled occupation, though fast becoming a skilled occupation, received an increase of only 18 cents during the same period.

Among the unskilled occupations the plasterers' labourers were obliged to accept a reduction in wages from 3.50 dols. per day to 3.25 dols. per day, but the general increase in the other unskilled occupations amounted approximately to 25 cents per day on the average.

On Thursday last, the 27th ult., the Prime Minister received at the House of Commons the deputation appointed by a conference representing the Parliamentary Committee of the Trade Union Congress, the General Federation of Trade Unions, and the National Executive of the Labour Party, to which we referred in our last issue (see page 285 *ante*). Mr. Arthur Henderson, M.P., introduced the deputation, and, together with Mr. J. A. Seddon and Mr. W. A. Appleton, spoke in support of the four resolutions passed at the conference.

The Prime Minister expressed his entire agreement with the deputation with regard to the termination of existing trade disputes, the settlement by amicable arrangement of future difficulties, and the desirability of the cessation of overtime wherever possible. He stated that he was in sympathy with the suggestion that the machinery of the trade unions should, if possible, be employed for the relief of their members, in conjunction with the local relief committees, but he added that the question of the appropriation grant was a large and difficult one, which he must submit to the careful consideration of his colleagues.

Our contemporary, *L'Industria*, Rome, states that the question of the Saturday half-holiday is not one which has ever to any degree occupied the attention of the Italian working classes. Except in very few isolated cases, on occasions when the men have asked for a reduction in working hours, has the question been raised, and the men have agreed to let the matter slide immediately the employers have commenced to argue the point with them. In Italy, the main reason for reducing the number of working hours on Saturdays—*i.e.*, the absolute observance of Sunday as a day of rest—is non-existent. Speaking generally, the working classes do not feel the need of the "British week," and the industry of the country is not in a condition to bear the extra expenditure which it would entail.

The same journal also states that the war has produced in a number of Italian industrial firms an abnormal state of affairs, quite apart from the results due to financial perturbations. It would therefore not be surprising if a number of Italian firms preferred to close altogether temporarily, or were compelled to do so. Our contemporary would deem it prudent on the part of the firms who are actually, or who may find themselves shortly, in difficulties caused by the war, immediately to take the necessary measures, and see whether it would not be preferable to close their establishments several days a week. By taking this action they would be able to exist over a longer time, and to give their whole staff occupation—reduced, it is true—but nevertheless of great value in the circumstances. This would be much preferable to working full time for a shorter period, then closing down completely, and immobilising the whole staff. After writing the above, our contemporary was glad to add, in an editorial note, that the measure thus advocated had been adopted by most of the Italian works.

In an article in the New York *Railway Age Gazette*, on "German Criticism of State Railway Management," it is said that Germany's State railway management is an oppressive monopoly and a political mistake. Recently this view was expressed at three different industrial congresses, and in one case the indictment was backed by a two-thirds majority. This revolt against railway nationalisation comes just at the time when some Americans and Englishmen have begun to see in nationalisation an easy, infallible way out of all railway troubles. What aggravates the indictment is that it is mainly directed against the Prussian State system, which of all railway systems in Germany is the most flourishing and efficient. Every charge that is customarily levelled against corporation railway ownership is now (July 19) levelled against the Prussian State system. The main charge is that the Prussian system makes for monopoly and restraint of trade. In committing all the offences which private corporations commit, the State knows no fear, for against it the public is doubly helpless, and there are no competing roads which can be used to bring the extortionate State to reason. German experience shows that State ownership does not prevent monopoly. Monopoly remains monopoly, even though it is managed by officials, and the State is only the national organ of erring men.

CONTRACTS.—The Edison and Swan United Electric Light Company, Limited, have received a contract for 12 months' supply of standard type "Royal Ediswan" drawn wire and also "Royal Ediswan" carbon and special type lamps for H.M. Office of Works.

GERMAN AND AUSTRIAN TRADE IN BRASS AND BRASSWARE.—Another White Paper has recently been issued by the Commercial Intelligence Branch of the Board of Trade relating to the exports of brass and brassware by Germany and Austria. Compared with our own exports in these trades, those of our rivals are enormous, though the available figures seem slightly less favourable to the United Kingdom than they actually are, since their figures cover certain articles not included in our own. As far as they form a guide, however, in a recent year, while the United Kingdom exported goods of this class to the amount of 1.6 million sterling, Austria's exports were 1 million and Germany's nearly 6.5 millions. The principal exports of Germany were:—Brass, tombac, and similar alloys, 549,650*l.*; rods, sheets, &c., of same, 1,088,700*l.*; wire of copper alloys, 314,200*l.*; lacquered and other wares of sheet brass, &c., 2,368,200*l.*; wares of copper, tombac, brass, &c., "verniert," coloured, coated with nickel, &c., 1,075,000*l.* In many of these articles France and Italy are the largest purchasers from Germany, but in others Great Britain ranks as the largest buyer. In one or two cases Russia is Germany's largest market. Like previous reports, this one gives interesting information on the markets, extracted from consular reports, &c., and all interested in enlarging their business while the opportunity offers would find these well worth perusal.

THE IRON AND STEEL INSTITUTE.—We are informed that in consequence of the war, the Comité des Forges de France has been obliged to cancel all arrangements for an autumn meeting of the Institute in France this year. Under the circumstances, the Council have decided that it would be advisable to postpone for the present the organisation of any alternative arrangements for an autumn meeting for the reading and discussion of papers. The following papers have been submitted:—(1) "Note on the Theory of Hardening and on the Constitution of Steel," by E. D. Campbell; (2) "By-Product Coking Industry and its Relation to the Manufacture of Iron and Steel," by G. S. Cooper; (3) "Determination of Cobalt in High-Speed Steels," by L. Dufty; (4) "Electrolytic Iron: its Manufacture, Properties, and Uses," by L. Guillet; (5) "Transverse Testing of Cast Iron," by G. Hailstone; (6) "Utilisation of Heat Contained in Slags," by W. L. Johnson; (7) "Mechanical Charging of Blast-Furnaces," by N. G. Kapp; (8) "Iron-Ore Deposits of Lorraine and the West of France," by P. Nicou; (9) "The Transformations of Steels," by H. de Nolly and M. Veyret; (10) "Oxygen Content of Open-Hearth Steel," by J. A. Pickard and F. M. Potter; (11) "Decarburisation of the Steels in Salt-Hardening Baths," by A. M. Portevin; (12) "Influence of Coalescence on Mechanical Properties of Steels and Alloys," by A. M. Portevin and V. Bernard; (13) "Use of Liquid Ferro-Manganese in the Steel Processes," by A. Sahlin; (14) "New Process for Heating Blast-Furnace Stoves," by A. Spannagel. The Council propose to print in the usual way advance copies of those papers approved for publication, and to invite discussion thereon by correspondence. It is expected that the copies will be ready for issue about the second week in September, and they may then be procured from the Secretary by members who desire to send in written contributions to the discussions. The papers and correspondence thereon will be published in the next number of the Journal. If, later in the year, any meeting becomes necessary for the discharge of formal business of the Institute, due notice will be sent to all members. The Council wish to place on record an expression of their most sincere sympathy, which they are sure will be shared by all members, with their President, Mr. Adolphe Greiner, and his family in the great anxieties under which they are at present suffering, in common with his countrymen, at whose hands the Institute experienced such kindly hospitality in the autumn of last year. We take this opportunity of associating ourselves fully with the Council of the Iron and Steel Institute in their expression of sympathy to Mr. Adolphe Greiner and his family.

PROFESSIONAL EXAMINATIONS.

To the Editor of Engineering.

SIR,—Now that many of the younger engineers will no doubt have joined, or be joining, some branch of the national forces, there would seem to be a possibility that a considerable number may be prejudiced in respect to the various professional examinations to be held in the near future. It would manifestly be an injustice to those candidates who are absent performing their first duty to their country if those who remain behind, and so avoid such duty, should be placed in any position of advantage over them in respect to these examinations, and whatever prestige they confer.

I would therefore suggest that the various examining authorities should carefully consider this matter with a view to devising some equitable solution of the difficulty; or even that the examinations should be suspended for a time, and so enable all to compete on equal terms eventually, all being meanwhile free to undertake their patriotic duties.

My views are taken from an impartial, and not from any personal, standpoint. I am of an age far beyond any examination, and have neither relative, pupil, assistant, nor friend who can be affected one way or the other. It is without any personal bias, therefore, that I ask for this matter to be considered.

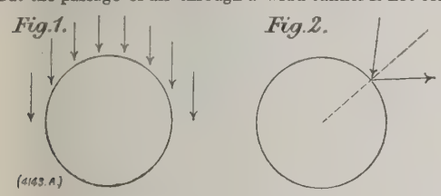
Yours faithfully,
AN AGED ENGINEER.

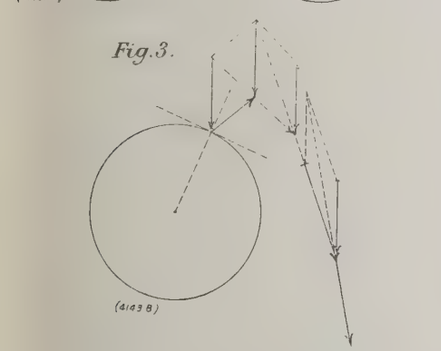
Westminster, September 2, 1914.

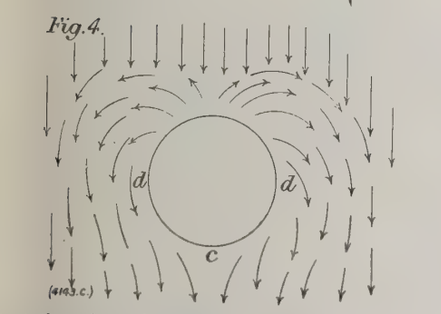
"DISTRIBUTION OF PRESSURE AROUND CYLINDRICAL RODS AND BODIES WHEN EXPOSED TO UNIFORM AIR-CURRENTS."

To the Editor of Engineering.

SIR,—The article by Dr. Thurston on "The Distribution of Pressure Around Cylindrical Rods and Bodies when Exposed to Uniform Air-Currents" is of great interest; but are the conditions under which the experiments were made conformable to real life? Apparently the experiments were conducted on the same lines as those of Messrs. Irminger and Iterson—viz., the suspension of the object in a "wind tunnel" or tube. But the passage of air through a wind tunnel is not constant throughout the section of the tunnel. It would move slower at the circumference than in the centre, being retarded at the sides by friction; and, further, the object experimented upon contracts the area of the tunnel, and obstructs its flow, thus driving the air against the sides of the tunnel, where, not being quite so free to escape, it has to squeeze in between the object and the sides of the tunnel. These are not the conditions in open air. In open air the velocity would be practically uniform, and would meet with no resistance in an outward direction—that is, at right angles to the flow—beyond the pressure of the air-current against the yielding air wall. It would not be confined by any unyielding tunnel walls. If the circular rod, 0.832 in. in diameter, were placed in a tunnel of double the diameter of the former tunnel, would the results be identical?







The curves given, without doubt, reveal the truth approximately, and can, perhaps, have light thrown upon them in the following way:—

Consider the air current to be split up into a number of equi-distant streams, represented by a number of jets of water playing on the cylinder in parallel lines, or by a number of balls projected forward with equal force, thus (see Fig. 1).

Consider the effect of each stream separately and independently of the rest. It is obvious that the effect would be a rebound from the surface struck, as shown in Fig. 2. But as each rebounding jet or ball is struck by the next on-rushing jet or ball, its course is altered, as indicated in Fig. 3, the combined effect of the whole of the rebounds being to push the on-rushing current aside and produce a suction on the two sides, as represented in the diagram accompanying Dr. Thurston's paper.

I should not have thought, however, that the suction would have been uniform in the lower half, but somewhat greater at c than d, as shown in Fig. 4.

It is interesting to observe, as pointed out and illustrated in my work on "The Guide-Framing of Gasholders" (published in 1889), that the effect of wind pressure on the floating bell of a gas-holder is not that of the wind thrusting it directly against the standards. The force of the wind is not conveyed around the floating holder as if it were an arch, or in the manner it would be if there were no internal gas pressure. The holder is pushed over by the internal gas pressure on the off side, through the wind pressure neutralising the gas pressure on the near side, or the side against which the wind impinges.

If the diagram of external wind pressure given by Dr. Thurston is combined with a diagram of the internal gas pressure which acts radially outwards uniformly around the circle, it will give for all practicable purposes the resultant forces acting on the floating holder, together with the guide-framing supporting it.

Yours truly,
August 29, 1914. F. S. CRIPPS.

PERSONAL.—The Dey Time Registers, Limited, of Queen Victoria-street, E.C., have amalgamated with the International Time Recording Company, Limited, of City-road, E.C., and both firms will give up their present premises. The combined businesses will be known as the International Time Recording Company, Limited, and will occupy the entire five-storey building at 30/32, Farringdon-road, E.C. This brings together the two oldest and largest firms in the business.—The engineering business established forty years ago by the eminent Swedish engineer, the late Mr. Richard Schram, and since his decease, fifteen years ago, carried on under the title of Schram, Harker and Co., will henceforth be carried on under the designation of Harker, Cable and Co., at the same address, Cannon-street House, London, E.C.

LLOYD'S STATISTICS OF VESSELS LOST, &c.—During the quarter ended March 31 last, 13 British steamers, totalling 13,600 gross tons, were removed from Lloyd's Register. Of these ships, one was abandoned at sea, two were lost in collision, one foundered, four were reported as missing, and the other five were wrecked. As would be expected, this loss is greater than that of any other country, but as the tonnage lost is only 0.07 per cent. of the total steam tonnage owned in this country, the figures may be regarded as satisfactory. The British Colonial losses are six ships, of an aggregate tonnage of 4247, during the period, this loss being 0.27 per cent. of the total tonnage owned in the Colonies. The United States lost three vessels, making 12,382 tons together, and Sweden lost five vessels, totalling 12,175 tons, the percentages of the total tonnages owned in these countries being 0.63 and 1.29 respectively. Next in order on the list come Norway with ten ships (10,017 tons), Japan with six ships (9366 tons), Germany with 11 ships (7961 tons), Italy with six ships (5558 tons), and Denmark with three ships (4660 tons); the percentages lost in the case of these five countries are 0.54, 0.62, 0.17, 0.44, and 0.66 respectively. The only other countries mentioned individually in the statistics recently issued by Lloyd's Register are Spain, France, Holland, and Russia, and their respective losses are 2969 tons, 2289 tons, 2192 tons, and 1749 tons. Other countries have, however, lost ships of an aggregate tonnage of 7465 between them, thus bringing the grand total for all the countries of the world to 78 steamers, of 96,630 tons in all. Coming now to sailing-ships, we find that altogether the world's losses amount to 73 vessels, aggregating 49,221 net tons. The United States heads the list for this class of shipping, having lost 23 vessels, making 19,854 tons together, which is 1.93 per cent. of the total sailing tonnage owned in the United States. Norway takes second place, this country's losses having been 10 ships, aggregating 9966 tons (1.7 per cent. of the total tonnage), while Great Britain comes third on the list, our losses having been 6841 tons, in 14 vessels, and the tonnage lost being 1.62 per cent. of the total British tonnage of sailing-ships. The British Colonies have lost six ships, making 1373 tons in all, which is 0.86 per cent. of the total Colonial tonnage. The only other countries with losses exceeding 1000 tons are: Germany, with 5202 tons; Italy, with 2495 tons; and Sweden, with 1618 tons; the percentages of the total tonnages owned by these countries are 1.53, 1.01, and 1.57 respectively. In all cases, it will be noticed, the percentage of sailing tonnage lost is considerably higher than the corresponding figure for steamships, and this fact clearly indicates the greater risks to which the former class of shipping is exposed. In the above figures it should be mentioned that, in the case of steamships, the tonnage given is the gross tonnage in each case, while for sailing-ships the net tonnage is quoted. Vessels of less than 100 tons, and the ships trading on the Great Lakes of North America, are not considered in compiling the above statistics.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, August 19.

THERE has been a general falling off in business in all lines of iron and steel. Numerous encouraging inquiries come from the Pacific Coast asking for material to prosecute urgent work. The European war is primarily responsible for the stringency of bank money to push much pending construction work. Until this banking problem is solved, the structural mills especially will suffer. Railroads are ordering next to nothing. Even the car-builders report no new order. Great apprehension is felt in all American shipyards over the prospective passage of a law permitting American registry to purchase foreign ships. If the coastwise shipping can be excepted, the law will be acceptable, as American shipyards exist on this patronage. Plans for securing as much Western Hemisphere trade as possible continue to be formulated. Actual steel production has not as yet declined, but many tin-plate mills have shut down, owing to the inability to obtain tin. Steel production is jeopardised by the exhaustion of ferro-manganese. Pig-iron is hardening in prices without a corresponding demand. Small advances have been made in bars, sheets, and crude steel. The American steel trade has assumed the attitude of "watchful waiting." The anticipation of a heavy demand for mill products is general, but the extent of damage that may be suffered from existing embroilments abroad cannot be guessed at. Our iron and steel export trade is not seriously affected, as over 40 per cent. of it is absorbed in Canada.

MESSRS. R. AND W. HAWTHORN, LESLIE AND CO.—The thirtieth annual meeting of Messrs. R. and W. Hawthorn, Leslie and Co., Limited, was held on Monday, Sir B. C. Browne in the chair. The accounts showed a divisible balance of 101,477*l.*, and dividends amounting to 7½ per cent. were proposed for the year, the reserve fund being increased to 186,000*l.*, and 30,788*l.* being carried forward. The chairman said the company had been busy during the past twelve months, and all departments had done well. The largest share of the work turned out had been carried out for the British Admiralty; and as long as the war lasted the company must sacrifice everything to meet the requirements of the Government.

THE CHADWICK TRUST AND THE WAR.—We are informed that the following resolution has been passed by the Chadwick Trustees:—"In view of the immense importance of encouraging in every way the promotion of careful sanitary organisation in the naval and military services during the present campaign, the Chadwick Trustees have resolved, under the powers conferred upon them under the scheme they administer, to announce their intention to award, at the close of this year, the Chadwick Gold Medal and 50*l.* each to the naval and military medical officer respectively in the British Service who shall have distinguished himself most in promoting the health of the men in the Navy and the Army. The nomination for such presentations to be, as provided by the terms of the trust, by the Directors-General of the Naval and Military Medical Services respectively." The Chadwick Trustees are also making arrangements for providing, or assisting in the provision of, lectures and demonstrations on naval, military, and hospital hygiene. Particulars of these lectures will shortly be announced.

COMPETITION WITH GERMANY AND AUSTRIA-HUNGARY.—In connection with the campaign undertaken by the Board of Trade, on the advice of their Advisory Committee on Commercial Intelligence, to assist British manufacturers and merchants to secure trade formerly in the hands of German or Austro-Hungarian firms, the Board have received a very large number of inquiries for names of sellers or buyers of articles of which sources of supply or markets have been interfered with by the war. Special arrangements have been made in the Commercial Intelligence Branch of the Board of Trade for dealing with the inquiries, and lists are being prepared and circulated of articles which inquirers desire: (*a*) to purchase; and (*b*) to sell. The first lists are now ready, and may be obtained on application to the Branch. Firms interested in any of the goods mentioned, either as buyers or sellers, should communicate with the Director. An enlarged sample-room will also be established very shortly for the purpose of exhibiting samples of German and Austrian or Hungarian goods or materials which have competed with British products at home or abroad, especially those which are necessary for the continuance of British manufacture, but which it is now impossible for them to obtain from their previous sources. Firms who may wish to exhibit goods are invited to make application to the Commercial Intelligence Branch. It should be expressly understood, however, that the Exhibition is intended exclusively for samples of goods which have formerly been obtained in Germany and Austria-Hungary alone and which firms may now desire to purchase in the United Kingdom. Notice will be given of the opening of the Exhibition. A catalogue library will also be opened, and firms who may not desire to exhibit samples are invited to furnish catalogues of goods formerly received by them from Germany and Austria-Hungary; these catalogues to be classified by trades in order to be readily accessible to inquirers. The address of the Commercial Intelligence Branch is 73, Basinghall-street, London, E.C.

MAIN ENGINES FOR THE CANADIAN CUSTOMS CRUISER "MARGARET."

CONSTRUCTED BY MESSRS. JOHN I. THORNYCROFT AND CO., LIMITED, SOUTHAMPTON.

Fig. 24.

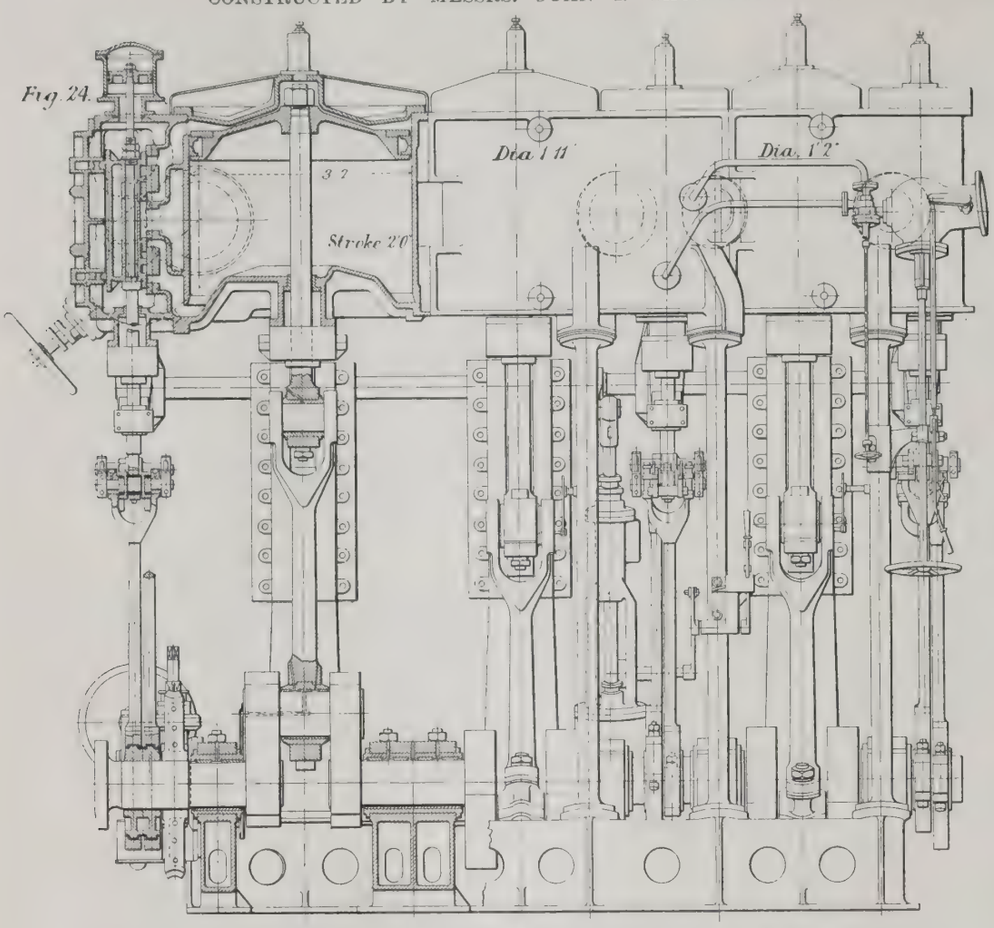


Fig. 26.

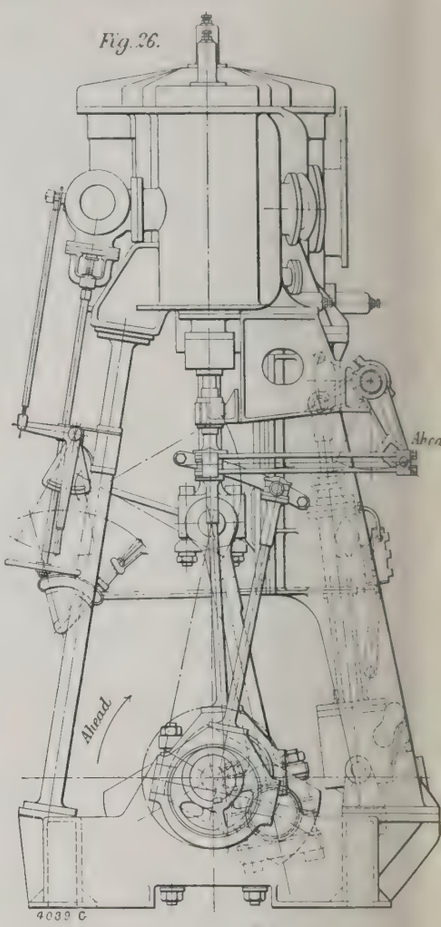


Fig. 25.

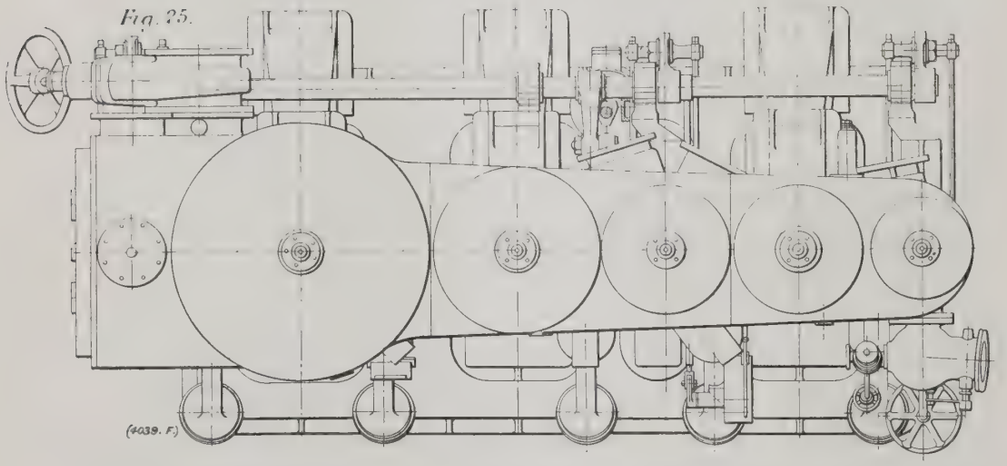
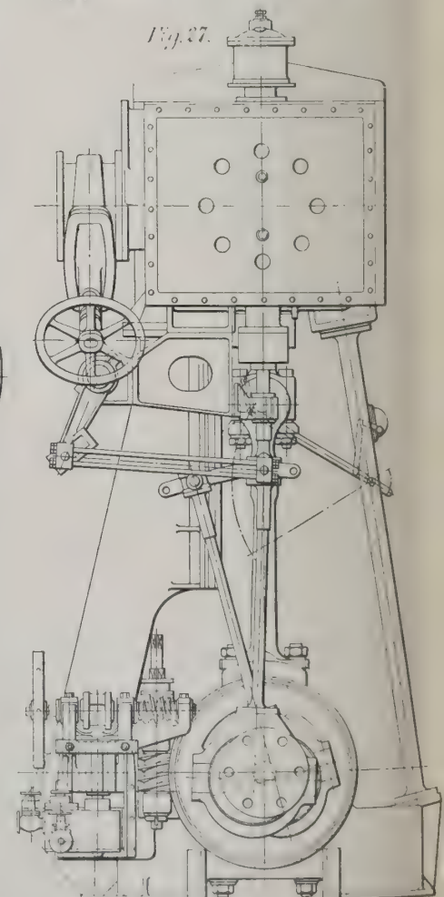


Fig. 27.



CANADIAN CUSTOMS CRUISER.

(*Concluded from page* 247).

Having dealt in our last article with the deck and cabin arrangements of the Canadian Customs cruiser Margaret, we now propose to deal with the machinery equipment. Various figures illustrative of this will be found on Plate XXII., and on the present and opposite pages. The propelling machinery, which is shown in position in the ship in Figs. 15 to 17, on the plate, and in greater detail in Figs. 24 to 27, annexed, consists of two sets of vertical reciprocating engines having a combined indicated horse-power of 2000 at 180 revolutions per minute. The cylinder diameters are 14 in., 23 in., and 38 in., and the stroke is 24 in. The high-pressure and intermediate-pressure cylinders are fitted with piston-valves, and the low-pressure cylinder with a flat double-ported valve with relief-rings on the back. The valve-gear is of the Stephenson type, with double bar-links, and is reversed by a direct-acting engine, built by Messrs. Scott, Mac-Taggart and Co. Each main engine has an independent steam turning engine, while alternative hand-gear is fitted. The arrangement can be seen in Fig. 27.

Each engine has a separate condenser with steel body and cast-iron ends. The tubes and tube-plates are of brass. Circulating water is delivered to the condensers by two independent centrifugal pumps, driven by vertical open-type engines. The pumps and engines were built by Messrs. Gwynne. In the engine-room there is a 15-ton evaporator by Messrs. Weir, which is used for make-up feed purposes, the vapour-pipe being led direct to the port condenser. It can be seen in Fig. 16. The two air-pumps are of the Weir monotype, having their suctions connected to the condensers, and each delivering to feed filter-tanks in the engine-room. The main and auxiliary feed-pumps are of the Weir type, their steam supply being automatically controlled by a lever actuated from their common float-tank. The main feed-pump is arranged to draw from the feed filter-tanks, reserve feed-tank, or direct from the condenser and deliver through a Rankine filter, then through a Weir surface feed-heater, to the main feed-valves on the boilers. The auxiliary feed-pump suctions are as above, but the pump delivers direct to the auxiliary feed-valves on the boilers. The other auxiliary machinery in the engine-room comprises bilge-pumps, fresh-water pump, general-service pump, and sanitary pump. These pumps are all of Messrs. Weir's make. The services they perform were dealt with in our previous article. Their positions in the engine-room can be seen in the various figures on Plate XXII. The electric lighting and power plant is shown in Figs. 15 and 16. It consists of two 15-kw. 110-volt steam sets, by Messrs. Clarke, Chapman and

CANADIAN CUSTOMS CRUISER "MARGARET;" ARRANGEMENT OF MACHINERY.

CONSTRUCTED BY MESSRS. JOHN I. THORNYCROFT AND CO., LIMITED, SHIPBUILDERS AND ENGINEERS, SOUTHAMPTON.

(*For Description, see Page* 302.)

Fig. 15.

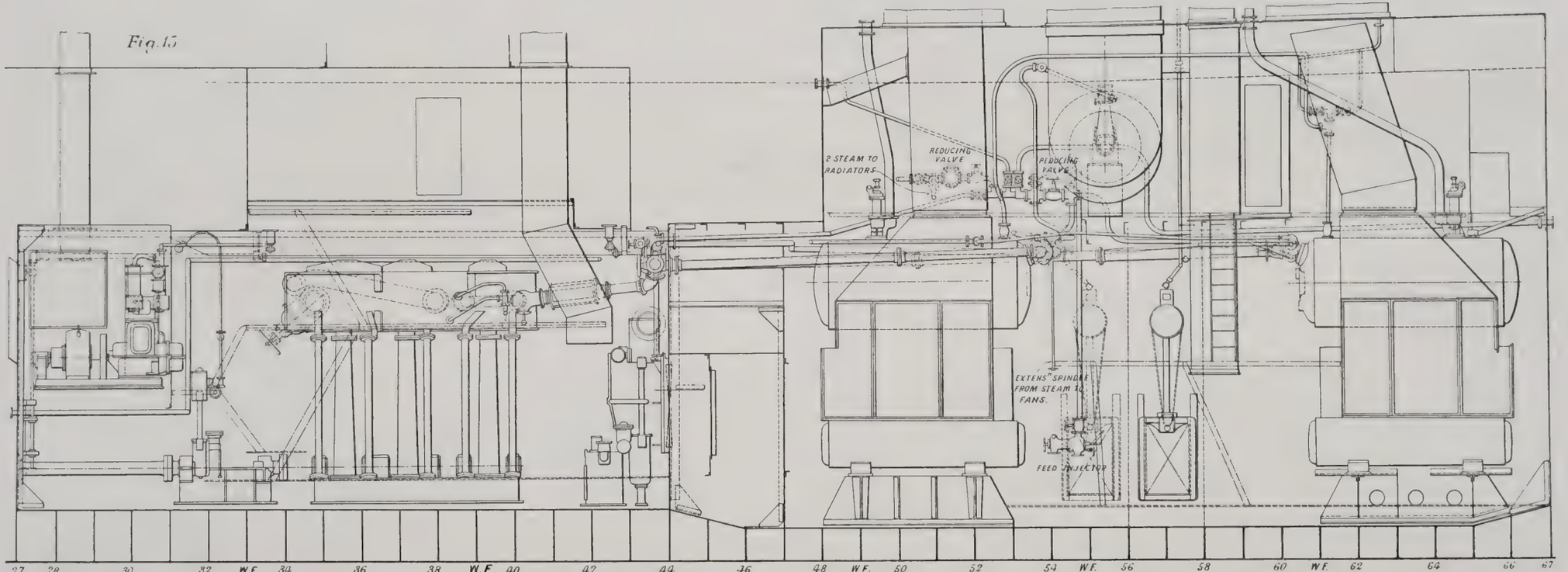
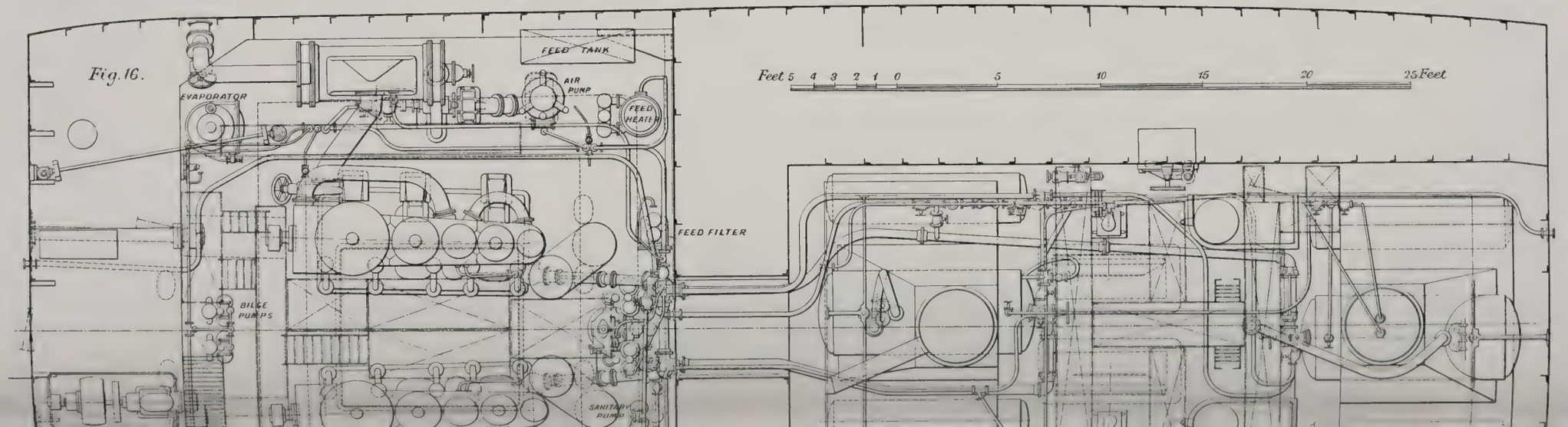

2 STEAM TO RADIATORS
REDUCING VALVE
REDUCING VALVE
EXTENS" SPINDLE FROM STEAM TO FANS.
FEED INJECTOR
27 28 30 32 W.F. 34 36 38 W.F 40 42 44 46 48 W.F. 50 52 54 W.F. 56 58 60 W.F. 62 64 66 67

Fig. 16.



ENGINE ROOM LOOKING FORWARD

Fig. 17.

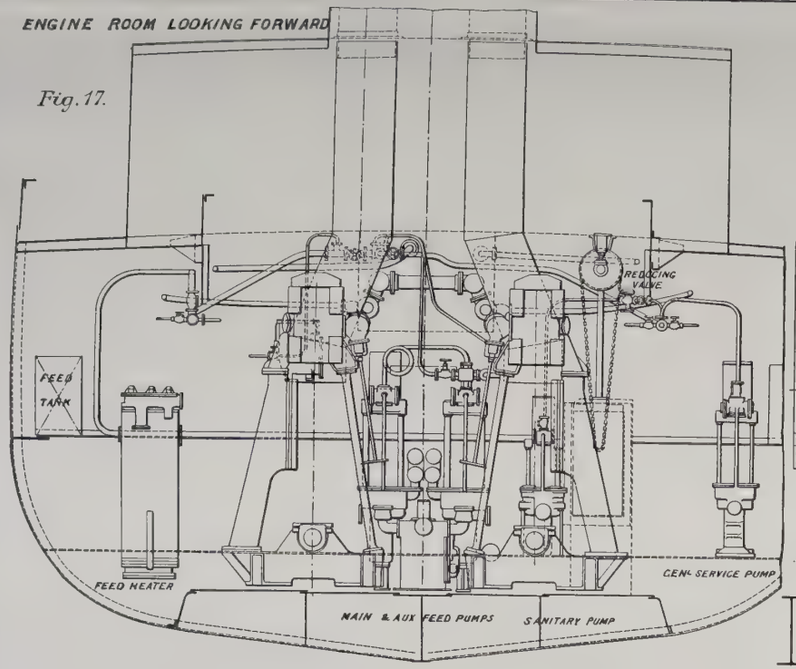
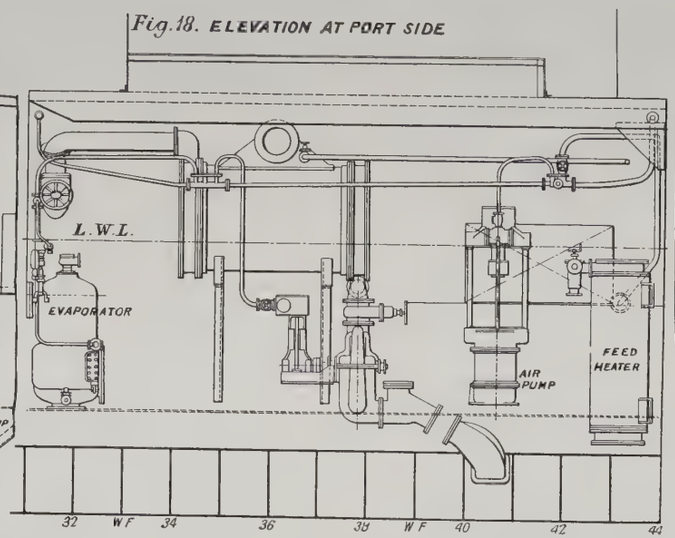
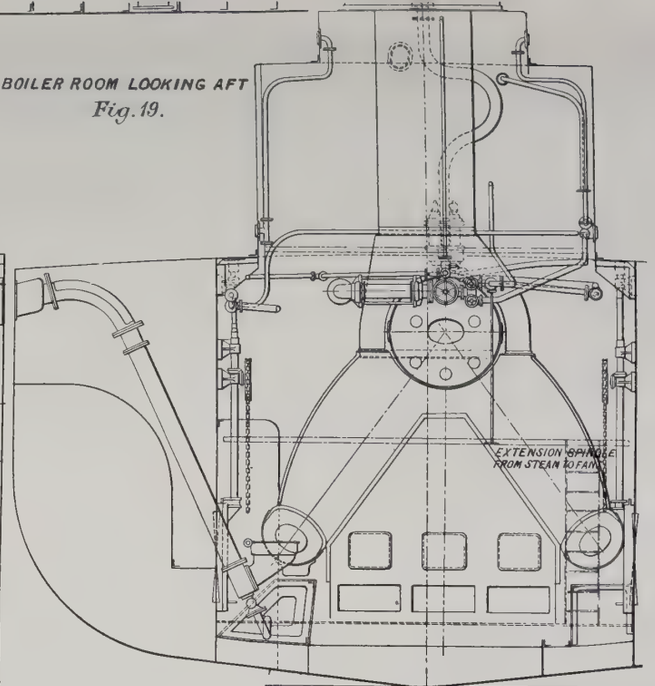


Fig. 18. ELEVATION AT PORT SIDE



BOILER ROOM LOOKING AFT

Fig. 19.



BOILER ROOM LOOKING FORWARD

Fig. 20. ENGINE ROOM LOOKING AFT

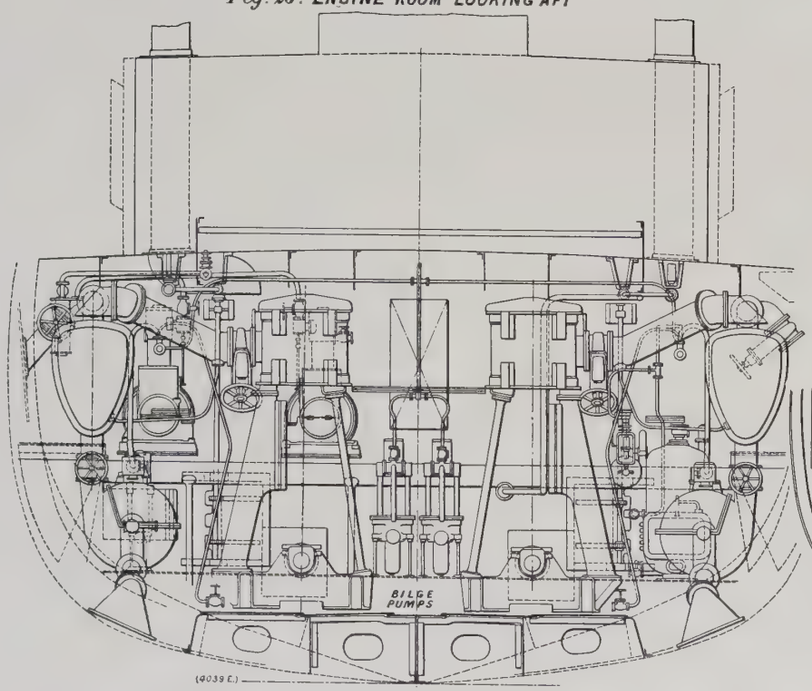


Fig. 21.
AIR PUMP AT FRAME 40

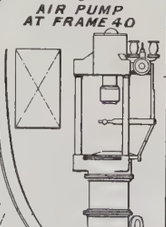


Fig. 22. ELEVATION AT STARBOARD SIDE.

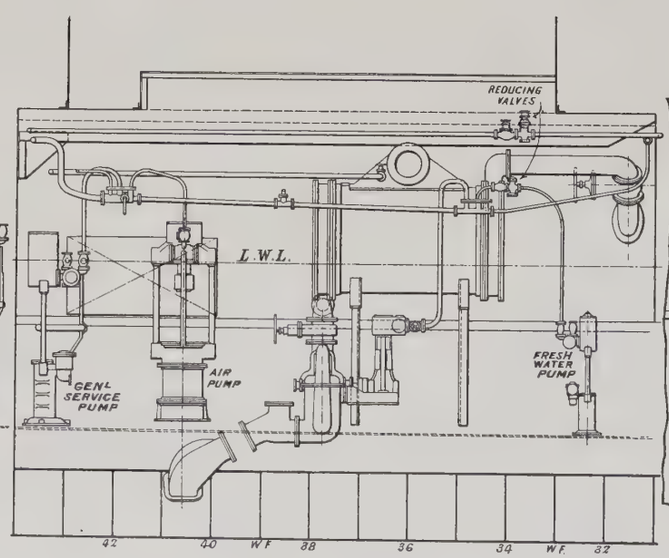
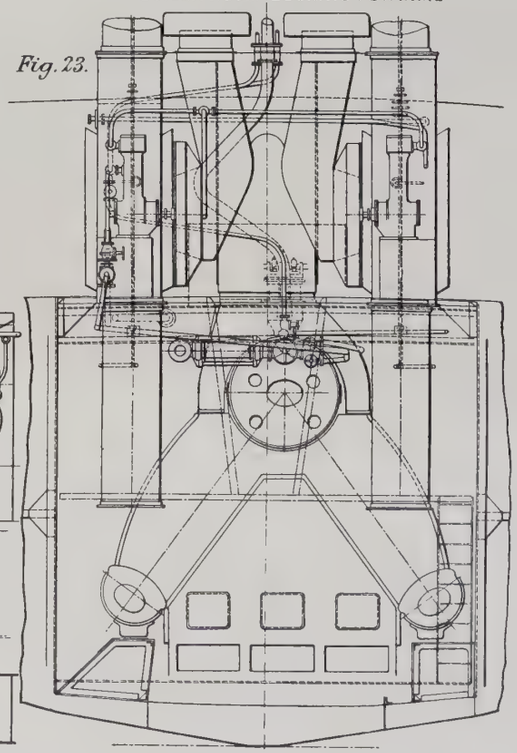


Fig. 23.



THE CANADIAN CUSTOMS CRUISER "MARGARET."

CONSTRUCTED BY MESSRS. JOHN I. THORNYCROFT AND CO., LTD., SOUTHAMPTON.

Fig. 28. Wireless Telegraphy Room.

. In addition to furnishing lighting and power for
ns, &c., the generating sets supply current for the
reless-telegraphy outfit. This, which is illustrated
Fig. 28, above, is a standard 1½-kw. Marconi in-
llation, with emergency gear.

The boiler-room is reached from the engine-room
rough an air-lock, controlled at the engine-room
lkhead by a Mechan's patent sliding-door. The two
lers are of the water-tube type, coal fired. The
rking pressure is 220 lb. per sq. in., the heating
face being 3297 sq. ft., and the grate surface 60.4
ft. in each case. Each boiler is fitted with
mford's feed-regulating gear and Madan's patent
-extinguishers. Air is supplied to the stokehold by
o Brotherhood fans and engines of the enclosed type.
Sellar's self-acting feed injector is fitted in the
kehold, and arranged to draw from the reserve-feed
k, and deliver to the boilers through the auxiliary
d-valves. The steam-pipes are of solid-drawn steel,
main steam ranges having expansion joints. The
kehold is provided with a See's patent ash-ejector,
ing its water supply from the general-service pump.
e bunkers have a total capacity of 200 tons, giving
ange of nearly 2000 miles at full speed, and about
0 miles at an economical speed.

The Margaret was launched on January 14 last, in
unusually advanced condition; the machinery and
ommodation being so nearly completed that a pre-
inary six-hour trial was carried out on January 20.
e progressive trials were held on January 25. Four
s were made at varying speeds from 6 knots up to
knots, the load consisting of 157 tons on a draught
0 ft. 2 in. The results obtained were very satis-
ory. Forced draught was only used on the last
runs at 13¾ and 15¼ knots. Consumption trials
e afterwards carried out at 12¾ and 8¾ knots. On
uary 29 the official full-power trial was run con-
ing of six hours at full power. Six runs each of
mile in the middle of the six hours showed a mean
ed of 15.415 knots, with the engines running at
revolutions per minute and developing 2050 indi-
d horse-power. The mean speed over the whole
hours was 15.37 knots, the mean revolutions per
ute 186¾ and the indicated horse-power 2050. The
l load carried on this trial was 140 tons on an
eme draught of 10 ft. 1 in. Circle trials were
ied out on the completion of the official full-power
l, and the results were exceptional for a boat of
size and class. The circle was completed under
helm and with both engines full ahead on each
in two minutes each way, and the diameter of
circle measured only about two lengths. Gun
s and electric trials carried out at a later date
ed satisfactory in every way. The trials were conducted under the direct supervision of Mr. Warren, the surveyor to the Canadian Government.

BUCYRUS DIPPER-DREDGERS ON THE PANAMA CANAL.

In one of our series of articles on the Panama Canal we gave a short description* of two very powerful dredgers which were then under construction for the Panama Canal. These dredgers are actually the most powerful dredgers in the world, being equipped for operating dippers having buckets of 15 cubic yards capacity. These two dredgers, named the Gamboa and Paraiso, were recently delivered, and commenced operations in the Culebra Cut, the former on April 3, and the latter on June 6. They have been constructed by the Bucyrus Company, of South Milwaukee, Wis., by whose courtesy, through their British representatives, Messrs. Geo. F. West and Co., Caxton House, Westminster, we are enabled to give on page 306 four illustrations showing them at work.

These dredgers have a displacement of about 1500 tons, the hulls, of steel, having an over-all length of 136 ft., width of 44 ft., and depth at bow of 15½ ft., and at the stern 13½ ft. The framing of the hull is spaced approximately at 24-in. centres, the floor beams being 12 in. by 25 lb. channels, and the deck beams 5 in. by 3¼ in. by $\frac{6}{16}$-in. Z-bars, 11.6 lb. per ft. The frames are 6-in. by 3½-in. by $\frac{8}{16}$-in. Z-bars, every fifth frame being a $\frac{8}{16}$-in. web-plate frame 30 in. deep, with 3½-in. by 3½-in. by $\frac{8}{16}$-in. angles. Intercostal stringers of 15-in. by 33-lb. channels are placed between the web-frames to support the Z-frames. A heavy structural-steel truss is built into the hull, with cross-trusses in certain positions.

Each dredger has two dippers respectively of 15 and 10 cubic yards capacity. The former measure 10 ft. 9½ in. in height from the bottom band to the lip. They are of ¾-in. plate, the dumping-door being of 2-in. steel plate. The upper edge is stiffened by a 2-in. by 14-in. steel band, which is tied back to a casting on the end of the dipper-boom or handle. The front and sides of the bucket are supported at the bottom by a 2-in. by 16-in. steel band. These large dippers are for use in soft material. They have lips of manganese steel, 2 in. thick and 50 in. deep at the centre, reduced to 9½ in. at the back edges. They have no teeth. The dredgers are shown at work in our illustrations with their 10-cubic-yard buckets in hard ground. These buckets are also constructed out of ¾-in. plate, and the lips are furnished with four forged and hardened-steel teeth. The dipper handle is Oregon fir. It is no less than 72 ft. long, and is stiffened by top and bottom steel bars 2 in. by 12 in., and on the sides by 1-in. by 22-in. plating. The racks are of nickel-chrome steel, with shrouded teeth 12 in. wide and 3 in. pitch. The dipper-handle weighs 81,000 lb.

The dipper-boom or jib is built up of two steel-plate girders, with curved top and bottom chords, and is 62 ft. long, weighing, with machinery, 113,000 lb. At its lower end it has a cast-steel foot stepped in a cast-steel pivot-bearing. This pivot-bearing rotates on a base-plate bolted to the hull. The pintle is bushed with bronze, and a large bronze washer is placed between the boom step collar and the base-plate. The swinging circle is of structural steel, and is 24 ft. in diameter. It is mounted on the hull truss, and has steel centre castings and bearings, with bronze liners. Connection with the boom is by two horizontal built-up girders projecting from the circle, one on either side of the boom. The A frame is of steel, each limb being of box section. The back guys are of 3-in. steel rope, and are equalised. The front guys to the boom-head are also equalised. Hoisting is by a single 3¼-in. steel cable, and the rope for the swinging circle is 2-in. steel cable.

The main hoisting-engines are of the twin tandem compound type, with cylinders 16 in. and 28 in. in diameter by 24-in. stroke, with Stephenson valve-gear, and piston-valves for the high-pressure cylinders, and double-ported balanced slide-valves for the low-pressure cylinders. The winding-drum is graduated from 55 in. in diameter to 84 in. in diameter, winding being on the smaller end when digging and slow speed is required. The winding-shaft is 16 in. in diameter, and carries outside the drum gears 12 ft. in diameter, driven by intermediate spurs from the engine. The drum is mounted loose on the shaft, power being transmitted to it through a steam-operated wood-lined clutch-strap, worked by a 14-in. steam-cylinder. The swinging-engine has two cylinders, 12 in. in diameter by 16-in. stroke, with steam-operated link reversing gear. The swinging-drum is 42 in. in diameter, and is fitted with a wood-lined steam-operated brake. The shipper-shaft on the boom is of nickel-chrome steel, and is provided with two large brake-wheels, 75 in. in diameter by 12-in. face.

These dredgers are fitted with three spuds. The two forward spuds are 72 ft. long and 48 in. square, with cast-steel diaphragms 5 ft. apart, and the side plating strengthened with continuous 10-in. I-beams. The forward spuds are placed far enough back to allow a swing of 180 deg. for the boom. They are fitted with collapsible feet, consisting of two heavy steel castings pivoted to the end of the spud by a 12-in. pin, and when open forming a foot about 7 ft. by 9 ft. The third spud is placed centrally at the stern, and is 80 ft. long and 30 in. square. The forward spuds are operated by 2¼-in. steel cables controlled by double-cylindered 12-in. by 16-in. engines, the winding-drums being 42 in. in diameter. The back spud is worked by rack and pinion drive.

The engines are designed for 125 lb. steam pressure, supplied by two Scotch marine-type boilers, each of about 2700 sq. ft. heating surface. The plant further includes a condenser of about 1500 sq. ft. surface, feed-water heater, &c., a complete electric-lighting equipment, fuel oil and water-tanks of 18,000 gallons capacity, fire-service equipment, &c. Two three-drum winding-winches are also fitted for handling barges, one winch being on each side of the main deck.

These two dredgers, which will work to a depth of 50 ft., are at present in use in the Culebra Cut. Figs. 1 and 2, page 306, show the Gamboa working on the Cucaracha slide near Gold Hill, on which slide the Paraiso, shown in Figs. 3 and 4, has also been engaged. The rate of working of the Gamboa is said to average 6000 cubic yards per day in two 8-hour shifts. The material is largely hard rock, and the occasional size of the lumps may be gathered from Fig. 4, which shows a 50-ton rock brought up by the Paraiso. Such material is too large to dump, and is therefore drilled while on the bucket and shot, the fragments being redredged subsequently. The photographs, being all taken while working in this class of material, show the 10-cubic-yard buckets only in use. The 15-cubic-yard buckets are for use on smaller material. The illustrations show the dredgers delivering into 1000-cubic-yard sea-going hopper-barges.

* No. VII., Engineering, vol. xcvi., page 546.

Royal Technical College, Glasgow.—The calendar of this college for the ensuing session, which commences on the 23rd inst., has recently been issued. The book, which contains over 500 pages bound in blue cloth covers, gives lists of the governors, committees and staff, and also contains a brief account of the history and constitution of the college. Regulations for day and evening classes, and particulars of courses of study in civil, mechanical and electrical engineering, mining, metallurgy, naval architecture, chemistry, dyeing, sugar manufacture, textile work, architecture, building, and other subjects, are also included. Particulars of the various bursaries, scholarships, and prizes available to students are also given, together with lists of the successful candidates in the 1913-14 session; the class examination papers for last session are also reprinted.

THE LATE ENGINEER REAR-ADMIRAL W. T. HOCKEN.

It is with regret that we have to announce the death, on Friday, August 28, of Engineer Rear-Admiral W. T. Hocken, who was serving in the Engineer-in-Chief's Department at the Admiralty on duties in connection with the engineering *personnel* of the Fleet. He attended his duties until a few days previously, and it is probable that the extra stress due to the war may have been a contributory cause to the fatal termination to his illness.

The deceased officer, who was in his fifty-fourth year, had a long and extensive sea experience, and his services may be briefly detailed. He entered the Service as acting assistant-engineer, July 1, 1881; served on the China Station as assistant-engineer in H.M.S. Audacious, September, 1882; and in the receiving ship at Hong Kong in July, 1883. He returned to England in March, 1886, and was appointed to H.M.S. Black Prince in the following May. He was promoted to the rank of engineer, with seniority of September 1, 1886, and in January, 1887, was appointed to H.M.S. Galatea. In October, 1889, he was appointed to H.M.S. Lizard, on the Australian station, being transferred to H.M.S. Rapid, on the same station, in March, 1891. He returned to England in July, 1893, and in the December following joined H.M.S. Hussar. While in this ship he was promoted to Chief Engineer, with seniority of May 31, 1894. His next appointment (in June, 1895) was to H.M.S. Isis (building), and he remained in that ship on her commissioning in May, 1898, for the Mediterranean. He was advanced to Staff Engineer on May 31, 1898, being transferred to H.M.S. Royal Sovereign in April, 1899. On his return home he was appointed to H.M.S. Agamemnon in December, 1901, and later to H.M.S. Bellerophon (March 26, 1902).

Advancement to the rank of Fleet Engineer came on May 31, 1902, this title being superseded a year later by the new rank of Engineer Commander. In June of 1903 he was appointed to H.M.S. Conqueror, and in October, 1904, to H.M.S. Donegal, in the first cruiser squadron, where he remained till August, 1906, when he was appointed to assist in the supervision of machinery of torpedo-boat destroyers and torpedo-boats at Devonport. He was transferred to H.M.S. Leander for similar duties in May, 1908. Six months later he was appointed to H.M.S. Defiance for charge of the torpedo store at Devonport.

He was promoted Engineer-Captain with seniority of February 21, 1911, and in June of that year was appointed on the staff of Vice-Admiral Sir John Jellicoe in the Atlantic Fleet. He was transferred in April, 1912, to the staff of Vice-Admiral Burney in the Home Fleet, where he remained until appointed to the Admiralty at the close of 1912 for duty in the Engineer-in-Chief's Department in connection with engineer *personnel*.

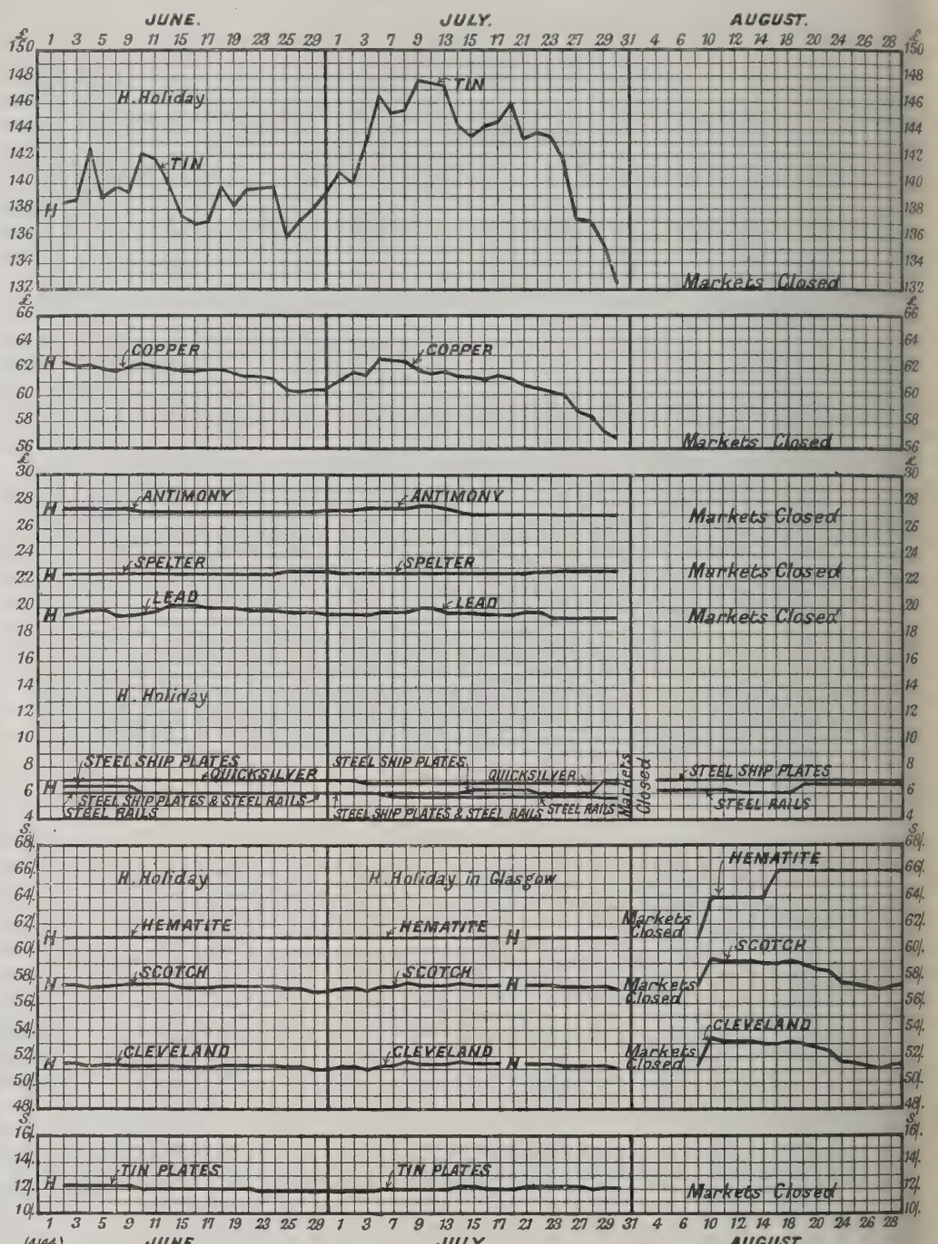
Motor Ambulances.—The Ford Company, of 55, Shaftesbury-avenue, have brought out a light canvas-covered body, which can be applied to any of their chassis, and will thus convert a car into an ambulance carrying two patients. The body complies with the specifications of the ambulance authorities.

The Petroleum Year-Book, 1914.—This year-book, which is compiled by Mr. Sydney H. North, the author of "Oil Fuel," "Petroleum," &c., is published at the price of 5s. net by Messrs. Wilkinson Brothers, Limited, 133, Cannon-street, E.C. It measures $8\frac{3}{4}$ in. by $5\frac{3}{4}$ in., and contains over one hundred pages of statistical data on the production of petroleum in the various countries, the ruling prices over long periods, &c. The table of prices is most interesting; it shows that the average price, taking a few of the years dealt with, of crude petroleum in Baku was, in kopecs per pood, 13.7 in 1899, 19.9 in 1905, 21.04 in 1909, 15.04 in 1910, 21.7 in 1911, and 34.92 in 1912. No less interesting is the other information which the book contains on the oil-fields of the world and on the uses of petroleum.

University of London, University College.—A course of twelve lectures on "The Theory and Practice of Radiotelegraphy" will be delivered by Professor J. A. Fleming, M.A., D.Sc., F.R.S. (University Professor of Electrical Engineering), at University College, on Wednesdays at 5 p.m., beginning October 28, 1914. The course will be in two parts, six lectures before Christmas and six between Christmas and Easter. It is open to both members and non-members of the university. It is intended for telegraphic engineers and electrical students who have already some elementary knowledge of the subject, and it will presume an elementary acquaintance with the differential calculus, and with the properties of vector quantities. The object of the course is to impart a more advanced knowledge of the theory and practice of wireless telegraphy in its modern form. University College is provided with an antenna and P.M.G. license for its use. The course will be illustrated by numerous slides, experiments, demonstrations, and diagrams; also by printed notes of formulæ and various data. The fee for each part, which may be taken separately, is 1*l.* 11s. 6d. Application for tickets of admission should be made to Mr. Walter W. Seton, Secretary, University College, Gower-street, London, W.C.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS

(Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



In the accompanying diagrams each vertical line represents a market day, and each horizontal line represents 1s. in the case of tin-plates, hematite, Scotch and Cleveland iron, and 1*l.* in all other cases. The price of quicksilver is per bottle, the contents of which vary in weight from 70 lb. to 80 lb. The metal prices are per ton. Heavy steel rails are to Middlesbrough quotations. Tin-plates are per box of I.C. cokes.

Note.—Owing to the European War the London Metal Exchange has been closed since July 30. Private transactions have, however, taken place at prices which have been made public in some cases. The price of tin is about 139*l.* per ton, and the quantity in stock, or in transit to the United Kingdom on the 31st ult., is given, in some statistics issued by Messrs. Ricard and Freiwald, as 11,443 tons. According to Messrs. J. Lewis and Son's monthly report, transactions in Standard copper, which is the quality usually plotted on our Diagram of Metal Prices, have taken place at receding prices, which have not been made public. Quotations for Best Selected have, however, been declared, and these show an advance from 60*l.* on the 4th ult. to 68*l.* 10s. on the 11th ult., followed by a steady decline to 60*l.* on the 28th ult. Electrolytic has fallen to 60*l.* for prompt cash, and 58*l.* to 59*l.* for forward delivery, after selling at 70*l.* to 72*l.* for immediate delivery ex-warehouse. The total arrivals in England for the month have been 12,754 tons, and the deliveries 11,960 tons fine, so that stocks have increased by 794 tons. Antimony has changed hands at prices ranging from 35*l.* to 40*l.* per ton; spelter at from 28*l.* to 34*l.* per ton; and soft foreign lead at from 21*l.* to 24*l.* per ton. Quicksilver fell from 7*l.* to 6*l.* 15s. per bottle on the 31st ult., and tin plates now stand at from 13s. 3d. to 13s. 6d. per box of I. C. cokes, f.o.b. Wales. The prices of steel ship plates and steel rails are given in the above diagram, as also are the settlement prices for pig iron since the Glasgow pig-iron warrant market reopened on the 7th ult. According to statistics issued by Messrs. W. Jacks and Co., the total shipments of pig-iron from Middlesbrough (including Skinningrove) during August have been only 31,870 tons, whereas in July 82,412 tons were shipped, and the total shipments for August of last year were 111,254 tons. The diminution has been principally due to the reduction of foreign shipments, which have fallen from 44,948 tons in July to 7935 tons in August, while coastwise shipments have only dropped from 37,464 tons to 23,935 tons. The foreign shipments have been distributed as follow:—China and Japan, 1454 tons; India and Australia, 65 tons; France, 219 tons; Belgium, 1226 tons; Germany, 780 tons; Norway and Sweden, 1938 tons; Italy, 1510 tons; and other countries, 743 tons.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade. — Though beset with difficulties of transport and shipment which render a normal volume of business impossible, the steam-coal market maintains a fairly even tone. Big tonnages are still held up in wagons at the ports, but the prospects of shipment to friendly and neutral countries are slowly but steadily improving, and an expansion of this section of trade is expected. The Russian railways are again coming into the South Yorkshire market for steam coal supplies for shipment from the Humber to Archangel. As the White Sea ports close at the beginning of October, deliveries will be executed as rapidly as possible under the circumstances. Country deliveries have been slightly delayed, owing to the holding-up of general traffic for Government purposes on two of the principal lines. The pits have difficulty in working three days a week. Those that rely very largely on export business have only been engaged two days. Considering the general trade upheaval, the local industrial demand is good. Not only are heavy tonnages going into consumption in the armament factories, but there is a lively demand from the general steel trades. Prices are firm. The house-coal trade is easier, with a corresponding slackening in values. Some stocking is in progress, Gas fuels are active on inland works contract account. Coke is in heavy demand at the furnaces, but slacks are weakening. Quotations:—Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. to 13s.; Derbyshire best brights, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 10s. 3d. to 11s. 3d.; small nuts, 9s. to 10s.; Yorkshire hards, 10s. to 11s.; Derbyshire hards, 10s. to 11s.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.; smalls, 2s. to 3s.

Iron and Steel.—The South Yorkshire steel and iron trades are making fair headway in circumstances of a widely varying character. On the one hand there is great pressure, due to the war, but on the other there is the difficulty of replacing valuable export business. The demand upon locally-produced raw material has again been great, but makers have wisely refrained from more than fractionally raising values that are considered to be inflated. West Coast hematite is quoted at 79s. 6d.; East Coast hematite at 77s 3d.; Lincolnshire foundry at 60s. 8d.; Lincolnshire forge at 59s. 8d.; Derbyshire foundry at 59s. 3d.; and Derbyshire forge at 56s. East Coast hematite has now approximated the figure of September, 1913, but West Coast hematite has still an advance of 6s. to make before it reaches that prosperous level. The bar-iron mills are more busily engaged than for many months past, and, judging from the steady flow of inquiries, activity in this branch is likely to increase rather than diminish. In view of the strong position held by local makers, in consequence of the demand for war material, and the absence of Continental dumping and underselling, a further advance on the top of the 1*l.* rise already recorded would not come as a surprise; but makers have adopted a cautious policy, and the South Yorkshire Bar-Iron Association has decided not to interfere with the basis quotation of 8*l.* 10s. Scrap values are moving upward. For a long time the market has been flooded with all kinds of scrap, available at cheap rates, but a fair demand has now sprung up, and wrought-iron scrap is making up to 65s., and heavy steel scrap about 60s. Such a pressure of work has never before been experienced by the armament firms. Guns, shells, and all kinds of munitions of war are being made at an unprecedented rate. One of the largest firms has received orders to supply until further notice as many shells of all sizes as it can possibly turn out. Extra men are being employed. British Government requirements, however, are by no means restricted to armaments, substantial orders having been received for tools to be used by soldiers for engineering purposes. The diversion of export business from Austria and Germany has given rise to an improved outlook in the general steel trades, but shipping risks still constitute a serious drawback. The advanced quotations for billets are firmly held.

WAR MAPS.—We have received from Messrs. Edward Stanford, Limited, of Long Acre, W.C., another war map showing Belgium, Lorraine, Alsace, and the area of France comprised between these countries and Poitiers in the south and St. Nazaire on the west. The map therefore includes the line of the Loire. It is priced at 3s. 6d. unmounted, or 5s. mounted.

DISTRIBUTING CONCRETE THROUGH OPEN SPOUTS.—In a paper recently published in the Journal of the Western Society of Engineers an account is given of the system of concreting through open spouts now largely adopted in America. The concrete is mixed to such a consistency that it flows readily along these spouts and into the forms. If too wet, the water drains out, and the spout blocks; and, similarly, if the concrete be too stiff, it will not flow. With the proper consistency, however, it flows readily, and it is claimed that the forms are filled more solidly than when a stiffer mixture is used and rammed. The system in question has, Mr. B. J. Sweatt states, been used for the concreting of a large arched bridge at Cedar Rapids, Iowa, constructed in reinforced concrete. The bridge, which is 308 ft. long between abutments, has three spans of 96 ft. each, the roadway being 48 ft. wide, bordered by two footpaths, each of a clear width of 10 ft. The whole of the concrete was distributed to the required positions from a high tower, from which the distributing spouts were fed. The system is claimed to be an ideal one where the length to be covered does not exceed 300 ft. from the tower. From the discussion it appears that a gradient of 1 in 7 is a good slope for the spouting.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade. — The pig-iron market is lifeless. Buyers and sellers alike show little inclination to operate, and attention is centred on operations in France. What little business is passing is confined to transactions in small parcels for early delivery almost entirely to home customers. Practically no effort is made to do foreign business. A general feeling of uncertainty prevails. No. 3 g.m.b. Cleveland pig is 51s. 6d. to 51s. 9d.; No. 1 is 54s. to 54s. 3d.; No. 4 foundry and No. 4 forge, each 51s. 3d., forge being very scarce; mottled, 50s. 9d.; and white, 50s. 6d. Demand for East Coast hematite pig has fallen away, home consumers having apparently satisfied their requirements, at all events for the time being. Producers still ask 70s. and 72s. 6d., and in some cases even more for Nos. 1, 2, and 3, but buyers will pay no such rates, and report that they experience no difficulty in buying all they need from second hands at 68s. As a matter of fact, at least one transaction has been put through at 67s. 6d. So far as can be ascertained efforts to sell foreign ore this week have not been successful. Consumers are said to be in the market, but not disposed to pay the prices asked. In the absence of transactions market rates are nominally on the basis of 19s. 6d. ex-ship Tees for Rubio of 50 per cent. quality. There is rather more coke offering, and sellers appear more disposed to meet customers. The supply, however, is by no means abundant. Durham beehive blast-furnace coke of average quality is on sale at 18s. delivered at Tees-side works.

Stocks of Pig-Iron.—Makers' stocks of pig are not now made known, but they have been accumulating rather rapidly during the past week or two, and by this time must be considerable. The stock of No. 3 Cleveland pig-iron in the public warrant stores here at the end of last month stood at 94,703 tons, 12,674 tons having been withdrawn during August. There are warrants in circulation for 87,000 tons.

Iron and Steel Shipments.—With exports cut off and coastwise despatches very considerably curtailed, shipments from the Tees during August were small. The clearances of pig-iron averaged 1225 tons per working day, the total despatches being returned at 31,870 tons. Clearances of manufactured iron amounted to 14,122 tons, 7512 tons of which went foreign, and 6610 tons coastwise; and despatches of steel reached 25,771 tons, 21,170 tons going abroad, and 4601 tons to home customers. The Argentine, with 6031 tons, was the largest buyer of manufactured iron, whilst India was the best customer for steel, taking 5130 tons. Other principal buyers of steel were:—The Argentine, 4924 tons; South Australia, 4205 tons; New South Wales, 2546 tons; and West Australia, 1001 tons.

Manufactured Iron and Steel.—The finished iron and steel trades continue to be fairly active. A local firm has this week booked a substantial order for rails. Specifications, especially for structural material, are coming in freely, and in the absence of all German competition, the local steel works are in a healthy position, most of the firms having work in hand to last until the end of the year. Prices all round are strong. Principal market quotations stand:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 5s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 7*l.* 10s.; iron ship-rivets, 9*l.*; iron girder-plates, 7*l.* 5s.; steel bars (basic), 6*l.* 15s.; steel bars (Siemens), 6*l.* 15s.; steel ship-plates, 7*l.* 5s.; steel ship-angles, 7*l.*; steel boiler-plates, 8*l.*; steel joists, 7*l.* 2s. 6d. to 7*l.* 5s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 15s.—all less the customary 2½ per cent. discount; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 15s.; steel railway sleepers, 7*l.* 15s.—all net at works.

FIRE TESTS WITH DOORS.—The Red Book of the British Fire-Prevention Committee, No. 183, gives illustrated particulars of tests with doors encased with steel sheeting, the centre being reinforced with steel bars and filled in with concrete. One of the doors was hung on runners and made to slide. It was fixed on the inside of an opening. The other, on hinges, was fixed in a reveal on the inside of an opening. Both installations were by the Chubb and Sons' Lock and Safe Company, Limited, London.

MARKETS FOR MACHINERY BELTING.—British manufacturers of leather, hair, and cotton belting for machinery will be interested in a memorandum just issued by the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, E.C., showing the principal markets to which German and Austrian goods of this class have been exported. Although German exports of these products do not appear to rival ours in value, they are in some directions very considerable. Even in this country no less than 98,700*l.* worth of belting from Germany has been sold in a recent year, most of it being of other classes than leather, cotton, or wool. In other countries the sales are also large. For instance, Germany sold to Russia recently in one year leather belting to the value of 131,700*l.*; to Sweden to the value of 22,950*l.*; Italy, 23,000*l.* Of German woven hair or cotton belting, Russia took 70,700*l.* worth; France, 14,150*l.*; and so on. Roumania is a large purchaser of all classes of German beltings, though latterly the country has developed an industry of this kind itself. France takes a considerable amount of woven belting from Germany. The Russian trade was formerly in the hands of British firms, but has been captured by German efforts. In 1912 Germany's total exports of belting were worth 735,000*l.*

NOTES FROM THE SOUTH-WEST.

Cardiff.—In the steam-coal trade business has been somewhat restricted, in consequence of shortage in the supply of large descriptions. These shortages are due to a shrinkage in production, on the one hand, and heavy bookings, on the other hand. Not only have the Lords of the Admiralty continued to book the full production of some of the leading collieries, but provision has also had to be made for the requirements of the French and Italian fleets and railways, as well as for a demand from Egypt and Russia. It is stated that between 15,000 and 20,000 men have left the South Wales coalfields to join the army; such an extensive transference of labour must, of course, have some effect upon the output. Smalls have been in good demand. The best secondary steam coal has made 20s. to 21s.; other secondary descriptions, 19s. to 19s. 6d.; best bunker smalls, 7s. 9d. to 8s.; and cargo smalls, 5s. to 7s. per ton. The best household coal has brought 19s. to 20s.; good households have made 17s. to 18s.; No. 2 Rhondda large has made 13s. 6d. to 14s.; and No. 2 smalls have realised 6s. to 7s. per ton. Patent fuel has been quoted at 19s. to 20s. per ton. Special foundry coke has made 27s. 6d. to 30s.; good foundry coke, 21s. to 25s.; and furnace coke, 18s. to 20s. per ton. As regards iron ore, Rubio has been quoted at 20s. to 21s. per ton upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

The Tin-Plate Trade.—The aspect of the tin-plate trade in the Neath district has improved, half the mills at the works being employed, so the men can go to work by rotation. The Neath District Council is finding employment for a number of men on constructive works.

Dowlais.—The Dowlais works have resumed operations, and have again been active. The Goat Mill has turned out steel rails, billets, steel sleepers, &c., and its production has been speedily despatched. The Big Mill has been engaged on steel tram-rails, fish-plates, &c. The collieries have been working an extra hour, and a heavy tonnage has been brought to bank.

Newport.—Business in Monmouthshire steam-coal has been checked by the fact that few sellers are in a position to accept fresh orders for some weeks. There has, however, been no lack of inquiries. Smalls have shown steadiness; house coal, patent fuel, and coke have remained without quotable alteration.

The Swansea Valley.—The blast-furnaces at Landore have been in full swing. Things have been better in the tin-plate trade, and ten mills have been in operation at Cwmfelin, eight at Beaufort, eight at Duffryn, four at Forest, four at Aber, and three at Midland. Six mills which had been stopped for repairs have also been restarted at the Worcester Works. The steel trade has shown some slackness. There has been an active demand for weldless tubes at the Mannesmann Works.

COLLEGE CALENDARS.—We have received from the City of Bradford Education Committee the calendar for 1914-15 of the Bradford Technical College. At this institution both day and evening classes are held, and, as is natural, special attention is paid to textile courses, wool-working and dyeing being a staple trade of the district. The engineering section is under the direction of Professor G. F. Charnock, assisted by lecturers in mechanical engineering, electrical engineering, and civil engineering, and the college is well equipped with laboratories.—The new calendar of the Merchant Venturers' Technical College has also been received. This institution is that in which the Faculty of Engineering of the University of Bristol is provided and maintained. The department of civil engineering is under the direction of Professor R. M. Ferrier, whilst Professor J. Munro is the responsible head of the mechanical and mining engineering section, and Professor David Robertson is in charge of the department of electrical engineering. There is also a special section devoted to automobile engineering, under the direction of Professor Wm. Morgan. The degrees of B.Sc. and D.Sc. are granted in engineering. In addition to day classes, the school conducts a comprehensive scheme of evening classes.

CEILING ROSES; BRITISH STANDARD SPECIFICATION.—At a time like the present, when a special effort is being made to supply as far as possible ourselves those needs hitherto met by imports from the Continent, the British Standard Specification for Two and Three-Plate Ceiling-Roses will be welcomed by manufacturers anxious to enlarge their business in this direction. This matter has been taken in hand by the Sub-Committee on Electrical Plant Accessories of the Engineering Standards Committee; in their work this body has had the assistance of the British Electrical and Allied Manufacturers' Association, and this fact should ensure the general acceptance of the specification by the electrical industry. The standardisation of two and three pin-plug fittings is being proceeded with, but it has been thought that it would be most convenient to issue separate specifications, so that standardisation, as far as it has gone, might be taken up at once. This report (No. 67) specifies the material to be used and the dimensions of all essential parts. The terminal plates are of different shapes, a system which, for reasons stated in the report, the Committee consider more satisfactory than the use of different colours. The report may be obtained post free for 5s. 2d. from the offices of the Committee, 28, Victoria-street, Westminster, S.W., or from Messrs. Crosby Lockwood and Son, 7, Stationers' Hall-court, E.C.

THE DIPPER-DREDGERS "GAMBOA" AND "PARAISO" ON THE PANAMA CANAL.

CONSTRUCTED BY THE BUCYRUS COMPANY, SOUTH MILWAUKEE, WISCONSIN, U.S.A.

(*For Description, see Page* 303.)

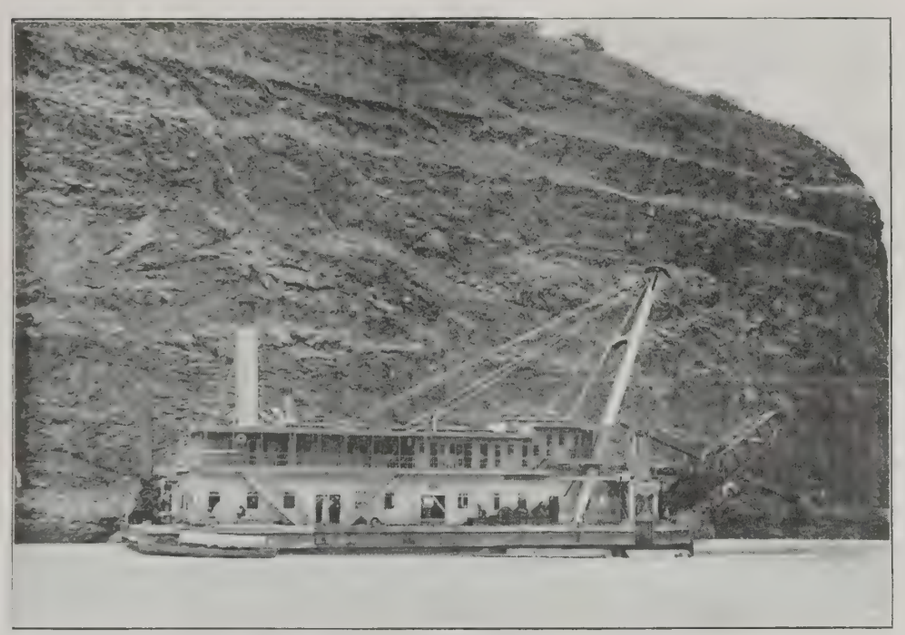


FIG 1. THE DREDGER "GAMBOA" IN THE CULEBRA CUT.

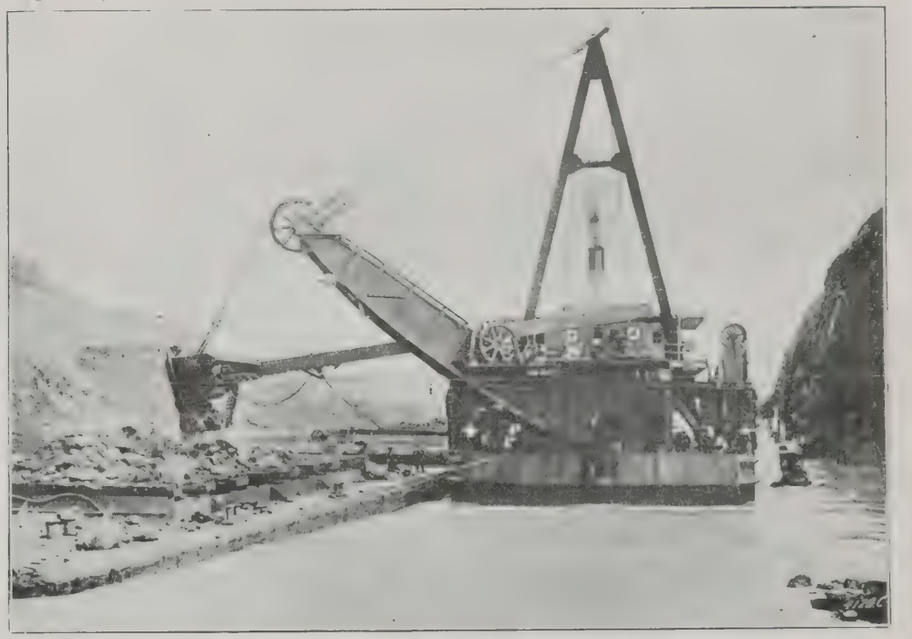


FIG. 3. THE DREDGER "PARAISO" WORKING ON THE CUCARACHA SLIDE.

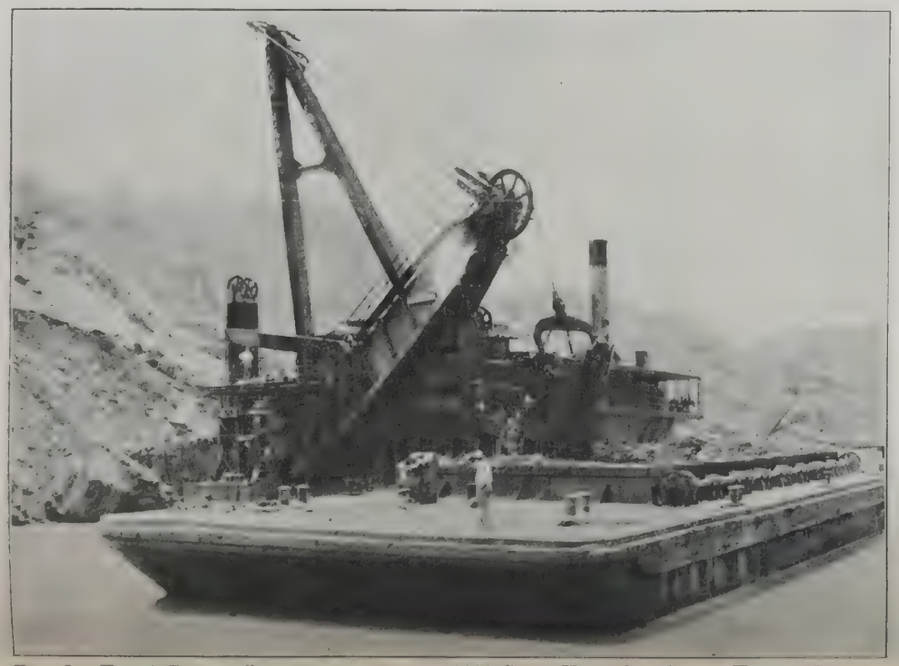


FIG. 2. THE "GAMBOA" DELIVERING INTO A 1000-CUBIC-YARD SEA-GOING HOPPER-BARGE.

FIG. 4. A 50-TON ROCK DREDGED BY THE "PARAISO."

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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Thick ,, ...	£1	16	0 ($8.75)
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Thin paper copies	£1	16	0
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Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

READING-CASES.—Reading-cases which will hold twenty-six numbers of "ENGINEERING" may be had of the Publisher or of any newsagent. Price 6s. each.

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With a Two-Page Plate of the CANADIAN CUSTOMS CRUISER "MARGARET"; ARRANGEMENT OF MACHINERY.

NOTICES OF MEETINGS.

THE INSTITUTION OF MINING ENGINEERS.—Wednesday, September 9, at 10.30 a.m., at the Central School of Science and Technology, Stoke-on-Trent, twenty-fifth annual general meeting. Owing to the war, it has been considered desirable to cancel all the arrangements in connection with the dinner, visits to works, excursions, &c. The annual report of the Council will be read, and the names of the officers for the year 1914-15 announced. The following papers will be read or taken as read:—1. "The Absorption of Oxygen by Coal." Part II.: The Quantity of Oxygen Absorbed; Part III.: The Thermal Value of the Absorption; Part IV.: The Influence of Temperature; Part VI.: The Ratio of Spontaneous Heating of Coal. By Mr. T. F. Winmill, B.A., B.Sc., Chief Chemist at the Doncaster Coal-Owners' Research Laboratory. 2. "The Absorption of Oxygen by Coal." Part V.: The Influence of Temperature on the Rates of Absorption of Different Parts of the Barnsley Bed. By Mr. J. Ivon Graham, B.A., B.Sc., Chemist at the Doncaster Coal-Owners' Research Laboratory. 3. "Self-Contained Rescue Apparatus and Smoke-Helmets for Use in Irrespirable Atmospheres." By Mr. J. S. Haldane, M.D., F.R.S., Director of the Doncaster Coal-Owners' Research Laboratory. 4. "The Unknown Clays in Coal-Mines." By Mr. J. W. Mellor, D.Sc. The following papers will be open for discussion:—(*a*) "A Method of Measuring Goaf Temperatures." By Mr. T. F. Winmill, B.A., B.Sc. (*b*) "The Absorption of Oxygen by Coal." Part I. By Mr. T. F. Winmill, B.A., B.Sc. (*c*) "Self-Contained Rescue Apparatus for Use in Irrespirable Atmospheres" (First Report not yet published, but advance proofs available). By Mr. J. S. Haldane, M.D., F.R.S.

THE INSTITUTE OF METALS.—Thursday, September 10, at 4.30 p.m., at Caxton House, Westminster, for formal business only. No papers will be read, but the following papers will be open for discussion by correspondence up to September 30:—1. "The Widmanstätten Structure in Various Alloys and Metals," by Captain N. T. Belaiew. 2. "Tensile Tests on Copper at High Temperatures," by Dr. G. D. Bengough, M.A., and Mr. D. Hanson, M.Sc. 3. "The Critical Point at 460 deg. Cent. in Zinc-Copper Alloys," by Mr. O. F. Hudson, M.Sc. 4. "A Note on the Annealing of Brass," by Mr. F. Johnson, M.Sc. 5. "The Deposition of Metals by the Spraying Process," by Mr. R. K. Morcom. 6. "The Effect of Hydrogen on the Annealing of Gold," by Mr. J. Phelps, M.A. 7. "A Contribution to the History of Corrosion." Part III. Coke, Condenser-Tubes and Corrosion, by Mr. A. Philip, B.Sc., A.R.S.M. 8. "The Surface Tension of Molten Metals," by Mr. S. W. Smith, B.Sc., A.R.S.M. 9. "The Behaviour of Copper-Zinc Alloys when Heated in a Vacuum," by Mr. W. E. Thorneycroft, B.Sc., and Professor T. Turner, M.Sc. Copies can be had on application.

NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to some Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, SEPTEMBER 4, 1914.

THE SCIENCE OF EDUCATION.

THE proceedings of the British Association in Australia have been enlivened by the delivery of two somewhat contentious addresses on the subject of education. Of these, the first was read by Professor H. E. Armstrong, at Melbourne, on Friday, August 14, whilst Professor John Perry, the President of the Section of Educational Science delivered his presidential discourse at Sydney on August 21. Both papers deal with the same theme and should be read together, since the well-known fervour of the President of the Section, which lends a glow of eloquence to all his deliverances, has in this instance led him to somewhat overstate his case, a tendency which finds a useful corrective in the somewhat less revolutionary views expressed by the Vice-President.

Both speakers agree in attacking the classical basis on which the bulk of the youth of the country is being educated, or, as one may more properly say, being partially educated. This, of course, is an old story. Dickens relates that Mr. Edward Carstone "had been eight years at a public school, and learnt, I understand, to make Latin verses of several sorts in the most admirable manner." This accomplishment still appears to be held as the height of achievement by the senior classic of the old school and no inconsiderable proportion of his successors. Other supporters of the classical tradition are, it is true, less fatuous, but Professor Perry quotes from one, a wild rhodomontade to the effect that classical studies are the cause "of all imaginative aspirations, all intellectual interests," "it enabled men to appreciate all the great thoughts of all ages and all lands, and to be awake to the movements of their own day." On this basis, Burns can have had no intellectual interests or imaginative aspirations; and Shakespeare, with his little Latin and less Greek, must have been in an almost equally parlous state. As to the appreciation of the great thoughts of all ages, history does not record that the senior classic and his peers have welcomed with any special ardour, or been in any way peculiarly receptive, of the two great thoughts of the past century embodied in the doctrine of evolution and the principle of the conservation of energy. In fact, when a classical enthusiast is cross-examined it invariably turns out that it is not the thought he admires, but the setting. Nevertheless, fine craftsmanship may be, and often is, exercised on raw material the most unworthy. A more plausible claim is that a study of the classics facilitates clearness of thought and expression; but here again the facts hardly support the contention. Of the two great political orators of the past century, Bright was superior to Gladstone, not merely in the height of eloquence at times attained, but in clarity of expression, in which his classically-trained rival was, indeed, notoriously deficient.

No one, of course, wishes to abolish classical studies, or, indeed, to diminish the attention paid to them by those with special aptitude for this course of training. Man does not live by bread alone, and the classics, archæology, and physical astronomy are as legitimate pursuits as engineering, chemistry, or bacteriology. All that is demanded by those who revolt against the classical tradition is the preservation of a due sense of proportion, and that the average lad should affect the studies which are revolutionising the world rather than, as in the past, spend the major portion of his school period in memorising exceptions to the rules of the Latin language, which is nearly as far as the average schoolboy gets.

Professor Perry complains that some members of Parliament appear to think that a knowledge of science should be a disqualification for a committee appointed to deal with scientific business. Perhaps, however, this view is somewhat less absurd than it seems at first sight.

The Advisory Committee on Aeronautics consists, quite properly, wholly of qualified men, but there are other cases in which there is not a little to be said for constituting the committee of intelligent laymen. It has been, indeed, contended that no important scientific generalisation is secure until it can be explained in a fashion intelligible to the man in the street, and until this stage is reached some caution is necessary in placing too much reliance on the views of so-called experts. The bacteriologist of a quarter of a century ago maintained that water once contaminated was rendered permanently unfit for human consumption. The rule-of-thumb water-works engineer declared that the contrary was proved by his daily experience; and time, with its fuller knowledge, has shown that he was perfectly correct in this contention. Experience has proved that a House of Commons Committee, in spite of its lack of technical knowledge, can and does deal quite competently with matters of this kind so long as politics can be excluded. On the other hand, had the French Panama Company obtained, and acted on, the most competent medical advice open to it, it could not, with the knowledge then existing, have rendered the Isthmus healthy. Again, a lay committee has reported very fairly on the subject of vivisection. In fact, where general principles are involved the specialist must convert the public, and if he cannot start with the conversion of a lay committee, which is by the very manner of its appointment of somewhat above average intelligence, the time is certainly not ripe for extensive State action on his advice. This is certainly so in a democratic country, where the public strongly resents being "organised" in advance of its convictions.

It is nevertheless quite true that the country is severely handicapped by the general ignorance of scientific principles prevalent amongst factory owners and financiers, though Professor Perry seems to take a somewhat exaggerated view of the pernicious effects of the almost exclusive devotion to classics of the better endowed youth of the country. He even attributes to this the circumstance that the sons of able lawyers and the like sometimes marry chorus girls—a proposition which appears to be a direct plagiarism from "Patience," where the results of the improper upbringing of Teasing Tom are summed up thus:—

> "The consequence was he was ruined totally,
> By marrying a girl of the corps-de-ballet."

On the other hand, Professor Perry appears much too sanguine as to the results to be reaped from a greater prevalence of scientific studies in the educational course. Genius, he tells us, is very common, but 99 per cent. of it is destroyed

at the schools. All one can say is that Professor Perry must include amongst his geniuses a vast mass of what the rest of us would call mediocrities. All experience shows that the commodity in question is exceedingly scarce, and little affected by schemes of education. On this point Professor Armstrong's testimony is in direct conflict with that of Professor Perry. He insists, in fact, that creative ability is extremely rare, and that the sole hope for the future of democracy is that it shall recognise in time that there is an aristocracy of genius, and few thinking men will fail to agree with him. On the other hand, there seems no justification for Professor Armstrong's claim that wisdom and science are interchangeable terms. Etymologically, science means knowledge, and the etymological definition still remains the correct one. The antithesis to wisdom is folly, and to science ignorance. Ignorance can be cured, but there is excellent authority for the view that, though you bray a fool in a mortar, yet will he not be parted from his folly. Conversely, it is equally true that no system of training can either create or destroy wisdom; it can merely enlarge or restrict the data on which the few wise men born into the world frame their conclusions. No improvement in our national scheme of education can increase the innate wisdom of the individuals who, taken in the mass, constitute the public; it can widen their perspective, but cannot enlarge their mental capacity. Knowledge comes but wisdom lingers is likely to remain the complaint of the far-sighted of many generations yet unborn.

Professor Perry really seems to believe that creative ability can be generated merely by a greater insistence on the importance of laboratory work as an integral part of the education of youth. For our own part we should be disposed to question whether the laboratory really does much even in the matter of developing reasoning power. This has, in fact, been the experience with the heuristic system of teaching science as applied in Ireland. A youth learns, for example, that adding an acid to zinc leads to a certain gas being generated. The question set him to discover is whether the gas comes from the zinc or from the acid, and by a carefully-arranged programme of experiments he is forced to the conclusion that it is the acid which furnishes the hydrogen. Obviously, such a system of instruction requires a great expenditure of time for the acquirement of very few facts. Were it true that the average youngster gained by this course, the power to follow the heuristic method "on his own," the time might be deemed well spent; but it is reported that this is not the case, and that generally the pupil never thinks of applying such methods of science outside of the school laboratory. Indeed, whilst he can work successfully to a prescribed programme, such as the foregoing, it is only the exceptionally gifted who could originate a single important step in that programme. It has, moreover, to be observed that in most of the work of the world the logical faculty plays but a small part, and this is necessarily so, owing to the inadequacy of the premises available. Logic is, in fact, the weapon of youth, which starts in life with certain general principles and little or no experience. If enthusiastic, the young man is disgusted to find that his elders express doubts as to the accuracy of conclusions which appear to him inevitable deductions from basic principles, as, indeed, they may be. Nevertheless, owing to the incompleteness and inadequacy of these principles, the man of experience proves right nine times out of ten, though every now and then it is the young would-be reformer who turns out to be correct, and civilisation receives another push forward.

Professor Perry, indeed, contends that were the average boy properly taught, he would prove very superior to the boy who is usually called clever, educated in the ordinary way. No doubt if the latter were, without preliminary training, pitted against Professor Perry's average pupil in the subjects in which these pupils have specialised, he might show up very unfavourably; but this would imply nothing more than that he had been worse taught. The real test of capacity would come when both reached waters beyond the depth covered by the training in question.

Dr. Ray Lankester has remarked that the primitive mammals differed from their successors mainly in the smaller ratio of brain to body weight. For their normal needs he considers, nevertheless, that these early types were probably not notably worse off than their more intellectual successors. In fact, for the common round of their life a mere speck of grey matter (comparatively speaking) sufficed; but it was the reserve of mentality held by their rivals that ensured their ultimate success in the struggle for existence. This will undoubtedly prove to be the case when Professor Perry's average pupil meets the competition of the exceptional man, no matter how indifferently the latter has been trained initially. In fact, Madame Montessori has shown that, by her methods of education, the idiots sent to her from asylums were as forward at the same age as normal children taught in the usual way. Unlike Professor Perry, however, she would not maintain that these unfortunates would continue, as time went on, to rival the better-endowed, but worse-educated, normal child.

Laboratory training is no doubt a very excellent means of education, but it cannot work miracles, and has the drawback of being expensive. He would be a bold man, moreover, who claimed that it was the sole method of equipping a man for effective scientific research. If we mistake not, Mr. Oliver Heaviside enjoyed but small advantages in this regard. Yet the value of his highly original contributions to electrical theory is universally recognised. Many men there are, like Faraday, who need to view an experiment for themselves, but a man may be both a clever experimenter and a careful observer without the imagination and insight needful to effect important generalisations.

Amongst scientific investigators, Kepler will thus always hold a rank in advance of Tycho Brahé. There is far too great a tendency at the present date to maintain that research work is possible only in the laboratory. Many careful workers are, in fact, incapable of correctly interpreting their own results, which may, however, prove very fruitful in the hands of a philosopher gifted with that Vorstellungs-fahigkeit which Tyndall notes as the most remarkable endowment of such thinkers as Newton and Darwin. The late Mr. W. Sutherland, we believe, based almost the whole of his very original and interesting hypotheses on the experimental work of others.

Professor Perry has admittedly done most excellent service in reforming the methods of teaching mathematics to the average boy by insisting on familiarising the pupil, by actual experiment with compass, ruler, and squared paper, with the nature of the conceptions involved. The change is of the utmost value, not because it will convert the average boy into a mathematician, any more than laboratory training will make him a creative thinker, but because it will enable him to appreciate to some degree the aim and methods of both. Punch's professional golfer assured the anxious amateur that though he would never learn to play golf well, he might in time attain to the stage of recognising good golf when he saw it. *Mutatis mutandis*, this sums up not unfairly the principal benefit to be derived from a more widespread scientific knowledge. Even the clever lad will benefit by Professor Perry's system as a preliminary to the older orthodox methods, but as a preliminary and nothing more. In fact, we have known one of the more successful of Professor Perry's pupils to observe that the mathematics he learnt on the orthodox system he could use, but what he acquired under Professor Perry, though interesting, had to be learnt over again before it became available as an instrument of research. It remains as true now as in the days of Alexander that there is no royal road to mathematics.

A laboratory training is not, in fact, even essential to the successful conduct of experimental research, as the man will always be greater than the method. Nevertheless, it is unquestionably useful. Two faults are commonly conspicuous in the average product of our technical college laboratories, and the remark may be extended to the American. The pupils either believe in their actual observations, or they do not. In the former case they tend to base wide generalisations on crude and inaccurate experiments, and in the other alternative to "cook" their results to fit in with some preconceived theory. It required a man of genius to discover argon from an almost insignificant difference in the density of atmospheric nitrogen and that derived from a chemical compound; and, in spite of Professor Perry, genius will never be other than scarce.

Sir J. J. Thomson has observed that faith in the experimental method is only achieved with much labour. The novice finds results not merely inconsistent with themselves, but with every law of Nature, either known or conceivable, almost justifying such observations as the well-known aphorism that the laws of mechanics were never discovered in the laboratory.

Both Professor Armstrong and Professor Perry conceive the German system of education to be worse than our own. In this they have the support of no less eminent a philosopher than Mr. Dooley, who remarked to the long-suffering Henessey that certain educational methods were a "good thing for Germany, because all a German knows is what someone tells him, an' his grajation papers is a certy-ficate that he don't need to think any more." Perhaps the critics are too severe, the German scheme having certain by no means unimportant advantages. It was Moltke who took the view that in war the genius was supreme, but that it was difficult to make certain of the possession of a genius when the crisis arrived. The average commander being a mediocrity, organised mediocrity would beat unorganised mediocrity every time, and in view of the rareness of genius, the chances of warfare lay with the country that made best use of its average talent, rather than with the nation that based all its hopes on the opportune discovery of a heaven-sent commander. Germany has organised her science study on a not essentially different plan, and undoubtedly has accomplished much highly valuable work. Ostwald has, however, declared that the system is not without some very material drawbacks, remarking that men like Liebnitz and Kelvin would, by the machine-like organisation of the German system, be still indistinguished from the ruck at an age when, as matters actually stood, they had already acquired an international reputation.

Both Professor Armstrong and Professor Perry refer to H. G. Wells and his theories. The former attributes little value to Wells's views, an opinion which finds ample justification in Wells's frank admission that his views are not a scientific deduction from observation and experience, but as he says, "I make my beliefs as I want them," disregarding all such inconvenient facts as clash with his *à priori* conclusions. His dialectics, in short, bear a by no means remote resemblance to those of the Bellman in the "Hunting of the Snark," who stifled incipient controversy by the emphatic assertion that "What I tell you three times is true." The scientific and the literary temperament are seldom combined in the one individual, and there have been other instances of keen observers and able writers equally incapable of formulating effective generalisations. Of Goethe, Tyndall writes: "In sharpness of observation in the classification of facts according to the analogies discerned, Goethe possessed extraordinary powers." He had, in other words, excellent qualifications for what Huxley has called a "Hodman of Science." "He could not formulate distinct mechanical conceptions, and in regions where such reasoning reigns supreme he became a mere *ignis fatuus* to those who followed him." As Huxley has pointed out, the methods of deduction adopted in the mechanical sciences are applicable to all generalisations, a contention which unintelligent critics have attempted to pervert into the totally different proposition that nothing was to be believed in unless it could be weighed or measured in a laboratory.

Fortunately, however, Mr. Wells is a much better novelist than philosopher, and his characters, naturally drawn by the instinct of genius, refute the very theories they are supposed to establish. It is, in short, a case of General Février turning traitor, or better, perhaps, of Frankenstein's monster turning on his creator. This is well exemplified in the "History of Mr. Polly," which Professor Perry quotes as an illuminative illustration of the consequences of a defective education. This, no doubt, was one thesis the author intended to establish; but it is very apparent that Mr. Polly was a mediocrity, with the soul of a very minor poet or artist that no system of education could have rendered other than futile, and who was actually fortunate in ultimately finding a niche that exactly suited his indistinguished characteristics.

We have headed this article the "Science of Education," but Professor Perry declares that there is no such thing, but merely an art of pedagogy, "just as there used to be an art of engineering." It was, he says, only slowly that the science of engineering was developed, and he remarks that in the creation of a science we have for long periods the observation of detached phenomena with no obvious connection between them. Ultimately experiment simplifies

things, and the science is gradually created by inductive reasoning and research. Speaking generally, this is probably a not inadequate description of the growth of science, but there appear to be some curious exceptions in the case of practical engineering. This is not infrequently more "scientific" at the outset of a new departure than subsequently. The pioneer has to make use of all the scientific knowledge he possesses, and to guide his path by experiment and deduction, his procedure being truly scientific in character. After he has accomplished this, however, experience provides rules of thumb, and his successors are able to build highly efficient machinery with but very little recourse to the methods of science. Nevertheless, we have never met an engineer who confessed to having a greater knowledge of either physics or mathematics than he could find a use for, though he might be very positive that some other engineer was "far too theoretical." In fact, an industry that does not progress stagnates, and even the builders of such a product of experience as a locomotive do find it possible from time to time to make improvements, even though these may be framed in a somewhat minor key. The development of each new pattern calls, indeed, for some exercise of the methods of science, although it will probably remain true to the end of time that mechanical engineering is essentially an art rather than a science. It is this fact that makes experience in any particular line of construction so extremely valuable, and in the average daily work of the engineer, logical deduction from first principles can never play other than a subordinate part.

BRITISH PATENTS AND FOREIGN PATENTEES.

LAST week we reviewed the position of British patents, designs, and trade-marks granted to alien enemies. We were not able to deal completely and satisfactorily with the matter, as the Government had not made their intentions as clear as they might have done, and they complicated matters, just before we went to press, by the introduction of a Bill amending the Patents, Designs, and Trade-Marks (Temporary Rules) Act, 1914. As the Bill has now been printed, indeed has become an Act of Parliament, we have the whole of the Government's proposals before us, and are thus in a position to deal fully with the matter.

To distinguish the two Acts we will refer to the earlier of the Acts as the Temporary Rules Act, and the amending Act of last week as the Amending Act. We pointed out last week that the Temporary Rules Act gave the Board of Trade power to do such things as they thought expedient for avoiding or suspending any patent or licence granted to, and the registration of any trade-mark the proprietor whereof is, a subject of any State at war with His Majesty, and any proceedings on any application made by any such person for either a patent or a trade-mark. The Amending Act now gives the Board of Trade power to avoid any patent or licence the person entitled to the benefit of which is the subject of a State at war with His Majesty. The amendment appears at first glance to be merely a verbal one, but on consideration it will be seen to be of considerable importance. The Temporary Rules Act was limited to patents and licences granted to an enemy; the words "granted to" were unduly limiting as they excluded patents that had been granted to British subjects on inventions communicated from abroad by an enemy; they also excluded patents that had been sold or assigned to an enemy, and they further excluded cases in which British patents were held by British or other subjects as nominees of an enemy.

A curious point in connection with the Temporary Rules Act was the omission of power to avoid or suspend a registered design. The oversight has been noticed, and the Board of Trade has now power to avoid or suspend any registered design or trade-mark. The Amending Act, in addition to the inclusion of designs, also gives the Board of Trade power over all and any rights conferred by the registration of a design or a trade-mark. Another curious point in connection with the Temporary Rules Act was that it gave power to avoid or suspend the proceedings on a pending application for design registration, but did not give, as we have pointed out, power over a registered design.

A new feature in the Amending Act is one to enable the Board of Trade to grant in favour of persons other than subjects of a State at war with His Majesty, on such terms and conditions, and either for the whole term of the patent or registration or for a less period, as the Board may think fit, licences to make, use, exercise and vend patented inventions or registered designs liable to avoidance or suspension.

It will be seen that the Board has now three alternative courses of action open to it, and can either order avoidance, suspension, or a licence. The latter power will be of great benefit to the community and will enable manufacturers to spend money in plant and commence manufacture secure in the knowledge that at the end of the war they will not be liable to be called on by the owner of the patent under which they have been working under licence for the payment of a royalty in the future of an unknown amount. It was not to be expected that manufacturers would spend money laying down plant if they were only to be allowed to use a patent or registered design during the period of its suspension—that is, for an unknown term. The granting of a licence is preferable to the avoidance of an enemy's patent. The avoidance of patents, designs, and trade-marks would, we fear, be found to be a two-edged sword, which, while damaging the enemies' interests in this country, would cause damage to our interests in their countries. In our opinion, the Temporary Rules Act and the Amending Act are not to be used to confiscate completely the rights of enemies in the patents, designs, and trade-marks which they held previously in this country, but are rather to be regarded as levers to obtain better terms, and protect our interests abroad in the future. The object of the two Acts is to suspend, not to destroy.

The intended practice before the Patent Office in connection with applications for suspension of a patent, design or trade-mark, or the grant of a licence, may be summarised as under:—

When an application is received notice will be sent to the patentee, licensee or registered proprietor at his registered address for service, and the application will be advertised in the Illustrated Official Journal (Patents). There will be a short opposition period, and a date for hearing will also be advertised in the Illustrated Official Journal. At the hearing a representative of the patentee will be entitled to be heard against the grant of such suspension or licence. If applications are made by several individuals in respect of the same patent, they will, as far as possible, be heard together. It is not at the moment possible to state definitely whether licences granted in each case will be exclusive or not. Much will depend upon the circumstances of each case. The question is really one for the tribunal hearing the application to decide; but where the circumstances show that an exclusive licence is the only way of obtaining the article to an adequate extent, and at a reasonable price, it is possible that an exclusive licence will be granted, subject to power to withdraw the licence or impose fresh terms if the conditions are not fulfilled. Licences may be either for the continuance of the war or for any period during the term of the patent, and may be subject to terms and conditions, including the payment of royalties, in proper cases, either to the State or to the patentee, if the licence is continued beyond the conclusion of the war.

The expression, "subject of any State at war with His Majesty," is given in the Amending Act a meaning more extended than that ordinarily employed, and is to apply also to any person resident and carrying on business in the territory of a State at war with His Majesty, as if he was a subject of that State. Also the expression, when used in connection with a company, is to include any company or firm whose business is managed or controlled by such subjects, or is carried on wholly or mainly for the benefit or on behalf of such subjects, notwithstanding that the company may be registered within His Majesty's dominions.

As the two Acts give power to avoid or suspend any pending applications for patents, designs, or trade-marks, the Comptroller has given notice that, during the continuance of the war, no patent will be sealed and no registration of a trade-mark or design will be granted to an alien enemy, and that in the case of applications which are not yet in a condition for grant or registration, the proceedings will not be interfered with until the applications become ripe for acceptance, when the formal acceptance will be held back for the time being. The right of opposition to the grant of patents and the registration of trade-marks is withdrawn from alien enemies, but our subjects and alien friends have the right to oppose pending applications of alien enemies, the proceedings, after the giving of notice of opposition, being suspended until the end of the war.

The Comptroller has power during the continuance of the Temporary Rules Act to extend the time during which any Act or thing may or is required to be done under the main Patents and Trade-Marks Acts, and he has given notice that he will extend the time upon such terms and subject to such conditions as he may think fit in the following cases, namely:—

(*a*) Where it is shown to his satisfaction that the applicant, patentee, or proprietor was prevented from doing an act, or filing a document, by reason of active service or enforced absence from this country, or any other circumstances arising from the present state of war, which, in the opinion of the Comptroller, would justify such extension.

(*b*) Where the doing of any act would, by reason of the circumstances arising from the present state of war, be prejudicial or injurious to the rights or interests of any applicant, patentee, or proprietor.

Applicants are, however, warned that those who fail to conform to the provisions of the main Patents and Trade Marks Act will run the risk of losing their rights unless they are able to bring themselves under one or other of the two provisions mentioned. Applications under (*a*) are to be made and will be considered at such time as the applicant, patentee, or proprietor is in the position to do the act or file the document, and applications under (*b*) are to be made before the date for the doing of any act or the filing of any document.

THE LATE LORD MERTHYR OF SENGHENYDD.

As announced in our last issue, the Right Hon. Lord Merthyr of Senghenydd died at Newbury on Thursday morning, the 27th ult., in his seventy-ninth year. His loss will be felt through a wide range of the social strata, for while attaining honours and wealth, he had also secured the esteem of all with whom he came in contact. In his life he played many parts, the volume of his activities widening with the years until it brought him into contact with all classes of his fellow-countrymen in South Wales, and with many elsewhere. He was engineer, coal-owner, iron-master, steel-maker, philanthropist, industrial peace-maker, and much else. To all this he attained entirely by the force of character and intellect, for he owed little to social position, and less to scholastic education.

The subject of our memoir was the second son of Thomas William Lewis, of Abercanaid, and was named William Thomas—his father's christian names, but inverted in order, according to the Welsh custom. He went to school at Merthyr at the age of 7½ years, and remained there nearly six years. Then, in 1850, at about the age of thirteen, he was apprenticed at the Plymouth (Merthyr) Iron Works, under his father, who was mechanical engineer at the works, and for several years he worked twelve hours a day, passing through the pattern-shop, the fitting-shop, and the various other departments. Owing to his close attention to his duties, and to his studies, he was able, before the expiration of his apprenticeship, to become his father's assistant. On leaving the Plymouth (Merthyr) Iron Works, he came in touch with Mr. W. S. Clark, viewer for the Bute Mineral Estate in North Wales. Mr. Clark was at that time (in the early 'fifties of last century) engaged in constructing the East Bute Dock, at Cardiff, the Rhymney Railway, and in colliery workings at Treherbert. On January 1, 1855, the deceased, then only eighteen years of age, and known under his patronymic of William Thomas Lewis, called at Mr. Clark's residence at Aberdare, taking with him a series of working drawings he had prepared, which so impressed Mr. Clark that he engaged young Lewis as one of his junior assistants. Later, from 1857 to 1861, he acted as chief assistant to Mr. Clark. From 1861 to 1864, Mr. Lewis was partner with Mr. Clark in carrying out the same duties. These comprised the widening and deepening of the entrance to the Bute Docks; making a tidal dock and breakwater; erecting coal and ballast staithes; constructing high-level and wharf lines of railway, the installations including a stone viaduct and several stone

and iron bridges; sidings for coal-wagons; and also reporting, as occasion offered, on other important mineral properties in South Wales, &c.

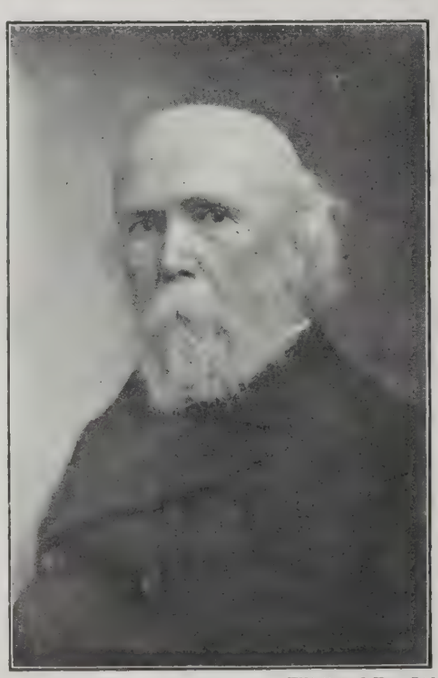
In 1864, on the death of Mr. Clark, Mr. Lewis was selected out of a large number of applicants for the post of mining engineer to the Bute estates. In the same year he married Anne, the daughter of Mr. W. Rees, a colliery owner, of Llettyshenkin, Aberdare, and a granddaughter of Mrs. Lucy Thomas, known as the "mother of the Welsh steam-coal industry," from the fact that it was she who exported the first cargo of Welsh steam coal. This first cargo of steam coal was from the Waunwyllt Colliery, and, owing to its smokeless quality, attracted the attention of the late Mr. John Nixon, whose name became associated with South Wales coal. Mr. Lewis, besides being engineer to the Bute Trustees, acquired a large private practice as mining engineer and valuer. In 1867 he became a colliery owner himself by the purchase of interests in the Hafod Colliery, and as the result of a prolonged strike in that colliery, he succeeded a few years later in forming the organisation which ultimately became known as the Monmouthshire and South Wales Coalowners' Association. Mr. Lewis was the founder of the Sliding-Scale Committee, following the great lock-out of 1875.

In order to emphasise Mr. Lewis's action in the above connection, we may state that the strike we refer to, and others which occurred in neighbouring collieries, convinced him of the necessity for organisation; hence the formation of the Coalowners' Association we have referred to, an association of which he was president for many years. Further, he was not only the founder of the Sliding-Scale Committee, but was a member of that committee as long as it existed, occupying the chair for twenty years. Together with the Right Hon. William Abraham ("Mabon"), M.P., he signed the first sliding-scale agreement in 1876. He always entertained feelings of the greatest respect for "Mabon," testifying to his nobleness as an opponent and his great co-operation as a colleague. These feelings are best expressed in a remark of his to the following effect: — "The lasting impression which 'Mabon' left on my mind is his splendid co-operation. We fought for our own sides, of course—and twenty years is a long time to fight—but it is 'Mabon's' co-operation that I remember best and respect most. I shall never forget his helpfulness, which was always uppermost even when he was most loyal to the men." In recognition of his eminent services to the Sliding-Scale Committee, Mr. Lewis was repeatedly pressed by the Coalowners' Association to accept an honorarium, which he invariably declined. But in 1882, on the suggestion of the late Lord Swansea, he was presented with an address and a cheque for 1000 guineas. Some years later he was presented with a sum of 3000 guineas, all of which he devoted to various charitable, educational, and other public purposes.

Upon the retirement of Mr. Boyle, in 1880, the late Marquis of Bute placed the sole management of the Bute estate in South Wales, with its docks, railways, and colliery property, under Mr. Lewis's control. In 1908 he retired from the management of the Bute Docks, a position which he had held for a period of twenty-eight years, but retained the management of Lord Bute's colliery interests and landed estates.

Mr. Lewis was knighted in 1885; he received a baronetcy in 1896, and was created a baron in 1911. When only twenty-six years of age he was elected an Associate of the Institution of Civil Engineers, becoming a full member at thirty. During his career he occupied the positions of President of the University College of South Wales and Monmouthshire; Member of Council of the Institution of Civil Engineers; President of the South Wales Institute of Engineers; President of the Mining Association of Great Britain; President of the Institution of Mining Engineers; Vice-President of the Iron and Steel Institute; Vice-President of the Institution of Mechanical Engineers; and chairman of many local bodies. He always took a most keen interest in the local affairs of Aberdare, and we may add that for many years he was a member of the Aberdare Local Board of Health.

His work in the interest of industrial peace was frequently in request. In the year 1900 he was successful in settling the Taff Vale Railway strike after the Board of Trade had failed. Shortly afterwards he submitted a scheme for the formation of Boards of Arbitration for the prevention of railway disputes to the Boards of the Taff Vale, the Rhymney, the Barry and the Cardiff Railway Companies. The last-named company was the only one to accept the principle he put forward and the proposal was dropped. When, however, in 1908, the Amalgamated Society of Railway Servants threatened to bring about a national strike, Mr. Lloyd George, who was then President of the Board of Trade, brought the contending parties together, and when he, Mr. Lloyd George, received the freedom of the city of Cardiff, he acknowledged in most generous terms the invaluable assistance given him by Lord Merthyr—then Sir William Thomas Lewis—in drafting the scheme which was ultimately accepted by the railway directors and the men's representatives. That scheme, which averted the threatened railway strike, was almost identical with the one that Lord Merthyr had asked the local railway companies to adopt eight years before. On the occasion we allude to, Mr. Lloyd George gave at Cardiff the following frank acknowledgment of the assistance he had received from the deceased:—"With respect to the railway settlement,



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The late Baron Merthyr of Senghenydd.

I am very glad of this opportunity to recognise with gratitude the assistance which I got from your distinguished fellow-citizen, Sir William Thomas Lewis, who I hope will allow me to proclaim him as my friend. His experience and his counsel were invaluable to me. Throughout I was in close personal touch with him. I sought his advice, and, what is far more than most people can say when they get good advice, I followed it, and followed it with results which I think are pretty patent to the whole country, and I am glad to take this opportunity of thanking him in the presence of his fellow-citizens. You will be glad to know that the scheme of conciliation which we agreed upon then has been put through with very considerable success."

The Monmouthshire and South Wales Miners' Provident Society, which was founded in 1882, to aid the miners and their families, was started by the deceased, who, as early as 1869, had strongly advocated the formation of such a society. It is interesting to add that in recognition of his numerous gifts, particularly to the Merthyr Hospital, the Board of Management of the Miners' Provident Society met at the Merthyr Hospital, in September, 1889, for the purpose of unveiling a memorial tablet placed therein, bearing the following inscription:—

"In commemoration of the gift of Sir William Thomas Lewis, Knight, to the Merthyr General Hospital, of 35,000 pennies, presented to him on the occasion of his receiving the honour of knighthood, by 35,000 members of the Monmouthshire and South Wales Miners' Provident Society, in grateful recognition of the fact that the formation of their society was mainly due to his untiring energy. October, 1886."

Besides the management of Lord Bute's interests and estates, Lord Merthyr acquired very large interests of his own as a coalowner. He amassed great wealth by his control and part ownership of some of the largest undertakings in the South Wales coalfield, including the Lewis Merthyr Consolidated Collieries, the International Collieries, and others. The explosion which occurred at the Universal Colliery, Senghenydd, with its appalling loss of life, was the source of much grief to him, and affected his health.

He was also a pioneer in the construction of iron and steel works, among which we may mention the Cardiff-Dowlais Steel Works, and, in conjunction with other prominent men in the trade, he put down and remodelled other works. In fact, Lord Merthyr was remarkable for indefatigable industry; he was also in perfect touch with every detail of all the concerns with which he was connected.

The news of his death was received with deep sorrow. He had suffered of late years several illnesses, and it was feared that his age would prevent his complete recovery from the effect of these. About three months ago he had another illness, which made it incumbent upon him to seek complete rest previously to undergoing an operation, for which purpose he was removed to the London residence of his second son, the Hon. Trevor Lewis. Lord Merthyr withstood the operation satisfactorily, and was placed in a nursing home at Oakhurst, near Newbury, Berkshire. Here, unfortunately, congestion of the lungs supervened, and he passed away at 2 A.M. on Thursday, the 27th ult.

It will be remembered that Lord Merthyr had been nominated as President of the Iron and Steel Institute for the two years from 1909 to 1911, but at the last moment he found himself unable to undertake the office. Sir Hugh Bell, the retiring President, thereupon kindly consented to retain the office of President for another year, and at the spring meeting of the Institute, 1909, he expressed his sincere regret that Lord Merthyr—then Sir W. Thomas Lewis—had been compelled to arrive at the decision he had taken, all the more so because that decision had been brought about by personal suffering. Lord Merthyr leaves two sons and six daughters, and is succeeded in the title by his elder son, the Hon. Herbert Clark Lewis.

THE USE OF MUD-LADEN FLUID IN OIL-WELL BORING.

In drilling for oil, large quantities of natural gas are very often encountered. As the oil-fields are frequently comparatively isolated and far from industrial centres, there may be at the moment no market for this gas. This, and the fact that it is a hindrance to drilling operations, causes it to be regarded as a nuisance. Hence it is not infrequently allowed to waste, and through the lack of an appreciation on the part of the oil prospectors or producers of its potentialities, a commodity which might later prove a valuable asset is irretrievably lost. Cases of this kind have been innumerable in the United States. In time the gas becomes exhausted, and, possibly, just when it could be usefully applied, the supply may fail, or fall so materially as to be of little commercial value. In one instance on record a well, which, on first striking gas, produced 6,000,000 cub. ft. per day, was allowed to waste for twenty-two months, in which time the output shrank considerably. From the immediate neighbourhood the gas from other wells had been piped to two towns six miles away. The capacity of the latter bores has rapidly diminished, owing to the failure to close the first promptly. If the amount thus wasted had been conserved it would alone have met the present demands of the towns for no less than twenty-four years, whereas the supply is showing signs of rapid exhaustion after a period of only about six years.

The gas is frequently at high rock pressures, 600 lb. to 800 lb. per sq. in., and one bore may emit as much as 40,000,000 cub. ft. per diem. There are well-authenticated cases of wastage to the extent of 1,500,000,000 cub. ft. from a single bore in a very short time, owing to a failure to take prompt measures on striking gas. Whether a present market exists for the gas or not, the destruction of natural resources at this rate is greatly to

be deprecated. If it could be conserved, it might be that in a short time a demand for the gas itself would arise in the neighbourhood, or perhaps the future would bring with it other means of utilising it. Much of the gas is suitable for the production of gasoline, and even now a large industry of this kind is carried on. Three years ago about eight million gallons of gasoline were produced by compression from natural gas in the United States, and now we may reasonably assume that the industry, often showing attractive profits, has increased. The number of wells actually furnishing gas for gasoline production is at present small, compared with that of the wells known to supply suitable gas. It is clearly desirable that present waste should be avoided, since the future may very likely bring with it a market, even if for the moment the commodity appears to be valueless and superfluous. It is said to be largely the fault of terms of the drilling contract that such waste exists. The contractor aims at reaching the oil-bearing sands with the least possible delay. Frequently not till the gas is emitted in such volumes that it is an actual hindrance to boring operations is much notice taken of it, and then perhaps only with the result that the work is abandoned, temporarily at least.

The United States does not stand alone in furnishing examples of the waste in pioneering work. In no country, however, has the neglect been on quite so large a scale. In many directions the lavish gifts of Nature have been abused rather than properly utilised. Most people admit that the "conservation of natural resources" movement, inaugurated some years ago, was timely, though exaggeration may have been introduced now and then into the arguments. With praiseworthy solicitude, the United States Bureau of Mines of the Department of the Interior has been endeavouring to encourage oil producers to conserve the gas encountered at oil-wells, with a view to its future use. The gas often issues from strata above the oil-bearing sands, and it is a common practice to bore a well and put down casing to the oil-sands, leaving the gas from the strata above free to enter the space between the casing and the sides of the hole. It is then possible for the gas to pass from its own strata to others of a porous nature, and to travel thus for great distances, with much loss, and also with danger to neighbouring wells. It is desirable that the gas should be either sealed off from the bore, or that, if utilised, it should be taken to the surface through a proper casing.

The officials of the Bureau of Mines have been conducting a campaign having for its object the adoption of the use of mud-laden fluid in oil-well boring. This has met with considerable success in the Cushing field in Oklahoma. Mud-laden fluid has been used for some years with rotary rigs, but it was only last year adopted, at the suggestion of this Bureau, with the ordinary rig. In rotary drilling the fluid is forced down inside the hollow drill stem and passes up the hole. In this way a circulation is kept up, which not only keeps the bit clean, but brings drillings to the surface, so that a knowledge is obtained of the strata passed through. At the same time the fluid keeps the sides of the hole from caving, and gas is shut off without withdrawing the drill stem. Bores of great depth have been safely accomplished by these means without setting the first string of casing. It has now been found that a similar use can be adopted with the ordinary cable rig employed in dry-hole drilling—that is, drilling in which only enough water is used to keep the drillings slushy enough to allow the bit to strike the bottom. The fluid employed is best made with fine sticky clay, capable of remaining a long while in suspension in water, the proportion used being about 20 per cent. by weight of the water. Such a fluid interferes no more with the drop of the tools than does clear water, but it has immense advantages over the latter. The objection to the use of clear water is that it encourages caving, while it is frequently impossible to keep a bore sufficiently filled with it to overcome the head of gas, owing to rapid flow into surrounding beds. The attempted use of clear water has sometimes permanently drowned out gas sands.

The mud-laden fluid acts in a different manner. If there is any tendency for the fluid to flow into beds passed through, the suspended clay acts as grout, gradually clogging the interstices, and sealing the walls of the hole. Practically any bore may ultimately be made gas-tight, provided a sufficient head is obtainable, either statically or by pumping. When once sealed, work can be continued through the fluid to greater depths, while if it be necessary subsequently to open up the gas supply, this can be readily done by bailing out until the pressure of the gas overcomes the head of the fluid column, when the gas will blow out and clean the sand automatically. The treatment of a well has to be adapted to circumstances. If gas-bearing strata are expected, it is naturally best to forestall trouble by drilling with the hole full of fluid. The presence of the fluid in a hole does not interfere in any way with the setting of the casing. A hole already "wild" may be reclaimed by the application of the fluid; but in such cases, naturally, special measures have to be taken to introduce it into the hole. When flows are encountered, so great that the boring tools will not drop with any force, it is clear that the fluid would be ejected before sufficient had been inserted to provide the required head. In such a case a kind of fluid-lock is fitted to the head of the casing already inserted in the hole and reaching as far down as possible. This lock consists of a gate-valve fitted to the head of the casing in the hole, with a length of about 40 ft. of 10-in. casing, having a second gate-valve at the top. When ready the lower valve is closed, and fluid is pumped into the 10-in. casing, and when this is full the top valve is closed and the lower one opened. Gas then passes up into the lock displacing the fluid. The process can be repeated until the bore has been supplied with sufficient fluid to overcome the head of gas, when the lock can be dismantled, the hole filled if necessary by pumping in direct, after which drilling may proceed. If the length of casing inserted in the hole is well-seated, but so short that the weight of the casing and lock does not overcome the gas pressure, the whole may be anchored down if the difference is only slight, or another method may be advantageously adopted. In the latter, a tee-head with a large valve is fitted to the casing, and through the tee a string of tubing of smaller diameter and supplied with a non-return valve at the bottom is inserted in the bore to a point below the gas sand. This smaller tubing, which passes through a gland in the tee, is coupled to a pump, by which fluid is forced into the well, being delivered below the gas-bearing stratum. At the same time the gas is allowed to escape through the large valve which, however, is closed down just so much as is required to prevent the fluid being blown out with the gas. In this way several wells have been successfully shut off. In some cases, where a static head has proved insufficient to overcome the gas-pressure, the fluid has been kept under pressure by pumping for a few hours, after which work has been renewed, but in such a case it is necessary that only a moderate amount of drilling should be done before renewing the fluid pressure, as the clogging action does not penetrate very deep. Care should always be taken to admit the fluid to the hole through a pipe ending as near the bottom as possible, in order to prevent possible damage to the sides.

With this system all waste outside the casing from one stratum to another can be avoided, and water prevented from passing to gas sands, or salt-water to fresh-water beds. Faulty seatings of casing have been rendered tight, while wells can be safely drilled through gas strata to oil sands, or through one oil sand to another at a greater depth. Combination wells drawing oil from different beds, or oil from one and gas from another, can also be bored and cased without trouble or loss.

NOTES.

"All the World's Aircraft."

This is the title of the annual founded and edited by Mr. Fred T. Jane, the founder and editor of "Fighting Ships." It was originally known as "All the World's Airships." This is the sixth year of issue, and the work is divided into four parts, dealing with the aeroplanes and dirigibles of the world, historical aeroplanes of the last six years, the world's aerial engines, the fourth part being an aerial directory. It opens with the following statement, which we feel sure will meet with general approval in this country, so far as the British machines and motors are concerned:—"On account of the general European war, it has been decided to publish the first edition of this book a month earlier than was generally anticipated. This means that the Italian and United States pages have to go to press imperfectly brought to date. On the other hand, though certain details which would otherwise have appeared are necessarily lacking, the matter collected concerning the principal belligerents is of such a nature that immediate publication seems desirable, and to justify the unfinished state of the British pages, from which, for obvious reasons, a good deal has been deliberately deleted." A number of illustrations of British machines and motors have been, and very rightly so, completely blocked out in this first edition, a copy of which we have received from the publishers, Messrs. Sampson Low, Marston and Co., Limited. But the information it contains on the aircraft and engines of the other nations of the world, with the reservation in regard to Italy and the United States, reproduced above, will prove most interesting for reference purposes at the present time. The information is arranged alphabetically according to countries, and includes the names of the aviators, aerial societies, and aerial journals; military, naval, and private flying-grounds, and illustrated data on the various machines—length, span, area, weight total and useful, type of motor, speed, number of machines built, &c. The fourth part of the book is the commercial part, in that it gives the names and addresses of the firms throughout the world who manufacture or deal with the various parts entering in the construction of aircraft.

The Board of Trade and Manufacturers' Inquiries.

We have in recent weeks on several occasions referred to the energetic action taken by the Board of Trade with the object of assisting British manufacturers to occupy the markets hitherto served by Germany and Austria. With commendable promptitude the Board has issued a series of White Papers dealing with a variety of classes of manufactures, and giving statistics relating to the magnitude of Germany's and Austria's trade in the principal countries. This will give some idea as to the value of the market to be approached, while not less interesting are the extracts from consular and other reports, which in many instances give admirable advice as to the best way of meeting the needs of the country and combating the competition of our rivals. We now have to refer to another very important step taken by the Board. Since communication with certain European countries has been cut off, many traders here have had difficulty in securing for their manufacturing processes supplies which they formerly drew from the Continent. In many instances such supplies are procurable here. Other firms whose Continental market has temporarily gone are in the position of seeking buyers. The Board of Trade has made arrangements to put such firms into communication with each other, and in another column we reproduce an official notice in this connection. A list has been published by the Commercial Intelligence Branch of the Board of Trade, divided into two sections. The first names articles which inquirers desire to purchase; the second, articles which inquirers desire to sell. We notice in the lists several articles relating to the engineering and hardware trades. Many of these articles appear in both lists, and we conclude the inquirers in these cases have been put into touch with each other. Inquirers of either class should avail themselves of the facilities thus offered. Communications should be addressed to the Director, the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, E.C. In addition to this useful departure, the Board is arranging for an exhibition of German and Austrian-made goods competing abroad with British-made goods, from which our manufacturers ought to be able to derive valuable information.

Refractory Materials.

The material that has been used in the United States for some years in the manufacture of silica gas-retorts is identical apparently with the ganister quartz of Yorkshire, &c., and contains 95 per cent. of silica; it is crushed, mixed with 2 per cent. of milk of lime, and worked into strong retorts of excellent appearance. "Whole" moulded silica retorts are only made up to 18 in. in length; generally the retorts are built up of tiles and bricks. They expand when heated by $\frac{1}{8}$ in. or $\frac{3}{16}$ in. per lineal foot, unless the joints are made with thick paper or straw-board, or with a cement of mild aluminous clay, which shrinks when the settings are put to work. The retorts do not crack when first lighted up nor later when cold air rushes in; further to

obviate this danger the mouth-piece is frequently made of solid moulded fireclay. Stoking-machines (De Brouwer, Fiddes-Aldridge, Ritter Conley Bredel) can be used with such retorts; the retorts so stoked last three or four years—that is, longer than clay retorts. The experience so far gained is favourable. These facts were reported to the Institution of Gas Engineers at the recent meeting at Liverpool by the Refractory Materials Committee. This committee has also tested refractory materials under load in a way that imitates working conditions so far as possible. In conjunction with Dr. J. W. Mellor (of the Retort and Fire-Brick Section of the Society of British Gas Industries), samples of fireclay, &c., were obtained from Stourbridge, Yorkshire, Newcastle, and Scotland, and were tested under load. The interesting observation was made that the melting-point of the material was lowered by 12 or 13 per cent. when the sample was subjected to a pressure of 54 lb. per sq. in. Thus, samples normally melting at 1650 deg. Cent., melted at 1435 deg. with a load of 54 lb., and at 1380 deg. with a load of 72 lb. per sq. in.; the melting-points of another specimen were 1690 deg., 1435 deg., and 1410 deg. In another series, pressures of 84 lb. and 112 lb. per sq. in. were applied, and the melting-point of a very good china-clay was thereby lowered from 1770 deg. to 1520 deg. and 1400 deg. Cent.; a fireclay gave the melting-points, 1730 deg., 1460 deg., and 1410 deg., and was thus equally strong under pressure as the china-clay. In the settings, this lowering of the melting-point was probably not so large; but the observation was important and deserves further study.

Foreign Competition in Pumps and Pumping Machinery.

Statistics for a recent year show that while our exports of pumps and pumping machinery to all markets abroad amounted to 677,800*l.*, those of Germany to foreign markets amounted to the value of 533,900*l.* Of this figure, pumps worth 18,450*l.* came from Germany into this country, but Germany's greatest shipments to any one foreign country were to Russia, to which she sent machinery of this class to the value of 91,850*l.* At the same time we sold goods worth 72,800*l.* in that market. It is stated that although we have taken a prominent part in the supply of such machinery, our share there would have been greater had our firms realised the extent of the possible business, and had they been more willing to meet the Russian commercial methods. The change that is taking place in the Urals from placer-mining to methods requiring more machinery should create a good market, if adequately handled. The United States are large exporters of pumps to Russia. In Canada, the bulk of this trade is in the hands of the United States, though Germany sends to that country pumps to the value of ten times the amount we do. In South Africa we have a strong footing, but the United States and German trade is considerable. It is stated that for this market manufacturers should develop suction-gas pumping plants suitable for use with Colonial anthracite containing a high proportion of sulphur. In Egypt, although German trade of this class of plant is very much smaller than ours, it is, nevertheless, worth combating, as it tends to increase. German firms usually give longer credit in Egypt than do the firms of other countries. In Servia, Bulgaria, and Roumania, Germany does a large trade, mostly in the better class of pumps. The cheaper kinds, in which also a large business is done, come from the United States. From Bolivia, where Germany competes with British products, it is reported that British prices do not attract. Germany sells there pumps of cheaper qualities, giving also longer credit. Agents are said to be constantly canvassing the country for the German firms, and are in with quotations as soon as there is any probability of an order. Sales are pushed vigorously. In Japan Germany has a strong footing in the matter of electrically-driven pumps for mines. To France Germany sends pumps to the value of 52,300*l.*, while we send there only 28,000*l.* worth. Again, in Italy, Germany disposes of about 34,000*l.* worth, while our business only amounts to 20,200*l.* In the Argentine, where this country has so much in its favour, though we sell to the value of 64,400*l.*, Germany manages to do trade to the amount of 29,300*l.* The Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, E.C., has just issued a memorandum on this subject which will well repay study.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. I

By Frederick William Lanchester, M. Inst. C.E.

Introduction.

All authorities may to-day be said to agree on the broad fact of the utility and importance of the flying-machine or aeroplane—or, more broadly, aircraft—in warfare; but at present the air service as a fourth Arm of the military organisation, either of this country or of any of the other great military Powers, can only be regarded as of a tentative and experimental character.

It is, unfortunately, not yet possible to draw conclusions of a lasting nature from the actual usage of aircraft in the present war, mainly for two reasons. Firstly, the machines at present available (with possibly a few exceptions) are entirely without armour or defence of any kind, and, dirigibles apart, are, generally speaking, without guns or other offensive armament of an effective character. Secondly, the machines are numerically so weak that, as an Arm of the Service, the aeronautical forces are a negligible factor. The question of sufficiency in numbers is evidently dependent upon the point of view taken. On the one hand, if we regard the flying corps as merely the successor to the pre-existing balloon corps, the numbers, as they at present stand, may be regarded as sufficient; indeed, perhaps, even liberal. On the other hand, if we would recognise in the advent of the aeroplane the dawn of a fourth Arm (this being the point of view adopted in the present series of articles), the present numbers, which in no case represent one-twentieth part of 1 per cent. of the total forces, are a truly negligible quantity. In order to get a fair perspective of the position from the present standpoint, it is sufficient to institute a comparison with the cavalry, to which Arm, from its function, the aeronautical Arm is most closely akin. Here the accepted numerical proportion in a modern army is about 6 per cent. of the total of all arms. Now there are many otherwise competent authorities who would deny to the aeroplane (or to aircraft generally) the potential importance which the writer hopes satisfactorily to demonstrate is its due; let us put the matter to the test. We hear constant reports of the work done by German aircraft, and particularly the effective tactical reconnaissance of the German aeroplanes, which appear to be continuously employed during the course of every engagement for locating our gun positions, directing gun-fire, following up bodies of troops in retreat, &c. We also hear reports of their wider field of operations, presumably carrying out reconnaissance of the strategic distribution of the forces of the Allies at points remote from the enemy's lines. We may presume that the Belgian, French, and British aircraft are employed with equal success; but here, in the nature of things, the information that appears in our own Press is meagre. As already pointed out, the total number of machines engaged is microscopic; the Germans are reputed to have possessed at the outbreak of hostilities some 500 machines in all. If the German cavalry had been limited to 500 mounted men, would they have been ever heard of at all? Answer is unnecessary. It may be reasonably argued that the capital value of an aeroplane, with pilot and observer, being so much greater than that of a cavalryman, the above comparison is unfair; granting this objection, we may perhaps admit that the cost equivalent of 500 aeroplanes would be ten squadrons of cavalry, say 1500. This does not seriously alter the position; such a force would be quite unperceived and be of no tangible service to the German army of to-day.

If, then, instead of the present moment being that of the introduction of the aeroplane (and dirigible), it had chanced to be the moment when mounted men were put on trial for the first time as a fighting machine, and presuming the initial trial to have been made on a similarly modest scale, the mounted men would, relatively speaking, have proved a failure, and no one, not possessed of exceptional intuition or foresight, would have had the least conception of the possibilities of cavalry when numerically sufficient, and handled in sufficient masses and with appropriate supports.

The foregoing is not put forward as a rigid demonstration that the air service is in the future destined to become as important an auxiliary to an army in the field as the cavalry of to-day; it is no more than an illustration illuminating the view the present writer (in common with some few others) holds, but which clearly is not yet the official view, in this country at least. The great difficulty in connection with the present subject is that in order to get the future into true perspective, it is necessary to be able to look forward along two parallel lines of development—*i.e.*, to visualise the improvements of aircraft possible in the near future as a matter of engineering development, and simultaneously to form a live conception of what these improvements and evolution will open up in the potentialities of the machine as an instrument of warfare. The writer of the present article does not wish it to be supposed that he is endeavouring completely to lay down axioms as to the military future of aircraft of a positive character, or that he pretends to be in a position to formulate a cut-and-dried constructive programme; his intention is rather to give something in the nature of a lead in the direction in which it appears development may be logically anticipated.

The Primary and Secondary Functions of the Aeronautical Arm.

It is generally recognised that in its employment in connection with military operations a most valuable property of the flying-machine or aeroplane is its mobility; it is, in fact, mobile to a degree that can scarcely have been dreamt of in warfare of the past. When, therefore, we look for uses in co-operation with an army in the field in which the aeroplane may show to advantage, we naturally turn to examine the duties at present fulfilled by the cavalry, hitherto the Arm to be employed wherever mobility is of importance. Thus it is well recognised that one of the main duties for which the cavalry have hitherto been responsible—namely, reconnaissance—is a duty to which aircraft are eminently suited. It is at the outset important to realise that the cavalry, in face of the improvements in small arms and artillery, with the advent of the armoured motor-car, and with the greater mobility of the main bodies of troops in modern warfare, have been finding the difficulties of effective reconnaissance continually on the increase. It is stated by one of the greatest authorities on the subject that of the reports sent in by cavalry patrols not more than 1 per cent. are of any use to the commanding officer, usually owing to fact having anticipated the receipt of the information; in other words, the whole process of tactical reconnaissance by cavalry has become far too slow to keep pace with the conditions of modern warfare.

So far as the writer is aware, there has, up to the present, been no serious attempt to work out in complete detail the duties that can be undertaken by aircraft, or to define in specification form by any process of logic the types of machine that will be necessary at the outset to deal with the various duties so postulated. It is necessary to say *at the outset*, in view of the fact that if to-day we had a perfect organisation based on existing conditions, the first great Power to be similarly equipped would require to be answered in the form of a further equipment especially directed to his destruction, and so (as in the evolution of the Navy) we shall probably have in due time aerial destroyers and "super" destroyers, and again still larger and more heavily armed machines for the destruction of these.

The primary function of, and basic justification for, any Arm is the execution of its duties in relation to other than its own kind; thus, though it is admittedly one of the first and most important duties of cavalry to drive the enemy's cavalry out of the field, and establish superiority, this is actually the secondary function of the cavalry Arm; its primary function is the observation and harrying of the other Arms of the Service. Again, the primary function of a fleet is neither to hold nor defeat a hostile fleet, although this, its secondary function, is universally admitted to be its first and most important objective. Ultimately, in every case, there must be some primary purpose which gives rise to the need for any kind of fighting machine, apart from its power of offence or defence against its own kind; it is this primary purpose that imparts the initial impulse and direction to its development.

It is proposed forthwith to define the primary function of the aeronautical Arm as comprised by its duties and actions relating to the three pre-existing Arms of the Service—viz., the infantry,

cavalry, and artillery.* Its secondary function is defined as comprised by its duties in the attack on and defence from its like Arm—*i.e.*, the destruction or countering of hostile aircraft.

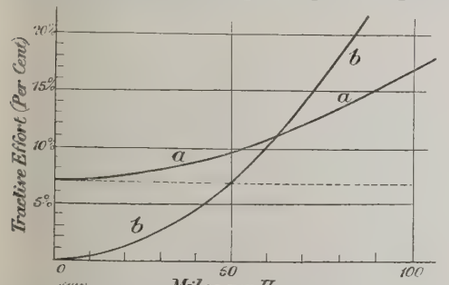
It is necessary to be perfectly clear as to the above definitions. In considering, in the first instance, the comparative merits of the aeronautical and the older Arms of the Service for any particular duty, as it is needful to do in order to justify, or otherwise, any particular type or usage, it is futile to import into the initial discussion the action or possible counter-manœuvres of the enemy's aircraft; this latter may, or may not, eventually prove an important factor, but its influence, when taken into account, must be studied not only as touching the air service, in contemplation, but also at the same time as affecting the other Arms of the Service (more particularly the cavalry) in its corresponding usage. In brief, as a matter of logic in discussing the functions and duties of the aeronautical Arm and the type-specifications of machines, by which its objects are to be secured, the primary function alone has to be considered. Subsequently, when a provisional scheme and specifications have been formulated, it is time to take count of the secondary function, and to endeavour by careful prevision to forestall the enemy.

AEROPLANE *versus* DIRIGIBLE.

Two questions are involved in the consideration of the relative merits of the aeroplane and dirigible. We are firstly concerned with their respective advantages and disadvantages in relation to their primary function — namely, as instruments of reconnaissance, attack, and defence; secondly, we have to take into account their secondary function —*i.e.*, their relative power of mutual destruction; whether, in fact, either can drive the other from the field, or whether each may have its own *rôle* to play in securing and holding the command of the air.

Before going into either of these questions in detail it is convenient to review a few of the facts by which limitations are imposed on the ultimate performance of either type of aircraft. We must avoid falling into any error by judging each too closely by its performance of to-day.

The all-important question of *speed* is a matter depending primarily on the lightness (*i.e.*, horse-power per given weight) of the prime mover, and the law of resistance. The horse-power per given weight available is roughly the same whichever type of aircraft is in question, and any future advance in the art of motor construction tending to diminish weight will, we may presume, be equally available for either type. The laws of resistance of the aeroplane and dirigible are well understood; in the case of the former the resistance is approximated by a curve *a a*, Fig. 1, representing the



sum of a resistance following the V-square law and a constant; the latter (the dirigible) may be taken as following the V-square law implicitly, Fig. 1, *b b*. Fig. 1 represents approximately actual values of the resistance coefficients, in tractive effort per cent., in machines of average size as they exist to day, for the speeds given in miles per hour.†

One salient fact is at once evident; the greater the horse-power available for a given engine weight the greater the advantage in the matter of speed in favour of the aeroplane. The highest speed of flight of an aeroplane attained to-day (through, *i.e.*, relatively to, the air) is already more than twice that of which the fastest dirigible is capable; there is every prospect that its advantage in this respect will increase rather than diminish with the march of progress.

Beyond the above, it is well understood that an increase in size is conducive to a reduction in the resistance coefficient; this applies to both aeroplane and dirigible. This fact has been one of the controlling considerations in dirigible design; no dirigible, other than of comparatively large size, has been found to be of real service. It is, moreover, evident that, in the case of some of the large Zeppelins, it will not be found practicable to go very much further in the direction of increase. Here again the aeroplane is at an advantage; we can in nowise regard the aeroplane of to-day as defining the limit of what can be reached.

It is abundantly manifest that the *dirigible is at a permanent disadvantage of not less than two to one in the matter of speed.*

The question of *range* and *duration* of flight is largely determined by petrol-carrying capacity. In the aeroplane both range and duration depend definitely upon the petrol supply holding out; in the case of the dirigible the same applies to a limited extent; but here the duration and, to a less extent, the distance can be greatly prolonged by reducing the speed to the minimum possible without jeopardising the control. In the dirigible the gradual loss of buoyancy, due to the leakage and escape of hydrogen, is an independent determining factor. As a matter of fact, there is not (taking everything into account) much to choose between the two types of aircraft in the matter of range or radius of action; on the other hand, under favourable conditions, the dirigible has undoubtedly the advantage on the score of duration of flight. The maximum may be taken as about 24 hours in the case of the aeroplane, against 48 hours in the case of the dirigible. This may be taken as a fair indication of their relative capacity, though of no quantitative value as a guide to what is to be expected under service conditions. The possibilities of the future are here rather in favour of the airship; there is an absolute limit both of range and duration where the aeroplane is concerned.

On the question of *storage* or *housing* the advantage of the aeroplane is overwhelming; the aeroplane, especially if furnished with folding wings, can be stowed away in any ordinary shed or barn, whereas the "balloon hall" necessary for the safety of an airship is not only most costly, but is an unmistakeable landmark for hostile aircraft at 20 miles distance. Again, bad weather affects the storage of an aeroplane but little, whereas the housing or getting out of an airship in a strong wind is a difficult and risky business, even under the best of conditions. A large Zeppelin may sometimes call for the services of 300 men.

The foregoing by no means exhausts the grounds of comparison, but is sufficient for the present purpose. It is scarcely necessary to point out the very great disparity of weight, and, incidental thereto, carrying capacity, between the two classes of machine; the large German Zeppelins have a gross weight, taken from their displacement, of 22 tons (military) up to 35 tons (naval); of the aeroplanes in service, practically all the military machines are less than 1 ton "tare," and most types do not exceed 1 ton gross—*i.e.*, with full complement, petrol, oil, &c.

If we were concerned with the primary function of the aeronautical arm alone, there appears to be no reason to doubt that both kinds of aircraft would have their place; the large air-ship has unquestionable advantages under suitable conditions: cruising at high altitudes over the battle-field, or over or in the rear of the enemy's lines, and reporting to head-quarters by wireless every movement of strategic or tactical importance, it can render the most vital service. It is able to carry a complement of officers trained to observation, capable of giving an accurate interpretation of what they observe, and acting under most favourable conditions, such as are not possible in any aeroplane; it can move at some fifty miles per hour, if required, or remain to all intents and purposes stationary; it can follow continuously the course of events from sunrise to sunset, and remain the whole time in touch with headquarters, either for sending or receiving. On the other hand, for bearing despatches, for flying at low altitude within range of shot and shell, as may be necessary for detail reconnaissance or in cloudy or misty weather, for bringing machine-gun fire to bear at some important point or at a critical moment, &c., all these are duties for which the aeroplane is pre-eminently suited, as also for rapidly locating and signalling gun positions, directing fire, and duties of such-like character.

It is more than questionable whether actual fighting is any part of the primary function of a dirigible at all; it is at least becoming apparent that bomb-dropping is an entire misuse of the large airship; the results are incomparably small in view of the means employed, and can never affect decisively the course of any battle or campaign.

It is important to note that though it is possible effectively to armour an aeroplane, at least to be proof against small-arms fire, and that in any case the vulnerable target is small, the dirigible, presenting a mark larger than the proverbial haystack, cannot be effectively protected. In spite of the fact that injury to the envelope is not necessarily dangerous, such injury has already necessitated in more than one instance a hurried descent into a hostile country, with the effective loss of both vessel and crew. These are the considerations that render the dirigible at a formidable disadvantage when within reach of the enemy's guns.

We may now pass to the discussion of the secondary function of the aeronautical Arm in its present relation—that is to say, we shall consider the question of aeroplane *versus* dirigible in armed conflict.

At the outset it is desirable to dispose of the much-worried analogy that crops up again and again when the present subject is discussed. Some of the most strenuous supporters of the airship as an auxiliary to the aeronautical service are fond of drawing a parallel between the air service and the Navy, the airship being put forward as analogous or comparable to the battleship or battle-cruiser, and the aeroplane to the torpedo boat or destroyer. In the writer's opinion any such analogy is totally fallacious. The effective area of the target presented by an aeroplane is but a few square feet. The effective target area of a torpedo-boat or destroyer is more than one hundred times as great. The time during which an aeroplane is visible and under fire, owing to its small size and high speed, is short compared to that of torpedo craft at sea.* The armament which a Zeppelin can bring to bear on an attacking aeroplane is confined to that which she can carry on a platform arranged on the top of the structure, since the hostile aeroplane making its attack from above can manœuvre to remain, in billiard phraseology, "snookered" so far as the car and main armament are concerned. Beyond the above, the speed of the aeroplane is approximately double that of the airship, whereas the speed of a fast destroyer is not more than 20 or 25 per cent. superior to that of a fast and heavily-armoured cruiser of modern type, and even this advantage is lost in heavy weather.

It will be realised in considering the above facts that the whole analogy breaks down—the continued existence of the battleship or cruiser in the face of torpedo-craft does not in the least degree imply or involve the continuance of the airship as a logical necessity.

MECHANICAL COOLERS FOR WATER AND OTHER FLUIDS.

ON the next page we illustrate a mechanical cooler of unusual design, which has been devised by Messrs. Heenan and Froude, Limited, of Worcester, for cooling the circulating water of internal-combustion engines, the condensing water of refrigerating machinery, the circulating water of air-compressors, and the like, plants for one or other of these purposes having been installed by the patentees in many quarters of the world. In these machines the water is cooled by exposing it in thin films to a current of air forced over it by means of a fan.

As will be seen on reference to Figs. 1 and 2, the machine is of very simple construction. It consists of a number of cylinders, each of which is built up of galvanised-steel sheets, which are wound spirally on to a cast-iron centre. This winding is done by special

* Also the Navy and merchant marine where naval warfare is in question.

† The maximum speed attained by an airship is approximately 50 miles per hour; the maximum in the case of an aeroplane is considerably over 100 miles per hour; thus (Fig. 1) the tractive coefficient in the case of the aeroplane is very considerably greater than in the case of the airship. The reason for this is that the dead-load in the airship—represented by the envelope and its appurtenances—is disproportionately great, and the proportion of the weight that can be devoted to the motive-power installation is relatively smaller than in the aeroplane. Were it not for this fact the airship would have held the advantage until speeds about 60 miles per hour had been reached and the aeroplane after.

* Added to this, to detect the approach of a hostile aeroplane the sky has to be scanned in the three dimensions of space.

MECHANICAL COOLER FOR WATER AND OTHER FLUIDS.

CONSTRUCTED BY MESSRS. HEENAN AND FROUDE, LTD., ENGINEERS, WORCESTER.

Fig. 1.

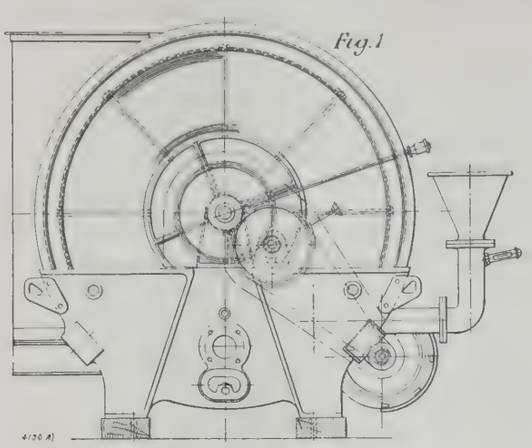
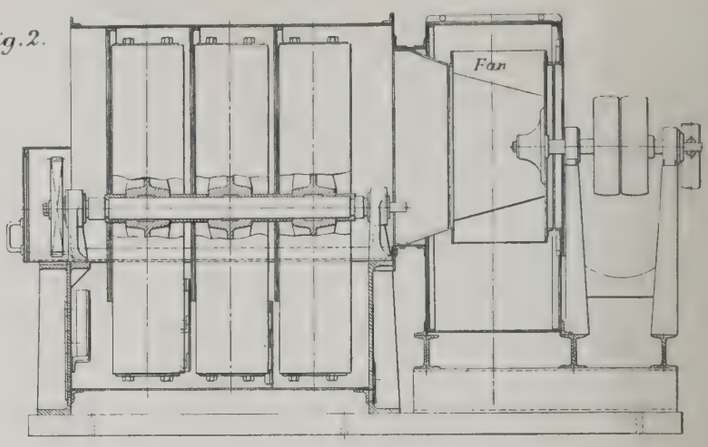


Fig. 2.



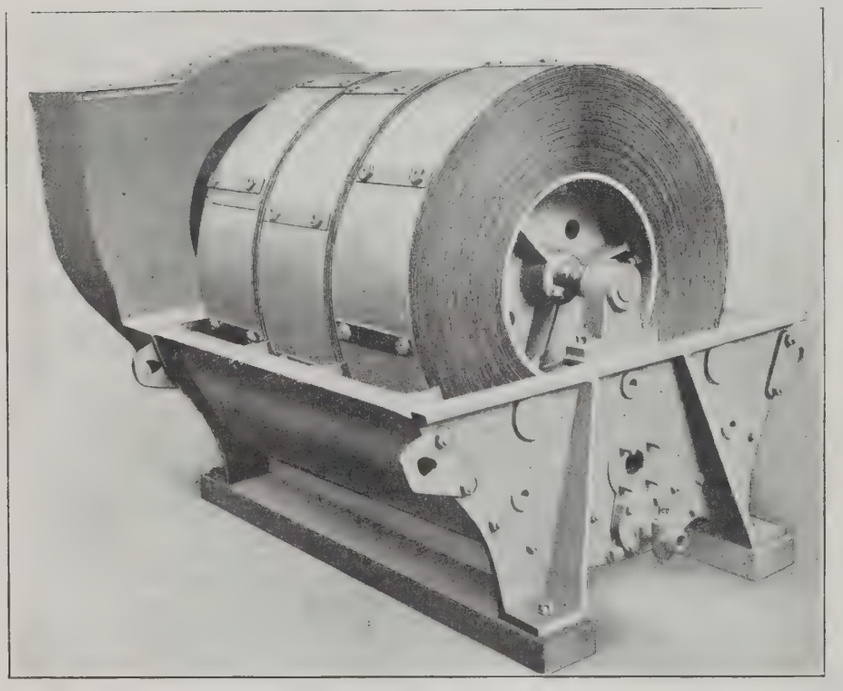


Fig. 3.

Fig. 4.

machines which leave a small space between the courses of the spiral for the passage of the air. The cylinders are mounted on a horizontal shaft carried on ball or roller bearings fixed to the end plates of the tank. The water contained in the tank is automatically maintained at a certain level by means of a ball-float valve, whilst air is driven by a fan through the spiral spaces of the upper half of the drum—that is, of the parts which are above the water-line. With this form of construction an enormous amount of surface can be packed into a very small space. The cylinders described are rotated at a slow rate, so that the surface of the drums is kept continuously coated with the water or other liquid to be cooled. The cooling effect is obtained partly by direct conduction of heat from the liquid to the air passing through the annular spaces, but also in most cases by the evaporation thus promoted, since the vapour drawn off by the air carries with it its latent heat. Perhaps an even better idea of the general construction of these coolers is afforded by Fig. 3, which represents the same machine as Figs. 1 and 2, but with the covers off, showing clearly the three drums dipping into the water-trough below.

It should be pointed out that as the water is spread over the cooling surfaces in a very thin film, it is impossible for the suction of the fan, which draws the air through the machine, to cause the water to heap up on the edges of the plates, forming globules or drops which would be carried away by the outgoing air in the form of spray. Hence the only water lost is that due to evaporation, and the cooler is thus very economical with regard to the make-up supply. To pass the necessary volume of air through the special drums a fan is used, either of the centrifugal or propeller type, according to the size and type of the machine, a centrifugal fan in a number of cases being found to be the more efficient. The drums are rotated by a side shaft driven by a chain from the fan shaft, as best seen in Fig. 1. As the air current is provided by a fan, the efficiency of the plant is independent of climatic conditions, which may seriously affect coolers dependent on natural draught.

An interesting feature of this type of machine is that it can be arranged for ventilating the engine-room as well as for cooling circulating water, the cooler being installed in the engine-room, and arranged with an outlet duct from the fan discharge through the roof or wall to the outside of the building.

A special and very compact form of the cooler has been developed for use on shipboard, where auxiliary lighting sets are now frequently driven by oil-engines. In this the fan is mounted on the top of the tank, and a chain-and-spur gear-drive is arranged between the fan-spindle and the drum-shaft; the steel-plate cover over the drums in the standard cooler is done away with by raising the height of the tank sides sufficiently to eliminate any possibility of water splashing out due to the rolling or pitching of the ship. Another special application of the cooler is for the cooling of oil used in the tempering and hardening of metals, such as steel forgings, castings, &c. The continuous cooling of the oil-bath increases considerably the output, at the same time eliminating all possibility of fire due to the oil becoming overheated.

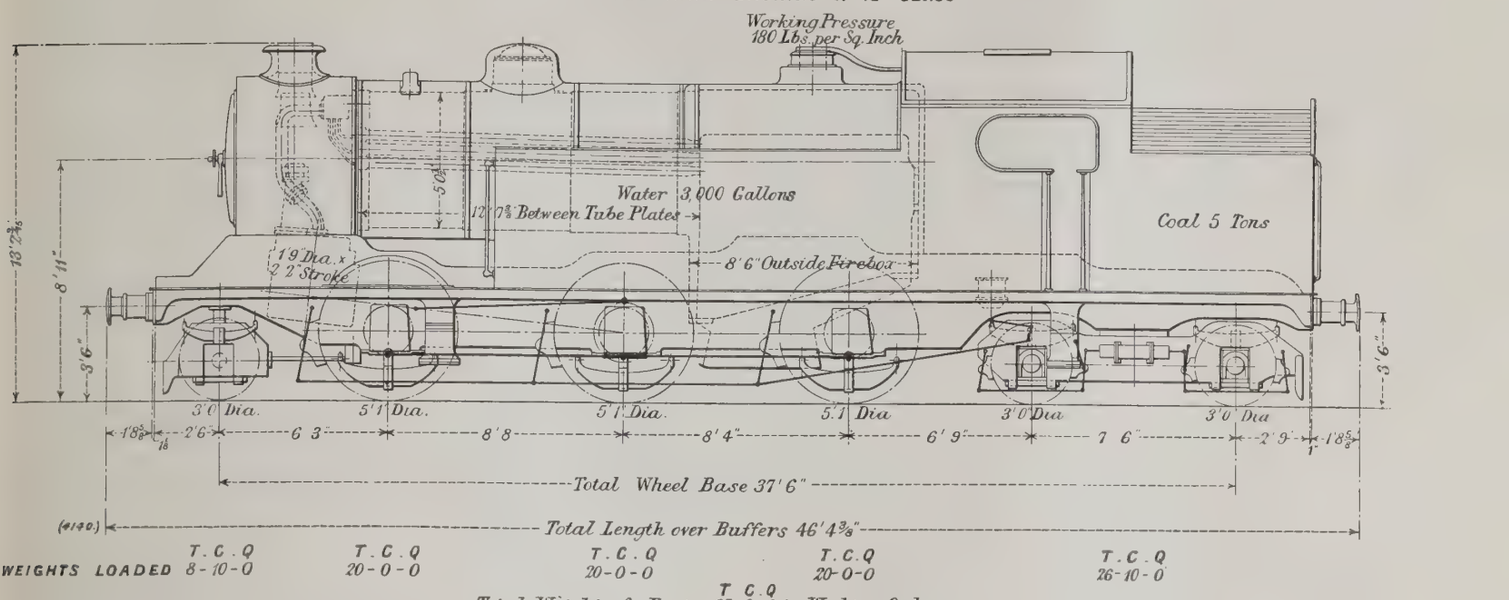
One of the most interesting applications of the Heenan cooler is in connection with filtering and cooling the air-ventilation supply of electric generators. In this application, stringent conditions have to be dealt with. In the first case, it is essential that there should be no trace of spray in the air entering the generator, as otherwise there would arise the danger of short-circuits in the winding and consequent fire. A general view of the cooler of this type supplied to the Birmingham Corporation, and designed to deal with 50,000 cub. ft. of air per minute, is illustrated in Fig. 4. The drums are practically the same as used in the water-coolers, and are rotated by a single worm-reduction gear, the worm-shaft being extended and fitted with a pulley to be driven by a small motor. On account of the water being spread in a very thin film over the surfaces, it is impossible for any loose moisture to leave the machine and enter the generator. Further, as a certain amount of evaporation takes place due to the passage of the air over the wet surfaces, a large cooling effect is obtained, the temperature of the air being reduced sometimes by as much as 20 deg. Fahr.

A further use of this machine as a filter or purifier is in connection with breweries, where a supply of purified and cooled air to the refrigerator and tun-rooms is of very great importance, particularly when the breweries are situated in industrial districts where the air is laden with dust and impurities. In such cases the plant consists of a machine built up on the same lines as the filter mentioned above, the air being blown through the machine by means of a forced-draught fan, and delivered to the various rooms through ducts having specially-designed orifices. The simplicity of the apparatus enables very large volumes of air to be dealt with at a low expenditure of power.

2-6-4 TYPE MINERAL TRAFFIC LOCOMOTIVE; GREAT CENTRAL RAILWAY.

CONSTRUCTED FROM THE DESIGNS OF MR. JOHN G. ROBINSON, M. INST. C. E., CHIEF MECHANICAL ENGINEER TO THE COMPANY.

2-6-4 GOODS TANK ENGINES Nº 18 CLASS



	T. C. Q	T. C. Q	T. C. Q	T. C. Q	T. C. Q
WEIGHTS LOADED	8-10-0	20-0-0	20-0-0	20-0-0	26-10-0

T. C. Q
Total Weight of Engine 95-0-0 in Working Order

A NEW type of mineral traffic locomotive is being built at the Gorton Works of the Great Central Railway, to the design of Mr. John G. Robinson, M. Inst. C. E., Chief Mechanical Engineer. These new engines are of the 2-6-4 type. They are intended for both goods and mineral traffic, but chiefly for the heavy coal traffic between the North Nottingham colliery district and the ports of Grimsby and Immingham, a distance of about 80 miles. The return trip in a day will amount to about 160 miles, and as, to avoid terminal delays, it has been necessary to adopt a type which will run equally well either end first, unusually large tank and bunker space has had to be provided. In fact, the water space is for 3000 gallons, while 5 tons of coal can be placed in the bunker. The weight of the engines in working order amounts to the considerable total of 95 tons, of which 60 tons are on the 5-ft. 1-in. coupled wheels.

A general idea of the design will be obtained from the diagram herewith. Through the courtesy of Mr. J. G. Robinson we hope to publish detail drawings later. The design embodies inside cylinders 21 in. by 26 in., having inside admission piston-valves 12 in. in diameter, worked by link motion and rocking-shafts. In many respects the cylinders and working parts duplicate with those of the "Sir Sam Fay" and the "Glenalmond" classes. The boiler is identical with that of the "Director" class. The boiler has a maximum outside diameter of 63 in., the barrel being 12 ft. 3 in. long, and the length between tube-plates 12 ft. 7⅛ in. The fire-box has an outside length of 8 ft. 6 in. The boiler has 157 tubes of 1⅞ in. outside diameter. A Robinson superheater is fitted, and the large smoke-tubes in which the twenty-four elements are arranged are 5⅛ in. outside diameter. Together the tubes provide 1390 sq. ft. of heating surface. The fire-box heating surface is 157 sq. ft., making a total of 1547 sq. ft. The superheater elements are composed of tubes having a diameter of 1⅜ in., and giving a heating surface measured inside of 304 sq. ft. The grate area is 26 sq. ft., and the working pressure 180 lb. per sq. in.

Water pick-up is fitted, and all coupled wheels and the trailing bogie-wheels are braked, the latter on both sides. An ejector and train-pipe, and also heater-pipe, are fitted, to enable the engines to handle local or excursion traffic, if need should arise. Sufficient allowance is provided laterally for the front and rear truck to ensure 5-chain curves being taken easily. The length of the driving-wheel base is 17 ft., and of the whole engine over buffers 46 ft. 4⅜ in. We will defer further particulars till we publish more complete drawings.

"THE HOLIDAYS."—This is the title given to a series of guides of the Midland, the London and North-Western, the Great Northern, the Great Eastern, the Great Western, and the Great Central Railways, bound in book form, and issued by Mr. Walter Hill, 67 and 69, Southampton-row, London, W.C., at the price of 1s. and 1s. 6d. post free. Since the public is invited both to work as usual and to take holidays as usual, notwithstanding the war, the book will prove useful in regard to the holidays and to the resorts covered by the railway systems enumerated.

STRESS DISTRIBUTIONS IN ENGINEERING MATERIALS.

Report of the Committee, consisting of Professor J. PERRY (Chairman). Professors E. G. COKER and J. E. PETAVEL (Secretaries), Professor A. BARR, Dr. C. CHREE, Mr. GILBERT COOK, Professor W. E. DALBY, Sir J. A. EWING, Professor L. N. G. FILON, Messrs. A. R. FULTON and J. J. GUEST, Professors J. B. HENDERSON and A. E. H. LOVE, Mr. W. MASON, Sir ANDREW NOBLE, Messrs. F. ROGERS and W. A. SCOBLE, Dr. T. E. STANTON, and Mr. J. S. WILSON, *to report on Certain of the More Complex Stress Distributions in Engineering Materials.**

THE reports presented at the Birmingham meeting of the Association led the committee to the view that the co-ordination of the results of various researches was rendered difficult by the diversity of the materials used in the tests. It was therefore thought desirable to obtain complete and systematic data with regard to three definite materials—namely, a mild steel, a hard steel, and a steel alloy.

In accordance with a resolution passed at the meeting of December 19, 1913, a stock of 3 tons standard steel has been obtained for the committee by Dr. F. Rogers. This consists of:—

(1) Dead mild steel (carbon 0.12 per cent.).
(2) Axle steel (carbon 0.3 per cent.).
(3) Nickel steel.

Some of the steel has already been sent to various members of the committee, and in due course full information will be available with regard to the behaviour of the three materials under a large number of different tests.

The mild steel was kindly presented to the committee by Messrs. Steel, Peach and Tozer, and the axle steel was also presented.

Information with regard to the manufacture of the standard steels is given in an Appendix.

A report on the "Experimental Determination of the Distribution of Stress and Strain in Solids" has been presented by Professors Coker and Filon.

A paper on the "Internal Stresses in a Built-up Steel Compression Member," by Mr. H. Delépine, has been communicated by Professor Petavel, and will be read at the meeting.

A number of members of the committee have, during the past year, been engaged on subjects dealt with in last year's report, but in most cases the experimental work is not yet completed.

The subjects under investigation are the following:—

Professor Coker and Mr. Scoble: Shear Tests.

Mr. Cook: Tests of the Physical Constants of the Standard Steels.

Messrs. Cook and Robertson: Further Work on the Strength of Thick Cylinders.

Mr. Fulton: Alternating Stress at Low Frequencies.

Mr. Guest and Professor Lea: Combined Stresses.

Mr. Mason: Repeated Combined Stresses.

Mr. Scoble: Repeated Combined Stresses.

Dr. Stanton: Repeated Shear Tests.

Mr. Mason has installed, in the engineering laboratory at the University of Liverpool, a machine specially designed for experimental work on alternating bending, alternating torsion, and simultaneous alternating bending and torsion. He has also constructed an apparatus for measurement of hysteresis.

* Report presented to Section G of the British Association in Australia.

Dr. Stanton has made arrangements to test the standard steels—firstly, by reversals of simple shearing stress, then by superimposing bending and direct stresses. The committee ask to be reappointed, with a grant of 100*l*.

APPENDIX.

Outline of Manufacture of the Standard Steels.

By Dr. F. ROGERS.

No. 1 Steel (0.12 per cent. Carbon).

The materials used in the manufacture of this steel are hematite pig-iron, steel scrap, and ore of the purest descriptions, melted very carefully in the acid open-hearth furnace. The composition is adjusted by the addition of ferro-manganese, after which the metal is cast into ingot moulds. The ingots are then rolled, with several heatings, into bars, which are reeled when black-hot, giving a straightening and burnishing effect without injuring the steel. This method is suitable for high-class mild steel. The bars supplied to the committee are the whole usable portion of two ingots, and weigh nearly 22½ cwt.

No. 2 steel (0.3 per cent. carbon).

Report not yet received.

No. 3 steel (— per cent. nickel).

Report not yet received.

Experimental Determination of the Distribution of Stress and Strain in Solids.

By Professors FILON and COKER.

Very little has been done hitherto in the way of determining directly the distribution of stresses and strains in the interior of an elastic solid. The investigations which have been made deal almost exclusively with the more restricted case of two-dimensional stress and strain, or of stress and strain in a thin plate parallel to the faces of the plate itself, a problem known to elasticians as that of "generalised plane stress."* In these cases two methods have proved available. The first method consists in measuring directly the deformations of the body studied, by observing the actual distortion of a face of the solid parallel to the plane of strain. In practice this may be done by ruling this face into squares and observing, with a kathetometer or micrometer, the relative shifts of various parts of the network. From these, the extent by which the angle at a node of the network has been changed from a right angle can easily be found, and this quantity, as is well known, measures the shearing strain (or "slide," according to a terminology followed by many writers on elasticity, who reserve the word "shear" to denote the shearing stress). In this way values of the shearing strain are obtained at the various nodes of the network. Again, the changes of distance between adjacent nodes can be found, and from these, if the squares of the network are sufficiently small, the extensions at the various nodes, parallel to the lines of the net, can be obtained. The plane strain can therefore be mapped out over the whole face of the solid which is under observation. If this method is to give satisfactory results, it must be applied to materials where the strains are comparatively large. It has been applied with considerable success by Professor Karl Pearson (1)† and various workers associated with him to models of dams constructed of gelatine-glycerine jelly, and in this way various results of interest in the theory of masonry dams have been obtained, although it cannot be said that the complete system of stresses in such dams is

* Love, "Theory of Elasticity," page 135.

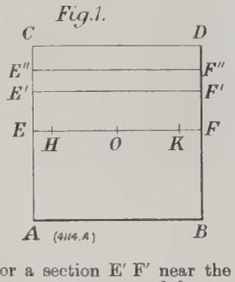
† See Notes, page 316.

yet known with any certainty. In other cases measurements of the distortions produced in circles described on the face of a model have been used to determine the principal strains and their directions, as in the experiments of Messrs. Wilson and Gore (2).

Dr. E. N. da C. Andrade (3) has also employed a block of jelly to investigate the distribution of slide in such a block when two of its opposite faces A B, C D (Fig. 1), constrained to remain plane and parallel and undisturbed, are given a translatory displacement relative to each other, parallel to their plane.

Dr. Andrade found that along the middle plane E F of the block (half-way, that is, between the two faces whose displacement was prescribed) the distribution of slide gave two maxima at points H, K, distant about one-sixth of the length from the unstressed faces perpendicular to the plane of strain, the slide falling gradually to a minimum at O. For a section E′ F′ near the middle plane an effect of the same type occurred, but was less marked. For a section E″ F″ near the face C D where the constraint was applied the slide remained fairly uniform over the greater part of the length of the section, going down rapidly at the ends to the value zero at C D.

Fig.1.



The problem attacked experimentally by Dr. Andrade is one of which no exact theoretical solution is known. Dr. Andrade himself attempted to fit his conditions by an approximate solution, but either through the failure of the approximation, or from some other cause, the results of observation and calculation agreed only qualitatively.

The second method used for the investigation of the distribution of stresses inside a plate subjected to stress in its own plane depends on the property, discovered by Sir David Brewster in 1816, and independently by Fresnel, that glass and other isotropic transparent substances become doubly refracting under stress. Since then this effect has been studied by a number of observers (4). It may be taken as fairly well established that when a ray of polarised light traverses a plate stressed in its own plane, it is broken up into two components, polarised along the two lines of principal stress at the point where the ray crosses the plate, and the relative retardation of these two rays on emergence in air is

$$C\,\tau\,(P - Q),$$

where τ = thickness of the plate, P and Q are the two principal mean stresses in the plane of the plate, and C is a coefficient depending upon the material and the wave-length of the light (5).

Clerk Maxwell (6) was the first to go fairly fully into the theory of the appearances presented when a plate under varying stress in its own plane is placed between crossed nicols. He showed that the light is restored at all points except those for which :—

(*a*) The lines of principal stress are parallel to the axes of the nicols.

Since the condition for the extinction of the light is here independent of the wave-length, these lines will be quite black. These may be called the lines of equal inclination, or isoclinic lines.

(*b*) The principal stress-difference has such a value that $C\,\tau\,(P - Q)$ is an exact multiple of the wave-length.

These will be lines of equal principal stress-difference, and will give a different set of lines for different wave-lengths. They are thus, in general, brilliantly coloured, the same stress-difference corresponding to the same tint. The only exception is the line corresponding to $P - Q = 0$. These may be called (following Maxwell) the isochromatic lines, the black line corresponding to $P - Q = 0$ being called the neutral lines.

Observations of the isoclinic lines have the advantage that these lines are exhibited under comparatively small stress, and are independent of the coefficient C. Their use does not, therefore, require straining the material to an extent likely to produce permanent set, and they can be shown by comparatively thin specimens. Also they do not require any previous investigation of the coefficient C for the given material or of its dependence upon the wave-length.

In theory, observation of the isoclinic lines is sufficient to determine the stress system, provided we have information as to the actual stresses at a very limited number of points (7). Such information is generally available from the known boundary conditions. On the other hand, the calculations required actually to deduce the stresses from the isoclinic lines are complicated, and are very difficult to apply to cases where the data are expressed by purely empirical curves.

The isoclinic lines are therefore better suited to experimental verification of stress distribution already known from theory, and for which the theoretical isoclinic lines can be calculated beforehand and compared with observation. They have been so used by M. Corbino and Trabacchi (8) using rings of gelatine to verify Volterra's (9) theory of internal strains in a multiply connected elastic solid ; and also by Filon (10), who used glass beams to verify the ordinary theory of stresses in a beam at a distance from points of isolated loading, and also his own theory of the distribution of stress in a beam near a point of isolated loading. Both Corbino and Trabacchi, and Filon found that their experimental results confirmed the predictions of the theory of elasticity (11). Carus Wilson (12), who used in his investigation both the isoclinic and the isochromatic lines, was the first to apply the optical method to discover the laws of stress distribution in a glass beam, doubly supported and centrally loaded.

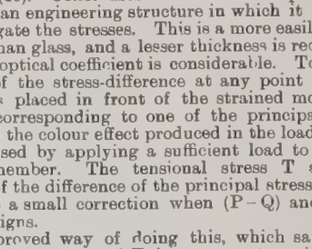
He gives a drawing of the lines of principal stress in such a beam, but does not use them further, and restricts his comparison of theory with experiment, to the stresses in the cross-section immediately under the load ; the theory with which he compares his results was originally given by Boussinesq (13), and treats the height of the beam as infinitely thick. Sir G. G. Stokes gave, in a note to Carus Wilson's paper, an empirical correction to Boussinesq's theory. An exact theory of this problem has since been given by Filon (14).

The use of the isochromatic lines, and generally of experiments depending upon tint, has this advantage —that it yields directly the value of the stress difference P – Q. If this be combined with a determination of the direction of principal stress at each point, then considerable direct information is given at once, and some cases of practical importance have been examined by Hönigsberg and Dimmer (15).

The determination both of P – Q and of the directions of principal stress may be combined in one measurement, which is very simply made by means of an apparatus due to Coker (16). Coker uses a thin celluloid plate cut to represent an engineering structure in which it is desired to investigate the stresses. This is a more easily-worked material than glass, and a lesser thickness is required, as its stress-optical coefficient is considerable. To obtain a measure of the stress-difference at any point a tension member is placed in front of the strained model, in a direction corresponding to one of the principal axes of stress, and the colour effect produced in the loaded model is neutralised by applying a sufficient load to this calibrating member. The tensional stress T affords a measure of the difference of the principal stresses (P – Q) subject to a small correction when (P – Q) and T have different signs.

An improved way of doing this, which saves these repeated adjustments of T, is to use a test-piece under pure flexure (without shear) in its own plane. This can be readily produced in a straining frame, as in the accompanying diagram. The stress will then vary linearly

Fig.2.



from P to Q, and may be read off along a scale P Q, which can be previously calibrated against a specimen under known tension.

A little sideways shift of the test-plate is then all that is required to compensate the stress difference at any given point, provided that the direction of principal stress had been found previously.

Coker has used a calibration tension member to determine the distribution of stress in plates of various shapes —for example, in tension specimens pierced with circular holes, decks of ships with various openings, cement briquettes, &c. (17). He has also (18) investigated Andrade's problem of the block whose opposite faces slide with regard to one another remaining undistorted, and he obtains by this optical method a distribution of shear very similar to that obtained by Andrade from direct measurements of the slide. Mr. Scoble and he have also applied this method to determine the distribution of stress due to a rivet in a plate (19).

The photo-elastic determination of stress carried out in this way does not, however, determine the stress in the plate completely. It will be noticed that all the method gives is the principal stress-difference at any point. If each principal stress at a given point be increased by any arbitrary quantity, the appearances are in nowise altered. To obviate this Coker has used the stretch-squeeze effect in the plate to measure the sum P – Q of the principal stresses, a suggestion due originally to Mesnager (20). For clearly, if τ be the thickness of the plate, η Poisson's ratio, the plate, at the point where the principal stresses are P, Q, will become thinner by an amount $\eta\,\tau\,(P + Q)$, an amount which is small, but with delicate instruments not impossible to measure.

It will be noticed that this provides yet a third method for exploring the field of stress in a plate. There is, however, no necessity for doing this, as the information derived from the known values of the stress difference and the direction of the lines of principal stress can be readily applied to find the complete system of stresses. Let the axes of x and y be taken in the plane of the plate. Let P and Q now denote the normal stresses across elements $d\,y$ and $d\,x$ respectively, S the shearing stress across either of the above elements ; then, if the lines of principal stress make an angle α with the axes, and if R is the principal stress difference, it is well known that

$$P - Q = R \cos 2\,\alpha$$
$$2\,S = R \sin 2\,\alpha.$$

Thus a determination of R and α at every point leads to the value of S at all points. On the other hand, considering the equilibrium of a small rectangle $d\,x, d\,y$, and neglecting body-forces, we have the well-known body-stress equations for generalised plane strain :—

$$\frac{\delta P}{\delta x} + \frac{\delta S}{\delta y} = 0. \qquad \frac{\delta S}{\delta x} + \frac{\delta Q}{\delta y} = 0.$$

Now, at a point of the boundary, all the stresses will be known.

For the normal stress across an element of the boundary where the outward normal makes an angle with the axis of x is :—

$$P \cos^2\theta + Q \sin^2\theta + 2S \cos\theta \sin\theta$$
$$= \frac{P + Q}{2} + \frac{P - Q}{2} \cos 2\theta + S \sin 2\theta.$$

S and P – Q being known from optical data, and the normal stress across the boundary being also known from the boundary conditions, the above equation determines P + Q, and hence (P – Q being known) P and Q.

Consider now a point A of the plate. Draw a line through A parallel to the axis of x to meet the nearest boundary at a point $A_0\,(x_0, y)$.

Then, integrating the equation

$$\frac{\delta P}{\delta x} + \frac{\delta S}{\delta y} = 0$$

along the line A_0 A, we find

$$P - P_0 = -\int_{x_0}^{x} \frac{\delta S}{\delta y}\,.\,d\,x,$$

where P_0 is the value of P at A_0.

Similarly, if a line through A parallel to the axis of y meets the nearest boundary at a point $B_0\,(x, y_0)$ when the value of Q is Q_0,

$$Q - Q_0 = -\int_{y_0}^{y} \frac{\delta S}{\delta x}\,.\,d\,y.$$

Now, if we know the value of S at all points, the values of the partial differential coefficients $\frac{\delta S}{\delta x}, \frac{\delta S}{\delta y}$ can be obtained approximately by taking differences. P and Q can then be found as above by the ordinary process of graphical integration, P_0, Q_0 being known, as explained. This method can be used with any set of experimental data, provided only that these are accurate enough to allow of differences being taken to calculate $\frac{\delta S}{\delta x}, \frac{\delta S}{\delta y}$. In any case, before actually applying the method, the curves for S when either x = constant or y = constant should be "smoothed" so as to take out accidental inequalities. A check on the accuracy of the calculation is easily provided, for the calculated P – Q should agree with the value optically observed.

In many problems it is known that one of the normal stresses is throughout very small. In this case, if Q, say, is nearly zero, we have $P = R \cos 2\,\alpha$, and the stress-difference leads easily to the complete system of stresses. This assumption has been made by Coker in his earlier papers, but it would seem desirable to justify it more fully.

NOTES.

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(3) E. N. da C. Andrade : "The Distribution of Slide in a Right Six-Face Subject to Pure Shear," R. S. Proc., A., vol. lxxxv., pages 448 to 461.

(4) Sir David Brewster : *Phil. Trans.*, 1816, page 156. *Annales de Chimie et de Physique*, vol. xx. Fresnel : *Œuvres d'Augustin Fresnel*, tome 1, page 713. F. E. Neumann, *Abh. d. k. Acad. d. Wiss. zu Berlin*, 1841, vol. ii., pages 50 to 61. See also *Pogg. Ann.*, vol. liv. John Kerr : *Phil. Mag.*, 1888, ser. 5, vol. xxvi., No. 161. G. Wertheim : *Annales de Chimie et de Physique*, ser. 3, vol. xl., page 156.

(5) F. Pockels : "Ueber die Aenderung des optischen Verhaltens Verschiedener Gläser durch Elastische Deformation," *Ann. d. Physik*, 1902, ser. 4, vol. vii., page 745. L. N. G. Filon : "On the Variation with the Wave-Length of the Double Refraction in Strained Glass," Camb. Phil. Soc. Proc., vol. xi., Pt. vi., vol. xii., Pt. i., and vol. xii., Pt. v. "On the Dispersion in Artificial Double Refraction," *Phil. Trans.*, A., vol. ccvii., pages 263 to 306 (1907). "Preliminary Note on a New Method of Measuring Directly the Double Refraction in Strained Glass," R.S. Proc., A., vol. lxxix., pages 440 to 442 (1907). "Measurements of the Absolute Indices of Refraction in Strained Glass," R. S. Proc., A., vol. lxxxiii., pages 572 to 578 (1910). "On the Temperature Variation of the Photo-Elastic Effect in Strained Glass," R. S. Proc., A., vol lxxxix., pages 587 to 593 (1914).

(6) Clerk Maxwell : Trans. Roy. Soc. Edin., vol. xx., 1853, page 1172 ; or "Collected Papers," vol. i.

7. A proof of the statement in the text is as follows :— Let E be the stress function for generalised plane stress (Love, "Theory of Elasticity," pages 86 and 446) ; P, Q, S the mean stresses $\widehat{x\,x}$, $\widehat{y\,y}$, $\widehat{x\,y}$ in the usual notation ; R the principal mean stress difference ; ϕ the angle which the lines of principal stress make with the axes.

Then it is known that—

$$R^2 = (P - Q)^2 + 4\,S^2$$
$$\tan 2\,\phi = 2\,S/P - Q$$
$$2\,S = P \sin 2\,\phi \qquad P - Q = R \cos 2\,\phi.$$

Also the mean stresses are given in terms of the stress function by—

$$P = \frac{\delta^2 E}{\delta y^2}, \quad Q = \frac{\delta^2 E}{\delta x^2}, \quad S = -\frac{\delta^2 E}{\delta x, \delta y}.$$

Using the transformations

$$2\xi = x + \imath y$$
$$2\eta = x - \imath y$$

we find readily

$$Q + \imath S = \frac{\delta}{\delta x}\left(\frac{\delta E}{\delta \xi}\right) \qquad Q - \imath S = \frac{\delta}{\delta x}\left(\frac{\delta E}{\delta \eta}\right)$$

$$S + \imath P = -\frac{\delta}{\delta y}\left(\frac{\delta E}{\delta \xi}\right) \qquad S - \imath P = -\frac{\delta}{\delta y}\left(\frac{\delta E}{\delta \eta}\right)$$

$$\therefore \quad Q - P + 2\imath S = \frac{\delta^2 E}{\delta \xi^2} \quad . \quad . \quad . \quad (1)$$

$$Q - P - 2\imath S = \frac{\delta^2 E}{\delta \eta^2} \quad . \quad . \quad . \quad (2)$$

$$Q + P = \frac{\delta^2 E}{\delta \xi \, . \, \delta \eta} \quad . \quad . \quad . \quad (3)$$

From (1) and (2)

$$-R\epsilon^{-2\imath\phi} = \frac{\delta^2 E}{\delta \xi^2} \qquad -R\epsilon^{2\imath\phi} = \frac{\delta^2 E}{\delta \eta^2}$$

$$\therefore \quad \epsilon^{4\imath\phi}\frac{\delta^2 E}{\delta \xi^2} = \frac{\delta^2 E}{\delta \eta^2} \quad . \quad . \quad (4)$$

Now, the isoclinic lines give ϕ as a function of x y, and therefore of ξ, η for every point. On the other hand, it is well known that E satisfies the equation :—

$$\nabla^4_{x,\,y} . E = 0,$$

or

$$\frac{\delta^4 E}{\delta \xi^2 \, . \, \delta \eta^2} = 0$$

of which the solution is :—

$$E = E_1(\xi) + E_2(\eta) + \eta E_3(\xi) + \xi E_4(\eta). \quad (5)$$

E_1, E_2, E_3, and E_4 being arbitrary functions.

(4) then gives :—

$$\epsilon^{4\imath\phi(\xi\,\eta)}\left[E_1''(\xi) + \eta E_3''(\xi)\right] = E_2''(\eta) + \xi E_4''(\eta) \quad (6)$$

Putting $\eta = 0$, $\xi = 0$ successively in the identity (6)

$$E_1''(\xi) = \epsilon^{4\imath\phi(\xi,\,0)} \, . \left[E_2''(0) + \xi E_4''(0)\right] \quad . \quad (7)$$

$$E_2''(\eta) = \epsilon^{4\imath\phi(0,\,\eta)} \, . \left[E_1''(0) + \eta E_3''(0)\right] \quad . \quad (8)$$

Differentiating (6) with regard to ξ, η, and then putting $\xi = 0$ and $\eta = 0$ respectively, we find

$$E_4''(\eta) = \left\{\frac{\delta}{\delta \xi} \, . \, \epsilon^{4\imath\phi}\left[E_1''(\xi) + \eta E_3''(\xi)\right]\right\} \xi = 0$$

$$E_3''(\xi) = \left\{\frac{\delta}{\delta \eta} \epsilon^{-4\imath\phi}\left[E_2''(\eta) + \xi E_4''(\eta)\right]\right\} \eta = 0$$

i.e.,

$$E_4''(\eta) = 4\imath\left(\frac{\delta \phi}{\delta \xi}\right)_{0,\,\eta} E_2''(\eta) + \epsilon^{4\imath\phi(0,\,\eta)}$$

$$\left\{E_1'''(0) + \eta E_3'''(0)\right\} \quad . \quad . \quad (9)$$

$$E_3''(\xi) = -4\imath\left(\frac{\delta \phi}{\delta \eta}\right)_{\xi,\,0} E_1''(\xi) + \epsilon^{-4\imath\phi(\xi,\,0)}$$

$$\left\{E_2'''(0) + \xi E_4'''(0)\right\} \quad . \quad . \quad (10)$$

Assume $E_1''(0) = A$, $E_3''(0) = B$, $E_1'''(0) = C$, $E_3''(0) = D$.

Equations (7)-(10) determine $E_2''(\eta)$, $E_4''(\eta)$, and hence $E_1''(\xi)$, $E_3''(\xi)$ as homogeneous linear functions of A, B, C, D.

Hence $E = A\,e_1 + B\,e_2 + C\,e_3 + D\,e_4 + \alpha\,\xi + \beta\,\eta + \gamma\,\xi\,\eta + \delta$, where e_1, e_2, e_3 e_4 are now known functions, and α, β, γ, δ are arbitrary constants.

The terms in α β δ do not affect the stresses, and may be dropped.

The term $\gamma\,\xi\,\eta$ may add γ to P + Q.

If, now, the value of any stress be known at a given point, this leads to a linear equation between A, B, C, D, γ.

Hence the complete specification of the stress at two points leads to six equations for A, B, C, D, γ ; in like manner, if we consider the conditions at the boundary, where two of the stresses are in general known, the conditions at three points give six equations. In either case we have more than enough equations to determine A, B, C, D, γ. Thus the stress conditions at a few points, together with the isoclinic lines, determine the stress system completely.

(8) O. M. Corbino and Trabacchi : *Rendiconti Acad. dei Lincei*, vol. xviii., 1909. See also letter by O. M. Corbino in *Nature*, January 16, 1913.

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(11) Volterra, *loc. cit.* Note (8); Corbino, *loc. cit.* Note (7). Filon, *loc. cit.* Note (9); also Filon, *Phil. Trans.*, A., vol. cci., pages 63 to 155.

(12) Carus Wilson : *Phil. Mag.*, ser. v., December, 1891.

(13) Boussinesq : *Comptes Rendus*, vol. cxiv., pages 1510 to 1516. See also Flamant : *Comptes Rendus*, vol. cxiv., pages 1465 to 1468.

(14) L. N. G. Filon, on "An Approximate Solution for the Bending of a Beam of Rectangular Cross-Section under any System of Load," *Phil. Trans.*, A., vol. cci., pages 63 to 155.

(15) O. Hönigsberg and G. Dimmer : "Interferenzfarben beanspruchter durchsichtiger Körper." O. Hönigsberg : "Unmittelbare Abbildung der neutralen Schichte bei biegung durchsichtiger Körper in zirkularpolarisierten Licht," International Association for Testing Materials, Brussels Congress, 1906.

(16) E. G. Coker : "The Determination by Photo-Elastic Methods of the Distribution of Stress in Plates of Variable Section, with Some Applications to Ships' Plating." Transactions of the Institution of Naval Architects. See especially pages 9 to 11.

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(18) E. G. Coker : "An Optical Determination of the Variation of Stress in a Thin Rectangular Plate Subjected to Shear," Proc. Roy. Soc., 1912.

(19) E. G. Coker and W. A. Scoble : "The Distribution of Stress Due to a Rivet in a Plate," Transactions of the Institution of Naval Architects, 1913.

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COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on the subjects dealt with can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

New Zealand : The Imperial Trade Correspondent at Auckland reports, on the authority of the local Press, that the ratepayers of Mount Albert, a suburb of Auckland, have sanctioned the proposal of the Borough Council to raise a loan of 29,500*l.* for municipal works. Of this amount 12,000*l.* is set apart for road construction and improvement works, 1500*l.* for road-making plant, 9500*l.* for water supply extension, and 500*l.* for drainage works.

Italy : The *Gazzetta Ufficiale*, Rome, announces that tenders will be received, up to September 11, by the Direttore Generale delle Opere Marittime, Ministero dei Lavori Pubblici (Sezione Contratti), Rome, for the construction of piers, wharves, and breakwaters at the port of Spezia. The upset price of the contract is put at 2,778,560 lire (about 111,140*l.*), and a provisional deposit of 100,000 lire (4000*l*) is required to qualify any tender. Although the foregoing contract will doubtless be awarded to an Italian firm, nevertheless the carrying out of the works may involve the purchase of materials and accessories outside Italy.

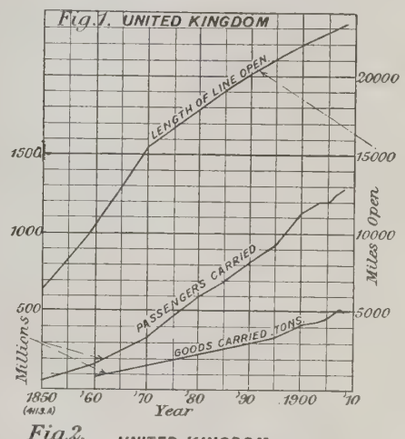
Greece : The Acting British Consul at Piræus reports that the Greek Government Gazette notifies that tenders are invited by the Ministries of the Interior, of Finances, and of Communications, for the construction, maintenance, and working of the undertakings necessary for (1) the supply of water to Athens, Piræus, and their suburbs by using the springs at Stymphalie or Medas ; and (2) for the laying of a distributing system in Athens, Piræus, and North Phaleron for water supply and sanitation. The estimated value of the contract is 56,000,000 drachmæ (2,240,000*l.*). Sealed tenders will be received by the Ministry of Communications, Athens, up to 11 a.m. on March 27/April 9, 1915. A receipt for the payment of a provisional deposit of 500,000 drachmæ (20,000*l.*) to the Caisse Centrale d'Etat, or the National Bank of Greece, must accompany each tender.

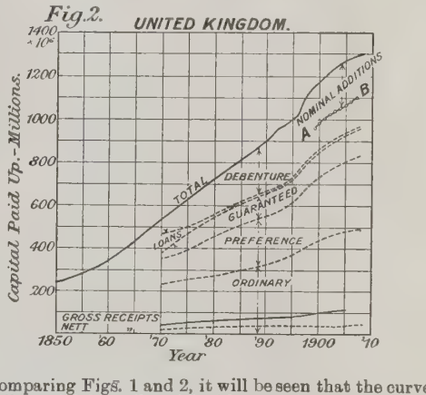
Brazil : H.M. Consul-General at Rio de Janeiro reports that the construction of the bridge connecting the Ilha das Cobras with the mainland is rapidly approaching completion, and the opening ceremony has been fixed for October 12. The bridge is constructed on the "Arnodin" system, the roadway being suspended from two sets of duplicate parabolic cables. A local firm secured the contract at a price of about 57,000*l.*, but the materials were supplied by a Hanover firm. The roadway of the bridge, which is intended only for pedestrians, is 30 m. (about 98 ft.) above sea-level, so as not to interfere with maritime traffic. The height of the supporting towers is 50 metres, and the distance between them is 170 metres. The bridge is built to carry a normal weight of 32 tons, but it will be tested up to 140 tons. In each tower will be installed an electric lift for the conveyance of passengers, who will be conveyed across the bridge by means of a travelling electrically-driven cable transporter, with a capacity for 50 first-class and 350 second-class passengers. The time of transit in the transporter will be two minutes from tower to tower.

RAILWAYS AND MOTIVE POWER.*

By Professor W. E. Dalby.

In all new countries railway development is a subject of paramount importance. The prosperity of the individual and the wealth of the community largely depend upon the extent to which railways are developed in the land. The object of this brief paper is partly to initiate a discussion on the subject of Australian railways and partly to show the results obtained by the development of British railways. For this purpose I venture to reproduce some diagrams from my address to the Engineering Section at Sheffield on British railways. The curves are plotted from information given in the railway returns issued by the Board of Trade. The curves in Fig. 1 show how the length of line open has increased from 1850 to 1910, with corresponding curves showing the number of passengers carried and the goods carried. Fig. 2 shows what this quantity of construction has cost. The curve marked "Total" in Fig. 2 shows the total paid-up capital plotted against the year, the dotted lines indicating the kind of stock making up the total. The lower curve in Fig. 2 shows the gross receipts, whilst the dotted line below this indicates the net revenue after deducting the working expenditure from the total receipts. It will be seen from the curves that the paid-up capital in 1908 was 1310 millions of pounds sterling. The increase from 1850 to 1896 is fairly regular, and is at the rate of nearly 10 millions per annum. The nominal additions to the capital by the process of splitting the shares is indicated by the curve A B. In the year 1808 the nominal additions amounted to 196 millions of pounds. It will also be seen that in 1908 the gross receipts amounted to 120 millions sterling, and the dotted curve shows that the net revenue in 1908 amounted to 43½ millions, corresponding to an average of 3.32 per cent. on the paid-up capital. If the net receipts are reckoned as a percentage of the paid-up capital, after deducting the nominal additions to capital, the return is increased to 3.9 per cent.





Comparing Figs. 1 and 2, it will be seen that the curves of mileage (23,205 miles of double track in 1908, including sidings, 85 per cent. of which are standard gauge), passengers carried, and goods carried, increase regularly with increase of capital, indicating that even now the possibility of remunerative return on capital invested in railway enterprises in Great Britain is not exhausted. In Australia the ultimate return is certain. Very approximately the British companies carry per annum one passenger and 0.4 tons of goods for every pound sterling of paid-up capital. In Fig. 3 the upper curve shows the working expenditure per cent. of total receipts. This expenditure is gradually increasing, and had reached 64 per cent. in 1908. The lower curve shows the net receipts as a percentage of the paid-up capital. There is also shown the net receipts exclusive of nominal additions as a percentage of the paid-up capital. It will be seen that the net receipts have declined only about ½ per cent. since 1870, notwithstanding the increase of working expenditure.

Fig. 4, page 318, shows the cost of working the traffic expressed in terms of train-miles. The scale at the side shows the equivalent dividend ; that is to say, if the whole of the locomotive power could be obtained for nothing, the dividend could be increased 1¾ per cent. Reckoned on the ordinary stock alone, the increase would be about three times this amount. The cost is altogether 41.63d. per mile for the year 1908. This is an average figure taken over the whole of the railways of England and Wales.

In the address mentioned above, the author made a comparison between the financial position of the London and North-Western Railway in 1908 and the London and Birmingham Railway, from which it has grown, in 1840. Briefly, the capital of the London and North-Western Railway in 1908 is returned at 125 millions ; twenty-four times the capital of the London and Birmingham Railway in 1840. Its gross receipts in 1908 amounted to

* Paper read before Section G of the British Association, in Australia.

15½ millions, 22.6 times the amount in 1840. The mileage open in 1908 was 5406 miles of equivalent single track, 21.6 times that of 1840. The train-miles run during 1908 were 48⅜ millions, 68.3 times the number in 1840, but the receipts per train-mile fell from 231d. in 1840 to 76½d. in 1908—that is, to one-third. The working expenses, however, fell from 93d. to 50d. per train-mile in the same period, but the expenditure in 1908, expressed as a percentage of the gross receipts, was 1.62 times the expenditure in 1840.

It will be seen from these figures that the gross receipts have increased in the same proportion as the miles open. The money earned per mile of track is thus the same after a lapse of 70 years. But to earn this amount, however, the trains in 1908 must run three times the distance, since the receipts per train-mile dropped to 0.33 that in 1840. The capital has increased at a greater rate than the miles open, so that although the earnings per mile are the same in 1908 as in 1840, there is the obligation to pay interest on a larger proportionate capital. Lower dividends are therefore inevitable. These figures show that if a more conservative system of financing the railways had been adopted when the receipts per train-mile were higher, and extensions and increased equipment had been charged more freely to revenue rather than to capital, the railway companies would to-day have been in a position to meet the increased and increasing cost of working with equanimity.

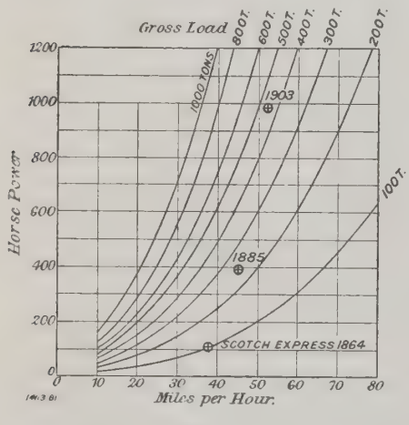
Let us now turn to the consideration of the motive power which is required for the operation of a line. The kind of problem with which the locomotive department has to deal is illustrated better by a particular case than by generalities.

Fig. 5 shows vertically the horse-power required to draw a train of given weight at a given speed on the level, calculated from an approximate formula which need not be quoted here. The results are comparative therefore, although the actual values of the horse-power are subject to large corrections, depending upon the type of stock, the condition of the permanent way, and the many other factors which enter into train resistance.

Each curve in the figure represents a definite weight in tons.

Three points are located on the diagram marked respectively 1864, 1885, and 1903. These points represent

Fig.5. POWER REQUIRED TO MAINTAIN SPEED ON THE LEVEL.



the conditions of working on the West Coast route of the Scotch express which, since 1863, has started from Euston at 10 a.m. every morning. This is an historic service, and has been in existence since 1844. The conditions of working have changed greatly, as will be seen from the diagram. A typical train in 1864 weighed 100 tons, and required 100 horse-power to maintain the average speed at 38 miles per hour. In 1885 the weight of the train had increased to 250 tons; the average speed to 45 miles per hour; and the average horse-power required from the locomotive to perform this service was 400. In 1903 the weight of train had increased to 450 tons, and the average speed to 52 miles per hour, necessitating an average horse-power of 1000. These figures show clearly the price which has to be paid for speed, and indicate the kind of problem pressing upon the locomotive departments—namely, to provide a locomotive of sufficient power within the limits of the constructional gauge. If possible, the constructional gauge of the new Australian railways should be kept larger than the present requirements determine, because the time will come when the power required from the engines will increase, and an economical engine of large power cannot be built within a limited constructional gauge. Large powers mean large boilers, and provision should be made in arches, tunnels, and cuttings for as large a gauge as possible.

This brings us to the question, What is the economy of a steam locomotive? A diagram was then shown on the screen in which energy distribution through a steam locomotive was shown graphically. After allowing for all losses, about 4 per cent. of the total energy of the fuel fired into the fire-box appeared as mechanical energy at the driving-wheels of the engine; that is to say, in order to enable the locomotive to work at the rate of 400 horse-power against the resistances to traction, it must be fed in the furnace with heat energy at the rate of 10,000 horse-power. This looks appallingly wasteful; but the science of thermodynamics, which shows us the limitations placed by natural conditions to the transformation of heat energy into mechanical energy, indicates that a perfect engine—perfect in the sense that there are no losses of heat by radiation, conduction, leakage, &c.—would require to be fed at the furnace at the rate of 1200 horse-power to obtain a rate of working from the engine of 400 horse-power.

The next question which arises is, Cannot the locomotive be replaced by a tractor which is more efficient? Tentative experiments are being made with locomotives fitted with Diesel oil-engines, but any increase in efficiency is to be considered in relation to the comparative cost of oil and coal. There may be conditions where oil is cheap and plentiful and coal is dear and scarce. An oil locomotive could then be used with advantage. At the present day, however, the choice is usually between steam locomotives and electric locomotives. Electric working does not promise much increase in actual efficiency. It is still necessary to feed the furnaces of the central stations with heat energy at the rate of 10,000 horse-power to obtain 400 horse-power at the wheels of the electric locomotive or the motor-coaches.

A diagram was then shown in which the energy distribution from the furnaces of the central station to the

Fig.3. UNITED KINGDOM.

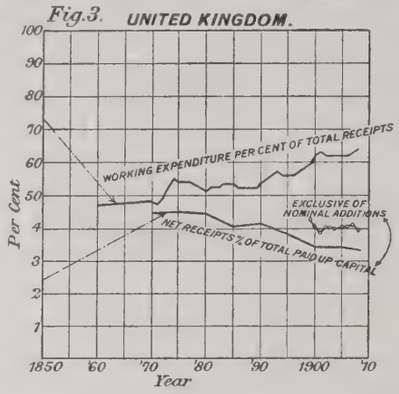

WORKING EXPENDITURE PER CENT OF TOTAL RECEIPTS
EXCLUSIVE OF NOMINAL ADDITIONS
NET RECEIPTS % OF TOTAL PAID UP CAPITAL
Per Cent
Year

Fig.4. COST OF WORKING PER TRAIN MILE OF RAILWAYS IN ENGLAND AND WALES.

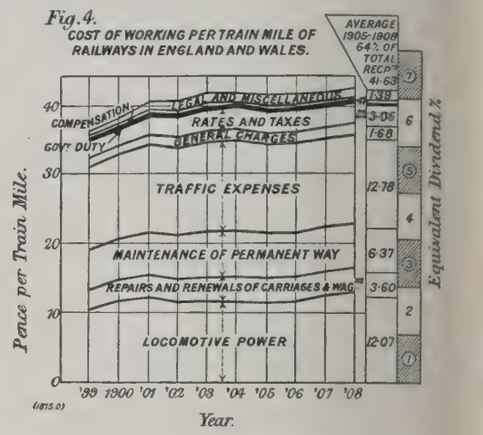


Fig.6. SPEED-TIME-DISTANCE DIAGRAM.

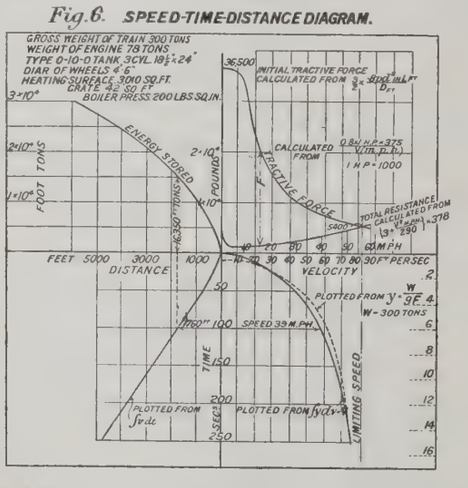
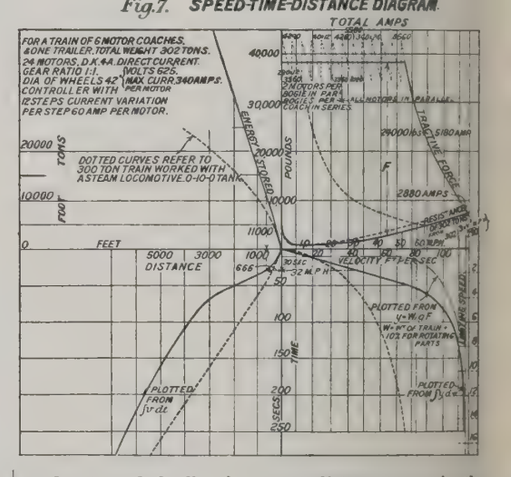


Fig.7. SPEED-TIME-DISTANCE DIAGRAM.



The large tank-engine was the only one of its kind ever built, as it was constructed for experimental purposes. The large power required is well illustrated by quoting from a paper by Mr. Philip Dawson, who has so successfully electrified the suburban services of the London and Brighton Railway Company. During the accelerating period of one of these Brighton trains the horse-power touched the value of 1600—a value quite beyond the capacity of any steam locomotive which could conveniently be employed on a suburban service. Of course, this rate of working rapidly falls off as the journey speed is approached, and the journey speed can be maintained by working at a mere fraction of this rate.

The whole problem is better illustrated by means of the diagram, Fig. 6, shown,* in which the tractive force and the train resistance are plotted vertically in the first quadrant as a function of the speed; the time-speed curve is plotted in the quadrant below, and is obtained from the part of the tractive force available for acceleration; the time-distance curve is plotted in the next lower quadrant; and, finally, the energy-distance curve in the remaining upper quadrant. The method of drawing this diagram is fully explained in the paper above mentioned. The diagram is for a train weighing 300 tons, drawn by a locomotive which can exert a maximum tractive force at starting of 36,500 lb., with a boiler large enough to develop 1000 horse-power. It will be seen that in the conditions assumed the locomotive can produce a speed of 39 miles per hour in 100 seconds.

Similar curves are shown in the next figure, Fig. 7, for an electric multiple-unit train. The initial tractive force can now be maintained constant during a longer period with a constant larger difference between the tractive force and the resistance, and hence the accelerating force is greater. In the diagram the dotted lines show the curves corresponding to the steam locomotive train, and the full curves to a train of the same weight driven electrically.

For a long run, where the accelerating period is a negligible fraction of the total period between stops, the electric motor has no advantage over the steam locomotive in ordinary working conditions, since there is no difficulty in building a locomotive of sufficient power to deal with any of the problems connected with the running of ordinary and express services.

Some of the conditions in Australia would seem to point to an oil locomotive as the most suitable type. The advantages in its favour are that the heat energy in a ton of oil is about 30 per cent. greater than the heat energy in a ton of coal, and that, apart from the water circulating through the jackets of the cylinders of the oil-motors, no water is required for evaporation in a boiler. Oil locomotives could be used to work traffic through a district where there is a scarcity of water such as would make it difficult to obtain an adequate supply at all times for steam locomotives. For example, in a

* "Characteristic Dynamical Diagrams for the Motion of a Train," by W. E. Dalby. Proceedings of the Institution of Mechanical Engineers, 1912, part 4.

journey of 100 miles a steam locomotive might burn 1½ tons of coal and evaporate 12 tons of water. In corresponding conditions an oil locomotive would consume under a ton of oil, and would require no water for evaporation in a boiler. There is no time to enter into the subject of traffic working and signalling, so I will bring these remarks to a conclusion, in the hope that a good discussion on the general questions raised in the paper may follow.

CATALOGUES.

Pulley-Blocks, Cranes, Runways, &c.—The Godfrey Manufacturing Company, Limited, Old Crane Works, Grafton-place, Crane-street, Leicester, have sent us a copy of their latest catalogue of lifting machinery. The catalogue gives full particulars, including prices, of spur-geared chain-blocks for loads up to 10 tons, worm-geared blocks for loads up to 15 tons, travelling blocks, travelling crabs, overhead cranes, portable jib-cranes, electric hoists, shearlegs, jacks, chain-slings, chain-wheels, sockets for wire ropes, and other accessories for lifting machinery. It also illustrates examples of overhead runways constructed by the firm, and includes a number of useful tables.

Electricity in Mines.—Messrs. J. H. Holmes and Co., of Portland-road, Newcastle-on-Tyne, have sent us a copy of the fourth edition of their pamphlet relating to the use of electricity in mines. The pamphlet illustrates examples of continuous-current and alternating-current generators installed in colliery power-stations, and also shows pumps, haulage-gears, hoists, coal-cutters, air-compressors, and other machinery operated by "Castle" or "Holmes-Clayton" motors; examples of switch-gear for use in mines are also included. Some leaflets devoted respectively to electrical measuring-instruments, oil-break switches, and high-tension ironclad switch-gear have also been received.

Searchlight Projectors.—Messrs. Crompton and Co., Limited, of Chelmsford, have issued a pamphlet illustrating and describing their searchlight projectors for commercial and military purposes. The standard sizes, which have mirrors varying from 12 in. to 42 in. in diameter, are mounted on pedestals or on short conical bases, and are operated either by hand or by means of small electric motors. The lamps are of the horizontal type, arranged for both hand and automatic working; that of the 42-in. projector requires 150 to 180 amperes at from 50 to 70 volts. The projectors are shown fitted with single diverging lenses, and with louvre shutters for signalling purposes. A separate price-list, dealing with projectors up to 36 in. in diameter, has also been issued by the firm.

Suction-Gas Producers.—A catalogue illustrating and fully describing their suction-gas producers for wood refuse and other similar fuels has reached us from Messrs. Ruston, Proctor and Co., Limited, Sheaf Iron Works, Lincoln. In these producers, which are made in nine sizes, giving from 25 to 400 horse-power, almost anything can be gasified. Some of the more uncommon fuels successfully dealt with are olive residue, dried prickly pears, rice husks, cocoa-nut shells, cotton refuse, sugar-cane refuse, and even dung-cake. This catalogue also deals with the firm's improved suction-producers for ordinary fuels, such as anthracite, coke, and charcoal. These producers are made in twelve sizes, with capacities ranging from 7 to 550 horse-power. Both types can be used to supply gas for heating purposes as well as for power production.

Electrical Machinery and Apparatus.—We have received from the General Electric Company, Limited, 67, Queen Victoria-street, E.C., a batch of trade literature relating to their productions. Included among it is a bulletin illustrating examples of turbo-alternators, alternating and direct-current generators, rotary converters, motor-generators, continuous-current motors, induction motors, and switchboards constructed by the firm. Other pamphlets and circulars deal with "Angold" magazine-type flame-arc lamps for alternating currents, speed or revolution-counters, measuring-instruments, switches and cut-outs, and half-watt lamps. The latter, we notice, are now made in twelve standard sizes, of which the smallest, giving 200 candle-power, is suitable for 50 to 65-volt circuits. Lamps for projection-work are also made in four sizes, for use either in the vertical or horizontal positions. Fittings specially designed for use with half-watt lamps are also listed.

Electrical Machinery and Apparatus.—Among the recent publications of the British Thomson-Houston Company, Limited, of Rugby, are price-lists and descriptive pamphlets relating to induction voltage-regulators for alternating-current feeders, motor and generator pulleys, aluminium lightning-arresters for alternating-current circuits, porcelain insulators, continuous-current crane-motors, and "Mazda" half-watt lamps. It is interesting to note that the latter are now made to take only 100 watts on 50-60-volt circuits. For 100-130 volt circuits the smallest lamp made takes 200 watts, and for 200-255-volt circuits 500-watt lamps are the smallest size listed. Altogether twelve different sized lamps of the standard type are listed, the largest taking 1500 watts; special lamps for use in projection apparatus are, however, made in four sizes, taking 300, 500, 1000, and 1500 watts on 100-130-volt circuits. Particulars are also given of fittings for indoor and outdoor use with half-watt lamps.

Electrical Supplies.—The Edison and Swan United Electric Light Company, Limited, of Ponder's End, Middlesex, and 123 to 125, Queen Victoria-street, E.C., have sent us a copy of their abridged catalogue, giving prices and particulars of wire-filament lamps, lamp-holders, ceiling roses, switches, cut-outs, fuse-boards, wires and cables, conduit, wood casing, wiring accessories, fittings and glass-ware, measuring-instruments, radiators, bells, batteries, telephones, arc-lamp carbons, &c. We have also received separate catalogues of heating and cooking apparatus, bells and batteries, fans, and half-watt lamps. The latter are now made in twelve sizes, which include several smaller lamps than could be made until quite recently. The new sizes are 100 and 200-watt lamps for 50-65 volt circuits, 200 and 300-watt lamps for 100-130-volt circuits, and a 500-watt lamp for 200-255-volt circuits. Larger lamps are made for all these voltages, the largest taking 1500 watts and giving 3000 candle-power.

Electric Transporters, Pulley-Blocks, and Runways.—From Messrs. S. H. Heywood and Co., Limited, of Reddish, near Stockport, we have received a catalogue containing a general specification of their electrically-operated transporters, pulley-blocks, and runways, and illustrating a number of installations to show some of the many purposes for which these appliances may be employed. The examples illustrated have lifting capacities ranging from ½ ton to 12 tons, and although the latter is unusually high, they can be designed for heavier loads if required. They are shown in use for handling coal and ashes in power-stations, moving machinery and materials in engineering works, handling paper reels in printing works, unloading wagons and barges, as well as for many special purposes in iron and steel works, foundries, textile mills, paper-mills, &c. The catalogue gives full particulars (including weights, speeds, and shipping dimensions) of blocks and transporters with capacities up to 6 tons.

Telegraph Instruments and Line Materials.—A very comprehensive catalogue of telegraph instruments and apparatus has recently been issued by the India-Rubber, Gutta-Percha and Telegraph Works Company, Limited, of Silvertown, London, E. This catalogue includes single-needle instruments, sounders and pole changers, keys, relays, lightning protectors, galvanometers, resistances, condensers, vibrators, switches and commutators, Morse inkers, Wheatstone automatic apparatus, and repeater and quadruplex sets. Several patterns of each are illustrated, and prices are stated in all cases. Another catalogue to hand from this firm deals with fittings and tools for the erection and maintenance of telegraph and telephone lines. Among its contents we noticed iron and creosoted wood poles, iron and copper line wire, galvanised iron fittings for poles and walls, porcelain and other insulators, iron and steel insulator supports, porcelain entrance tubes, porcelain cleats, linemen's tools, &c. Both catalogues are well printed and very fully illustrated, and both are provided with a good general index to their contents.

Overhead Cranes and Runways.—Two catalogues, dealing respectively with overhead cranes and runways, have reached us from the Brown Hoisting Machinery Company, of Cleveland, Ohio, U.S.A. The crane catalogue first deals with an interesting type of hand-power crane built up of a single I-beam supported on a cast-steel two-wheel truck at each end. The load is lifted by a Yale triplex block carried on a four-wheeled trolley, which runs on the lower flange of the beam. These cranes are made with capacities varying from ½ to 5 tons, and as all parts are standard, they can be kept in stock, so that early delivery can be given. If desired, they can be operated electrically. Cranes with lifting capacities greater than 5 tons are usually equipped with ends built up of steel plates and sections in place of the castings above referred to. Numerous examples of both types are illustrated and prices are stated. The other catalogue gives full particulars, including prices, of overhead runways, operated by hand or electric power, for loads up to 20 tons. Their construction is illustrated and described, and several complete installations are also illustrated. Both catalogues are useful and attractive publications, giving all the information likely to be required in a convenient form, and including no unnecessary matter.

Drop-Forging Plant.—A very comprehensive catalogue of drop-forging plant has been issued by Brett's Patent Lifter Company, Limited, of Coventry. After a few general remarks on drop-forging, the catalogue illustrates and describes the firm's patent lifters for working either by steam or by compressed air. These lifters are made in sizes suitable for tups weighing from 4 cwt. to 3 tons. Friction lifters are also illustrated and described, and these are followed by particulars of complete drop-stamps, illustrations of installations, and examples of work done. The firm's automatic self-contained drop-hammers are next dealt with. These hammers are driven either by belt or by an electric motor, and are suitable for planishing, embossing, coining, jewellers' stamping, and drop-forging small articles. They are made in twelve standard sizes, in which the weight of the tup varies from ½ cwt. to 10 cwt. The remainder of the catalogue is occupied with particulars and illustrations of bar and billet-heating furnaces fired either by coke or oil-fuel, power-presses for clipping the fins from stampings, and accessories and spares for drop-hammers. The catalogue is nicely got-up, and very conveniently arranged. It is divided into sections, each devoted to a particular class of plant, and a thumb index is provided so that any of the sections can be turned to instantly.

Electric Accumulators and Accumulator-Cars.—From Edison Accumulators, Limited, Edison Building, 2 and 3, Duke-street, S.W., we have received a pamphlet illustrating and describing the Edison battery, pointing out its many advantages, and mentioning some of its applications. It will be remembered that in these cells the positive plates consist of a number of perforated steel tubes containing nickel oxide and flake nickel, mounted in a nickel-steel frame. The negative plate, which is also of steel, is made up of a number of lozenge-shaped pockets of nickel steel filled with iron oxide. The plates are immersed in an alkaline electrolyte contained in a nickel-steel vessel. Among their principal advantages it is mentioned that they are lighter than lead cells, will withstand any amount of vibration, can be short-circuited without injury, may be completely discharged and left discharged without deterioration, are not injured by over-charging, and can be charged at a very high rate if necessary. They are suitable for motor-car ignition, self-starting and lighting of motor-cars, marine work, railway-train lighting, house-lighting, and for operating medical and surgical appliances; their principal sphere of usefulness is, however, in connection with traction work. Two separate pamphlets relating to Edison accumulator vehicles for pleasure and commercial purposes respectively have also reached us. The pleasure-car pamphlet gives specifications and states prices for two chassis, and shows them fitted with different types of bodies, for which prices are also stated; both chassis are capable of running from 50 to 60 miles on a single charge. The other pamphlet illustrates several examples of 1-ton and 2-ton delivery-vans, electric trucks, and other vehicles, and also gives some useful data of running costs. Commercial vehicles are made in ten different sizes for loads ranging from 7½ cwt. to 5 tons; abridged specifications for each size are included in the pamphlet. An interesting and very convenient instrument for use in connection with Edison or other accumulator installations is the Sangamo ampere-hour meter. It shows at a glance the amount of energy available for use in the battery at any time. Also, by combining the instrument with a circuit-breaker during the process of charging, the current can be automatically cut off as soon as the battery is completely charged. Two small pamphlets describing this instrument have also been issued by the firm.

Power-Meters.—A pamphlet relating to their power-meters, or integrating engine-indicators, has come to hand from the Lunken Company, Limited, 35, Great Dover-street, S.E. These instruments are difficult to describe fully without the aid of illustrations, but an idea of the principles upon which they depend for their action may perhaps be gained from the following brief remarks. The instrument consists of an indicator cylinder and piston, with external spring, connected to the engine cylinder in the usual way. On the piston-rod of the instrument is mounted a light friction wheel which runs on ball-bearings, and is capable of rotating about the axis of the rod. The ends of two cylindrical drums bear on opposite edges of the friction-wheel, contact being maintained by means of springs. The two drums are connected by mitre wheels to a cord-pulley driven off the engine cross-head so that they rotate in opposite directions by an amount proportional to the stroke of the engine, and also impart their motion to the friction wheel. With atmospheric pressure on both sides of the piston of the instrument the arrangements are such that the edge of the friction wheel is in contact with the centre of the drums, and thus the wheel does not rotate; but if the pressure below the piston increases or decreases, the friction wheel is moved radially over the ends of the drums, so that it rotates more or less according to its distance from the centre. It will thus readily be understood that the rotation of the friction-wheel is proportional to the product of pressure and distance travelled by the engine-piston, so that the amount of rotation is a measure of the work done. By connecting the friction wheel to an integrating mechanism, the total work done in a given time, and therefore the power of the engine, can thus be obtained from the readings of the instrument. For use with winding-engines, locomotives, and other engines running at varying speeds a stroke-counter is required, and this can be fitted to the power-meter at a small extra charge. The instrument above described is intended to be permanently attached to the engine; but another form, for test purposes only, is also listed. The latter instrument is provided with a vertical drum, on which indicator diagrams can be taken in the ordinary way. It is possible in this instrument to take cards at any time during a test without in any way interfering with the integrating mechanism.

MELBOURNE HARBOUR TRUST.—The Melbourne Harbour Trust is a corporate body established to regulate, manage, and improve the port of Melbourne and portions of the Rivers Yarra and Saltwater. The trust consists of five commissioners appointed by the Governor of Victoria in Council. The chairman has a salary not exceeding 1500*l.* per annum; the remuneration of the other four commissioners is not to exceed 250*l.* in any one year. The borrowing powers of the Trust stand at present at 3,000,000*l.* The trust has now been in existence for 35½ years, and during that period the net receipts amounted to 5,658,595*l.*, and the expenditure to 7,298,430*l.*; the aggregate expenditure thus exceeded the aggregate revenue by 1,639,835*l.*, to meet which the Commissioners raised loans amounting to 2,000,000*l.*, of which 1,700,000*l.* was outstanding at the close of 1912. Of the expenditure of 7,298,430*l.*, 2,225,625*l.* was incurred in connection with harbour improvements and maintenance, including dredging, landing, and depositing silt, the construction of wharves and approaches (1,771,136*l.*), and plant (665,171*l.*). The revenue collected for 1912 was 277,809*l.*, while the expenditure of the year was 366,090*l.* The excess of expenditure over revenue occurred under the heading of wharf construction and maintenance; this expenditure, which was larger than usual, was provided for out of the surpluses of previous years. In 1908 the revenue amounted to 222,323*l.*, and the expenditure to 184,618*l.*; in 1909 the revenue was 210,569*l.*, and the expenditure 170,398*l.*; in 1910 the revenue was 255,608*l.*, and the expenditure 168,450*l.*; and in 1911 the revenue was 273,946*l.*, and the expenditure 205,662*l.*

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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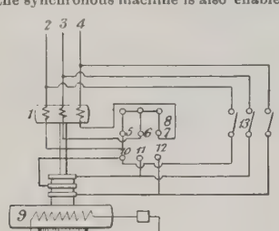
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

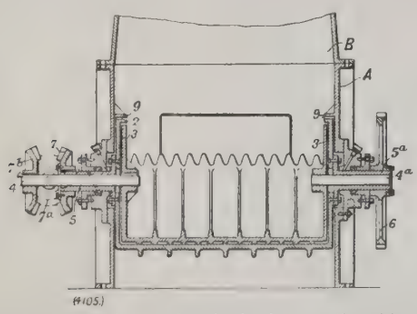
11,506/13. E. Rosenberg, Bowden. Dynamo-Electric Machines. [1 *Fig.*] May 17, 1913.—This invention relates to the starting of synchronous dynamo-electric machines and is an improvement on, or modification of, the invention described in Specification No. 9644, of 1912. In the prior specification a method is described for starting synchronous dynamo-electric machines by means of an electric motor in which a series or electrically equivalent connection is provided between the winding of the starting-motor and the synchronous machine for the purpose of effecting self-synchronising of the synchronous machine. According to the present invention, at starting, the starting-motor is electrically disconnected from the synchronous machine, and is connected in series with it only after speeding-up has been effected. The advantage of this method is that the residual magnetism of the synchronous machine is not affected by the first rush of current even if the starting-motor takes a large current, because at the start, and while the machine is running at a low speed, the electrical connection between the motor and the machine is broken. The field of the synchronous machine is also enabled to build up



in the right direction, and when the starting-motor is afterwards connected in series with the synchronous machine in order to obtain synchronisation, the polarity of the synchronous machine will not be affected. The starting-motor 1 has its windings connected to the supply mains 2, 3, and 4 and to the terminals 5, 6, and 7 of a double-throw three-pole switch 8. The rotary converter 9 has its slip-rings connected to the terminal 10, 11, 12 of the switch 8, and is also arranged to be connected direct to the supply mains through the main switch 13. In order to start the converter, the switch 8 is thrown to the position shown, in which the terminals 5, 6, and 7 are connected together, the switch 13 being open. After speeding-up has been effected, the switch 8 is thrown to its other position, in which the terminals 5, 6, 7 are connected to the terminals 10, 11, 12 respectively, thus connecting the windings of the starting-motor in series with the winding of the converter, and thereby effecting synchronisation of the latter. As soon as the converter is in synchronism, the switch 13 is closed so as to connect the converter direct to the supply mains. (*Sealed July* 30, 1914.)

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

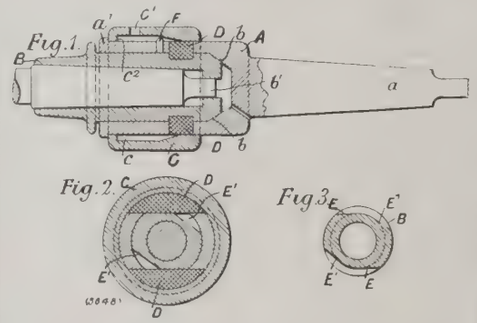
4105/13. Drakes, Limited, and A. Dobson, Halifax. Discharging or Charging Retorts. [8 *Figs.*] February 18, 1913.—This invention relates to mechanism for performing the operation of discharging or effecting the withdrawal of the spent contents of retorts of the vertical or inclined type used in the manufacture of gas, the distillation of shale or for like purposes, and the object of the invention is the production of mechanism of such a character as will enable the withdrawal or discharging of any desired and suitable quantity of the spent material without the possibility of any larger quantity than is desired being at any time permitted to descend by gravity or otherwise escape from same. A further advantage secured by the



employment of the improved mechanism in connection with retorts for the manufacture of coal gas, is that the coke extracted is not broken to the extent that is necessary for its discharge by devices at present in use. The invention may also be employed in the charging of retorts. In mechanism for discharging or charging retorts, according to this invention, semi-cylindrical drums mounted so that they will rotate about a common axis independently of each other are employed. A indicates the framework within which the parts are mounted, said framework being arranged to be secured to the lower or discharging orifice B of a retort. To attain the object of this invention, use is made in connection with each retort of mechanism consisting of a pair of semi-cylindrical drums or longitudinal segments of hollow cylinders 2 and 3, which are arranged so that their axes are coincident, one drum 3 being so much less in diameter and length than the other drum 2 that it will take into and operate within same; thus the drum 2 may be freely rotated in one direction, while the drum 3 is rotated in the other direction. The pivotal shafts 4, 4*a* of the inner drum 3 are made to take through the hollow pivotal shafts 5 and 5*a* respectively of the drum 2, so that by any suitable gearing, such as the spur-wheel 6, motion may be transmitted to the outer drum 2 and by the bevel gear 7 mounted on the other hollow shaft 5 the drum 2 may transmit motion through the bevel-gear 7*a* and the bevel-gear 7*b*, which is fixed upon the shaft 4, to the drum 3; thus while the one drum 2 is rotating in one direction the other drum 3 will rotate in the opposite direction. In the walls of the framework A bearings are mounted to support the shafts of the drums 2 and 3, while on the upper parts of the walls A the projecting flange 9 is formed to overhang the outer edges of the drums 2 and 3 in order to protect same from contact with the contents of the cavity above. As the pairs of drums are being rotated they will at one time present their open sides to the base of the retort, so that the material within said retort will, by gravity, descend and enter the drum 3. By continuing the motions of the drums 2 and 3 the opposite or opposing edges of these drums will commence to approach each other, gradually cutting their way through the material, which now extends from the interior of the drums 2 and 3 up into the retort above. These rotary motions being continued after the edges of these drums have met, the portion or part of the material within is cut off or detached from that above, and by the drums 2 and 3 still moving forward, their open sides are gradually brought face downwards to deposit their contents into the space below. By constructing the drums 2 and 3 as above described, although they present a large opening for the entrance and exit into and out of them for the material which they have to deal with, yet at all times they entirely close the opening or passages leading to the base of the retort B. (*Accepted May* 27, 1914.)

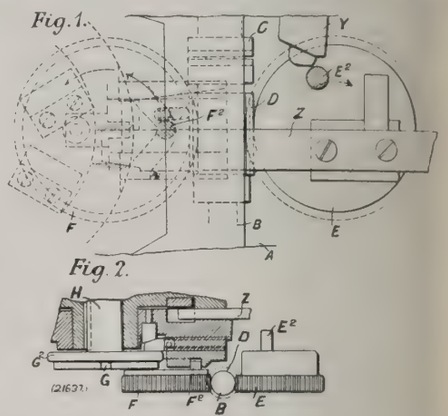
MACHINE AND OTHER TOOLS, SHAFTING, &c.

5648/14. The Electric and Ordnance Accessories Company, Limited, and L. M. Ellis, Birmingham. Tool-Chucks. [3 *Figs.*] March 5, 1914.—This invention relates to chucks or sockets which are intended more particularly for use with drills and similar tools, and are of the kind wherein the chuck or socket-body is provided with means comprising a sliding-sleeve co-operating with driving segments adapted to become engaged with or disengaged from flat surfaces formed on a tool-holder in accordance with the position of the sleeve, thus permitting of the tool being readily removed from the chuck or socket and replaced by another without necessarily stopping the machine to which the chuck is applied. According to this invention, the flat surfaces on the tool-holder are so constructed and arranged that they will be capable of engaging with the driving segments more readily than heretofore, for which purpose the engaging portion of the tool-holder is formed with two pairs of flat surfaces so situated that the flat surfaces of each pair are parallel and diametrically opposite to each other. A is the chuck-body provided at one end with a tapered shank *a* for insertion into a correspondingly tapered socket of the machine. B is the tool-holder, which is of cylindrical form externally, and has its inner end provided with conical surfaces *b*, *b*, which engage with correspondingly shaped surfaces on the interior of the chuck-body. The tool-holder is tapered internally in the usual manner for the reception of the tapered shank of the tool, a trans-



verse slot b^1 being formed at the inner end of the tool-holder for the usual tang on the shank of the tool to engage with. C is the adjustable sleeve which is capable of sliding lengthwise to a limited extent, and is formed with an internal recess *c* into which the driving segments D enter when the sleeve is at the limit of its movement in one direction and thus permit the tool holder to be withdrawn from the chuck-body. E, E and E^1, E^1 are the two pairs of parallel and oppositely-arranged flat surfaces of the tool-holder, with which the driving segments D engage when the sleeve C is moved to the extremity of its position in one direction, as shown in Fig. 1. In order to limit the movement of the sleeve C in the direction for causing disengagement of the driving segments D from the driving flats E, E or E^1, E^1 on the tool-holder, the chuck-body is provided with a projection or pin F which may be screw-threaded to engage with a correspondingly threaded hole in the chuck-body. The pin is inserted in the chuck-body after the sleeve C has been placed in position thereon, and to enable this to be accomplished the sleeve is provided with a hole or opening c^1 through which the pin can be passed, as is well understood. By adjusting the sleeve so that the said hole c^1 coincides with the screw-threaded hole in the chuck-body, the pin can be screwed into position until it stands below the inner surface of the wall of the recess *c* in the said sleeve, thereby allowing the latter to be freely moved within the limited distance provided by the pin F in one direction and the collar a^1 in the opposite direction co-operating with the shoulder c^2 of the said sleeve. (*Sealed August* 7, 1914.)

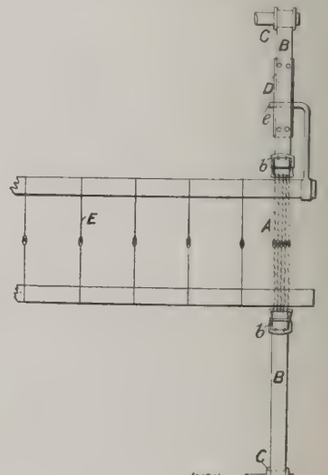
21,637/13. A. Herbert, Burford, and P. V. Vernon, Coventry. Turret Lathes. [2 *Figs.*] September 25, 1913.—In turret lathes certain operations have to be performed with regard to the turret, and it is the object of this invention to provide simple and direct means, movable with the turret-slide, for effecting such operations. The operations referred to are:—1. Rotation of the turret; 2. Clamping the turret; 3. Actuation of the index bolt; 4. Clamping the index bolt; 5. Engagement of a clutch on the turret-slide; and 6. Disengagement of that clutch. It is not essential that all these operations be performed, as in many cases, for example, the clamping of the index bolt is dispensed with. The mechanism employed is of the kind in which two rotating gear-wheels, movable with the turret-slide, are employed to effect the chief operations referred to, and its object is to improve upon mechanism of this kind by causing the rotating wheels or discs to directly engage the turret to bring about its operation, to directly engage the index-bolt and the clutch-lever and the turret-clamping mechanism. In this way more certain operation is obtained than in previous cases where there was considerable mechanism between the gear-wheel and the turret, and there is less liability of wear and consequent inaccuracy of operation occurring. Further, a cheaper and simpler mechanism is provided. Accordingly, the two discs are arranged close to the turret, and one engages directly with the turret in order to bring about its rotation, and also directly acts upon the clamping mechanism, whilst the other disc directly engages the index-bolt and the clutch-lever. The discs may be gear-wheels geared together. There is mounted in suitable bearings on the turret-slide A a transverse shaft B. This shaft rotates constantly, and it carries a clutch C, preferably of the "dog" type, which can be held in engagement with a corresponding clutch-member upon a worm D, mounted loosely upon the shaft. Thus, when the clutch is engaged the worm rotates with the shaft, but when the clutch is disengaged against the action of a spring the worm remains stationary. This worm



drives a pair of worm-wheels E and F mounted in bearings on the slide, and the wheels constitute the discs referred to. The disc F—*i.e.*, that nearest to the turret—carries a crank-pin F^2, which engages radial slots G in a plate G^2 attached to the turret, rotating the latter by the well known step-by-step motion. The turret is carried by the upper end of the stem H. This same pin F^2, or, if preferred, another, directly actuates the turret-clamping mechanism, which may be of any suitable type, and also, if necessary, the mechanism for clamping the index-bolt Z. The rear disc E is provided with a pin E^2, which moves the index-bolt. It is also provided with means for directly actuating a lever Y, which controls the clutch C previously referred to. For example, there may be a cam swell, crank-pin E^2, or the like on the disc, which is adapted to strike the clutch-lever and throw the clutch out of gear, arresting both discs. To engage the clutch, the lever may be moved endwise or otherwise disengaged from the pin E^2 or the equivalent, when the clutch will drop into gear and the disc rotate until the clutch-lever is again removed. (*Sealed August* 7, 1914.)

TEXTILE MACHINERY.

5191/14. Barritt and West, Limited, and E. T. West, Newbridge. Loom Shedding Motions. [6 *Figs.*] February 28, 1914.—This invention relates to harness motions for weaving selvages on satins, twills and similar cloths. It is designed to produce on satins, sateens, venetians and similar cloths, repp-edges or selvages such as have a lift of 5 up and 5 down, 3×3, 4×4, 6×6, 8×8, or other similar motion. It consists in the application to the side harness of lifting brackets or catches to be engaged by one of the healds or a rod or stave connected thereto, and be lifted or raised by the heald and allowed to remain up during the descent of the heald and be changed at the next lift. The side harness A of ordinary construction is supported by tapes B passing round bowls or pulleys C, the tapes B being preferably connected to the harness by



adjustable buckles or slides *b* to regulate and adjust the position of the harness. To the tapes B above the harness A hook shaped projection pieces or catches D of metal or other stiff material are attached, one at either side of the top supporting roller, and to any one of the ordinary healds E a short stave *e* is attached at each end or a stave or rod is attached to the lifting cords connected to the lifting-jacks. The projecting catches or projection pieces D are so shaped or constructed that the stave *e* will engage with them on the upward movement and pass them on the downward movement of the heald, and so that the one in the lower position will be in the path of the stave *e* and be raised thereby as the heald rises. By reversing the apparatus it may be worked from below the loom. (*Accepted May* 27, 1914.)

BENDING STRESSES IN HOOKS AND OTHER CURVED PIECES.

By ARTHUR MORLEY.

1. *Introduction.*—The extreme bending stresses in a curved piece or rib of any kind, and particularly in the principal section of a hook subjected to a pull, have comparatively recently been the subject of some little writing and research. In English and American text-books it was until comparatively recently common to estimate such stresses by the rules applicable to straight beams and to ignore the curvature. A much closer estimation may be made by Winkler's formula, which takes account of the curvature, but which has been adversely criticised by Mr. E. S. Andrews and Professor Karl Pearson, who derive much more complicated formulæ.

2. *Objects of this Article.*—The objects of this article are :—1. To show the relations between the foregoing rules. 2. To examine some of the experimental evidence in support of them. 3. To point out the liability of the arithmetical and graphical calculations to error, and how such error may be avoided. 4. To explain a graphical method of dealing with common actual sections. 5. To point out the serious errors in previously published results. 6. To establish very simple empirical rules for practical use to replace complex formulæ.

3. *Notation.*—Let Fig. 1 represent a hook subjected to a pull W distant l from the centroid C of the principal cross-section at A B. Let y ordinates be measured from the axis E F, positive towards A, the extreme values being $+ y_c$ and $- y_t$. Let R be the radius of curvature, O C, at C of the curve through the centroids of consecutive cross-sections.

Let $A = \Sigma (\delta a)$ be the total area of the principal cross-section A B, and let γ A or A′ be the modified area

$$\Sigma \left(\frac{R}{y+R}\ \delta a\right),$$

which may easily be drawn out by a well-known geometrical construction. Then

$$\frac{A'-A}{A}, \text{ or } -\Sigma\left(\frac{y}{R+y}\ \delta a\right) \div \Sigma(\delta a) = \gamma - 1.$$

Let

$$\Sigma\left\{\left(\frac{R}{R+y}\right)^{\frac{m+1}{m}} \delta a\right\} \div \Sigma(\delta a) = \gamma_1,$$

and

$$\Sigma\left\{\left(\frac{R}{R+y}\right)^{\frac{1}{m}} \delta a\right\} \div \Sigma(\delta a) = \gamma_3,$$

where $\frac{1}{m}$ = Poisson's ratio for the material, and let $\gamma_2 = \gamma_1 - \gamma_3$.

The degree of curvature is arbitrarily taken as $\frac{y_t}{R} = n$, say.

4. *The Three Formulæ.*—The three well-known formulæ for the maximum unit tension at the inner skin, or intrados, of a hook at its principal section when subjected to a pull W are :—

The beam formula—

$$f = \frac{W}{A}\left(1 + \frac{y_t\, l}{k^2}\right) \quad . \quad . \quad . \quad (1)$$

Winkler's formula—

$$T' = \frac{W}{A}\left\{1 + \frac{l}{R(\gamma-1)}\left(\frac{R}{R-y_t} - \gamma\right)\right\} \quad . \quad (2)$$

The Andrews-Pearson formula—

$$\frac{W}{A}\left[1 + \frac{l}{R\,\gamma_2}\left\{\left(\frac{R}{R-y_t}\right)^{\frac{m+1}{m}} - \gamma_1\right\}\right] \quad . \quad (3)$$

And the maximum unit compressive stresses at the outer skin, or extrados, of the principal section are respectively :—

$$p = \frac{W}{A}\left(-1 + \frac{y_c\, l}{k^2}\right). \quad . \quad . \quad . \quad . \quad . \quad (1A)$$

$$C' = \frac{W}{A}\left\{-1 + \frac{l}{R(\gamma-1)}\left(\gamma - \frac{R}{R+y_c}\right)\right\} \quad . \quad (2A)$$

$$C = \frac{W}{A}\left[-1 + \frac{l}{R\,\gamma_2}\left\{\gamma_1 - \left(\frac{R}{R+y_c}\right)^{\frac{m+1}{m}}\right\}\right] \quad (3A)$$

In many hooks l = R, and for simplicity this relation will first be assumed ; in other cases the modification necessary is simple.

The beam formula, although simple, has been shown to be very inaccurate if applied to curved pieces, while the other two are somewhat complex, especially the Andrews-Pearson formula.

5. *Liability of Calculations to Error.*—The formulæ (2) and (2A), (3) and (3A) are to be used with caution, for the quantities γ, γ_1, and γ_3 differ but little from unity, and consequently to obtain the small differences $\gamma - 1$ in (2) and $\gamma_2 = \gamma_1 - \gamma_3$ in (3) correct to 1 per cent. generally requires correct values of γ, γ_1, and γ_3 to some four or five or more decimal places, the number increasing with decrease of curvature. In obtaining numerical results for rectangular, trapezoidal, or circular sections which can be treated arithmetically, no great difficulty presents itself ; but it is significant that in even such simple cases Andrews and Pearson, using their own formula in their important memoir* on the subject, fall into errors equal to several times the difference between (2) and (3).

But for practical hook sections it is usually necessary to resort to a graphical estimation. A well-known graphical construction† for finding A′, and hence for γ, consists of increasing all the widths of the section in the necessary ratio R to R + y, and then measuring the modified area.

Andrews and Pearson in their memoir give a graphical method of increasing the widths of the section in the necessary ratios

$$\left(\frac{R}{R+y}\right)^{\frac{m+1}{m}} \text{ and } \left(\frac{R}{R+y}\right)^{\frac{1}{m}}$$

for finding γ_1 and γ_3 respectively.

But these graphical methods even when employed on a section drawn to an enlarged scale, and the full capacity of an ordinary planimeter, do not yield results sufficiently accurate to give reasonably close differences of area, upon which $\gamma - 1$ and γ_2 depend. The foundation for this statement is that published calculations for similar sections by such experienced and capable writers as Professor Goodman and others, using these graphical methods, are inconsistent by considerable amounts, as may be found by plotting, say, the values T/f on a base-line representing the degree of curvature, say, $\frac{y_t}{R}$. Instead of lying on a smooth curve, the values of T/f disagree by amounts, for ordinary degrees of curvature, greater than the difference between the formulæ (2) and (3).

6. *Alternative Graphical Methods.*—In comparing closely the numerical values of (2) and (3) for typical hook sections with continuously varying curvature the writer found it was possible to obtain consistent results with great care and much labour by drawing the hook section to a large scale, measuring a sufficient number of widths z, say, and calculating arithmetically the values

$$\frac{R}{y+R}, \left(\frac{R}{y+R}\right)^{\frac{m+1}{m}} \text{ and } \left(\frac{R}{y+R}\right)^{\frac{1}{m}}$$

times z for finding γ, γ_1 and γ_3 respectively. The *differences* between the original and the modified widths may be found by arithmetic subtraction and then plotted to any scale, and the resulting (difference) areas measured by a planimeter. The calculation of modified widths is laborious, but may be facilitated for a series of values by tabulation of the multipliers

$$-\frac{y}{R+y} \text{ for } \gamma - 1, \left\{\left(\frac{R}{R+y}\right)^{\frac{m+1}{m}} - 1\right\} \text{ for } \gamma_1 - 1$$

and

$$\left\{\left(\frac{R}{R+y}\right)^{\frac{1}{m}} - 1\right\} \text{ for } \gamma_3 - 1,$$

for values of y/R advancing by, say, $\frac{1}{10}$, and choosing widths z at intervals $\frac{1}{10}$ R along the line A B, Fig. 1. The accuracy obtainable for a given size of paper, or of planimeter, may be further increased by adding algebraically the resulting widths for equal and opposite values of y before plotting the final area, as shown in Fig. 2, for half a crane-hook section.

For a hook of sharp curvature this method is satisfactory, but for small curvatures intervals smaller than $\frac{1}{10}$ of R would be required, and the writer subsequently adopted another graphical method which is suitable for any degree of curvature, and is explained in the Appendix.

7. *Results.*—For a fairly full comparison of the three formulæ the extreme tensile and compressive unit stresses have been calculated for five different sections and various degrees of curvature n. The special crane-hook section is of typical shape, but exactly defined geometrically by Fig. 3. The special coupling-hook section is a Midland Railway

Fig. 1.

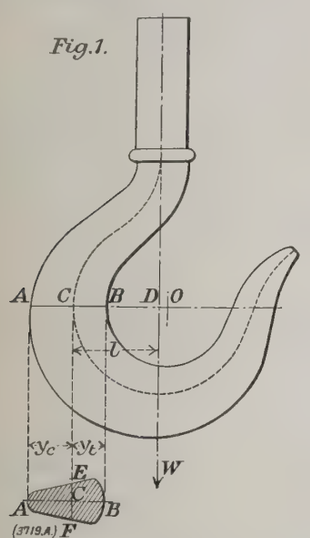


Fig. 2. LINEAGE AREAS FOR THE CALCULATION OF THE SPECIAL HOOK SECTION & ½=⅔ WITH ORDINATES DOUBLED OPPOSITE SIGNS SUPERPOSED IN PAIRS BEFORE PLOTTING.

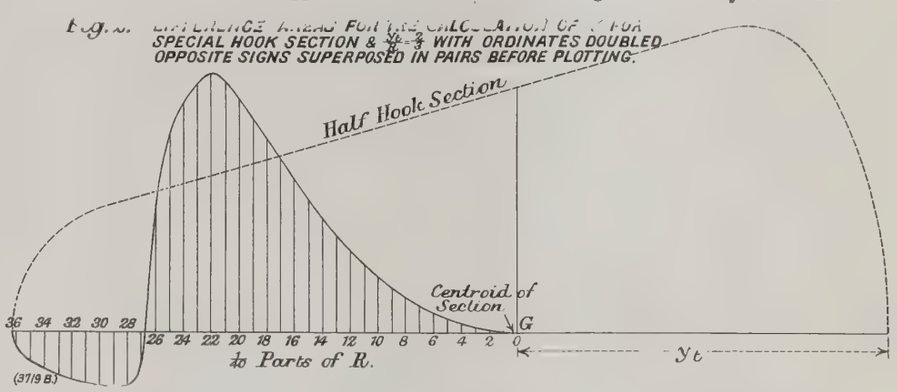


Fig. 3.

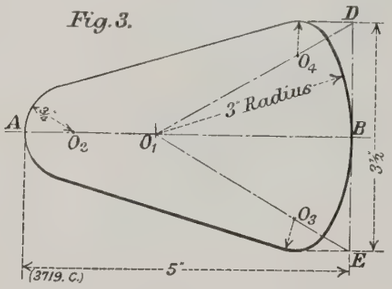
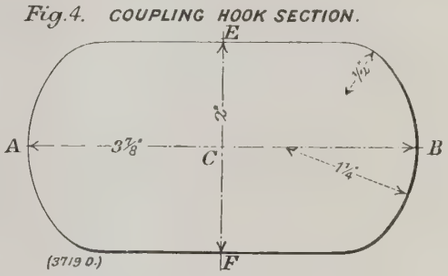


Fig. 4. COUPLING HOOK SECTION.



* Drapers' Company Research Memoirs, Technical Series I. "On a Theory of the Stresses in Crane and Coupling-Hooks."

† It is given in the writer's "Strength of Materials," Art. 131.

type, shown in Fig. 4, for which the writer is indebted to Mr. Henry Fowler, Chief Mechanical Engineer of the Midland Railway.

These stresses have been calculated for loads which give average unit stresses of unity (say, 1 ton load per square inch of section). The results are shown in Table I.; they have been calculated for the ratios $\frac{T}{f}$ are not greatly different from these. The curves of the ratios $\frac{T'-1}{f-1}$, if plotted, would lie a little lower down than those shown in Fig. 5, the difference widening with greater curvature, as shown by the column $\frac{T-1}{T'-1}$ in Table I.

From the relatively small differences (about 5 per cent. for ordinary crane-hook curvature) between the curves in Fig. 5 for greatly differing sections, it is evident that the curve for the special crane-hook section might be applied with very slight error to any similar crane-hook section, and the curve for the coupling-hook section to any similar coupling-hook section. Thus, taking a crane-hook from Professor Goodman's paper,* 5B, Second Set, for which $n = 0.433$, reading from Fig. 5, $\frac{T-1}{f-1} = 1.640$. The calculated bending stress f was 8.79 tons per sq. in. for a load $\frac{W}{A} = 1.21$ tons per sq. in.; hence the true stress by rule (3) is about $(8.79 \times 1.64) + 1.21 = 15.6$ tons per sq. in.

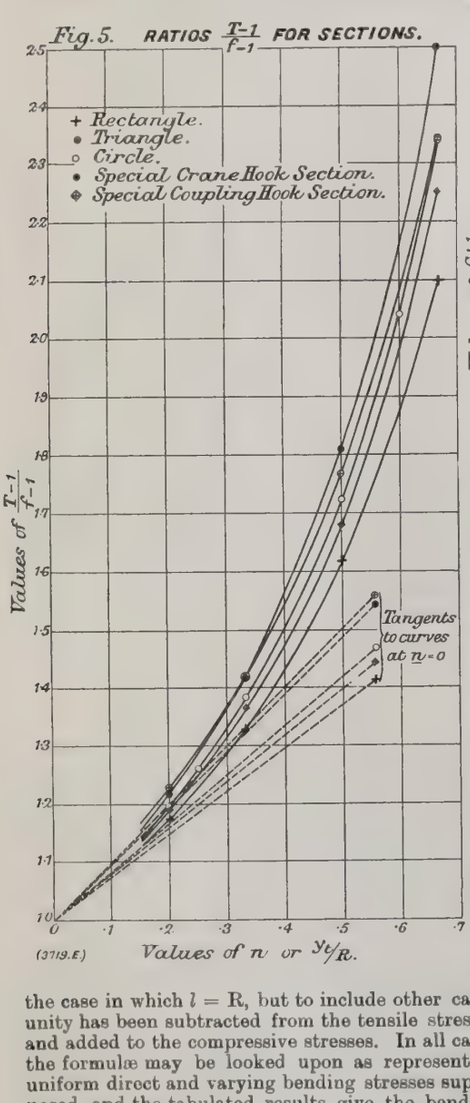
The ratios of $\frac{C+1}{p+1}$ are shown in Fig. 6 and are less important. Fig. 7 shows the stresses T, T' and f for unit pull per square inch of a rectangular section for different values of n, and Fig. 8 is the corresponding diagram for the coupling-hook. Fig. 4, which is interesting, as T and T' reach minimum values within the working range of n for such hooks.

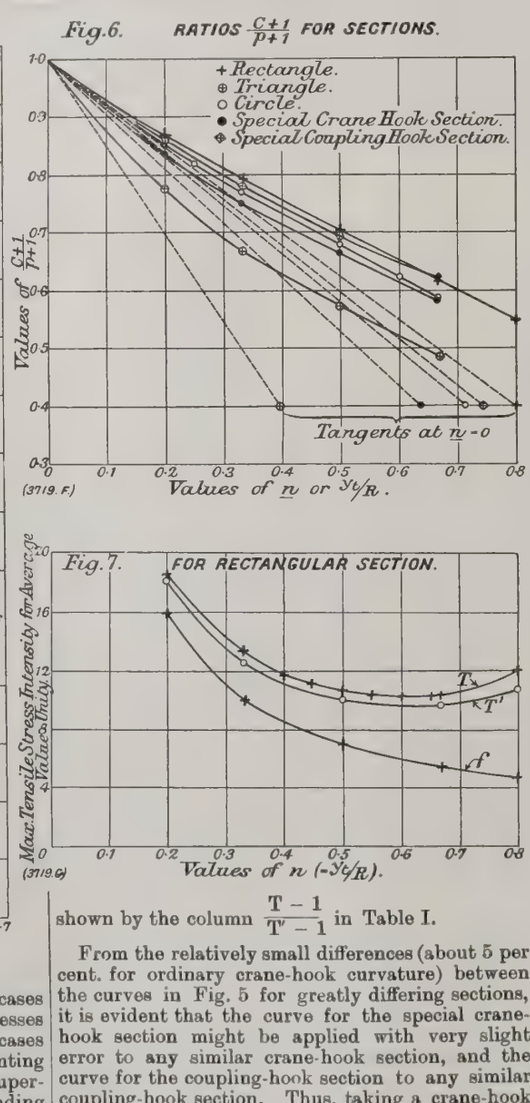
(To be continued.)

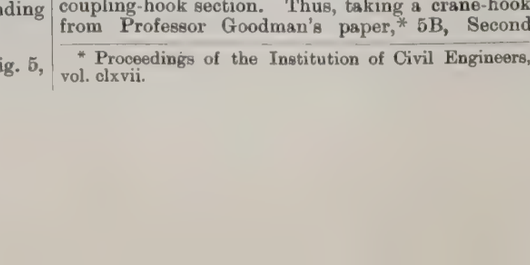
* Proceedings of the Institution of Civil Engineers, vol. clxvii.

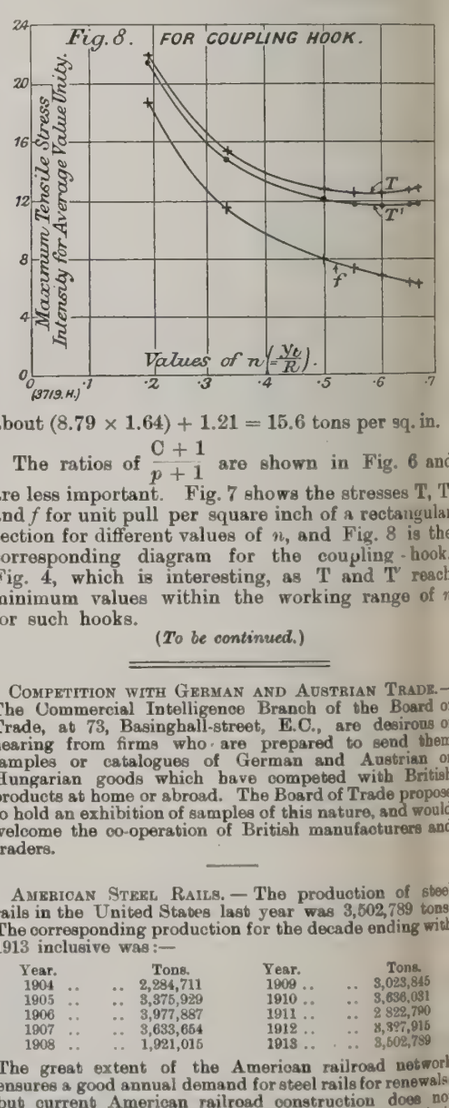
TABLE I.

Section and Value of $\left(\frac{k}{y_t}\right)^2$.	n	γ	γ_1	γ_2	Tensile Bending Stresses and Ratios. $f-1$	$T-1$	$T'-1$	$\frac{T-1}{f-1}$	$\frac{T'-1}{f-1}$	$\frac{T-1}{T'-1}$	Compressive Bending Stresses and Ratios. $p+1$	$C+1$	$C'+1$	$\frac{C+1}{p+1}$	$\frac{C'+1}{p+1}$	$\frac{C'+1}{C+1}$
Rectangle, 0.3 (Plotted +)	4	1.3733	1.5805	0.5344	3.75	11.03	9.72	2.94	2.59	1.134	3.75	2.059	2.191	0.550	0.585	1.064
	3	1.20708	1.30788	0.27978	4.5	9.44	8.66	2.10	1.92	1.090	4.5	2.787	2.932	0.619	0.652	1.052
	2	1.09861	1.1420	0.1276	6	9.71	9.13	1.62	1.52	1.062	6	4.227	4.380	0.704	0.730	1.036
	1½	1.03972	1.05648	0.05044	9	11.96	11.59	1.33	1.29	1.032	9	7.13	7.29	0.792	0.801	1.022
	1	1.013675	1.01928	0.01716	15	17.62	17.29	1.175	1.153	1.019	15	13.00	13.19	0.867	0.879	1.015
	small	1.0	1.0	—	—	—	—	$1+\frac{3}{4}n$	$1+\frac{3}{8}n$	$1+\frac{1}{12}n$	—	—	—	$1-\frac{3}{8}n$	$1-\frac{3}{8}n$	$1+\frac{1}{16}n$
Triangle, 0.5 (Plotted ⊕)	3	1.27023	1.3995	0.3619	3	7.04	6.40	2.35	2.13	1.100	6	2.911	3.115	0.485	0.519	1.070
	2½	1.13119	1.18770	0.16767	4	7.10	6.62	1.77	1.65	1.072	8	4.575	4.812	0.572	0.601	1.052
	2	1.0543	1.0767	0.0683	6	8.541	8.20	1.42	1.37	1.041	12	8.032	8.367	0.669	0.697	1.041
	1½	1.01923	1.02695	0.02393	10	12.31	12.00	1.231	1.20	1.026	20	15.47	15.87	0.773	0.793	1.026
	small	1.0	1.0	—	—	—	—	$1+\frac{23}{24}n$	$1+\frac{7}{10}n$	$1+\frac{3}{80}n$	—	—	—	$1-\frac{77}{96}n$	$1-\frac{77}{96}n$	$1+\frac{1}{160}n$
Circle, 0.25 (Plotted ⊙)	3	1.14585	1.2146	0.1943	6	14.09	12.71	2.348	2.12	1.108	6	3.533	3.743	0.589	0.624	1.060
	2½	1.1	1.16158	0.14565	6.6	13.61	12.50	2.042	1.875	1.089	6.6	4.160	4.375	0.624	0.657	1.052
	2	1.0718	1.10325	0.09236	8	13.81	12.93	1.726	1.616	1.068	8	5.423	5.643	0.678	0.705	1.041
	1½	1.0296	1.041756	0.037212	12	16.59	15.89	1.383	1.324	1.044	12	9.232	9.498	0.769	0.792	1.028
	1¼	1.01616	1.02280	0.02031	16	20.18	19.62	1.261	1.226	1.029	16	13.107	13.375	0.819	0.836	1.020
	1	1.0102	1.01439	0.01281	20	23.98	23.51	1.199	1.175	1.020	20	17.03	17.34	0.851	0.867	1.018
	small	1.0	1.0	—	—	—	—	$1+\frac{23}{24}n$	$1+\frac{3}{4}.n$	$1+\frac{3}{80}.n$	—	—	—	$1-\frac{37}{48}.n$	$1-\frac{3}{4}n$	$1+\frac{1}{80}.n$
Special Crane-Hook Section, 0.358 (Plotted ●)	3	1.1929	1.2816	0.2544	4.194	10.48	9.37	2.50	2.23	1.12	5.62	3.27	3.446	0.582	0.613	1.054
	2½	1.09598	1.13738	0.12300	5.59	10.09	9.40	1.81	1.68	1.07	7.49	4.96	5.179	0.663	0.692	1.043
	2	1.04013	1.05674	0.05053	8.39	11.94	11.46	1.42	1.37	1.04	11.24	8.44	8.69	0.750	0.772	1.028
	1½	1.01416	1.01994	0.01772	13.98	17.03	16.65	1.22	1.19	1.023	18.73	15.63	15.92	0.836	0.851	1.019
	small	1.0	1.0	—	—	—	—	$1+0.982\,n$	$1+0.873\,n$	$1+0.109\,n$	—	—	—	$1-0.946\,n$	$1-0.843\,n$	$1+0.104\,n$
Special Coupling-Hook Section, 0.2854 (Plotted ⊕)	3	1.1698	1.2508	0 2273	5.284	11.87	10.78	2.25	2.04	1.10	5.284	3.179	3.355	0.602	0.635	1.055
	2½	1.0828	1.1192	0.1070	7.006	11.77	11.08	1.68	1.58	1.06	7.006	4.83	5.025	0.691	0.718	1.04
	2	1.03375	1.04793	0.04278	10.51	14.34	13.76	1.365	1.31	1.04	10.51	8.196	8.397	0.780	0.800	1.02
	1½	1.01167	1.01647	0.01466	17.515	20.83	20.42	1.19	1.17	1.02	17.515	15.024	15.28	0.859	0.874	1.02
	small	1.0	1.0	—	—	—	—	$1+0.804\,n$	$1+0.715\,n$	$1+0.089\,n$	—	—	—	$1-0.804\,n$	$1-0.715\,n$	$1+0.089\,n$









COMPETITION WITH GERMAN AND AUSTRIAN TRADE.—The Commercial Intelligence Branch of the Board of Trade, at 73, Basinghall-street, E.C., are desirous of hearing from firms who are prepared to send them samples or catalogues of German and Austrian or Hungarian goods which have competed with British products at home or abroad. The Board of Trade propose to hold an exhibition of samples of this nature, and would welcome the co-operation of British manufacturers and traders.

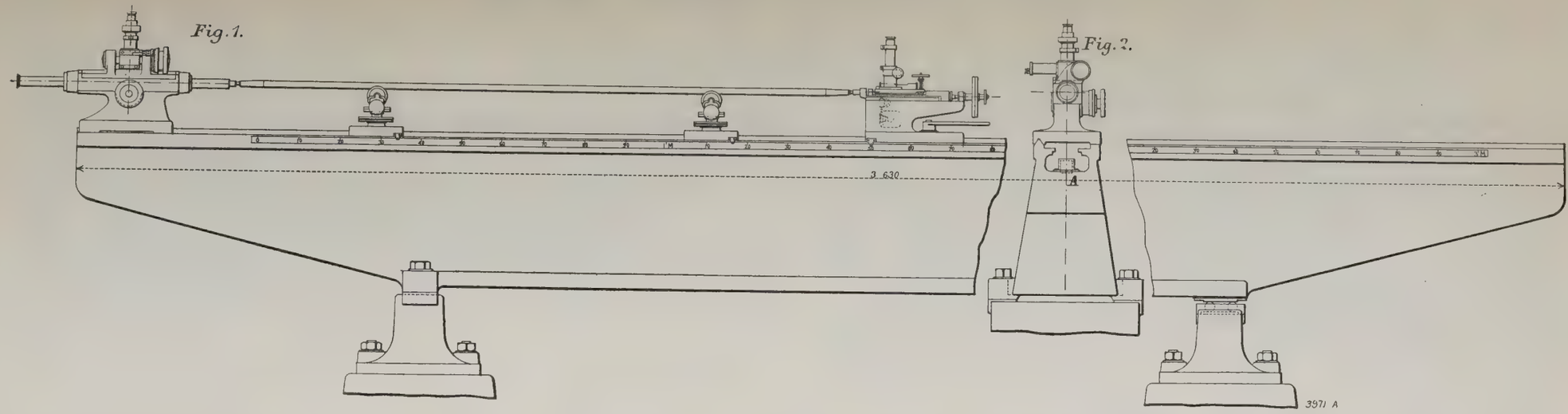
AMERICAN STEEL RAILS.—The production of steel rails in the United States last year was 3,502,789 tons. The corresponding production for the decade ending with 1913 inclusive was:—

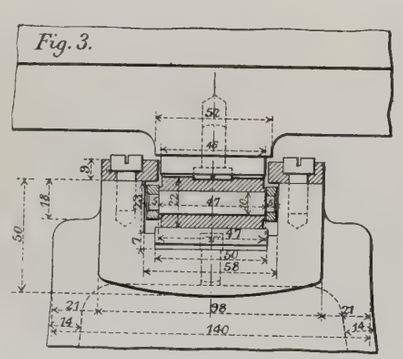
Year.	Tons.	Year.	Tons.
1904	2,284,711	1909	3,023,845
1905	3,375,929	1910	3,636,031
1906	3,977,887	1911	2,822,790
1907	3,633,654	1912	3,397,915
1908	1,921,015	1913	3,502,789

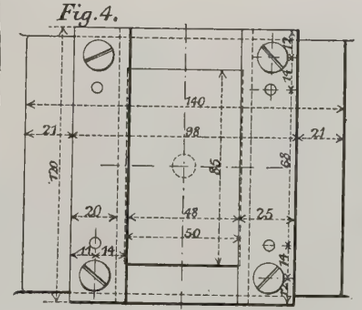
The great extent of the American railroad network ensures a good annual demand for steel rails for renewals, but current American railroad construction does not exhibit the vigour and energy of former years, and it is significant that American railroad bonds to the aggregate amount of 578,673,000 dols. are at present in default with respect to their interest.

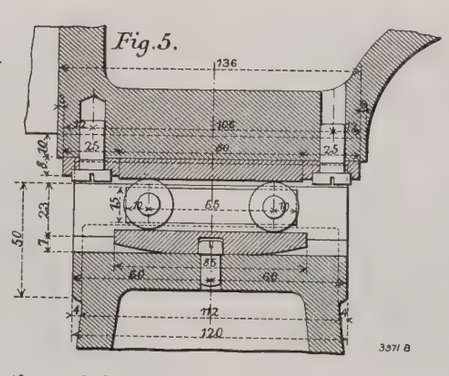
3-METRE WORKSHOP MICROMETER MEASURING-MACHINE.

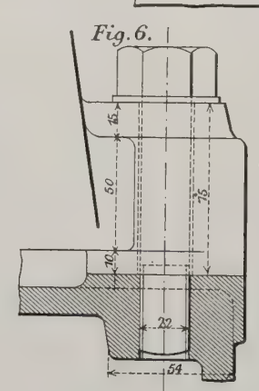
CONSTRUCTED BY THE SOCIÉTÉ GENEVOISE, GENEVA, SWITZERLAND.

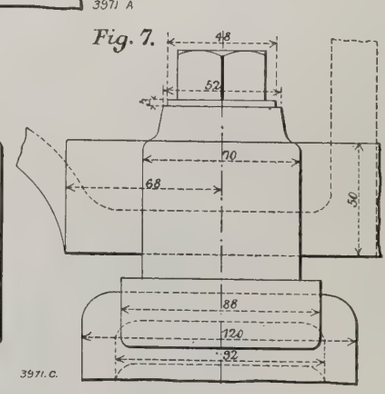












LARGE MICROMETER MEASURING-MACHINES.

On this page and on pages 324 and 325, we illustrate two types of large micrometer measuring-machines constructed by the Société Genevoise, of Geneva, whose agent in this country is Mr. O. Paul Monckton, of 87, Victoria-street, S.W.

The 3-metre machine, which is represented in Fig. 1, has been designed with especial reference to workshop requirements, and is constructed in sizes from 60 in. up to 160 in., or from 1.50 metres up to 4 metres on the metric system. The limit of accuracy guaranteed in these industrial machines is $\frac{1}{2500}$ in., but a materially higher degree of accuracy is secured with the precision machines to be described later. The machine shown in Figs. 1 and 2 has a very stiff cast-iron bed, supported on the three-point system, the tail-stock end resting, moreover, on roller-bearings, thus ensuring an entire absence of any constraint from temperature changes. Details of this roller support are illustrated in Figs. 3 to 5. At the other end the bed is secured to the pedestal by two studs, details of the connection being represented in Figs. 6 and 7. At one end of the bed is fitted a fixed headstock provided with a microscope scale and micrometer screw adjustment, whilst a second headstock, fitted with a microscope and micrometer adjusting-screw, but no scale, is arranged to slide along the ways. On the front of the bed is a millimetre scale; this scale serves for roughly adjusting the loose headstock and for placing the supports, on which a bar is mounted during measurement, near the "Airey points." In determining the length of a bar, moreover, the "even" millimetres are read from this front scale, but the true standard of reference for obtaining the exact dimensions of an end measuring bar is a decimetre scale fixed along the centre of the bed a little below the level of the ways, as shown at A, Fig. 2. To the divisions on this scale the cross-hairs of the microscope carried by the tail-stock are accurately adjusted by means of a screw of 1 mm. pitch.

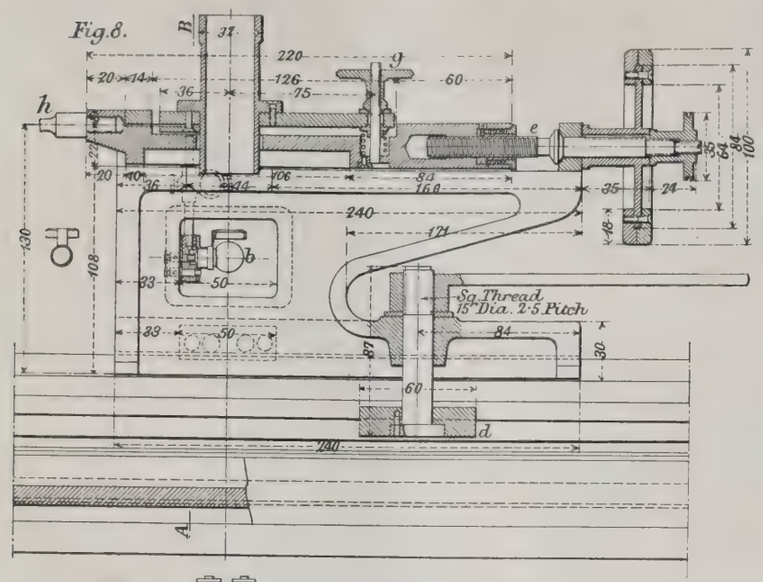
This loose headstock is shown separately in Figs. 8, 9, and 10, page 324. In Fig. 10, moreover, the position of the reference scale, below the ways, is shown at *a*. The bar on which this scale is engraved is of H section, and the scale is engraved along the upper surface of the web, which coincides with the neutral surface of the bar. Its length, therefore, is not affected by any slight bending strain. Brass cover-strips protect the scale from dust and dirt, only the part immediately under the microscope being uncovered in setting the headstock. During this operation the corresponding division of the scale is illuminated by an electric lamp mounted at *b*, the light of which passes through the lens at *c*, and is thence reflected down on to the scale. The headstock, it will be seen, consists of two portions. The lower portion slides on the bed, and can be clamped into position by the clamp *d*. The upper portion slides over the lower along accurate guides and carries the telescope, being adjusted into position by the screw *e*. In making this adjustment two cross-wires fixed in the telescope are shifted until they are accurately bisected by the scale division. Greater accuracy is thus secured than by the use of a single movable cross-wire brought into coincidence with the scale division. A level *f* allows of any accidental tilt of the telescope being detected, and corrected by the milled nut *g*.

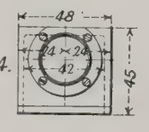
At its front end the upper slide carries a hardened-steel contact-piece *h*, the face of which is accurately plane, and exactly perpendicular to the axis of the machine. This contact-piece is that employed in the normal use of the machine, but for special work a spherical cap is provided, fitting over and secured to *h*. A view of the scale at the front of the bed of the machine and the fiducial mark on the loose headstock is represented in Fig. 11.

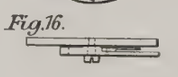
The fixed headstock is shown in Figs. 12 to 17, page 324. It consists essentially of a plunger *p*, Fig. 12, having a contact-piece *h* at its forward end, whilst its tail fits practically air-tight into a brass cylinder *q*. In the cap of this cylinder small non-return valves are mounted, which

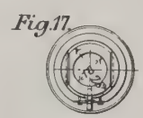
DETAILS OF WORKSHOP MICROMETER MEASURING-MACHINE.

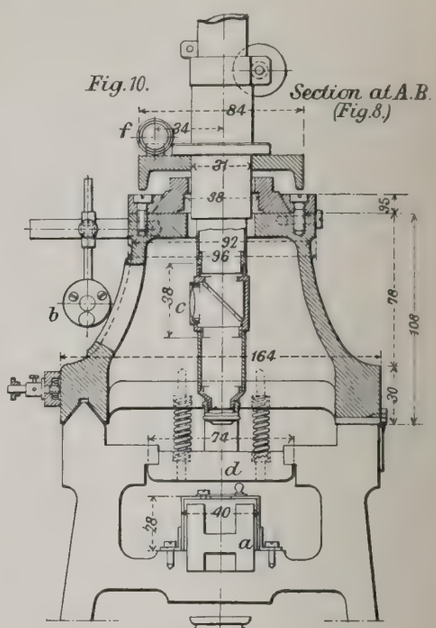
CONSTRUCTED BY THE SOCIÉTÉ GENEVOISE, GENEVA, SWITZERLAND.

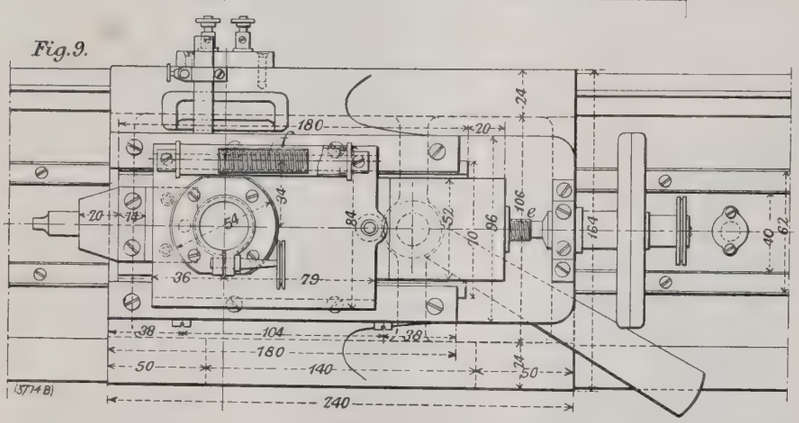


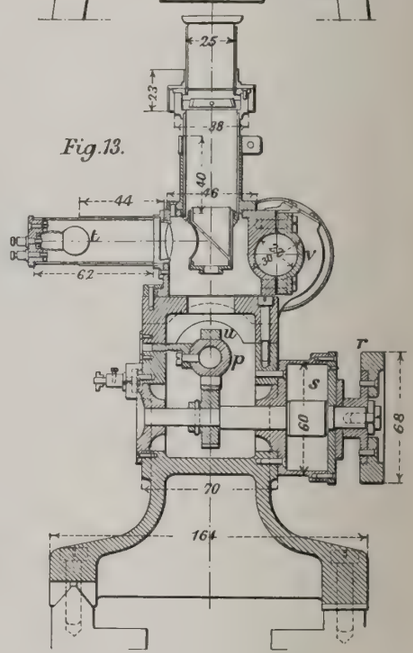


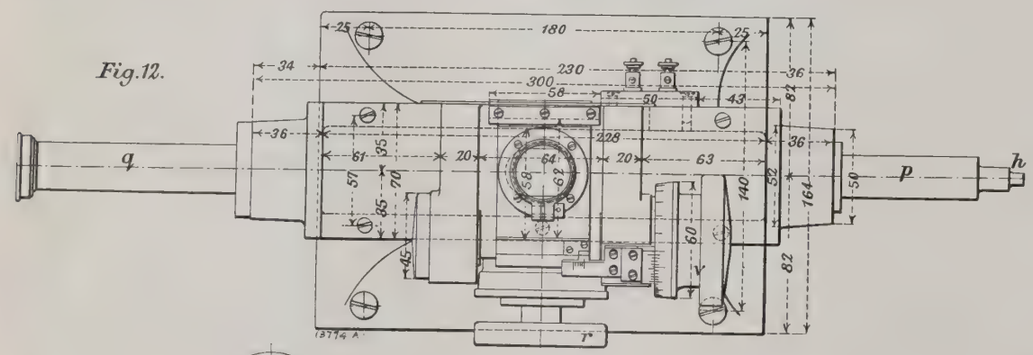


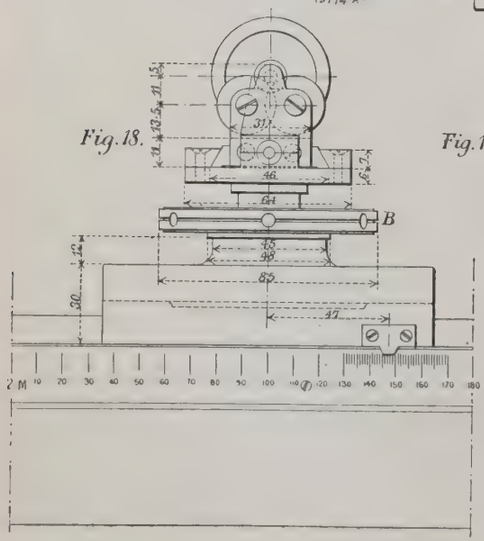


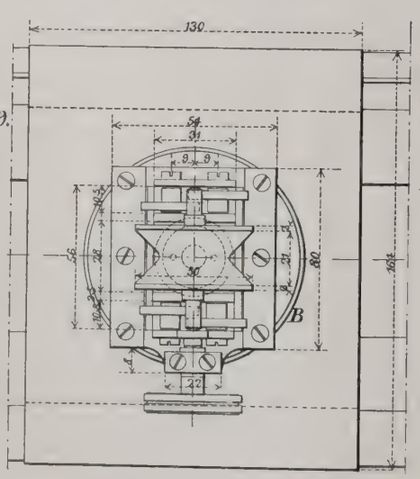


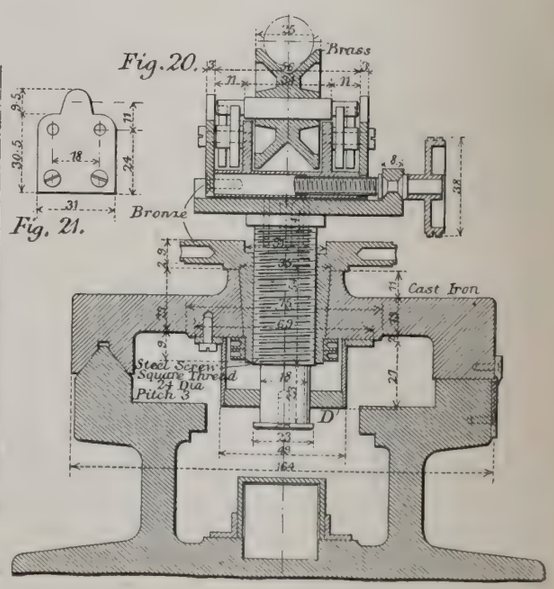












PRECISION MEASURING-MACHINES.

CONSTRUCTED BY THE SOCIÉTÉ GENEVOISE, GENEVA, SWITZERLAND.

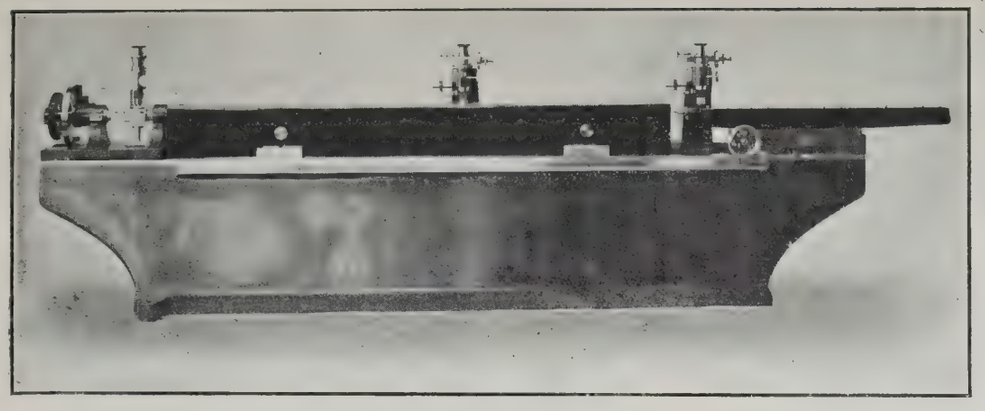


FIG 22.

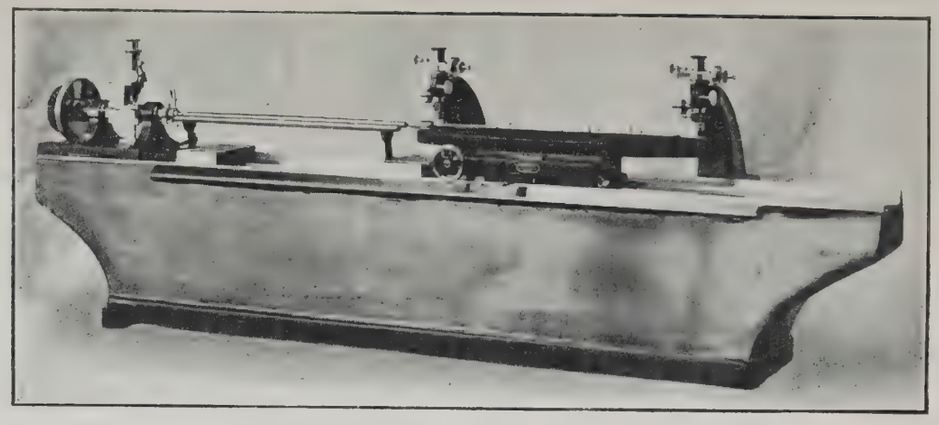


FIG. 23.

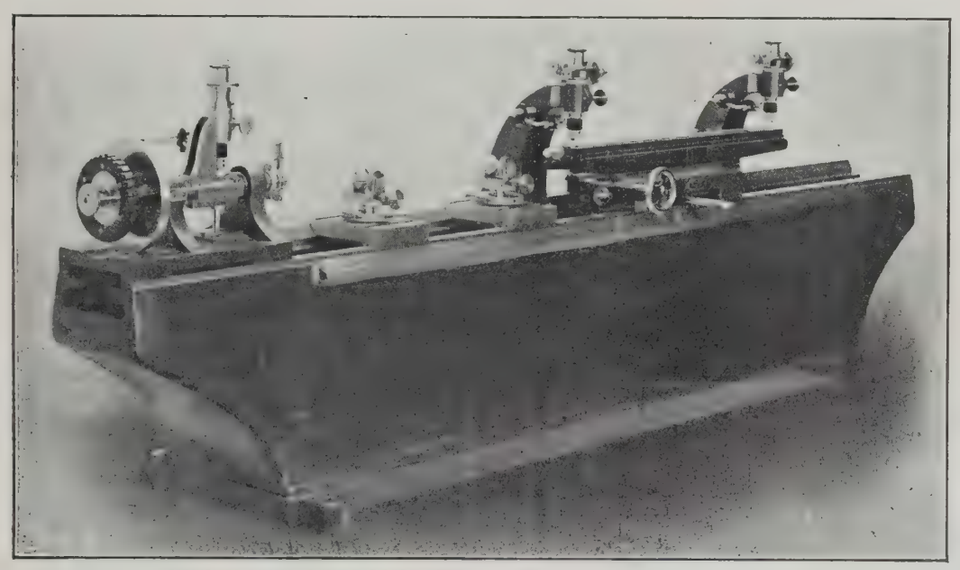


FIG. 24.

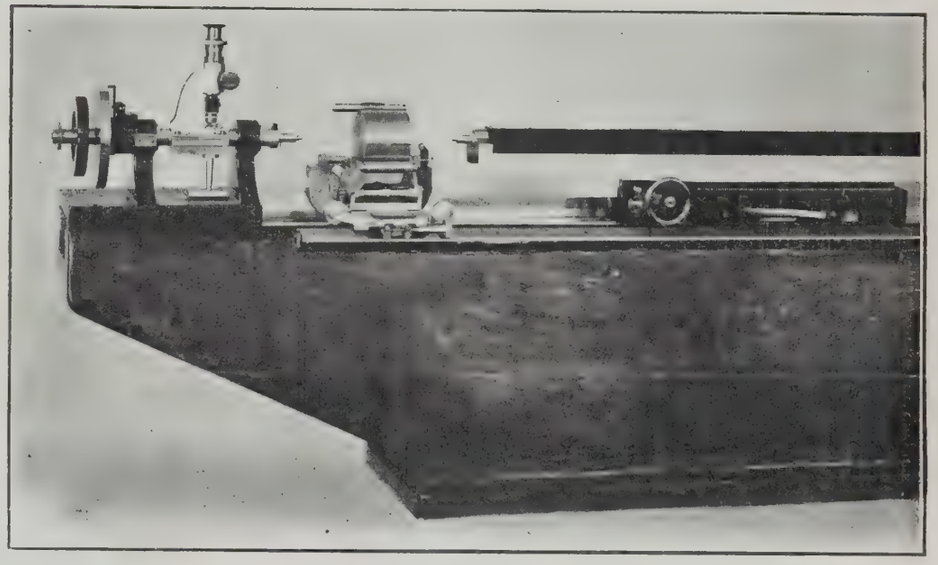


FIG. 25.

allow of air being driven out of the cylinder, but prevent its return. In using the machine after the loose headstock has been brought into alignment with the proper scale division, the plunger p of the fixed headstock is moved back to the limit of its travel by means of the hand-wheel r, which actuates a pinion gearing with a rack on the under side of the plunger. The spindle on which r is mounted is provided with a spring box s, Fig. 13, in which is coiled a flat spring, the tendency of which is to push the piston from right to left. In racking back the piston this spring is wound up, and is then prevented from uncoiling by a pawl and ratchet wheel shown separately in Figs. 15 and 16. During its backward motion the plunger p easily drives out the air trapped behind it through the valves already mentioned, as provided in the cap of the air-cylinder. The bar to be measured having been put in place between the contact-pieces, but clear of them, the pawl of the ratchet-wheel is released, and the spring, being thus allowed to uncoil, gently pushes up the contact-piece into contact with one end of the bar, and the whole then continues to move forward gently until stopped by the other end of the bar taking a bearing against the contact-piece on the loose headstock. The whole of this motion is accomplished not only automatically, but gently, since the forward motion of the plunger is governed by the rate at which air is able to leak into the air-cylinder behind it. The spring, moreover, which drives the plunger being a long one, the pressure it exerts is practically constant during the whole possible travel of the plunger, so that the pressure between the contact surfaces is sensibly the same, whatever the length of the specimen measured.

The correction to be added to the reading of the front scale on the bed of the machine is taken from a scale about 120 mm. long, mounted on top of the plunger p, as represented at u, Fig. 13. This scale is divided into millimetres, and is read by means of the microscope shown, being illuminated for this purpose by the small electric lamp shown at t, the light being reflected down on to the scale by means of the lens and transparent mirror shown. The microscope is

mounted on accurately-finished guides, and can be traversed over the scale below it by means of the micrometer screw and head v. Any backlash in this screw is taken up by means of a spiral spring. The screw has a pitch of 1 mm., and the head is divided into 100 divisions, and by means of a vernier gives readings to $\frac{1}{1000}$ mm. The amount of traverse from the zero position to bring the telescope central with a millimetre division of the scale below is read from this divided head.

The bar to be measured is borne by adjustable supports, shown separately in Figs. 18 to 21, page 324, each having a form of a grooved pulley, resting on roller-bearings. The bar rests in the vee of the pulley, and as the latter is mounted on anti-friction rollers, resistance to end motion is practically eliminated. The supports are adjustable both vertically and transversely. The former adjustment is effected by the milled head B, which, as shown in the sectional view, Fig. 20, is mounted on a conical bearing in the bed of the support. The cone is hollow, and screwed to take the vertical spindle of the support. This latter is prevented from turning by a key which slides in a keyway cut in the cap D. The transverse adjustment is made by the screwed head shown in Figs. 19 and 20. Provision is made for setting the supports in position by means of the scale engraved along the front edge of the bed.

The second type of machine is illustrated in Figs. 22 to 25, page 325, and Fig. 26, subjoined.

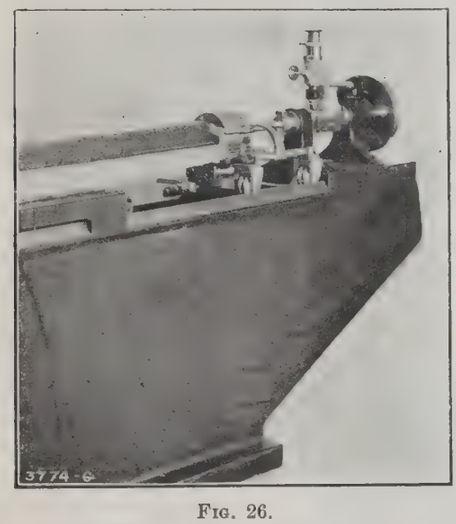


Fig. 26.

This is a precision machine, and is designed to give absolute measures of length to an extremely high degree of accuracy. It differs from the industrial machine already described in that the tailstock is fixed whilst the scale is movable. This arrangement is superior to that already described, since any tilt of the bed is magnified when the microscope is fitted to a moving headstock, whilst if the headstock and microscope be fixed, and the scale is the moving element, a small tilt of this scale involves an extremely minute error. The error in length due to tilt of the rule is, when the microscope is fixed and the scale the moving element, equal to $[1 - \cos a]$, where a is the angle of tilt. This angle of tilt is never more than an exceedingly small fraction of a degree. Even if the error in the parallelism of the scale attained the impossibly high value of $\frac{1}{4}°$, the consequent error would be less than 1 part in 100,000. With the fixed scale pattern, on the other hand, the error is proportional to the sine of the angle by which the axis of the microscope departs from a line perpendicular to the scale. Hence the error in this case is directly proportional to the angle of deviation, whilst with the moving-scale instrument it is proportional to the square of this very small quantity, and is thus wholly negligible.

The general arrangement of the precision machine is shown in Figs. 22, 23, and 24, page 325. There are, it will be seen, two microscopes at the tail-end of the bed, this arrangement being adopted so as to make it possible to measure long rods with a scale only half the maximum length that can be measured in the machine. The rule is divided with the greatest accuracy, and in a test of $\frac{1}{2}$ metre long, made at the Bureau International des Poids et Mesures, Paris, the maximum error at any division was only 6.45 μ, and these errors being determined once for all, and tabulated, the corrected measurements are accurate to about one μ, or $\frac{1}{1000}$ of a millimetre. The ease with which this scale can be calibrated constitutes one of the very great advantages of this type of machine.

As our engravings show, this rule is mounted on a sliding carriage which is pushed by hand into the approximate position required by the length of the rod to be measured. It is then clamped to the bed and can then be traversed in either direction by a worm and screw, which serve as a fine adjustment. The whole body of the rule is protected against dust and dirt by a cover which is removable in sections, and only that part immediately under the microscope in use is exposed in taking a measurement.

The headstock is fitted with a plunger having a hardened contact-piece. This plunger can slide longitudinally under the action of a spring. In making a measurement, the specimen is placed in position on suitable carriers, grooved rollers being used to support long specimens. The two contact-pieces are brought up against the ends of the specimen, the length of which to the nearest millimetre can be read from a scale at the front of the machine. By means of a tangent screw adjustment the nearest division of the movable scale is brought accurately between the cross-wires of the microscope. After this has been accomplished the plunger belonging to the fixed headstock is adjusted so that a fiducial mark on it bisects the cross-wires of the corresponding microscope. This adjustment is effected by the micrometer drum (reading to 1 μ), with which the fixed headstock is fitted. This drum is mounted on an exceedingly accurate screw of $\frac{1}{2}$ mm. pitch. The displacement thus made is subtracted as a correction from the scale reading. Where the highest precision is required, the specimen under measurement is enclosed by polished wood blocks, as indicated in Fig. 22. In Fig. 24, the roller-carriers used to support a specimen while being measured are clearly shown. These rollers are adjustable, both in height and transversely. An alternative method of support, adopted when two gauges are being compared, is illustrated in Fig. 23, on page 325, and in Fig. 26, annexed. Here the two rods are both carried on a pair of swinging arms, which facilitate the interchanging of the position of the two gauges, each being brought in succession between the contact-pieces of the machine. A mount used for supporting short specimens is illustrated in Fig. 25. Here the specimen is supported on a pair of horizontal rollers, the distance between which is adjustable by means of a screw-head. This enables the height to be adjusted as required by the diameter of the gauge. This carrier is, moreover, fitted with a turntable, so that both the diameter and length of a gauge can be measured by simply rotating the table through a right angle.

INDUSTRIAL NOTES.

It is most satisfactory to note that unemployment in London is much less prevalent than was anticipated in the early part of last month. However, according to *The Times*, furniture making, gold and silversmiths' work, the manufacture of fancy leather goods, and other trades dealing with articles which are not prime necessities, have been hard hit. In most of these the average workman is now only employed from one-third to one-half the normal time. There is, as yet, very little evidence of distress. The confectionery industry in London employs a large amount of labour, and this trade has been injuriously affected by the rise in price of sugar. Many manufacturers have adapted themselves to the new conditions, and employees who would normally be engaged now in making novelties for the Christmas market are turning out miniature flags, which cannot be produced rapidly enough to meet the demand. Very large orders have been given for jam for the Army and Navy, and these orders have, in many cases, more than compensated for the shrinkage in the consumption of confectionery.

It is a striking fact that at the Port of London trade is actually better, and unemployment is less, than it was a year ago. This is due to the fact that many cargoes of food-stuffs and other supplies which would, under normal conditions, have gone to German ports, have been diverted to London.

Inquiry by the Assistance Committee at the Mansion House has shown that in 204 banking and commercial firms, employing 11,440 persons in all, 9772 employees were in full work, 172 were working overtime, 451 were working short time, while 1131 had joined the Forces; only 63 were out of work. In banking and insurance offices the war has made no difference to women clerks and very little to men. It is estimated that there are 10,000 clerks employed in the Stock Exchange. Of this number 2300 are members of the provident fund, but there have been only fifty-two applications for assistance since the outbreak of the war. It many cases salaries have been reduced, but very few clerks have been dismissed.

The Board of Trade issues the following statement of unemployment:—

In the trades compulsorily insured against unemployment (viz., building, works of construction, engineering, shipbuilding, vehicle-making, &c.), the percentage of unemployment at September 4 was 6.24. This is practically the same as the percentage a week before (6.20), and may be compared with a percentage of 3.34 a year ago. The growth of unemployment in the insured trades has therefore, for the moment, stopped. Indeed, in engineering, construction of vehicles, and saw-milling there is an actual decline of unemployment. This is counterbalanced by a slight seasonal increase of unemployment in building and construction of works. The present unemployment percentage of 6.24 is well below the estimated average unemployment of the insured trades over a period of good and bad years. In the uninsured trades the number of men and women on the register of the Labour Exchanges for September 4 was 73,891, as compared with 80,868 a week before, and 34,879 a year before. The decline is confined almost entirely to men, and is, no doubt, due to the increase of recruiting.

As would be expected, the trade returns of the United Kingdom for August show a great reduction in both imports and exports. With Germany and Austria-Hungary trade has, of course, been extremely small, and that with other countries has been seriously interfered with. This has arisen more from the effects of the war on the foreign exchanges than from the war itself. During the month the value of the goods imported into this country was 42,362,034*l.*, which is 13,613,670*l.* (24.3 per cent.) less than was imported during August, 1913. Exports have, however, decreased from 44,110,729*l.* in August, 1913, to 24,211,271*l.* last month, the difference (19,899,458*l.*) amounting to 45.1 per cent. The percentage drop in the value of re-exported goods is almost exactly the same, the figures being 4,419,833*l.* for last month, and 8,150,499*l.* for August, 1913. British imports from Germany have fallen from 1,879,418*l.* in August, 1913, to 195,835*l.* last month—a reduction of 1,683,583*l.* More than half of this reduction—851,043*l.*—is accounted for by the diminution in imports of sugar; the figures for this commodity alone were 894,254*l.* in August, 1913, as against 43,211*l.* last month. Steel blooms, bars, girders, &c., account for another 153,881*l.* reduction, the imports being only 50,498*l.* last month, instead of 204,379*l.*, as in the corresponding period of last year. The total British exports to Germany have diminished from 2,249,067*l.* in August, 1913, to 799,017*l.* during last month, the difference being 1,450,050*l.* The principal item is coal, the amount exported last month having been worth only 75,816*l.*, whereas for August, 1913, the figure was 477,690*l.*; the difference is thus 401,874*l.* Wool and woollen goods come next, these having fallen off from 645,650*l.* to 283,375*l.*—a difference of 362,275*l.* Cotton yarn accounts for a further reduction of 206,262*l.*, the figures being 394,848*l.* and 188,586*l.* respectively for the two months we have been comparing. For iron and steel the figures show a reduction of 52,894*l.*, the exports last month having been 46,110*l.* as compared with 99,004*l.* for the same period last year. The only other item worth mentioning individually is textile machinery, which has fallen off from 60,488*l.* to 24,515*l.*, a difference of 35,973*l.* Although these striking figures give a very good idea of the influence of the war on British trade with foreign countries, its full effects are somewhat masked by the fact that the returns include some goods imported and exported before the declaration of war. The Royal Proclamation prohibiting the exportation of certain goods has also affected the figures.

The quarterly report of the National Amalgamated Union of Labour states that the funds of the union at the end of June last amounted to 12,798*l.* 7s. 11d., a reduction of 2264*l.* 1s. 1d. on the quarter; the membership showed a slight increase. The general secretary, Mr. J. N. Bell, stated that one effect of the war had been to reduce strike and look-out expenditure. In all cases where trouble threatened members had been advised to avoid entering into disputes while the war lasted. He, however, complained that some employers had taken advantage of the opportunity to enforce reductions, but added that none of the employers referred to belonged to the engineering trade. With regard to the relief of distress arising out of the war he thought it preferable that the local authorities should provide work for able-bodied men thrown out of employment, instead of making charit-

able grants. In this way recipients would be enabled to preserve their self-respect, and the public would eventually derive some benefit from the money spent.

Although unemployment has not yet become very serious, the distress committees and civic authorities of many of our large centres of population have been making plans for alleviating what distress there is, and for providing occupation for the larger number of workers who may be thrown out of employment in the immediate future. According to the *Manchester Guardian*, unemployment among men in Liverpool has only reached large proportions in one or two trades. Carters and clerks are suffering; but as many of the latter have joined the forces, the number unprovided for has been greatly reduced. Carters, warehousemen, &c., may possibly be employed at the docks, where a large amount of work is to be done. In any case the exceptional activity at the docks considerably mitigates unemployment among men in the city. Unemployment is, however, acute among women and juveniles. It has been suggested, as a temporary expedient, that girls should be formed into classes for some kind of technical instruction, and that boys might also have their education improved. The opening of relief workshops for women is also contemplated, the idea being to use the workshops to collect second-hand clothing and adapt it for wear during the coming winter. In this way both employment and clothing will be provided for the distressed. In Sheffield the relief committee is satisfied that there is not sufficient unemployment distress at present to justify the expenditure of relief funds. Sheffield, of course, contains several large armament works, which are exceptionally busy. Some parts of the cutlery and allied trades are also busy owing to Government orders. What unemployment there is exists mostly in the silversmiths' trade, in which a number of the smaller firms have had to close down through lack of orders. Even here as many hands as possible have been kept at work by working short time. Relief will, however, be distributed when unemployment exists on a sufficiently large scale. A number of proposals for public works will probably be submitted to the next meeting of the City Council. These proposals are all in the nature of works which would be required shortly in any case, but may be hurried on if the state of the labour market renders it desirable. Many of the schemes are for road improvements, &c., which will only require labour of the heavier type. One of the largest proposals, however, is for an extension of the sewage works, which may involve an expenditure of 100,000*l*. The position of Leeds is such that it does not expect to suffer so greatly as other large industrial towns. It is thought that, owing to the very diverse nature of its manufactures, slackness in one trade will be more or less compensated for by increased activity in others. The City Council of Manchester has approved several departmental plans for providing work for the unemployed. These include the construction of an open-air school, main-drainage works, a housing scheme, park improvements, sewering, levelling, and paving work.

THE DYNAMIC INCREMENT OF A SINGLE ROLLING LOAD ON A SUPPORTED BEAM.*

By Professor HERBERT CHATLEY, M. Inst. C.E.I., B.Sc. (Eng.), Tang Shan, North China.

In the course of a letter† which was published in July, 1912, the present writer advocated the use of a formula as follows for the maximum dynamic increment of a rolling load on a supported beam of constant section (at centre):—

$$\delta F = \frac{W}{g}\left(\frac{W V^2 L}{3 E I}\right) = \frac{c W}{3} \quad . \quad . \quad (1)$$

δF = the dynamic increment of the load W.
V = horizontal velocity of the load.
L = span of beam.
E = modulus of elasticity of the beam material.
I = moment of inertia of the beam section.
g = gravitational acceleration.
$c = W V^2 L \div g E I$.

The "compound interest" effect was assumed to be negligible, and it is the object of the present note to consider that question more thoroughly.

Let F be the effective force causing the deflection of the beam (equal to the load + its increment). Then the deflection under the load at a point x from the left support is—

$$\Delta_w = \kappa F . \psi(x) \quad . \quad . \quad . \quad (2)$$

where κ is a constant $= \frac{1}{E I}$,

and

$$\psi(x) = (L^2 x^2 - 2 L x^3 + x^4)/3 L.$$

$$\frac{d}{dt} \cdot \Delta_w = \frac{d \Delta_w}{dx} \cdot \frac{dx}{dt} = V \cdot \frac{d \Delta_w}{dx}.$$

$$\frac{d^2}{dt^2} \Delta_w = \frac{d}{dt}\left[V \cdot \frac{d \Delta_w}{dx}\right] = V \cdot \frac{d}{dt}\left[\frac{d \Delta_w}{dx}\right]$$

$$= V \frac{d\left(\frac{d \Delta_w}{dx}\right)}{dx} \cdot \frac{dx}{dt} = V^2 \frac{d^2 \Delta_w}{dx^2}.$$

$$\delta F = F - W = -\frac{W}{g} \cdot \frac{d^2 \Delta_w}{dt^2}.$$

$$= -\frac{W}{g} \cdot \kappa V^2 \frac{d^2}{dx^2}\left[F . \psi(x)\right].$$

$$= -\frac{W}{g} \cdot \kappa V^2\left[F \cdot \frac{d^2 \psi(x)}{dx^2} + 2 \cdot \frac{dF}{dx} \cdot \frac{d \psi(x)}{dx} + \frac{d^2 F}{dx^2} \cdot \psi(x)\right] \quad . \quad . \quad . \quad . \quad (3)$$

This differential equation contains the solution to the problem, but is not suited for practical application. By successive approximations, however, it is possible to arrive at a notion of the extent to which it differs from equation (1).

In the computations frequent reference will be made to $\psi(x)$, and its derivatives, and the following table will therefore be useful. The proof of the fundamental function will be found in all advanced books on strength of materials.

x.	$\psi(x)$.	$\frac{d \psi(x)}{dx}$.	$\frac{d^2 \psi(x)}{dx^2}$.	$\frac{d^3 \psi(x)}{dx^3}$.	$\frac{d^4 \psi(x)}{dx^4}$.
0. L	0.0 L^3	0.0 L^2	0.666 L	−4.0	8.0 L^{-1}
0.1	0.0027	0.048	0.306	−3.2	8.0
0.2	0.00853	0.064	0.026	−2.4	8.0
0.212	—	0.0659	0.0		
0.3	0.0147	0.0526	−0.173	−1.6	8.0
0.4	0.0192	0.032	−0.293	−0.8	8.0
0.5	0.02083	0.0	−0.333	0.0	8.0
0.6	0.0192	−0.032	−0.293	+0.8	8.0
0.7	0.0147	−0.0526	−0.173	+1.6	8.0
0.788	—	−0.0659	0.0		
0.8	0.00853	−0.064	+0.026	+2.4	8.0
0.9	0.0027	−0.048	0.036	+3.2	8.0
1.0	0.0	0.0	0.666	+4.0	8.0

First Approximation.—If we neglect the second and third terms on the right side in formula (3), and substitute W for F in the first term, putting $x = L/2$, we get

$$\delta F = F - W = -\frac{W}{g} \cdot \kappa V^2[W . (-0.\dot{3} L)]$$

$$= +\frac{W^2 V^2 L}{3 g E I} = \frac{c W}{3} \quad . \quad . \quad (1)$$

as before.

Second Approximation.—Proceed as in the first, but omit the substitution of W for F in the first term.

Then

$$\delta F = F - W = +\frac{0.\dot{3} L W F \kappa V^2}{g}$$

$$F = \frac{W}{1 - \frac{W V^2 L}{3 g E I}} = \frac{W}{1 - \frac{c}{3}} \quad . \quad . \quad (4)$$

Third Approximation.—Assuming F to be increased by the amount indicated in formula (1), the deflection and acceleration will be correspondingly increased so that the "compound interest effect" will be approximately allowed for if we take the product of (1) and (4) as follows:—

$$F\left(1 - \frac{W V^2 L}{3 g E I}\right) = \frac{W}{\left(1 - \frac{W V^2 L}{3 g E I}\right)}$$

$$F = \text{nearly } \frac{W}{\left[1 - \frac{2 W V^2 L}{3 g E I}\right]} = \frac{W}{1 - \frac{2 c}{3}} \quad . \quad (5)$$

Fourth Approximation.—Assuming δF is small, let us further assume that $\frac{d^2 F}{dx^2}$ is not appreciably affected by δF, then

$$\frac{d^2 F}{dx^2} = \frac{d^2}{dx^2}\left[-\frac{W^2 \kappa V^2}{g} \cdot \frac{d^2 \psi(x)}{dx^2} + W\right]$$

$$= -\frac{W^2 \kappa V^2}{g} \cdot \frac{d^4 \psi(x)}{dx} = -\frac{W^2 \kappa V^2}{g} \cdot 8 L^{-1}$$

When $x = \frac{L}{2}$, since $\frac{d \psi(x)}{dx}$ for that value $= 0$, the second term on the right side of (3) $= 0$. Substituting for $\frac{d^2 F}{dx^2}$ we get—

$$\delta F = F - W = -\frac{W}{g} \kappa V^2\left[-0.\dot{3} L F + \left(-\frac{8 W^2 \kappa V^2}{g L}\right)(0.02083\dot{3} L^3)\right]$$

$$= \frac{W \kappa V^2}{g}\left[+0.\dot{3} L F + \frac{W^2 \kappa V^2 L^2}{6 g}\right]$$

$$F\left(1 - \frac{W \kappa V^2 L}{3 g}\right) = W\left[1 + \frac{W^2 \kappa^2 V^4 L^2}{6 g^2}\right]$$

$$F = W \frac{\left[1 + \frac{W^2 \kappa^2 V^4 L^2}{6 g^2}\right]}{\left[1 - \frac{W V^2 L \kappa}{3 g}\right]},$$

or if $\frac{W V^2 L}{g E I} = c$,

$$F = W \frac{\left[1 + \frac{c^2}{6}\right]}{\left[1 - \frac{c}{3}\right]} \quad . \quad . \quad . \quad (6)$$

It is obvious that a still closer approximation can be arrived at by modifying $d^2 F/dx^2$ to agree with this formula. For all practical purposes, (5) would seem to be close enough, and the writer therefore suggests that formula as suitable for engineering practice.

* Paper read before Section G of the British Association in Australia.

† In *The Engineer* newspaper.

PATENTS AND TRADE-MARKS ACT OF 1907.

TO THE EDITOR OF ENGINEERING.

SIR,—I am interested in the proposal which is on foot to nullify the operation of the Patents and Trade-Marks Act of 1907. It will be recollected that this Act made the working of foreign patents compulsory in the United Kingdom if their validity here was to be maintained. As a result, works have, I believe, been erected and are in operation in this country for the express object of manufacture under such patents, though doubtless in some cases other manufactures were subsequently introduced in such works.

I shall be obliged if any of your readers could furnish me with some particulars of firms whose existence in Great Britain has been brought about by this Act.

Faithfully yours,
ALEX. E. TUCKER.

Birmingham Central Laboratories, 55, Station-street, Birmingham, September 7, 1914.

"BRITISH PATENTS AND FOREIGN PATENTEES."

TO THE EDITOR OF ENGINEERING.

SIR,—In your interesting article under the above heading, which appeared on September 4 last, you remark that the Board of Trade has three courses of dealing with an enemy patent, and can order either avoidance, suspension, or a licence.

There appears to be some doubt as to whether this is so, or whether there are only two alternatives—namely, suspension and avoidance—the granting of a licence being a corollary to the first of these courses.

Broadly speaking, a patentee possesses two classes of rights, namely:—

(*a*) The right to make, use, exercise, and vend the invention;

(*b*) The right to prevent others so doing.

Since the decay of the Merchants' Guilds, the first of these has become entirely subordinate and is possessed by everyone, subject only to the exercise of the second by the patentee.

Nevertheless, the grant of a licence specifically confers the first right, whilst the suspension prevents the patentee from exercising the second.

I am informed that in the event of a successful application to the Board of Trade the patent would be suspended in favour of the applicant, who would also be granted a licence, either subject to the payment of a royalty or, perhaps, in some cases, without any such stipulation.

The licence might be an exclusive one, or licences for the same patent might be granted to several applicants.

An exclusive licence would, of course, be preferable to the applicant, as he could then sue for infringement, whereas an ordinary licensee cannot.

Yours faithfully,
A. L. ANNISON.

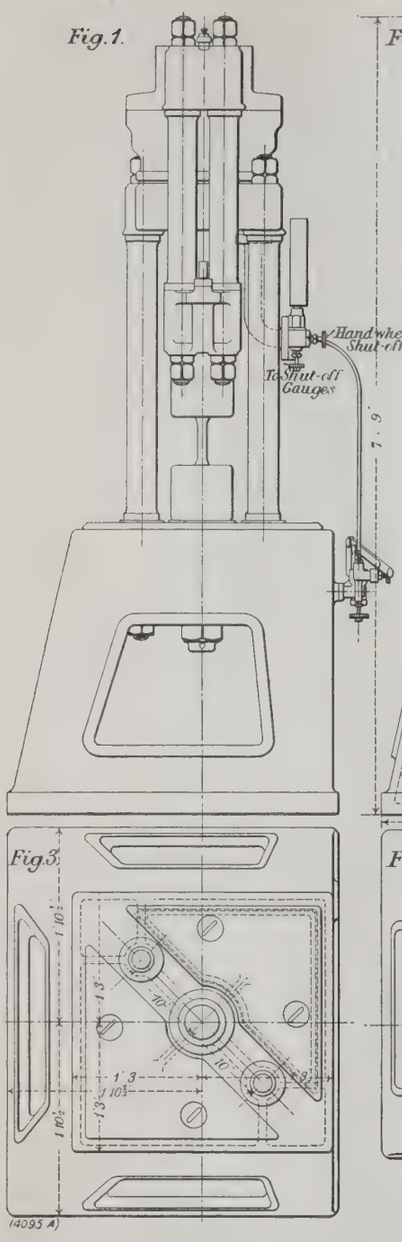
3, Central-buildings, Westminster, London, September 9, 1914.

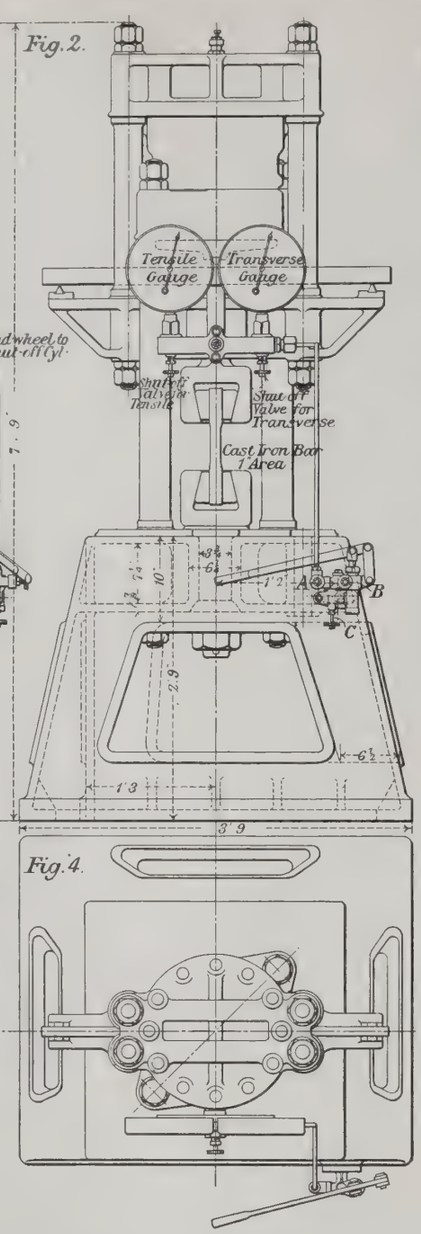
[The Temporary Rules Acts, 1914, state that the Board of Trade have power to avoid or suspend, in whole or in part, any patent or licence the person entitled to the benefit of which is a subject of any State at war with His Majesty. The Acts also give the Board power to grant licences to make, use, exercise, or vend patented inventions liable to avoidance or suspension as aforesaid. The Board would therefore seem to have three courses of dealing with an enemy patent. It probably will depend much on circumstances whether a patent is suspended or a licence is granted under it. The avoiding of patents will possibly only take place if Germany avoids patents granted to British subjects. Of course it could be argued that if the Board grant exclusive licences, the patent is suspended so far as a patentee is concerned; but if the Board grant ordinary licences, then the patent would not be suspended, as the patentee could still make, use, exercise, or vend the invention in competition with the licensee. No cases have been decided yet, and it is impossible to make any absolutely definite statement.—Ed. E.]

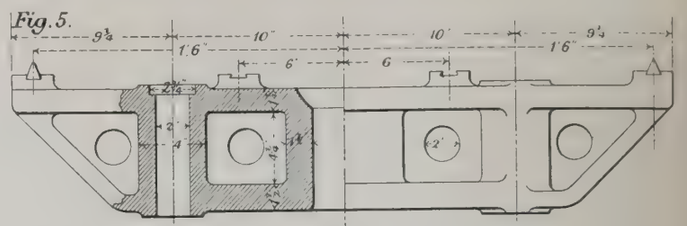
MARKETS FOR ENGINE AND BOILER PACKINGS.—In the year 1912 Germany exported 141,300*l*. worth of engine and boiler packings, and Austria-Hungary, in 1913, 38,480*l*. worth. A corresponding figure for the United Kingdom is 134,800*l*. for 1913. In the Indian, Egyptian, and Chilian markets we hold a strong position, while to the United States and Norway and Sweden our exports are about equal to those of Germany. In many important Continental countries, however, Germany holds a much superior position, and the present time should be a favourable one for an extension of this branch of our trade. Figures for the exports to a large number of countries are given in a White Paper issued during the last few days by the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, E.C. This paper will be of great value to such packing manufacturers as may be prepared to seize the present opportunity to make efforts to obtain some of the German and Austro-Hungarian trade.

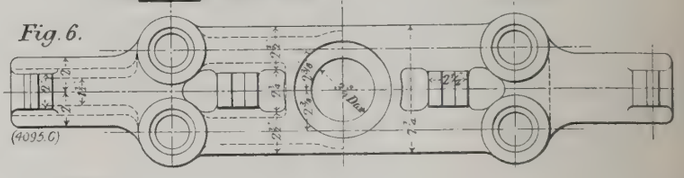
THE FOUNDRYMAN'S TESTING-MACHINE.

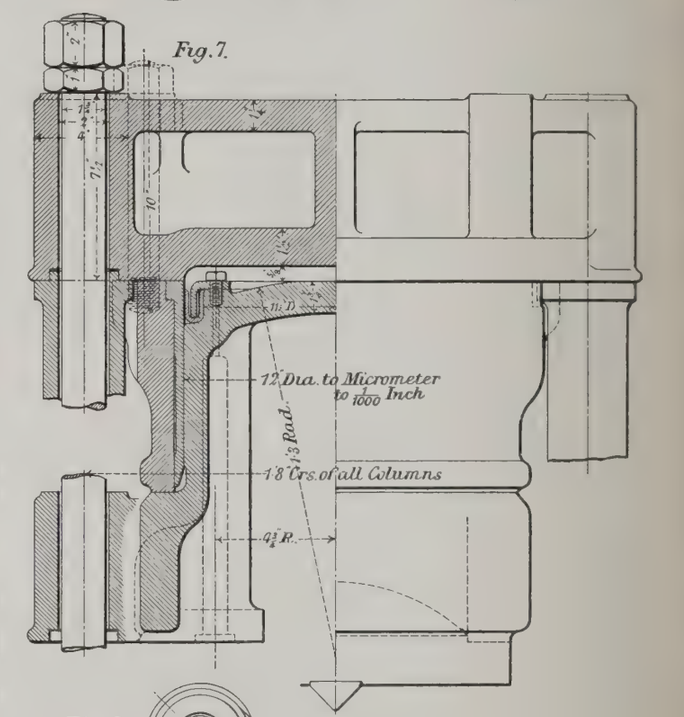
CONSTRUCTED BY MESSRS. BRADLEY AND TURTON, ENGINEERS, KIDDERMINSTER.

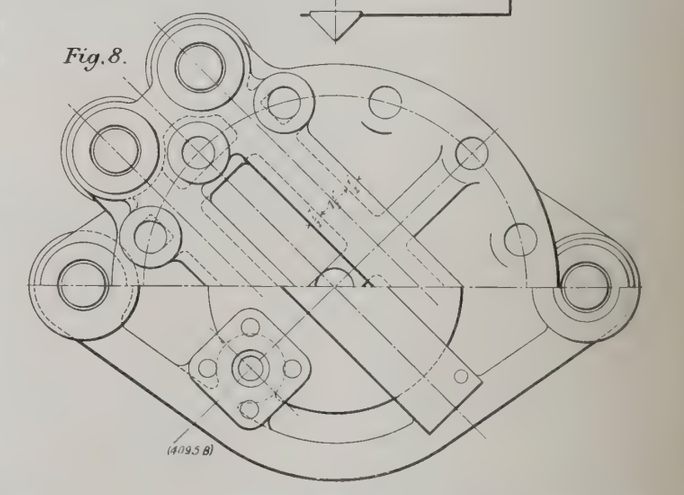


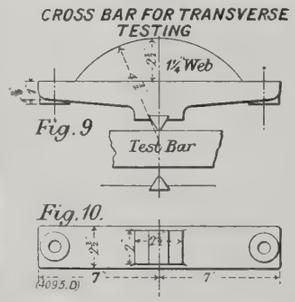












WE illustrate on this page a simple and relatively inexpensive testing-machine constructed by Messrs. Bradley and Turton, Limited, of the Caldwell Foundry, Kidderminster, specially to meet the requirements of ironfounders. The machine is capable of exerting a pull of 20 tons, and can therefore test in tension the strongest cast-iron bars up to 1 sq. in. section, whilst provision is made for the carrying out of transverse tests of bars measuring 3 ft. by 2 in. by 1 in. In this connection it may be noted that, with certain special cast irons, founders are now securing tensile strengths of the order of from 18 to 19 tons per sq. in. To test such irons, a machine capable of exerting a pull of 20 tons is very desirable, as the results obtained with small cast-iron specimens are apt to be misleading, giving no reliable indication of the real strength of castings made from the same metal. The machine illustrated is essentially an inverted hydraulic press, and the load applied to a specimen is read from one of two accurate pressure-gauges. Of these gauges, the one used in textile tests is graduated in tons of total load, the intermediate divisions being hundredweights. The second gauge, which has a more open scale, is used when the machine is employed in transverse testing; it reads to 50 cwt. by increments of 14 lb. The machine is calibrated by dead-weights to allow for the friction of the cup-leather packing, and the makers state that results are accurate within an error of under 1 per cent., which is, of course, more than amply sufficient for the needs of the foundryman.

The construction of the machine is well shown in Figs. 1 to 9, annexed. The hydraulic cylinder forms the moving part of the machine, fitting over a fixed plunger connected to the base-plate by two 1⅜-in. bolts placed diagonally, as shown. Four rods passing through strong lugs, cast in one with the cylinder head, support below the plunger a movable platen or cross-head, as best seen in Figs. 2 and 4. A grip for taking the upper ends of tension test-bars is provided below the centre of this cross-head, whilst on its upper surface are knife-edges to support the bars when making transverse tests. Views of this cross-head to a larger scale are shown in Figs. 5 and 6, whilst Figs. 7 and 8 give further details of the hydraulic cylinder and its plunger. The cylinder has, it will be seen, a gun-metal liner, and the plunger is made tight with a U leather packing secured in place with a guard-ring, as shown.

The central knife-edge, by which the load is applied in transverse testing, is mounted on the block illustrated in Figs. 9 and 10, and is secured to the underside of the fixed plunger. A tank is formed on the base-plate of the machine which takes the exhaust from the hydraulic cylinder, and the load is applied by the hand-pump shown to the right of Fig. 2. An independent screw-down plunger is provided at A, Fig. 2, by which the operation of breaking the bar is finally effected, after using the hand-pump to raise the pressure in the cylinder to nearly the breaking limit. A relief-valve of the needle type is fitted at C, and by manipulating A and C the final increments of load can be adjusted with great nicety. Shut-off valves are provided to each of the gauges, one or the other being closed according as tensile or transverse tests are being

made. The valve shown at B, Fig. 2, is used to couple up a length of flexible hose, permitting the machine to be used for testing castings by hydraulic pressure up to a limit of 400 lb. per sq. in. Compression tests can also be made between the upper surface of the moving cross-head and the lower surface of the fixed plunger.

The machine has been designed and patented by Mr. G. B. Richards, M. Inst. N.A., as the outcome of a long series of tests on cold-blast irons, which made very evident the need for a simple machine suitable for installation in the smaller as well as in the larger class of iron-foundry.

TRANSMISSION SYSTEM FOR HEAVY INTERNAL-COMBUSTION LOCOMOTIVES.*

By HEDLEY J. THOMSON.

THE progress in powerful internal-combustion engines has been slow for want of an efficient system of transmission to form a connecting-link between the prime mover and the driving-wheels. To obtain such a link, various means may be employed: a mechanical clutch system of the motor-car type; an hydraulic system depending upon oil-pumps; a compressed-air system; a purely electrical system, involving a whole electrical plant, to convert all the steam energy into electric energy, or at least an electro-mechanical system in which the output of the prime mover is divided and the energy transmitted partly by mechanical and partly by electrical means. The system of Mr. J. P. G. Thomas, of London, belongs to the last-mentioned type, and does not resort to a battery of accumulators. Treated purely as a variable-speed gear, the system consists of a planetary casing C, two electrical machines represented (in Fig. 1) by their armatures A and B, both capable of acting either as generator or as motor, and an electric controller not marked in the diagram. The casing C is driven at the same speed as the prime mover, or at a speed bearing a fixed ratio to it. In the casing are mounted duplex (double helical) pinions P, of different diameters, meshing the one with a large sun-wheel B_2, the other with a small sun-wheel A_2, mounted on the load-shaft B_1 and on the auxiliary shaft A_1. As illustrated, the gear reduction between one sun-wheel and the other through the duplex pinions would be 2.25 to 3 if the casing were momentarily stationary. Under working conditions the casing is never stationary, however, being driven by the prime mover, and if a torque of T foot-pounds were applied to the casing, it would (as can easily be shown) produce a torque in the same (positive) direction on the load shaft equal to 1.8 T, and a negative torque equal to 0.8 T on the auxiliary shaft; those torque relations always exist whether the load shaft B_1 be at rest or rotating, and at any speed of any of the three members of the planetary gearing.

These relative motions can be seen from the diagram, Fig. 2, on which the straight lines mark the respective speeds of the shaft, the engine speed being assumed a constant. If the resistance to the motion of the load-shaft B_1 be greater than 1.8 T, this shaft will remain stationary while the small member of the duplex pinion F_1 will run round, in planet fashion, the large sun-wheel B_2, and in so doing will rotate the other pinion at the same number of revolutions, but at a higher peripheral speed, the net effect of this higher speed being that the small sun-wheel rotates in the opposite directions. When the load-shaft is stationary the rotation of the small sun-wheel is 1.25 that of the prime mover, in the opposite direction, and the torque taken from the prime mover is just sufficient to overcome friction. When, however, the auxiliary shaft A_1 is prevented from rotating in the backward direction, then, if the load resistance be less than 1.8 times the engine torque (now increased), the large sun-wheel B_2 begins to rotate forward; under the conditions assumed, the speed of D_1 in the forward direction is a little more than half the engine speed (see Fig. 2). This, however, is not the practical limit of the speed variations of the load-shaft, if means be provided to rotate the auxiliary shaft forward; in that case the load-shaft speed can be made to coincide with that of the prime mover. At that moment two of the three members—and hence all the three members—are moving at the same speed. Hence by gradually speeding up the auxiliary shaft from rest until it reaches the engine speed, the speed of the load-shaft is automatically increased from a little above half the engine speed to that speed, when there is no relative movement between the three members of the gearing. This is realised by first taking power from the auxiliary shaft, and later by putting power into it; all this could, however, also be realised by means of a simple slipping clutch. What the Thomas gear does is that it admits of increasing the load-shaft torque above the 1.8 T, and this is attained by utilising the torque on the auxiliary shaft to drive the electric generator A, the current of which drives the motor B on the load-shaft; the arrangement resembles the Hopkinson testing method—both the machines were series wound. The field of A is first weak, but the current is delivered to B with full field acting as a motor, and the torque produced by B electrically is added to the mechanical torque on B *via* the large sun-wheel. The combined torques easily overcome the load resistance in starting, and B begins to rotate in the forward direction. But, owing to the inter-connecting gear, the speed (backward) of A decreases, and the field of A becomes stronger. The special controller of Mr. Thomas has four different positions for gradually strengthening the field of A, and the current is never interrupted. When further increase of the field strength of A is impossible, the control is changed over to B, the field of which is weakened; B, being a motor, runs faster as its field weakens. When the B field dwindles to zero, A is short-circuited; A then rotates (backward) very slowly, developing a negative torque of 0.8 T. At that stage, no power is electrically transmitted to the load-shaft B_1, and the energy losses are practically limited to the C^2R in A, to the controller, and to mechanical friction. By manipulating the controller, the speed of the load-shaft is varied from zero up to the intermediate mechanical speed, which is the limit of speed variation of the functions of A, and B cannot be interchanged. But the controller allows of reversing the field of B, which then generates current, stopping A, and reversing its movement, until it travels faster in a forward direction than the engine, and carries B with it in that rotation. Finally, all the three members move at the same speed, and any two may be coupled together.

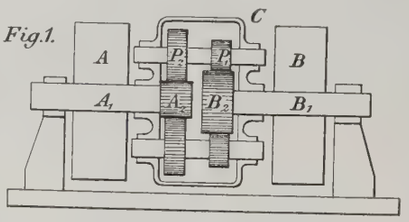


Fig. 1.

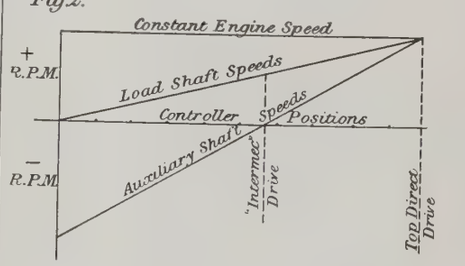


Fig. 2.

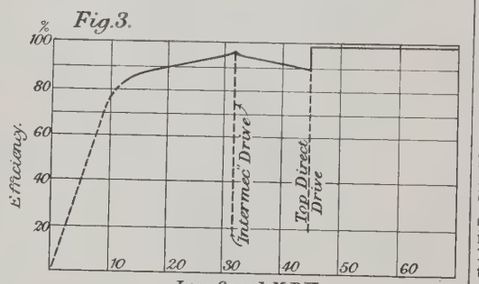


Fig. 3.

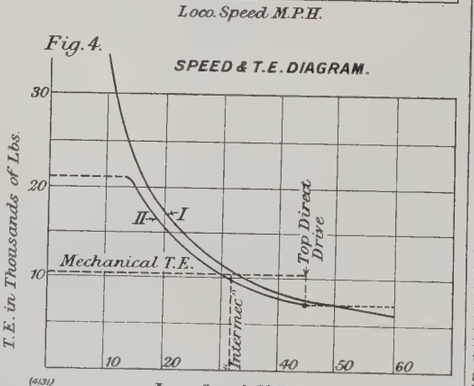


Fig. 4.

After effecting the coupling, the B field can again be reduced, until the voltage falls below the back electromotive force of A. The electric apparatus thus augments the torque at a gradually diminishing rate in a more efficient way than is realisable by purely mechanical means.

The power dealt with by the electric system is a maximum at low speeds of the load-shaft. It decreases almost to zero at intermechanical speed, and increases again afterwards to the top electro-mechanical speed, when this power dealt with electrically rarely exceeds one-half of the total power developed by the prime mover. This speed is not a running speed, but merely a temporary speed introduced for the purpose of bringing all the three members of the gear to the common speed; the electric transmission is then cut out, and the transmission becomes merely mechanical. The losses of power are a maximum at starting; they never exceed 6 per cent., and vanish at "top-direct" drive. The total electric losses amount to 4 per cent. at intermechanical speed; they may become serious beyond that point if the "top-direct" be not resorted to. The diagrams, Figs. 3 and 4, illustrate these features. For a considerable range on both sides of the intermechanical drive the efficiency is 90 per cent. and more, and this is realised by flexible and simple means. Fig. 4 is a tractive effort diagram, concerning a locomotive equipped with two engines, each developing 500 horse-power at 550 revolutions. The curve I is the characteristic for 938 horse-power delivered at the normal speed of 515 revolutions; curve II. shows the tractive effort that would be delivered if there were no gearing or bearing losses in the drive to the axles. The difference between the ordinates of these two curves therefore represents the loss due to the Thomas transmission. A horizontal dotted line corresponding to a tractive effort of 10,500 lb. (the constant tractive effort derived mechanically from the large sun-wheel) cuts the curve II. at a point corresponding to the intermechanical speed. The ordinate above this dotted line indicates the effort obtained by electrical means; this gained effort is maximum at starting, but it dwindles and finally becomes negative. At 45 miles per hour, therefore, the "top-direct" clutch is operated, and any further speed regulation of the locomotive is secured by means of the throttle. The losses are hence always small, and could, by suitably proportioning, altogether be eliminated during the greater part of the run.

The advantages are particularly striking, also, on heavy gradients, on which a locomotive of the mentioned power could run at 38 miles per hour, on a gradient of 1 in 200, and at 19 miles per hour on 1 in 60. For well over 90 per cent. of the total running time the direct drive would be utilised, and the losses due to the Thomas gear are practically confined to the remaining 10 per cent.; they are small, moreover, during that short period, so that the total power wasted in this variable-speed gear is about 1 per cent. These figures compare very favourably with those due to pure electric transmission system, which would require all parts of the machinery to be capable of dealing with the full load. This consideration also affects the question of steam locomotives for very heavy loads; to secure the necessary adhesion, such locomotives would have to be made of forbidding bulk. So far, Thomas-gear engines have been built for powers ranging from 12 up to 250 horse-power, and designs for 1000-horse-power engines have been worked out. On London omnibuses, fitted with the Thomas gear, the maximum efficiency is reached within a few seconds.

* Abstract of a paper read before Section G of the British Association at the Australian meeting.

NEW ATLANTIC LINER WITH GEARED TURBINES.—Messrs. Alexander Stephen and Sons, Glasgow, launched on the 3rd inst. the twin-screw geared-turbine steamer Tuscania, which they have built for the Anchor Line (Messrs. Henderson Brothers), Glasgow. The vessel is 567 ft. in length, 66 ft. 6 in. in breadth, 45 ft. in depth, of about 14,000 tons gross, and 20,000 tons loaded displacement. She will have accommodation for about 2500 passengers—350 first class, 150 second class, and about 2000 third class. The machinery installed is of special interest, as it and that of her sister-ship, the Transylvania—launched at Greenock in May last—are the first installations of geared turbines to be fitted in large Transatlantic vessels. The Tuscania is propelled by twin screws, each driven by turbines of the Parsons type working through reduction gearing. The gear-wheels are about 10 ft. in diameter and 5 ft. broad, and are driven by two turbines working in series and running at about 1500 revolutions per minute. An astern turbine of the impulse reaction type is incorporated with each low-pressure ahead turbine. The boiler installation consists of six large double-ended Scotch boilers working under natural draught at a pressure of 200 lb. The machinery has been constructed by the builders to the requirements of the Board of Trade and British Corporation Registry, and also to the American and Italian laws. The Tuscania, along with the Transylvania, is intended for the Mediterranean-New York service.

TASMANIA.—What is now the fine colony of Tasmania was discovered in 1642 by the Dutch explorer Abel Tasman. Tasman had two ships under his command, the Heemskirk and the Zeehan, and two peaks on the west coast of Tasmania are named after the Dutch vessels. Tasman concluded to name his discovery Van Diemen's Land; he died under the impression that it formed part of the great south land, or New Holland, as the Dutch were fond of styling what is at present known as the Australian Commonwealth. More would have been done in the matter of Dutch colonisation in New Holland had not the Dutch frigate Batavia been wrecked in June, 1629, on the Abrolhos Shoals. It was reserved for the Government of George III. of England to establish a settlement at Port Jackson, New South Wales. This settlement was due to three influences. In the first place, Cook had greatly increased our knowledge of the Australian coast-line; in the second place, George III. concluded that it was necessary to found new colonies in lieu of what his Government had lost in North America; and in the third place, it was deemed advisable to anticipate French explorers in the Pacific. The influence of the French upon the fortunes of Tasmania was considerable. In 1792 two French ships approached the island from the south and discovered D'Entrecasteaux Channel. They also further examined the Derwent, which had been discovered by Cook. The fact was further established by Lieutenant Flinders and Mr. Bass, surgeon of the Reliance, that Tasmania is an island separated from the Australian mainland by straits, to which the name of Bass was given. In 1803 a British settlement was finally established at Sullivan's Cove, the present site of Hobart, which has become the capital of Tasmania, and which now claims to possess the finest harbour of the Antipodes.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, August 26.

STEEL prices are fractionally advancing and the booking of orders is increasing. The opening of the Panama Canal is drawing business which awaited that event, because of the lower rates involved to Pacific points. The Argentine railways have transferred an order of 36,000 tons of rails from Germany to mills here. Inquiries from England for billets were answered at 5*l.* sterling f.o.b. New York, spot cash. Large orders are pending. Rates from Pittsburg *via* Panama to San Francisco are 46 cents per 100 lb., as against 80 cents by rail. Large dealings in steel were confidently anticipated with Canada, but conditions there are much disturbed. The supply of ferro-manganese being temporarily cut off, prices flew to 140 dols. per ton. It is proposed to reduce the quantity used. English shipments are assured if American consignees pay the war risk of 250 dols. per ton. Railroads continue to buy cautiously. Numerous enterprises are held in abeyance for financial reasons. General business in small lots is about as usual. Prices are hardening. Many mills have gone on full time to accumulate stock that will certainly be needed. The entire industry is getting into shape for an anticipated expansion of demand from foreign and domestic sources. Very many inquiries come from abroad relative to the assurances of fulfilling orders should they be sent. Large contracts are now being placed for bituminous coal for shipment abroad, and it appears probable that mine capacity will be taxed. Governmental action with regard to working ships in Atlantic Ocean service is being contemplated; the international features of such departure are the subject of consideration.

TRADE WITH DENMARK.—The Danish journal *Politiken* calls attention to the fact that the Danish market offers at the present time exceptional opportunities for British products. The financial situation in Denmark is excellent, and the purchasing power of the people is good. The country habitually imports large quantities of goods, among which are many of types manufactured here, such as hardware, tools, cycles, motor-cars, rubber goods, technical instruments, and also articles in common daily use. As our country is in a position to supply foreign markets, and communication with Denmark is being well maintained, it is suggested that this opportunity for trading should be taken promptly. Messrs. C. Mitchell and Co., Limited, Mitchell House, 1 and 2, Snow-hill, Holborn Viaduct, E.C., will be pleased, through the medium of their "Export Bureau," to afford British traders every assistance in taking advantage of the opportunity thus presented.

STANDARD PIPE UNIONS.—The Engineering Standards Committee has just issued a British Standard Specification (No 66) for Copper-Alloy Three-Piece Unions for Low and Medium Pressure. These are primarily intended for domestic and similar work, and the unions are for use with copper tubes conforming to one of the specifications (No. 61) issued last year. The work has been in the hands of the Sectional Committee on Screw-Threads and Limit-Gauges, by which a Sub-Committee on Metal Tubes and Connections was appointed in 1912. The committee has had the co-operation of a joint committee appointed by the Institution of Heating and Ventilating Engineers and the National Association of Master Heating and Domestic Engineers. The unions specified are designed for pressures up to 125 lb. per sq. in. The specification covers dimensions, analysis, mechanical, tensile, and hydraulic tests, &c., and appendices give data on standard threads, test-pieces, &c. The report may be obtained, post free, for 5s. 2d., from the offices of the Committee, 28, Victoria-street, S.W., or from Messrs. Crosby Lockwood and Son, 7, Stationers' Hall-court, E.C.

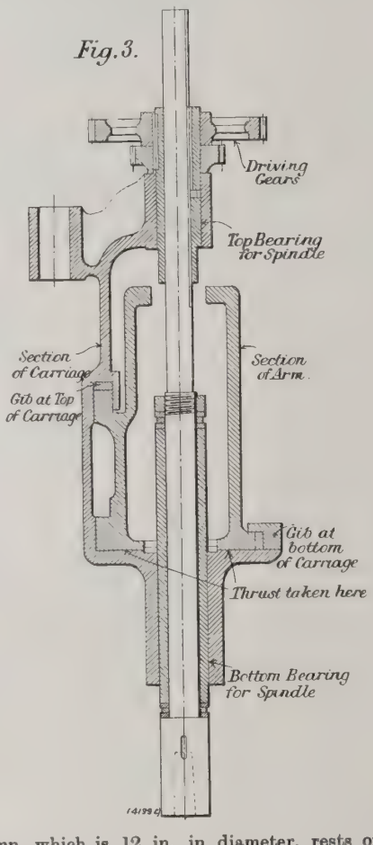
THE NEW ARMY.—Lord Kitchener has sent a letter, through Major-General Rawlinson, to the British Thomson-Houston Company, Limited, of Rugby, expressing his appreciation of the fact that 852 of their employees have entered the Army. The company are paying them half wages. Messrs. Hans Renold, Limited, inform us that they are giving to married men, who have enlisted, full pay for the first four weeks and half pay afterwards, provided their wages do not exceed 50s. a week. Other cases are dealt with individually. From the works and offices of the British Westinghouse Electric and Manufacturing Company, Limited, Manchester, 700 men have joined the forces. The staff has subscribed 937*l.* to the War Relief Fund, in addition to what the company are giving. Messrs. James Walker and Co., Limited, Garford-street, West India Dock-road, E., inform us that some of their employees have been called away to the Service, and that consideration is being given to such as are dependent on them. Half wages are being paid by the India-Rubber, Gutta-Percha and Telegraph Works Company, Limited, Silvertown, and by the Edison and Swan United Electric Light Company, Limited, Ponder's End, Middlesex, to the wives or dependants of all employees called up to the forces. The Engineers' Club, of Albert-square, Manchester, has decided to form a "Pals'" battalion in the new army for those engaged in works and offices of engineering concerns. They desire to receive names of candidates at once.

RADIAL DRILLING-MACHINE.

THE illustrations on page 332 are reproduced from photographs of a new design of radial drilling-machine recently constructed by the Selson Engineering Company, Limited, of 85, Queen Victoria-street, London, E.C. The special feature of this tool is the design of the arm and carriage, in order to avoid twisting stresses on the former. We shall deal with this point and with other notable characteristics of the design in the course of the following description.

The general arrangement of the tool is best shown in the front view, Fig. 1, while Fig. 2 shows the carriage on a rather larger scale. It will be seen that the machine is driven by a fast-and-loose pulley through a gear-box mounted on an extension of the bed-plate. The bed is deep and well stiffened by ribs, and also provided with planed T slots in the front and upper surface; the latter measures 3 ft. by 4 ft. It is extended at the back of the pillar, as shown in Fig. 2, in order to take a loose table. The inner pillar has an exceptionally large base, which is cut away in front so as not to interfere with the work; it is turned immediately under the locking ring to allow a swivelling table to be fitted if desired. The

Fig. 3.



column, which is 12 in. in diameter, rests on ball bearings, so that it can easily be turned into any position. It is locked in place by a special arrangement which binds it firmly to the inner pillar, and also prevents any tendency to lift under the pressure of the cut. This and the other locking devices are provided with handles, so as to avoid the necessity for using spanners.

The arm is of box-section, with slots in the top and bottom to clear the spindles, as shown in the cross-section, Fig. 3, on the present page. The side walls, which are strongly ribbed, increase in depth towards the column, and are placed as close as possible together. The arm has a long bearing on the column, to which it can be firmly locked by the hand-levers shown in Fig. 1. It has a self-acting vertical movement of 35 in., and can be swivelled, together with the column, by means of a handle placed on the end of the arm. Fig. 3 is a cross-section through the arm and carriage. From this it will be seen that the carriage is gibbed to the arm in front as well as at the bottom—an arrangement which gives great rigidity to the upper bearings of the spindles, and so avoids vibration. There are two spindles, one for drilling and the other for tapping. They are constructed of high-carbon steel, ground to size, counterbalanced, and provided with ball-bearings to take the thrust. Both spindles pass practically through the vertical axis of the arm-section, so that the thrust is equally divided between the two bottom surfaces of the arm, thereby avoiding all twisting stresses, as previously mentioned. The upper bearings of the spindles, together with the driving-gears and feed mechanism, are carried by the front plate of the carriage, while the lower bearings are formed in the bottom plate, as shown in Fig. 3. The drilling-spindle, which is 2¼ in. in diameter and is fitted with a No. 5 taper socket, has a maximum radius of 4 ft. 6 in., with a traverse of 14 in. It runs in a long non-rotating sleeve which is moved vertically by a rack and pinion, and serves to prevent lateral deflection of the spindle when the latter is in its lowest position. The double gear is placed directly on the drilling-spindle, so that the long driving-shafts have only to transmit a moderate torque; a single hand-lever serves for starting and operating this gear. The tapping-spindle is driven from the drilling-spindle at about one-third the speed of the latter. The reversing motion is effected by clutches operated by a hand-lever, and the quick withdrawal is controlled by a pull-down lever and rod.

The carriage is moved along the arm by means of a hand-wheel, and the mechanism is so arranged that, after a hole has been drilled, the tapping spindle can be brought into the exact position previously occupied by the drill. Holes can thus be drilled and tapped with one setting of the work, without removing either the drill or the tap from the spindles. The various handles for starting, stopping, reversing, and operating the feed motions are all placed on the front of the carriage, well clear of each other, and in convenient positions for the operator. There are four positive feeds, which can be changed while the machine is running, and tripped automatically at any desired point. They are stopped and started instantaneously by means of a friction-clutch. Eighteen spindle speeds, ranging from 18 to 340 revolutions per minute, can be obtained by means of the gear-box, which is entirely closed, so that the gears run in oil. It is also arranged so that all idle-running gears are avoided, only those actually required being in mesh.

With regard to the general design of the machine, we understand that all parts are sufficiently substantial to enable full advantage to be taken of drills of high-speed steel, and also that all gears are machine-cut from solid blanks, and all bearings bushed with gun-metal where necessary. If desired, a belt-driven machine can easily be converted for electric driving by mounting a 6 or 7-horse-power motor on top of the gear-box, which is planed for this purpose, and connecting the armature-shaft of the motor to the driving-shaft of the machine by silent gearing. The weight of the machine as illustrated is about 3 tons 12 cwt.

TRADE IN ITALY.—A communication from the Commercial Intelligence Branch of the Board of Trade states that the British Ambassador at Rome has cabled to the effect that there is a demand for goods in Italy which have hitherto been supplied by Germany. Among the goods mentioned are "carbons for arc-lamps, magnesium, silica, bricks, and special types of steel."

THE UNITED STATES NAVY.—It is stated that on the 1st inst. the Navy Department issued specifications for the three new dreadnoughts authorised by Congress this year. According to Admiral Richard Watt, Chief Constructor of the Bureau of Construction and Repair, the combined steel tonnage will aggregate approximately 65,000, made up of about 30,000 tons of armour, with a similar tonnage for plates and sections, and 5000 or 6000 tons of castings. The tenders for the ships will be opened at the Navy Department on October 6. These vessels will be the largest ever designed for the United States Navy. They will be heavily armoured, and will be propelled by turbines, and fitted with water-tube boilers designed to burn oil-fuel. Two of the new ships will in all probability be built by private yards, and the other at a navy yard, perhaps at New York. The vessels are to be named the California, Mississippi, and Idaho. The cost, exclusive of armour and armament, is to be a maximum of 7,300,000 dols. each. The main armament is to consist of twelve 14-in. guns. There are to be also four submerged torpedo-tubes, and twenty-two 5-in. quick-firing guns.

LONDON SCHOOL OF ECONOMICS.—We have received from this institution, the address of which is Clare Market, Kingsway, W.C., particulars of lectures and classes on railway and cognate subjects, to be held during the coming session. The lectures commence on the 8th prox., and an inaugural lecture, on "The Relations Between Railways and the State in Other Countries," will be delivered by Mr. W. T. Stephenson, on the 12th prox., at 6.15 p.m. The public will be admitted to this and to some other lectures without fee. The course includes introductory lectures on railway organisation, rates and fares, geography of Canadian and United States railways, and the Parliamentary history of English railways, as well as advanced lectures on railway economics and law, railway docks and shipping, and other subjects. Courses on subjects useful to railway students, and specially recommended to their attention by the Advisory Committee on Railway Subjects, are also included. A copy of the Calendar, giving detailed syllabuses of the courses of lectures and full information as to the prizes and scholarships offered by the School and by the London University, and also containing the regulations for degrees in the faculty of economics and political science, including commerce and industry, can be obtained, post free, from the Secretary, price 1s. 5d.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—When the pig-iron market opened last Thursday morning the lack of tone which has characterised its operations since the outbreak of the war was again evident, and while the quotations of Cleveland iron for cash and one month were nominally 1½d. per ton up, the price for three months dropped 2d. per ton. In the afternoon things steadied up a little, and some 1500 tons were disposed of at 51s. 10d. one month, and 52s. 3d. three months. On Friday the entire business done amounted only to 2000 tons, 1500 tons changing hands in the forenoon at 51s. 6d. cash and 52s. 3½d. three months; while the remaining lot went in the afternoon at 51s. 4½d., the closing prices being 51s. 6d. cash, 51s. 10d. one month, and 51s. 4½d. three months, a decline of from 1½d. to 3d. per ton from the previous day. Reviewing the work of the week, the feeling on Saturday was not unsatisfactory, because, although the turnover was small, it was still fairly steady, while over the week more business was done than on many other occasions, even since war broke out. The increased firmness gave a more hopeful outlook, the fact of 11,000 tons changing hands during the week strengthening this feeling. So long as the present financial situation lasts, it is highly improbable that much business of this nature will be done. On Monday forenoon the steadier tone noticeable at the end of the week was still in evidence, although the business done was restricted to three months warrants, 1000 tons changing hands at 52s. 3d., another lot of 1000 tons being dealt in during the afternoon at the same price, this time at one month. Yesterday morning absolutely no business was done, buyers' quotations for Cleveland iron having dropped 3d. to 51s., although sellers held out for 51s. 4d. This idleness continued in the afternoon, prices remaining unchanged. No dealings in Cleveland iron took place this forenoon, the cash price having advanced at 51s. 1d. buyers. A lot of 1000 tons was dealt with in the afternoon at 51s. 6d. one month, otherwise the market was again idle.

Scotch Iron Prices.—The market quotations for warrant and makers' iron issued yesterday were almost identical with those of last week, Shotts being a notable exception. They were:—Clyde, 69s. 6d.; Gartsherrie, 70s.; Summerlee, 70s.; Langloan, 72s.; Calder, 70s., all per ton at Glasgow; Glengarnock, 71s. at Ardrossan; Shotts, 70s. at Leith; and Carron, 70s. 6d. at Grangemouth.

Iron and Steel Trades.—Makers of malleable iron are not badly off at all; indeed, a few of the works are particularly busy with orders both for home and export trade. There are few shipping orders for pig-iron, and, in consequence, stocks are accumulating. Some of the furnaces which had been shut down have been relighted, a fact which seems to suggest a demand very shortly, both for home and foreign orders.

Steel Sheets.—Steel sheets in the thicker gauges are being made in considerable quantity at present, but there is little demand for the thinner quality. "Spelter," being contraband of war, has entirely displaced galvanised sheeting; but it is expected that large supplies will shortly be to hand from America and Japan, the price of which, no doubt, will be regulated by those ruling here when they arrive.

Export Trade.—The export trade is still in a rather unsettled state, many factors militating against it at the moment. Increased prices in finished material, heavier freight rates and bank charges, war insurance, and the present tightness in money, all tend to keep the foreign buyer out of the market. No doubt it will be some little time before a readjustment takes place.

Sulphate of Ammonia.—As regards sulphate of ammonia, little change has taken place.

SPELTER.—The United States Geological Survey has just issued a report that stocks of spelter increased by 23,380 tons in the first half of the year, and reached on July 1 the total of 64,039 tons. In the calendar year 1913 the production on the Continent of Europe was 655,454 net tons, about 150,000 tons being exported to England. The British spelter production was 65,197 tons. It is considered that to furnish 150,000 tons to Great Britain per year would not strain the resources of the United States. The price of spelter rose 1 cent per pound at East St. Louis between August 6 and August 20.

THE LATE MR. G. N. YOURDI.—We regret to have to record the death at Surbiton, on the 4th inst., of Mr. George Nicholas Yourdi. Mr. Yourdi, who was born in 1850, was identified during his professional career with some important water undertakings, being engaged for 22 years with Messrs. James Mansergh and Sons. He joined the firm in 1883 and was appointed resident engineer to the Stockton and Middlesbrough Water Board Works. This is the undertaking which is now carried on by the Tees Valley Water Board. Mr. Yourdi spent ten years in connection with this work and acted during the construction of the Fighting Cock's Reservoir, the Sadberge Reservoir, the Broken Scar Pumping-Station, and other reservoirs on the River Balder. In 1893 he was appointed chief resident engineer on the Birmingham (Elan Supply) Water Works for all the works on the watershed, including the masonry dams, Foel valve-tower, &c., and the conduit as far as the first syphon. During the last eight or nine years Mr. Yourdi had been in private practice in Victoria-street, dealing largely with arbitrations and valuations. He joined the Institution of Civil Engineers as an associate member in 1876, and was made a full member in 1884.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The iron trade presents no new features of moment. A quiet tone prevails, and there is a continued feeling of uncertainty with regard to the future. What business is passing is confined to transactions in small lots for early delivery. At the Clarence Works of Messrs. Bell Brothers a blast-furnace has been damped down, and there are reports that other firms may shortly put furnaces out of operation. There are now blowing on the North-East Coast seventy blast-furnaces, thirty-seven of which are producing Cleveland pig, and the remainder making hematite and special irons. No. 3 g.m.b. Cleveland pig is 51s. 6d.; No. 1 is 54s.; No. 4 foundry, 51s. 3d.; No. 4 forge, 51s.; mottled, 50s. 9d.; and white, 50s. 6d. Home consumers of East Coast hematite pig appear to have satisfied their needs, and demand is now on a very limited scale. Some of the makers still endeavour to fix the price of Nos. 1, 2, and 3 at 70s., but second hands are ready enough to sell at 67s. 6d., and even that figure might be shaded in some cases. There is little or nothing passing in foreign ore, values of which show an undoubted downward tendency, notwithstanding reports of mines being closed in Spain and consumers here running rather short of supplies. Dealers rather press sales, on the basis of 19s. ex-ship Tees for Rubio of 50 per cent. quality, but buyers consider that too high a figure, and doubtless contracts could be fixed on rather lower terms. There is little or nothing new ascertainable concerning coke. Supplies are anything but plentiful, and sellers continue to take a very firm stand. A good deal is being taken up for local consumption, and fair sales to West Coast users are reported. Durham beehive blastfurnace coke of average quality is put at 18s. delivered at Tees-side works.

Stocks and Shipments.—The stock of Cleveland pig-iron in the public warrant stores now stands at 95,538 tons. Since the beginning of the month the stock has been increased by 835 tons. Shipments of pig-iron from the Tees are on a fairly good scale. To date this month they average 3120 tons per working day, the total despatches being returned at 24,950 tons, 21,650 tons of which have gone from Middlesbrough, and 3300 tons from Skinningrove. To the same date last month the loadings were given at 8234 tons, or a daily average of 1029 tons, and for the corresponding part of September, a year ago, the clearances reached 28,940 tons, or an average of 3617 tons per working day.

Manufactured Iron and Steel.—The manufactured iron and steel works continue busily employed, and producers express the hope of receiving further orders. Manufacturers of shipbuilding material and joist makers are understood to be well placed, and rail producers are stated to have good order-books. Principal market quotations stand:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 10s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 7*l.* 10s.; iron ship-rivets, 9*l.*; iron girder-plates, 7*l.* 5s.; steel bars (basic), 6*l.* 15s.; steel bars (Siemens), 6*l.* 15s.; steel ship-plates, 7*l.* 5s.; steel ship-angles, 7*l.*; steel boiler-plates, 8*l.*; steel hoops, 6*l.* 15s.; steel joists, 7*l.* 2s. 6d. to 7*l.* 5s.; steel strip, 6*l.* 10s.—all less the customary 2½ per cent. discount; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 15s.; steel railway sleepers, 7*l.* 15s.—all net at works.

THE LATE SIR HENNIKER HEATON.—A circle wider even than our Empire regrets the death of Sir Henniker Heaton, who has done so much to bring about reforms in postal service. Sir Henniker died, on the 8th inst., at the age of sixty-six, at Geneva, where he had been ill since the outbreak of the war. Although not directly connected with the industries in which our readers are primarily interested, all will feel that the loss to our country is a severe one. The reforms introduced with regard to the cheapening of postage within the Empire and to Egypt and the United States have been of inestimable benefit to us as a nation, and were directly due to his untiring efforts. His services to the country were formally recognised in 1912, when a baronetcy was conferred upon him, although four times previously he had declined the distinction of K.C.M.G.

THE LATE SIR STEPHEN FURNESS.—We regret to announce the death of Sir Stephen Furness, which occurred through an accident at Broadstairs on Sunday last. The deceased gentleman was forty-two years of age at the time of his death. He was interested in many industrial undertakings, being chairman of Messrs. Furness, Withy and Co., Limited, the Irvine's Shipbuilding and Dry Docks Company, South Durham Steel and Iron Company, Neptune Steam Navigation Company, George Warren and Co., British Maritime Trust, United Shipowners' Freight and Protective Association, Peareth Steam Shipping Company, Geo. V. Turnbull and Co., Economic Insurance Company, British and Argentine Steam Navigation Company, London Welsh Steamship Company, and the Norfolk and North American Steam Shipping Company. He was vice-chairman of the Broomhill Collieries, Limited, the Tyne-Tees Shipping Company, Messrs. Richardsons, Westgarth and Co., the Weardale Iron and Coal Company, the Wingate Coal Company, the Houlder Line, and the Empire Transport Company, and a director of the Cargo Fleet Iron Company, Johnson Line, the Bank of Liverpool, the London Assurance Corporation, the North-Eastern Banking Company, the Northumberland Shipbuilding Company, and the Standard Protection and Indemnity Association.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Heavy recruiting of miners for the war is restricting the coal output of South Wales, and, at the same time, there are heavy demands from the French, Italian, and Russian Governments, so that it appears probable that large steam coal will show strength for some time. Meanwhile prices have exhibited little change. The best Admiralty large has made 21s. 6d. to 22s. 6d.; the best secondary descriptions have brought 20s. to 21s.; other secondary qualities, 19s. to 19s. 6d.; best bunker smalls, 7s. 9d. to 8s.; and cargo smalls, 5s. to 7s. per ton. The best household coal has been quoted at 19s. to 20s.; good household descriptions at 17s. to 18s.; No. 2 Rhondda large at 13s. to 13s. 9d.; and No. 2 smalls at 6s. to 7s. per ton. The current rate for patent fuel has been 18s. to 20s. per ton. Special foundry coke has made 27s. to 30s.; good foundry coke, 20s. to 25s.; and furnace coke, 18s. to 20s. per ton. As regards iron ore, Rubio has realised 19s. to 19s. 6d. per ton upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Newport.—The steam-coal trade has shown little, if any, change. Inquiries have been fairly numerous, and colliery-owners continue to report full order-books, with a well-sustained demand. House coal and patent fuel have been a little dull.

Patriotic Miners.—There was little difference of opinion in a conference held a day or two ago at Cardiff representing the miners of South Wales and Monmouthshire. The Conference unanimously agreed to a proposal that men and boys in employment for three or more days per week should pay 6d. and 3d. per week respectively in support of the Prince of Wales' National Relief Fund. It is estimated that this decision will represent a contribution of between 3000*l.* and 4000*l.* per week. The Conference also unanimously approved the action of the executive council in recommending the men to work one hour extra per day in pits on the Admiralty list in order that an ample supply of steam coal may be available for the Navy.

Bristol Docks.—Bristol port returns for August were, upon the whole, of a satisfactory character. The bulk of the Continental trade is almost at a standstill, only Swedish and Norwegian trades being maintained. The tonnage returns for Avonmouth for the last twelve months have shown a high average. The total arrivals at the docks in August numbered sixty-one, representing an aggregate burthen of 123,273 tons, or an average of 2021 tons per ship.

CANADIAN RAIL INDUSTRY.—The *Iron Age* reports that the Dominion Works have closed down and the Sault Mill has gone on half-time because railroad and other financing by England has been stopped by the war.

ENGINEER RECRUITS FOR THE ARMY.—A large number of the members of the engineering profession having expressed the wish to be allowed to serve their country together in one regiment or battalion, the Institutions of Civil, Electrical, and Mechanical Engineers have under consideration the formation and training of a battalion enlisted from among their members, with a view to its forming part of Lord Kitchener's army.

DRY FARMING.—In the southern third of the continent of Australia the rainfall is almost exclusively of the winter type, and the winter temperatures are sufficiently high to keep the ordinary cereals growing steadily during these months. Consequently, before the dry summer sets in, the crops have reached a sufficient degree of maturity to complete their ripening before the soil has become so dry as to arrest all further growth. Dry farming, therefore, has not to be resorted to, except where the rainfall is less than 10 in. According to Professor T. Cherry, M.D., of Melbourne, the chief problem now to be solved is to devise methods by which large numbers of sheep and cattle can be profitably kept on the wheat farms in the 10-in. rainfall regions.

GERMAN AND AUSTRIAN TRADE IN ANCHORS, GRAPNELS, AND CHAINS.—Germany has a considerable foreign trade in anchors and various types of chain both for ship and general use. Her exports in 1913 had a value of 165,700*l.* Excluding bicycle chains, the corresponding trade of Austria-Hungary for 1913 had a value of 11,910*l.* These figures are considerably below that of the United Kingdom for the same class of material, which in 1913 was 687,200*l.* The trade is one, however, with which this country is well equipped to deal, and any efforts made at the present time to obtain the German share should have considerable chance of success. The subject is dealt with in one of the memoranda which are being issued by the Commercial Intelligence Branch of the Board of Trade to assist British manufacturers to find new outlets for their material during the war. The tables which are published show that, as far as ships' anchors, grapnels, and cables are concerned, the trade is chiefly in the hands of the United Kingdom, but that there would appear to be small openings for the sale of British-made articles in Russia, Roumania, and Turkey. For chains, other than ships' chains and cables, the United Kingdom holds an exceedingly strong position in the Australian, Indian, South African, Canadian, Japanese, and South American markets, as well as holding a large share of the trade in the Norwegian, Spanish, and Portuguese markets. In the Netherlands, Sweden, France, Russia, Roumania, and the United States there would, however, appear to be a possibility of extending our trade in these goods.

CENTRAL-THRUST RADIAL DRILLING-MACHINE WITH SEPARATE TAPPING-SPINDLE.

CONSTRUCTED BY THE SELSON ENGINEERING COMPANY, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 330.)

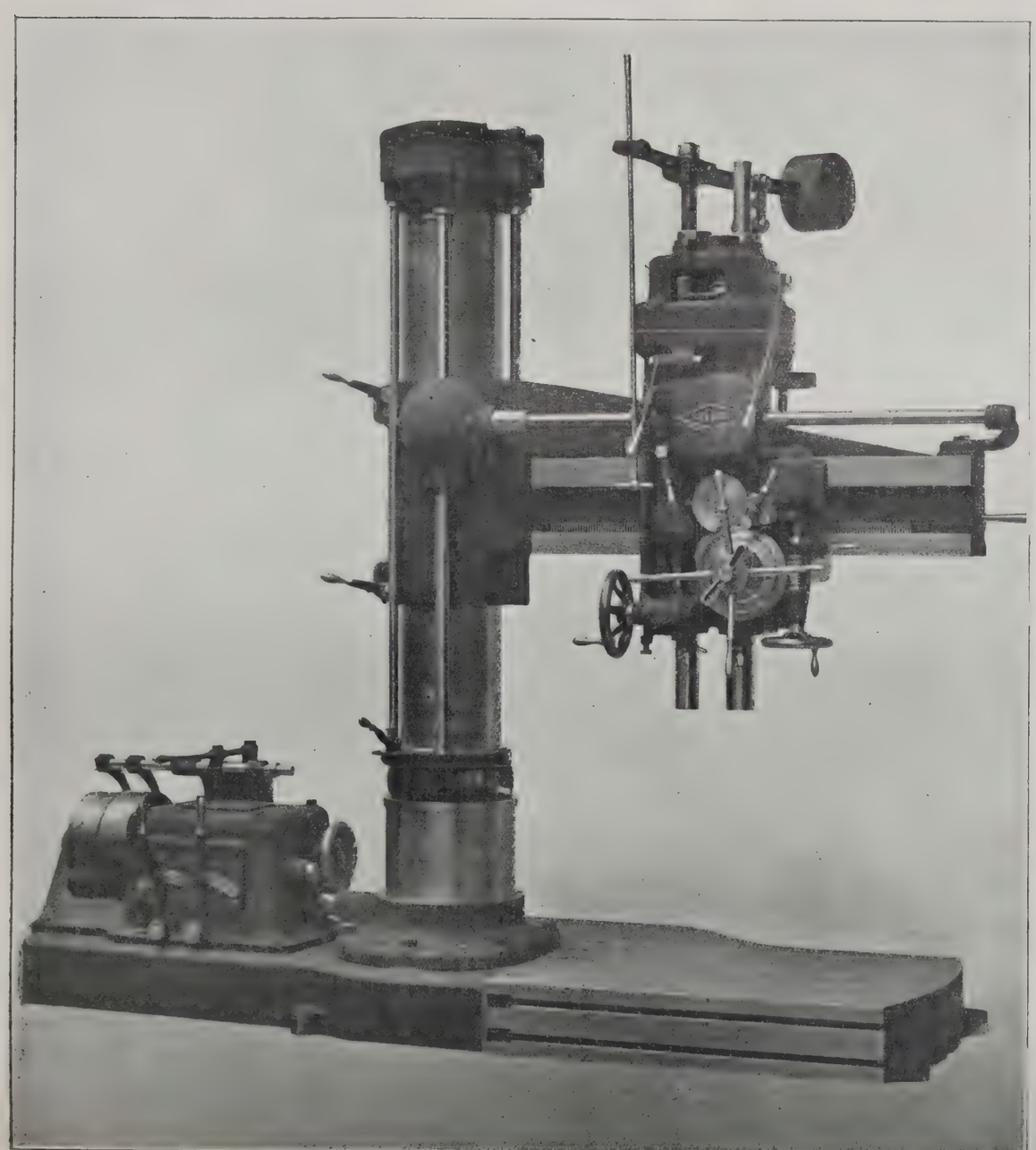


FIG. 1.

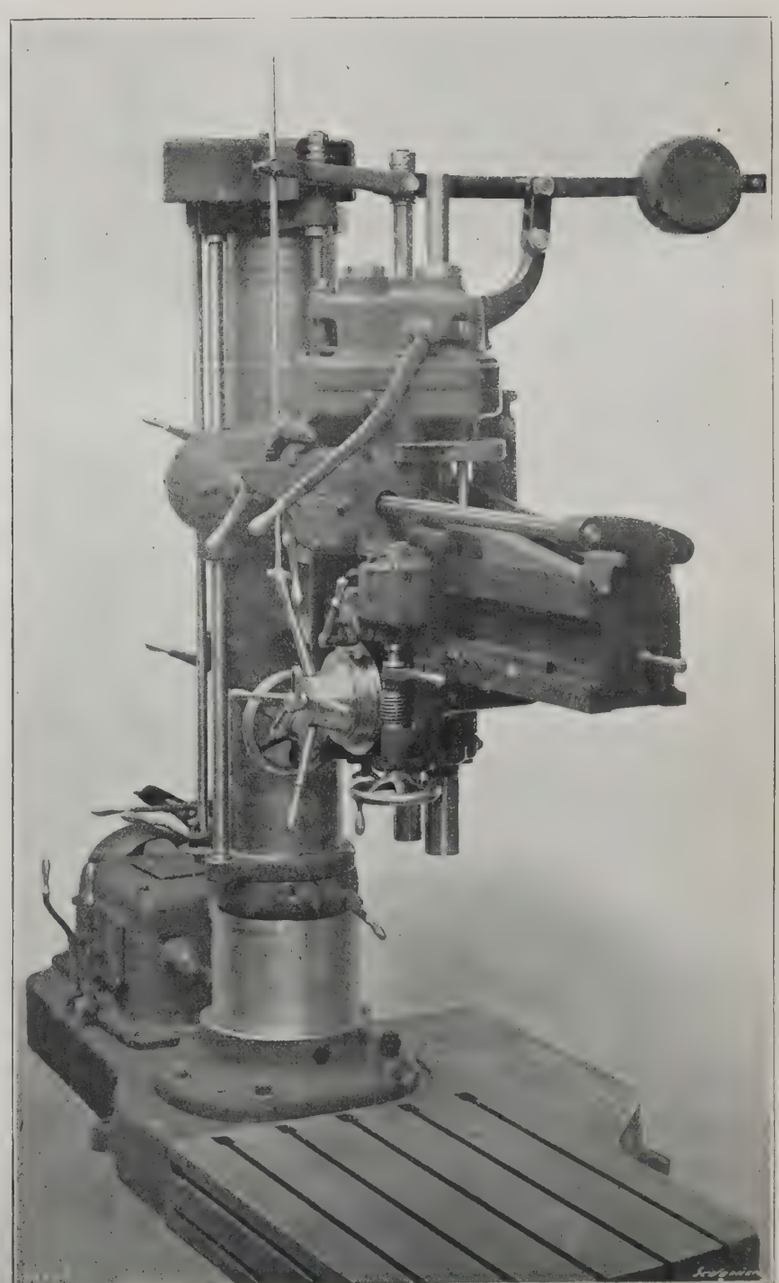


FIG. 2.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" can be supplied direct from the Publisher post free, for twelve months, at the following rates, payable in advance:—

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Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to some Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, SEPTEMBER 11, 1914.

THE BANKS AND MANUFACTURERS.

THE Chancellor of the Exchequer did well on Tuesday when he enforced the vital importance of conserving our financial resources: the command of ready money has ever been an important factor in every great war. The occasion was the reception of a deputation from the Association of Municipal Corporations who desired assistance in the raising of loans for undertakings by local authorities. Distress is inevitable under present international conditions, and it may be that the municipal authorities will require to provide relief works, but even these should be entered upon guardedly and after the fullest consideration. As Mr. Lloyd George said, "it is very much better that you should get the people to work in things that are normal if you can: our trade is not going; the seas are ours, and they will remain ours; we shall get not merely our own trade—except that in European countries—but we shall get a good deal of the enemy's trade as well." There is, however, a very important factor in the employment of men at their normal trade—the financial facilities available for paying the men; and we can only regret that the subject under discussion by the deputation did not recall to the Chancellor's mind the need for tackling this problem.

There can be no question of the splendid spirit prevailing throughout all industries, reflective of the calm confidence in our administration and in our fighting forces, and of the determination to complete the work we have undertaken. The financial situation of the country generally is most satisfactory. The decrease in the month's exports of twenty millions sterling is not alarming, as much of it is due to temporary dislocation. Our oversea supplies of raw material, as well as foodstuffs, are normal, except such imports as come exclusively from countries involved in the war. The things which militate against maintaining manufacturing are the increase in freight rates and the difficulty of finding money to meet the wages bill. With the insurance of war risks to shipping reduced to ordinary rates, there is a tendency, which we hope will be accentuated, towards freight rates being reduced, and there remains only the conservative attitude of the banks in the matter of financing manufacturers. This is a subject to which we have in normal times directed attention, because the difficulty is not new, although it has been greatly intensified by the excessive strain of war. It is appropriate therefore to consider not only the abnormal situation, with the view of evolving a remedy, but the more normal circumstances, in order to ascertain whether such remedy could not be of permanent advantage to manufacturers. The limitations of our system of banking, due to legislation and administrative methods, enter into the question, as well as the legitimate claims of industry.

Firstly, as regards the extraordinary conditions prevailing, the immediate result of the outbreak of war between so many countries, and the necessary restrictions to be observed by those countries not at war, in order to preserve their neutrality, was at once to put a stop to the foreign exchanges, and thereby cause a temporary cessation of international trade. One serious consequence of this was that most of the largest merchants in this country were unable to obtain the sums due to them from foreign clients, and naturally in their turn they were unable to meet their liabilities. Another result was that dealing in the bonds, stocks, and shares of countries with which we were at war was illegal. This, with other complications, immediately threw the whole Stock Exchange into confusion, and as there had previously been a great volume of selling orders, particularly from the Continent, prices fell disastrously, and the Stock Exchanges closed their doors to business.

Then followed the moratorium—a suspension of the payment of debts incurred before a certain date, but due for payment while the moratorium lasted. The period was originally fixed at one month from August 4, but it has been subsequently extended. The Government also wisely determined to conserve and increase the stock of gold in the country, and instead of suspending the Bank Charter Act, they issued Treasury notes for 1*l.* and 10s., made these notes and postal orders legal tender, and increased the supply of silver coin. To protect the traders they gave a State guarantee for the payment by the Bank of England of discounted pre-moratorium bills, and they have also instructed the Bank to provide acceptors with the funds necessary to pay all approved pre-moratorium bills at maturity, if required. These steps have already had the desired effect and bills are again commencing to move freely, while the stock of gold at the Bank of England is increasing quickly. But there is still a large proportion of the traders of the country who are feeling, and will feel, very acutely the aftermath of the terrible financial crisis through which we are passing. Their hard case is certainly one that requires close attention with a view to make the burden as light as possible.

Secondly comes the question of the remedy for this state of affairs, and whether such remedy cannot be made to advantageously benefit industry permanently. Undoubtedly there is a greatly increased balance at the banks. The low rate of interest on deposits is proof of this. To what extent are the banks justified in depleting their reserves in view of the interests of depositors, and what value of security must they exact for accommodation? These questions are the more important when one reflects upon the great influence upon industry of the banks. There is no doubt that the large increase in trade and commerce, which has been such a striking feature of modern times, is due to the wise and far-sighted care and judgment exercised by the banking authorities in their daily transactions with the traders of the country, and the cheap rate at which they have supplied the accommodation required. The tendency, however, has been undoubtedly more and more to consider the large capitalists at the expense of the smaller, and to make large advances to bolster up Stock Exchange transactions, the danger of which is very obvious at the present time. All this is to the detriment of the legitimate trader, whose transactions would tend to increase the wealth of the country. On the other hand, one must give consideration to the nature of the deposits held by the banks of this country. These deposits are held by them either repayable on demand or at a very short notice, usually seven days, and it is therefore necessary that they should keep a large portion of their funds easily available, so that should a sudden panic arise, and large demands for repayments be made by depositors, the money may be at their disposal to meet these demands. The only money they have at their disposal for any length of time is their capital, which is usually so small in comparison to the total of deposits that it is comparatively a negligible quantity. Another factor which must always be remembered is that the applications from borrowers are collectively almost invariably largely in excess of the funds at the disposal of the banks for lending; consequently they are able, and, indeed, compelled by their duty, to select only those applications which most nearly approach to their ideal for advances—that the advance should be speedily repaid, that it should be well secured, that the value of the security should be easily ascertainable, and that it should be readily realisable. It must not be forgotten also that the bank shareholders naturally expect a dividend on their capital commensurate to the risk they run on account of the large amount of uncalled-up capital.

On the other hand, there is the case of the manufacturer of comparatively small means, and with those means locked up in plant and material. It is important at all times, and vital in the interests of the nation in the present juncture, that he should be able to obtain funds to carry on business. Distress would be warded off in the present abnormal times, and prosperity promoted in ordinary circumstances, and a further great stimulation to trade be given, if some arrangement could be made to help this class. It has been suggested that bankers should accept deposits for fixed terms at fixed rates of interest, and thus create a fund

which, not being subject to call, would be available for making advances to *bonâ-fide* traders on the security of their business as disclosed in a balance-sheet properly prepared by an independent accountant to be appointed by the bank. Such advances might be, say, to the extent of a proportion of the orders he has in hand, the genuineness of which, and the standing of the parties giving the orders, being established to the satisfaction of the bank making the advance.

The rate of interest for such advances would, of course, have to be higher than that charged for properly-secured advances. We commend this proposal at the present juncture, and if the available capital at the disposal of the banks for such special advances were not sufficient there is justification for help being given to the banks by the Treasury. The one aim should be to keep manufacturers busy in order to relieve distress. Such Treasury support to the banks would be immensely preferable to municipalities being encouraged by loans to promote relief works. These are seldom reproductive and never economically executed by "unemployed" labour.

There is another phase of the subject of present and prospective importance. Much of the difficulty in assisting small manufacturers is due to the change in the character of the personal side of banking business, as a result of the conversion of the Banks into joint-stock companies with limited liability, and of the successive amalgamations of businesses which has continued. Now the aggregations have become so great that the management is worked as a great machine, with too little flexibility to meet sympathetically the ever varying conditions of each district and almost of each client. A great reform would be a scheme of devolution whereby local boards of directors with clearly-defined limitations and duties would be appointed in the various districts covered by the bank. There is need, too, of a rearrangement of the staffs to ensure that suitable men could be appointed in the different branches, after a general experience in all departments, and to be promoted through the senior posts, in due time reaching the managerial chair. In that position the manager would be of greater assistance when personally attending the Local Board and giving professional opinion in placing any proposal of an important nature before them. There would then be a body of gentlemen as local directors who, being naturally and closely in touch with local affairs, would know more or less intimately the customers of the Bank, and would thus correspond to the partners of the long-since-departed private bankers, who were of great service to their bank in this capacity. The London Board, no longer harassed by multitudinous trifling detail, could concentrate its energies on the more important large business, and certainly have much more time to direct the policy of the bank, doubtless to its great advantage.

THE MODEL AND ITS PROTOTYPE.

ALL design is based upon some principle of similarity, which, in fact, merely implies that, under corresponding conditions, a full-size machine and its model are subject to, say, the same stresses or to equivalent resistances. Were not this the case it would be impossible to develop the scientific side of engineering, and experience and empirical formulæ, having but a limited range of validity, would alone be of service. Nevertheless, it is not always easy to establish what should be the corresponding conditions between structures or machines differing in size. In certain cases matters are simple enough, and our early engineers had no difficulty in drawing sound deductions as to the strength of a proposed bridge by experiments on small-scale models. The method was, in fact, in no essentials different from what is still everyday practice. The engineer infers the strength of, say, an eye-bar from tests on a small specimen of the same steel. In this, however, he has to make an allowance for the well-known fact that large specimens commonly show a lower tensile strength and limit of elasticity than do small test-bars of the same quality of steel. Strictly speaking, our pioneers should have made an allowance of an opposite character in proceeding from their models to the full-sized structure, as it is now known that owing to the less trying character of a dead as opposed to a live load, higher working stresses are permissible in bridges of large span than would be safe on short beams carrying the same live load. In comparing their model with their proposed final structure, these early engineers adopted a very simple law of similarity. They assumed that the weight of the structure would increase as the cube of the ratio between the linear dimensions of the model and its prototype, whilst the strength would increase merely as the square of this ratio, and, as Professor James Thomson showed many years ago, and Professor Barr some years later, this rule has a very general validity. It follows accordingly that the limiting piston speed of a small engine is the same as that of a large one, and that of two engines built to run at the same piston speed, and with the same steam pressure, the smaller should weigh less per horse-power in the ratio of the piston diameters. Again, engines built from the same drawings, by merely doubling the scale, should prove equally satisfactory in service; and this was, in fact, done by the late M. Normand in the case of torpedo-boat engines, the machinery for the Russian boats Revel and Sveaborg being practically a replica of those of the Balny to 1.9 times the scale.

Nevertheless, if a series of engines built by one firm are compared, it will generally be found that the weights per horse-power are not very different whatever the size of the engine. For this there are several reasons. Thus large engines have commonly somewhat higher piston speeds than smaller ones built by the same firm, but the main cause of this discrepancy between theory and practice is that the scantlings of the smaller engines are frequently fixed by considerations of workshop and foundry convenience rather than by questions of strength. For example, an old rule for the thickness of a cylinder is:—

$$t = \frac{p\,d}{4000} + \tfrac{1}{2}\text{ in.},$$

where the $\frac{1}{2}$ in. is added for the convenience of the foundry and to facilitate re-boring. A strict adherence to this rule would obviously have made impossible the production of the modern petrol-engine, in the development of which it was necessary for the foundry to learn how to cast small cylinders in closer agreement with the theoretical requirements.

Another factor which is involved here is the difficulty of doing light and heavy work in the same shops. Not many years ago a firm which had acquired a considerable reputation as builders of large reciprocating engines were pressed by a satisfied customer to build him a high-speed engine. After a prolonged parley it was finally agreed to supply the engine desired. The only work the nominal builders did on this engine, however, was to chip off the name of the actual makers from the castings before forwarding the engine to its destination. Neither their equipment nor their experience were suited to the building of the type required. Had they attempted the task, it is pretty certain that an abnormally heavy and not very satisfactory engine would have resulted.

If, however, in place of comparing the weights of different sizes of engines built by the same firm, the products of specialists in large engines and those of specialists in small ones are compared, it will be found that the law of comparison in question finds considerable support, especially if both types are built to meet somewhat stringent requirements as to output. In fact, in such cases the small engine will often prove even lighter than the theory indicates, since it is commercially possible to obtain in small sizes a quality of material impractical of employment in large scantlings. The large gas-engine, for example, can never be made proportionately as light as some of the aeroplane engines, and the weight per horse-power will always be much more for the large engine than in proportion to the ratio of its cylinder diameters to those of the aeroplane engine.

Omitting such special engines as these, it is remarkable that gas-engines in general obey the theoretical law of similarity much more accurately than is commonly the case with steam-engines. This was very clearly established by an instructive comparison of the weights of large and of small engines made by Mr. Dugald Clerk at the Institution of Mechanical Engineers a couple of years ago. From the data then given it appears that the rule that the weight per brake horse-power varies directly as the cylinder diameter holds with very considerable accuracy for gas-engines with cylinders ranging from 12 in. up to 51 in. in diameter, the weight of the latter being about 460 lb. per brake horse-power. Pressures in gas-engines have always been higher than are usual with steam, so that the least thickness the foundry desired to cast has always been nearer that theoretically required than is commonly the case with steam-engines.

With engines of similar design, built to the same factor of safety, and run at the same piston speed and operating between the same limits of pressure, the proportion between the inertia stresses and the direct stresses will be the same whatever the size of the engine. Similarly, the pressure drop in the ports and passages will be the same. In a paper recently read before the South African Institution of Engineers, Professor Alexander extends this law of comparison to some other points. Thus the critical speeds of similar shafts are inversely proportional to the diameters. Similar fly-wheels and similar governors will give the same degree of regulation, whilst the lubrication will, he states, be effected in similar conditions if the running clearances are made proportional to the square root of the diameter. This rule, he finds, gives results in excellent accord with the "running fits" recommended by the British Engineering Standards Committee.

The laws of similarity above in question are remarkably simple, but, of course, apply in their entirety only when the linear velocity of the moving parts is the same in the small as in the large engine. Then only will the ratio of the static to the inertia stresses be the same in both cases. It often happens, however, that the angular velocity of the two engines is more nearly constant than the linear. Very high speeds of rotation are frequently inconvenient, and a small prime mover is, therefore, often run at much less than its "corresponding speed," the natural result of which is, of course, an equivalent augmentation of weight.

An interesting application of the laws of similarity was described by M. Normand in his paper entitled "Des Lois de Similitude dans Diverses Questions de Construction Navale," published in the *Bulletin de l'Association Technique Maritime*, in 1895. He showed that it was possible in this way to determine very readily the practicability of using the same general arrangement of machinery in a new vessel as in an old one, when the new vessel is required to steam at a higher speed.

Thus, suppose a satisfactory design exists for the machinery of a 20-knot cruiser, and that it is proposed to build another to steam at 22 knots. Then the point arises, will the old general arrangement be permissible, or must drastic changes be made in the disposition of the machinery and the protection of the hull and in the form of the latter. The laws of similarity show that to increase the speed from 20 to 22 knots the linear dimensions of the engine will be proportionate to $V^{\frac{2}{3}} D^{\frac{1}{3}}$, where V is the speed in knots, and D the displacement of the vessel. Now, $D^{\frac{1}{3}}$ is a linear dimension of the hull, so that the ratio of the linear dimensions of the engines to those of the hull will be increased in the ratio of $\left(\frac{22}{20}\right)^{\frac{2}{3}}$. Hence, if the original general arrangement be adhered to, the engine will occupy a proportion of the length of hull greater in the above ratio.

Again, of the total machinery weights, the engine weights will, he pointed out, vary as $F^{\frac{2}{3}}$, where F denotes the indicated horse-power, whilst the weight of the boilers and condensers will vary directly as F, so that the total machinery weights will vary as $a\,F + b\,F^{\frac{2}{3}}$, where a and b are constants.

Laws of similarity are, of course, by no means always so simple as those discussed above; the naval architect, for instance, adopts the law that for equivalent wave-making resistances the speed of the model should be to that of the ship in the proportion of the square roots of the linear dimensions. This is not the case, however, with the eddy-making resistances which originate in the viscosity of the fluid traversed, and, as Mr. R. E. Froude has pointed out, a model of a submarine to one-tenth scale should, accordingly, be driven at ten times the "full-scale" speed in order to get corresponding conditions. This result follows from the Reynolds-Rayleigh law that this desideratum is obtained when $\frac{\rho\,v\,l}{\mu}$ is constant; ρ denoting the density of the fluid, μ its viscosity, v the speed, and l the length of the model. With constant viscosity, there-

fore, the conditions will be identical when the product of the speed and the velocity is a constant. It was on these lines that Lord Rayleigh explained the apparently anomalous results obtained by M. Eiffel on the resistance of spheres of different sizes falling through the air. Hitherto naval architects have not made use of this law, but apparently builders of dirigibles will have to take serious note of it. In fact, in his paper on "The Law of Comparison for Surface Friction and Eddy-Making Resistances in Fluids," read before the Institute of Naval Architects in 1912, Dr. Stanton declared no other method of equal accuracy was available for predicting the resistance of dirigibles, submarines and torpedoes.

EXPORTS IN THE ENGINEERING INDUSTRIES.

THERE are many branches of our engineering industries which, we believe, turn out products as useful in the economic world as those of any of our rivals. For many years we have had a flourishing machine-tool industry. For long it was unrivalled, but latterly it has had to face competition, mainly from America and Germany. Briefly expressed, it may be said that as regards the United States, our rivalry is concerned mainly with questions of design. With Germany it is a matter more of price. The revival in our machine-tool design of some ten years ago put us in a position to supply large markets abroad, where, for their excellent wearing qualities, British products had won us a good reputation. In spite of this, however, our exports of machine-tools in 1913 were only of the value of 1,012,800*l.*, or about one quarter the value of those exported by Germany. What a hold Germany has in this trade is seen by the fact that though we have so large an industry of this kind, that country supplied us in a recent year with machine-tools to the value of 236,850*l.* Quite apart, therefore, from markets abroad, there is trade to be done within our own gates. Abroad there are vast possibilities if our makers can rise to the occasion. France, as we know, is now in the market with well-designed models, but that country recently imported from Germany machine-tools to the value of over half a million sterling. From us in the same period she only took machines valued at 142,100*l.* Our exports to Italy in 1912 were valued at 68,000*l.*; Germany's at 408,350*l.* To Russia Germany sent 595,550*l.* worth of tools, while we sent there 85,000*l.* worth. In many other countries the disparity is on a similar scale. It is all very well to flatter ourselves that our exports bulk large. A few years ago people insisted that all was well, because our works were busy and exports were well maintained. In the meanwhile Germany's were not only maintained, but increased very considerably. To-day we are told that we should step into the gap left by the temporary withdrawal of Germany. Sincerely we hope it may be possible for us to do so, but if such expansion is possible under the present trying circumstances, how much easier would it have been in better times to push slowly and steadily ahead, so that a greater portion of this trade might have been retained in our hands as it developed.

In most of the foreign markets in which Germany does much business in machine-tools the chief attraction is cheapness. This is the case in markets of so diverse a character as Denmark, Russia, and the Argentine. In one or two valuable markets, such as Australia and Japan, we have the larger business; but a good deal of the more elementary work can be done on a cheap class of machine, which, if we make it at all, is certainly not properly marketed, or our business would be larger in those countries where cheapness is a prime consideration. We have on other occasions referred to selling matters, and the value of a progressive attitude in this connection. Germany frequently sets about studying a market in a very methodical way, and before attempting to send goods, finds out exactly what will suit it. All this costs a considerable amount of money, which must be spent before any returns can be expected. In the end the results warrant the trouble. It is announced that a large commission is shortly leaving the United States for South America for the purpose of studying the markets hitherto supplied from Germany. We ought to take a like step, not only in South America, but in other countries nearer home. It is essential to success, and whether done by firms individually or in combination, if good is to follow, it must be taken.

A rather interesting development, which has been taking place in Japan, adds point to these statements. In Japan, in 1896, the imports of bicycles were divided among four countries: the United Kingdom, the United States, Germany, and France. The value of the machines imported from the United States was 6680*l.*, and from England, 1301*l.*, Germany being represented by 69*l.* only. In the following year the United States doubled her imports, and rapidly increased them until they reached a maximum of 88,105*l.* in 1903. Meanwhile English imports, after some increase, fell off to a few hundreds, but then came into favour again, the high-water mark being reached in 1907 with imports to the value of 112,175*l.*; since then, although there has been a considerable reduction of this trade as the Japanese home industry has grown, this country is far ahead of all others. In 1911 Great Britain sent to Japan bicycles valued at 70,664*l.*, the United States only 3265*l.*, and Germany, although her contribution had been valued at 8870*l.* in 1906, in 1911 only sent 11*l.* worth. It is distinctly stated that the American hold on the market was lost because no effort was made to improve the quality of the machines sent. The only American machine now sold is one of the higher-grade patterns. Their cheap types have disappeared. The change is strikingly illustrated by figures of average price. In the middle of its popularity in the Japanese market the average price per American machine was 3*l.* 9s. Now, with sales ever so much reduced, the average has gone up to 5*l.* 14s. On the other hand, when American machines were selling by thousands, while the English patterns hardly reached four figures, the average price of the latter was 6*l.* 2s. By carefully setting about to meet the requirements of the market for a good-wearing machine at a reasonable price, Great Britain has captured the trade, although the average price per machine is now only 3*l.* 11s. Similarly, in the matter of cycle parts, although at one time the United States stood a long way first, her imports have fallen to an inconsiderable figure, while Germany has advanced. Great Britain, however, has outstripped all, and recently exported cycle parts to Japan to a value of about three times that of the United States in its best year. In this item again the products of the United States and Germany fell short of the standard asked for at the price.

The trading in cycles and in cycle parts does not always vary consistently. In the principal markets abroad, Germany sold in a year cycles to the value of 261,100*l.*, while our exports to the same countries amounted to about 386,300*l.* In the matter of parts, however, Germany exported 467,750*l.* worth, while ours were valued at 836,750*l.* Perhaps the most interesting instance of this difference is in the case of the Netherlands, which import machines worth 75,600*l.* a year from Germany, and only 19,300*l.* from Great Britain. But we send them cycle parts valued at 186,500*l.*, against Germany's 133,100*l.* In Russia a similar state of affairs exists.

The trade in road locomotives and road-rollers is one which we are supposed to have made peculiarly our own, but to countries to which Germany exports to the value of 813,800*l.*, we only export to the value of 306,600*l.* To Russia, Germany again sends enormous quantities of these machines, their annual value being about 334,300*l.*, compared with our 18,700*l.* In Brazil again we are hopelessly behind, and in Belgium, France, Spain, Egypt, Turkey, Chili, and other countries there is German trade worth seeking. In Canada the imported machines of this class are valued at nearly 1,500,000*l.*, our share being less than one-hundredth part of the total.

In the matter of pipes, although Germany's exports are large, it is satisfactory to think that ours slightly exceed them. In the principal markets Germany sold pipes and tubes to the value of 4,383,000*l.* in one year, and she held the bulk of the Continental trade. The larger countries in which we held a preponderant share were the Argentine, Egypt, and some others, including the Colonies. There are numerous countries where, as in other products, Germany's trade in pipes and tubes is increasing, and success depends upon prompt tendering and such points, as much as on quality and price. Russia again offers a large market to Germany in this line. In fact, that country is one of Germany's best customers in most of the engineering and kindred trades. The business has been built up on long credit, as we have previously noted. A word of warning must be given in this matter. In the past it has been very easy for debtors in Russia to rid themselves of their liabilities by declaring themselves bankrupt. This fact has been a discouragement to British traders. There are now means in most districts of Russia of easily finding out whether the firms asking for long credit are reliable or not. In the case of reputable firms business might be much enhanced by conforming to the manner in which their affairs are usually conducted. In these matters the chambers of commerce, information bureaux and the Consular service now render a considerable amount of assistance. It is largely as a result of our Consuls' work abroad that the Commercial Intelligence Branch of the Board of Trade has been able to publish promptly so many bulletins dealing with Germany's export trade. Several of these bulletins deal with branches of work of interest to our readers, and those published during the last few days, on topics touched on above, are likely to be as valuable in suggesting openings for British trade as those issued earlier.

RECRUITING AND THE MANUFACTURE OF WAR MUNITIONS.

THE irresistible wave of patriotism which has encompassed the whole Empire, and in its flood has carried hundreds of thousands of our most vigorous and capable youths to recruiting stations, is only characteristic of our race. But there is need for a word of guidance in the presence of so much enthusiasm. It should not be forgotten that the requirements of the Navy and Army are most varied. The call to arms is the most obvious necessity, but there are others. The army at the front and the navy maintaining the command of the sea, with all that their work means to Britain's future, must have supplies. Without these their most insistent efforts would be soon brought to an end, and there is therefore an urgent call for men to maintain these supplies.

Many engineering factories are concerned with the most essential of these supplies—rifles, guns, ammunition, and even ships, as well as the mechanism for producing these, and the mechanical facilities from transporting them to the front. The manufacture of all such war munitions is as essential to the success of our enterprise as their use in the fighting line. The men engaged in their production are serving their King and country as efficiently and forcibly as the combatants in the field. Such men should therefore recognise that they are acting as loyally, and perhaps more efficiently, by giving of their best in mental and physical effort in the factory as by enlisting. Nor should the influence of their service in the factory be measured in a restricted sense. Some of the factories producing war munitions require to be extended and to have their capacity instantly augmented. Thus the work of men engaged in the construction of such new shops, and in the making of new presses and new machine-tools, is vital to the success of our enterprise at the fighting-line.

All such men must take a broad view of the necessities of the Empire, and before enlisting should consult their employers. These know not only the importance of the work which is in hand, but also of that which is likely to be undertaken in the near future, and can advise their employees accordingly. We are satisfied that employers will prove patriotic enough to give the guidance to the men most consonant with the national needs. Lord Kitchener himself has expressed his conviction that men engaged, directly and indirectly, "in carrying out the great work of supplying munitions of war are doing their duty for their King and country equally with those who have joined the Army for active service in the field." In order that such men may not be subject to reproach by their fellow-citizens, employers should issue a card to the men indicating clearly that the recipient is engaged in the manufacture of munitions of war, and therefore is unable to serve his country in any other way. Such an acknowledgment of splendid, yet silent, service, given as it is, without exception, in a full patriotic spirit, would itself be cherished and prove a stimulus, if such be needed, to still greater self-denying efforts. There is, it may be added, an ample sufficiency of eligible men to fill the fighting line without trenching on that great army who provide the necessities of warfare which must be turned out in ever-increasing quantity and with ever-growing speed.

NOTES.

WATER SUPPLY OF AN ITALIAN PROVINCE.

A VAST and costly water-supply scheme in Southern Italy is now approaching completion. Its purpose is to supply the province of Puglia or Apulia, on the eastern side of the Italian peninsula, with good water. This district has a length of 375 km. and a breadth of 75 km., and its population numbers about 3,000,000. There is literally no usable ground water, the soil, save a slight layer of mould, being a porous limestone, and what little water it carries is somewhat salt. The population, therefore, has been compelled to collect rain-water in cisterns, and in dry years the Government has been obliged to help by sending supplies of water by vessel or rail. Some eight years ago it was decided to arrange for a water supply for the entire province, the water coming from some springs in the Apennines, which have hitherto fed the River Sele, flowing into the sea on the opposite Italian coast near Salerno. The capacity of these springs is very considerable and uniform, amounting to some 675,000 cub. m. in the 24 hours, which is looked upon as being sufficient for the entire province for many years to come. The State has contributed a sum of about 5,000,000*l.*, which, however, does not cover the cost, the balance being found by a company, which for a period of 90 years is to have all the surplus, subject to it supplying all the towns with water, for private and public uses, at rates fixed by law. The main conduit has a section of 7 sq. m., and is taken through the Apennines, partly in aqueducts and partly through tunnels. The aggregate length of the water pipes amounts to some 3000 km. Some of the towns included in this supply system lie as much as 50 metres above the main line, and the water has to be pumped to these places; the necessary power is supplied partly by turbines operated by the water itself and partly by Diesel motors.

THE PROSPECTS OF TEXTILE MACHINERY TRADE.

There is every reason to believe that the war will result in an improvement of the already large textile machinery trade of this country. It will bring a stimulus to those branches which construct the special types of machines, for it is only in specialities that the Germans seriously compete with us. Without going into detailed figures, it can be said that practically the whole of the textile machinery imported by India is of British make. In Japan Germany has secured a footing which, considerable as it is at the moment, is likely to become much less so after the war. The bulk of the textile machinery in France and Italy is of British origin, and the same may be said of other countries on the Continent, with the exception of Russia and Holland. The special machines for raising the nap on fabrics, for finishing woollen and cotton fabrics, for winding yarns and threads, for drying and conditioning material, and for treating cotton waste, have all been highly developed by the German machinists. Besides this class of machinery, the Germans have developed knitting and embroidery machines to a very considerable extent. Several German and some Russian firms have taken up the construction of what one may term the ordinary Lancashire plain loom. It is a comparatively simple machine, and sells in this country from 6*l.* to 10*l.*, being in the main a foundry job. Quite a serious competitive blow, too, has been dealt to loom-makers in this country by German makers during recent years, not only in Germany, but also in Russia and Holland. After the war, the preference may be given to British makers in Holland and Russia. The new method of weft-winding has led to the adoption of pirn or cop-winding machinery of a new type. The first machines came from the United States, but German machinists evolved a machine of a somewhat different type which has been sold fairly considerably in this country. A Swiss machine is also on the market, and there is evidence that British machinists are entering into the competition with machines that certainly possess the qualities of endurance and stability. The scientific treatment of cotton-waste has been evolved by the Germans and Austrians, the Lancashire spinner having left the modern methods almost completely alone. Naturally the German machinists have designed the special machinery necessary, and although attempts have been made in this country to foster the trade—even with this machinery—they have so far been unsuccessful. The time is certainly ripe for machinists to consider the whole question of all such machinery, and to overcome their prejudice against these newer methods and machines which have proved so successful on the Continent. Hosiery machinery and raising-machinery makers will also benefit by the dislocation of Continental firms.

OPENING-BRIDGES.

In a recent issue of the Journal of the Western Society of Engineers, Professor W. M. Wilson describes in a highly illuminative fashion recent practice in the construction of opening-bridges. The author notes that at one time pontoon movable bridges were much favoured, being cheap to build, and, so long as traffic was light, the delays due to the impossibility of opening and closing them rapidly were not a matter of serious consequence. The fact that they could be used in cases where the river bed was too soft to support the foundations of a bridge of the ordinary type was a great advantage in certain cases, and led to the adoption of a pontoon structure for bridging the Hooghly between Calcutta and Howrah. With dense traffic, however, the considerable time necessary to open and close a pontoon bridge led to the development of the swing bridge, which is, he says, a type economical in design, simple in structure, rapid in operation, and rigid in service. During the last few years, however, conditions have arisen which this type of structure fails satisfactorily to meet. The increase in the water-borne traffic and the size of the craft navigating the rivers has rendered the central pier of the ordinary swing span undesirable, particularly in view of the fact that opening-bridges may now be called upon to take as many as four railway tracks. This, he remarks, necessitates a wide bridge and a pier of large diameter, if the swing type of structure be retained. Hence the bascule system has of late undergone a great development, about the first modern example being the Tower Bridge. As the width of the channel increases, the weight of the moving leaf of the bascule rapidly augments, necessitating a correspondingly large counterweight and imposing a very heavy load on the trunnions. In this respect the vertical lift-bridge has an advantage, as the counterweights can be much lighter, and Professor Wilson thinks that an extended use of this type is probable in the future. With this type both the live and the dead load are carried as in a simple span, and the live load passes direct to the masonry, and not through the trunnions. All the earlier opening-bridges were, Professor Wilson states, operated by hand. Even the double-leaf swing-bridge over the Penfield River at Brest, which gives an opening of 350 ft. in the clear, was originally designed for hand operation. Hydraulic gear came next into favour, but electric power is now most frequently adopted. Amongst the pontoon bridges described by Professor Wilson may be noted that carrying the Chicago, Milwaukee, and St. Paul Railroad over the Mississippi River, between Prairie du Chien and North Macgregor. Here the river is, he states, 7000 ft. wide, divided by an island into two navigable channels, through which navigation is maintained by draw spans consisting of pontoons 41 ft. wide, 6 ft. deep, and 408 ft. long. The river-level varies 22 ft. between high and low water, so that the track has to be jacked up and supported on blocking, varied in height to suit the water-level of the river. This span can be opened or closed in about three minutes. Amongst swing-bridges, Professor Wilson notes as an interesting type that constructed by Mr. J. A. Saner in 1899, to carry the road from Chester to Manchester over the River Weaver. Owing to subsidence, due to the salt workings in the neighbourhood, an existing swing-bridge had settled badly, and it was evident that a heavy load could not be carried by the piers. Mr. Saner theretore adopted the plan of taking the weight mainly on a pontoon enclosed inside the ring of piles which supported the track on which ran the rollers under the girders. The buoyancy of the pontoon was adjusted so as to reduce the load on these piles to a safe limit. Of bridges of the bascule type, the Scherzer rolling-lift bridge has been of late largely adopted. It has the advantage, Professor Wilson states, that the centre of gravity of each arm is at the centre of curvature of the circular arcs on which the bridge rolls. Hence the centre of gravity of the bridge is neither raised nor lowered when the span is opened. Since, moreover, the moving leaf rolls back as it is opened, the front end does not overhang the channel, and the angle of opening and length of span can thus be reduced to a minimum. In the Strauss type of bascule bridge, described by Professor Wilson, the counterweight is connected by link-work to the moving leaf, the arrangement being such that the centre of gravity of the counterweight moves in towards the trunnion as the leaf rises, so that the latter is balanced in all positions.

STATIC TORQUE EXPERIMENTS ON A PELTON WHEEL.

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IN a Pelton wheel the fluctuation of torque due to the movement of each bucket during the period the jet impinges upon it may be, and probably is, very considerable. An investigation of this fluctuation, together with information of the exact position of the bucket throughout the whole change, would throw great light on the design of the buckets. Under working conditions, however, the fluctuations are so rapid that it does not appear possible to measure them. Thus, if we take a wheel with fourteen buckets rotating at 428 revolutions per minute, a complete cycle of fluctuation takes place in 0.01 second. Under static conditions the fluctuation may be readily determined, and, by the device adopted in the experiments described in this paper, may be used for comparative results with the torque during working conditions. The experiments were carried out on an ordinary commercial Pelton wheel, which is part of the hydraulics laboratory equipment in the University of Bristol. The wheel has fourteen buckets, of the type shown in Fig. 1, and the perpendicular distance from the centre line of the nozzle to the axis of rotation is 6½ in. The nozzle is 0.69 in. in diameter. Water is supplied from a tank 75 ft. above the laboratory floor and discharges into a lower tank in the laboratory, from which it is pumped back again to the upper tank. The lower tank is subdivided so that the discharge of the Pelton wheel may be made into a separate portion from that from which pumping takes place. This arrangement enables the experimenter to have complete control of the experimental conditions and to preserve a constant head. The general arrangement of the machine during the static torque tests is shown in Fig. 2. A lever was clamped to the pulley of the machine, and from this lever was hung a scale-pan in which weights could be placed. An indicator-arm was also attached to the shaft, the top of the arm passing through the centre line of the shaft. The indicator moved over a vertical scale, so arranged that when the arm was horizontal the distance from centre of shaft to scale was exactly 20 in. The method of experimenting was as follows:—The valve being opened, the indicator was brought to a point 7 in. above its horizontal position, and weights were placed in the scale-pan until the wheel just moved in the opposite direction to the working rotation. This thus gave the static torque due to the jet plus the friction. The same plan was adopted for every ½ in. until the indicator was 7 in. below its horizontal position. This gives a total range of experiment of 38 deg. 36 min., so that it amply covers a complete cycle of fluctuation, which, with fourteen buckets, is 25 deg. 43 min. One set of experiments was made with the supply-valve fully opened as during the running of the wheel. In order to obtain conditions corresponding with varying speeds of rotation, the supply-valve was now partially closed, thus reducing the supply, and therefore the velocity, of water through the nozzle. Since the wheel is stationary during the experiments the absolute velocity of the water in this condition corresponds with the relative velocity when the machine is running. No comparison could, however, be made immediately, because with the reduction of velocity under static conditions there is also a reduction of the weight of water delivered. This was dealt with as follows:—The torque as actually observed was plotted against angle. Six of these results are shown in Fig. 3. The mean, over the complete cycle of 25 deg. 43 min., was then found for each case; and from this mean was subtracted the mean friction torque found in the same way. The result gives the mean torque due to the jet for each case. These means were now all altered for the same quantity of water per minute, and as the running conditions were for the valve fully opened, the maximum was the quantity chosen. The method is simple and is best illustrated by an example. It was found that with the valve fully

opened the water rose 4.28 in. in the collecting tank. In the case of No. 3 it rose 3.51 in. The mean observed torque for this case was 12.2 ft.-lb. Deducting the friction torque of 0.88 ft.-lb. the mean water torque becomes 11.32 ft.-lb. For the maximum quantity of water, but the same speed, this would be $11.32 \times \frac{4\ 28}{3.51} = 13.8$ ft.-lb. In this way is obtained the mean static torque for the maximum delivery, but for varying velocities, and these velocities are identical with the relative velocities in the direction of motion of the jet during running conditions. In all, thirteen points were obtained. These are plotted against the corresponding velocities in Fig. 4. For the upper points, the resulting graph, T_2, is an exact straight line, but the lower points do not lie on a straight line. This results partly from the fact that as the velocity of the jet is decreased during static conditions, it impinges on a slightly different part of the bucket. Nevertheless, as these points are fairly symmetrical about the straight line through the upper points, this straight line has been drawn in, and from it the resulting horse-powers for the corresponding speeds have been calculated.

Two other graphs are also shown on Fig. 4. First is the T_1 or theoretical torque graph. This is obtained in the following way :—

Let v = velocity of the jet in feet per second.
u = velocity of bucket in feet per second in direction of impinging jet at the radius at which the jet strikes.
r = radius of striking in feet.
w = delivery of water in pounds per second.
θ = angle between direction of striking and leaving.

Then, from the well-known theory—

$$\text{Force of impact} = \frac{w}{g}(v-u)(1-\cos\theta).$$

$$\therefore \text{Torque } T_1 = \frac{w\,r}{g}(v-u)(1-\cos\theta).$$

Since u is the only variable, this is a straight line passing through the origin if the axes represent torque T and relative velocity $v-u$ respectively.

The remaining graph (T_3) is the ordinary torque found during horse-power tests, and it is curious to note that it falls into two fairly well-marked straight lines. The highest point of this graph is identical with the highest point of the static torque graph, because this is the point of maximum torque for the stationary wheel.

From these graphs the comparison between the static mean torque and running torque can be made. The running torque is less than the static at low relative velocities, but rises more rapidly, and at a relative velocity of 32 ft. per second crosses, and then remains greater for the whole of the higher relative velocities ; this excess is really slightly greater than shown in the graph, because windage is included in the running torque. The chief interest of these graphs lies in the comparison near the position of maximum horse-power. In order to show the comparison clearly, the horse-powers for the three torques—theoretical T_1, static T_2, and running T_3—have been plotted against $v-u$ in Fig. 5, giving the curves HP_1, HP_2, and HP_3 respectively. The excess of actual horse-power over horse-power calculated from the static torque tests is very striking, and may be partially explained as follows :—

Referring to Fig. 3, it will be seen that the fluctuation in torque during static conditions is very considerable, and that the mean is very much reduced to the low points forming valleys in all the graphs. In order to see what these low points meant, the cover of the machine was removed, and the jet was started. It was suspected that the low torque was due to the jet striking the first lip of the bucket, and then being deflected back and striking the back of the next bucket. It was found, however, that the low value actually occurred just when the jet was leaving a bucket and was about to strike the next one, though it was true that the cause was the striking of the back of the oncoming bucket, thus giving a back torque.

Now during running conditions the centrifugal action will always tend to throw the jet radially outwards, and hence to make the jet partly clear the oncoming bucket, and thus to reduce the back torque. In addition to this, the jet intercepted by the oncoming bucket strikes the leaving bucket for some time after the interception during running conditions, since both jet and bucket are in motion, and the latter portion of the impact will give a higher torque than during the static conditions, for the bucket will, whilst running, be placed at a more favourable angle during the latter part of impact than when stationary.

It follows, from the above experiments, that it is impossible to design a Pelton-wheel bucket on static-torque tests alone ; but it is probable that improved static-torque results would mean improved running-torque results, for though centrifugal force acts very favourably, the low points in the static-torque results probably occur also in the running-torque results, though not in quite so marked a form. Further experiments are needed with different types of bucket before the real value of static-torque tests can be properly assigned.

It is perhaps worth noting that for any of the straight lines in the torque graphs the torque T may be expressed in the form—

$$T = a(v-u) - b,$$

where a and b are constants, and since horse-power $= \frac{T\omega}{550}$, where ω is the angular velocity,

$$\text{H.P.} = \frac{(a(v-u)-b)\,u}{550\,r},$$

an expression easily differentiated, and from which the maximum horse-power can be found. This form of expression helps to show why the maximum horse-power in a Pelton wheel does not occur when the speed of the vane is half the speed of the jet, since the best speed is modified by "b." The value of $(v-u)$ when horse-power $= 0$—*i.e.*, $(v-u) = \frac{b}{a}$, gives the speed when the wheel is running free, and when, therefore, the whole effect is absorbed in windage and friction.

It so happens that the maximum horse-power just occurs, during running conditions, at a value of the torque T_3 on the lower straight line. For this case—

$$T = 0.53(v-u) = 10.4 \text{ ft.-lb.}$$

$$\text{H.P.} = \frac{(0.53(v-u)-10.4)\,u}{550 \times 0.542} \text{ and } v = 68.1 \text{ ft. per second.}$$

From which, by differentiating,

H.P. maximum occurs at $u = 24.2$ ft. per second.

$v - u = 43.9$ ft. per second.

This gives maximum horse-power of 1.05.

The result is slightly in excess of that actually found, because the relative velocity 43.9 ft. per second is higher than the relative velocity on the lower straight part of the T_3 graph, but the difference is only 3 per cent. between the actual maximum and this result. The author desires to express his indebtedness to the Society of Merchant Venturers for the use of the machinery and laboratory during the experiments.

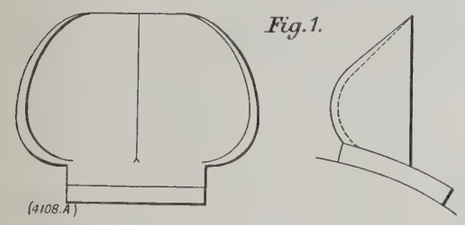


Fig. 1.

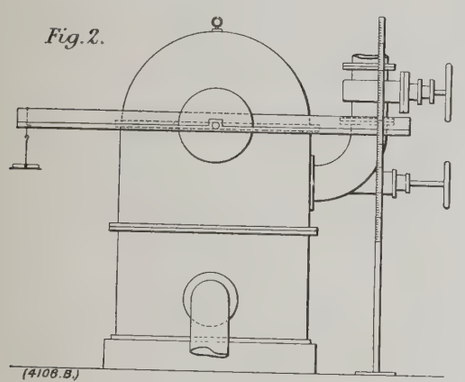


Fig. 2.

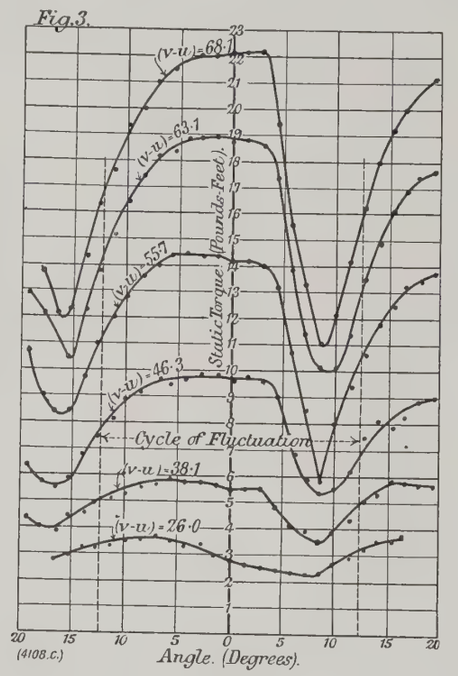


Fig. 3.

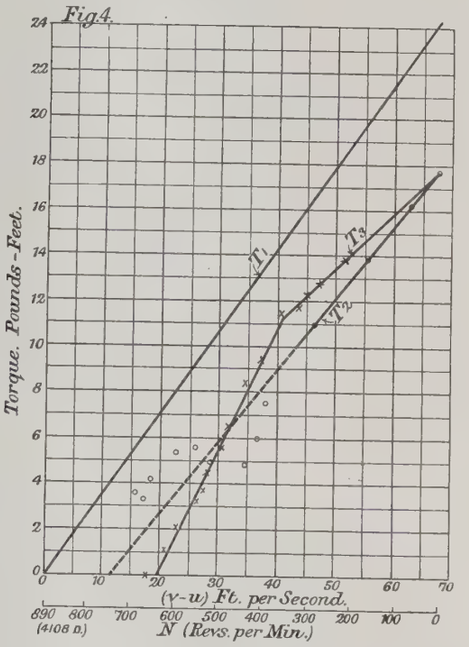


Fig. 4.

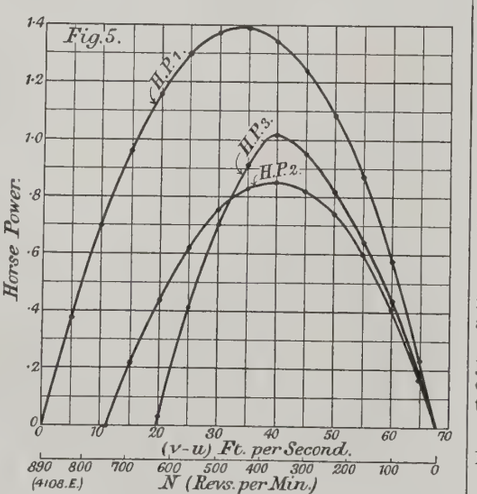


Fig. 5.

FERRO-MANGANESE.—The Illinois Steel Company have installed a 4-ton Heroult electric furnace to melt ferro-manganese for addition to steel. It is found that there is a saving of 30 to 40 per cent. of ferro-manganese by supplying it molten instead of solid,

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. II.

By FREDERICK WILLIAM LANCHESTER, M. Inst. C.E.

AEROPLANE *versus* DIRIGIBLE (*continued*).

HAVING in the preceding article devoted some attention to contrasting the respective merits and limitations of the aeroplane and airship or dirigible, and to disposing of the false analogy so frequently drawn between the air forces and the fleet, we pass to the consideration of their mutual relationship in matters of attack and defence. Firstly, it is evident that the attack will essentially be on the side of the aeroplane; the dirigible can do no more than act on the defensive. The great disparity of speed alone, whatever armament the airship may carry, settles this definitely; it is within the power of the aeroplane to choose precisely when, how, and where it will engage in conflict. The dirigible, like the submarine, is too slow to run the enemy to earth or to bring him to bay, and, to its disadvantage, cannot, like the submarine, make itself invisible and attack by stealth. Beyond this, its quarry (the aeroplane) is of small size, often scarcely visible at a mile or two distance, and when not actually in the air can be either concealed or efficiently protected. Any attempt at aggressive action on the part of the dirigible is totally and completely out of the question; it is in fact beyond the conceivable range of possibility.

On the other hand, if the airship is to continue as a factor in warfare at all, it must be able to defend itself against hostile aircraft, and in particular be capable of repelling the attack of the enemy's aeroplanes. Now the only power of defence possessed by a dirigible when attacked by an aeroplane is counter-attack by gun-fire; hence the extent, character, and distribution of its gun armament is one of the most important factors in its design.

In the earlier days of the development of the aeroplane, when its horse-power was but little in excess of the minimum required for the bare necessities of flight, its rate of ascent was so extremely slow (if it could be said to have any real rate of ascent at all) that it was commonly assumed that a dirigible, or airship, could seek safety in altitude. To-day, however, many aeroplanes will make altitude at a speed of 700 ft. or 800 ft. per minute, thus being more than able to hold their own with the lighter-than-air machine, and can ascend to over 10,000 ft. altitude (even twice this height has been reached); again having the dirigible at a disadvantage.

The method by which an aeroplane may most effectively attack a dirigible is a matter that remains for future experience to settle. If the aeroplane pilot is prepared to sacrifice himself, and has at his disposal a powerful machine of modern design, no dirigible can stand against him. If, as a matter of experience in actual service, men are found of sufficient grit and grim determination to adopt ramming tactics, and to hurl themselves and their craft bodily at the gas-bag of the dirigible, its destruction is immediate and complete. There is no defence possible against this mode of attack. The crew of the dirigible may not have even the most slender chance of stopping the aeroplane by machine-gun fire; the attack can be made from above by a steep *vol plané* or a vertical dive. In the case of a large airship of the Zeppelin type, even with machine guns mounted "on the roof," the chances of defeating such an attack are remote; the speed of a machine descending vertically, or steeply, is approximately that of its limiting velocity—commonly about 150 miles per hour—leaving a very brief period in which to score a hit. Beyond this, no ordinarily fatal hit is effective under the conditions in question; no injury to the motive-power installation is of the least effect as a stopper, and the pilot is in almost perfect security in his position behind the engine. If by an exceptional chance he should be wounded, he is still able to effect his purpose, unless totally disabled.

The steep or vertical descent is admittedly a dangerous feat of airmanship, but it is not intrinsically dangerous; the risk involved is due to the structural stresses to which the machine is subjected when "flattening out." These, it is well known, may become excessive; any objection on the score of danger has obviously no weight whatever under the conditions contemplated.

It is an open question whether airmen will always be found ready to step forward at the critical moment to go to certain death, and so the general feasibility of ramming tactics must for the time being remain in doubt. However, there are many other modes of attack open to the aeroplane pilot, all more or less untried at present; unquestionably also there are still other methods that will in due course be devised. In the case of the non-rigid dirigible, as in the ordinary spherical balloon, it is almost certain that a hundred or so yards of barbed wire trailed beneath an aeroplane would be a quite sufficient weapon; equally effective would be an incendiary shell, or a rocket, presuming any part of the envelope to be hit. Ordinary small-arm or machine-gun fire is comparatively ineffective, since the bullet holes are, in any case, small, and in some of the modern machines repairs can be effected without coming to earth. However, even rifle fire has proved sufficient to bring a balloon down. It is evident that the weak point of any dirigible or airship is its liability to attack from above; in the non-rigid type, without going to the length of any elaborate apparatus, and without endangering the attacking aeroplane, almost *any* angular and weighty object dropped from a height cannot fail to be of conclusive effect if it fairly hits the envelope, and likewise in the case of the rigid type—such as the Zeppelin—the structure would not stand up under a blow from, say, a steel bar of any ordinary stock section of 70 lb. or 80 lb. weight dropped from a height of 200 ft. or 300 ft. Without saying that the above are suitable methods of attack, it may be claimed that they fairly indicate the inherent weakness of the dirigible in face of attack by an aeroplane of sufficient power to master it in the matter of altitude. There are methods not mentioned here which are actually in use or in contemplation, but which, for obvious reasons, require to be treated as confidential. It is, however, in the writer's opinion, quite unnecessary to carry the matter further; the weaknesses of the dirigible on the defensive are so great and of such a character as to render it quite unfit to remain an active participant in aerial warfare. It may escape for a time, and may render a certain amount of useful service, but only thanks to the circumstance that the number of high-powered, fast-climbing aeroplanes is comparatively limited, and to the fact that scientific methods of attack have not yet been fully worked out or put into practice. However, even to-day the finest of Germany's fleet of Zeppelins would be absolutely at the mercy of a modern aeroplane in the hands of a man prepared to make his one and last sacrifice. So fragile and combustible a contrivance as a dirigible, whether rigid or non-rigid, can never, in the writer's opinion, survive in the face of the rapid development of the modern aeroplane and the engines of offence with which before long it will be furnished.

Before proceeding to the broader considerations, it has been thought desirable to dispose of the airship as a factor in the aeronautical service—its dismissal being an initial simplification. It is not altogether important whether or not this conclusion turns out to be literally true. It may be that, in spite of all that has been put forward, the large airship may retain some degree of utility, possibly reserving its appearance until after the annihilation of the enemy's air fleet; even if this be so, the main conclusions will be unaffected. It is the aeroplane, and the aeroplane only, either as a reconnaissance or a fighting machine, acting independently or in flights or squadrons, that in effect will constitute the aeronautical Arm; and whether the considerations we discuss are strategic or tactical, it is the potential capabilities and limitations of the aeroplane that we require to keep constantly in mind.

STRATEGIC AND TACTICAL USES OF THE AERONAUTICAL ARM.

In the present distribution of the cavalry Arm, the distinction between the strategic and tactical uses of cavalry is clearly recognised. For purely tactical purposes it is customary to attach one or more squadrons, usually a regiment of cavalry, to each infantry division. The main cavalry force is known as the independent cavalry, and constitutes a separate command, taking general instructions from the head-quarters staff. The independent cavalry may be engaged in operations of strategic import, as in the conduct of a reconnaissance in force, or in the execution of a wide turning or outflanking movement, or in the countering of such a movement on the part of the enemy. Alternatively, it may be employed in its tactical capacity, its full weight being thrown at some critical moment into the fighting line, it may be to attack and destroy the cavalry of the enemy, to raid and capture or put out of action his artillery, to harass him in retreat, or to convert a retreat into a rout. The divisional cavalry are, generally speaking, employed for the latter—tactical—duties only.

Similarly, aircraft are capable of employment in duties of both strategic and tactical import, and accordingly will probably need to be divided into divisional and independent commands. For example, in reconnaissance there is the strategic scouting, whose function is to inform the head-quarters staff of the main disposition and movements of the enemy's forces, positions of his dépôts, magazines, &c., points of concentration and strength of his reserves, and last, but not least, his main and perhaps auxiliary lines of communication. On the tactical side there are many duties to be carried out, in some cases analogous to those at present performed by cavalry; in other cases duties that we may almost regard as new, and brought into being by the peculiar power and capabilities of the new Arm; in the main, these are such as would indicate control by the divisional commander.

THE STRATEGIC SCOUT AND ITS DUTIES.

The strategic value of the aeroplane depends mainly upon its utility for the purpose of reconnaissance; briefly, it is its value as an informer, rather than as a fighter, that is of service to the head-quarters staff. The duties of a machine thus acting are necessarily of an entirely different character from those of a machine employed in the minor operations of the field, whether for tactical scouting, direction of gun-fire, or otherwise. Not only will the flight range, as determined by its petrol capacity, be a far more important factor in its design, since it will require to operate over a large area, and to cover long distances over the enemy's territory, where any renewal of fuel supply is impossible, but also its flight speed must be such as to render it reasonably secure against pursuit. Anything serious in the direction of armour or armament will be entirely out of place, since under no circumstances will such a machine be required to act in a combative capacity; its defence lies in its speed. It appears from all reports that the duties in question are such as to require an observer (probably a staff officer) of mature knowledge from a military standpoint, with considerable flying experience, possessing something of an intuition for reading the meaning of the incomplete and fragmentary indications that are obtainable from high altitude observation. It is evidently not impossible for a strategic scout (as we may term the machine under discussion) to descend to low altitude in pursuit of more accurate and precise information; but it is always to be remembered that any such manœuvre is dangerous to an unarmoured machine; it may be too easily shot down or destroyed by shrapnel. In this latter event it must be regarded as having failed in its purpose. The possession of a wireless installation may be assumed, but, in the event of the machine being lost, the fact that reports had already been transmitted to head-quarters would in no way mean that the machine had completely fulfilled its mission.

The work done by the strategic scout thus comprises the gleaning of information hitherto only to be obtained by a reconnaissance in force—that is to say, by a large force of cavalry with supports of horse artillery and infantry, often involving considerable fighting and loss. It is quite improbable that aeroplane scouting will prove an entire substitute for such reconnaissance; it may be said that cavalry can *feel* and *act* where the air-scout can only *see* and *report*, but, as a prelude to cavalry reconnaissance, and as an auxiliary thereto, the services of the strategic scout should prove of the utmost utility. It will, at least, enable the cavalry force acting at a distance from its base, frequently in the rear of the enemy, to keep in constant touch with the general at headquarters, and relieve the despatch rider of one of his most difficult and dangerous tasks. In service of this character it would seem probable that a *flight* or *squadron* of aeroplanes would be temporarily or permanently attached to the independent cavalry, as in the case of the supports representing the other two Arms of the Service. Under these circumstances the command of the combined force would remain, as at present, with the cavalry leader.

LITERATURE.

Structural Geology. By C. K. LEITH, University of Wisconsin. London: Constable and Co., Limited. [Price 6s. 6d. net.]

THIS book, intended mainly for students, has for its object to point out how rock structure may be correctly observed and how the collected facts may be intelligently interpreted. The author asks his pupils to take a broad view of surface formation, and to regard rocks as indicators of general problems, connected with the configuration of the earth and its history. He does not attempt to decide "how the earth rose out of chaos." It may have had its origin in the solidification of a ring of matter left behind from the shrinking of a central nucleus, as Laplace taught, or have resulted from the aggregation of innumerable small bodies, as Chamberlin and Moulton have suggested. He takes the earth as he finds it, with its evidences of growth and decay, subject to the action of gravity, of mechanical stress and strain, of thermal and chemical forces, and inquires how these have operated in the past, what traces of their action have been left, and what is the nature of the evidence upon which any theory can be built. Even with these restrictions there is abundant room for the exercise of imagination. The interior of the globe is a playground in which the mathematician and the physicist, as well as the geologist, can display their dexterity and artifice, but scientists do not always play the same game. The late Rev. O. Fisher used to complain that the geologists did not understand his mathematics, and the mathematicians did not understand his geology. It is a melancholy fact, and a measure of our ignorance, that so many rival theories hold the field. New methods of investigation do not bring confirmation of previous results; it might almost be said that each new engine of research builds up a theory of its own, having little relation to the most trusted theories of the past.

One distinctive feature here is the great attention bestowed on the phenomena described as the flowage of rocks. The author takes the view that rocks are deformed, either by fracture or by flowage. Fracture may be of various kinds, but sufficiently explains itself. Flowage implies no conspicuous fracture, the rock remaining at the end of deformation an integral body of permanent form. Rock fractures have characters of their own which are easily recognised, though it may be difficult to trace the causes with certainty. The author's discussion of stresses and strains may be as thorough as the circumstances allow; but it must be admitted that our knowledge of the stresses to which rocks are submitted under various conditions of compression and torsion is relatively small. The phenomena of rock flowage offer other difficulties. The passage from flowage to fracture is not sharply defined. One characteristic result of flowage is to produce a parallel arrangement of the constituents of the rock-mass, showing schistosity, cleavage, or banded structure, but these appearances may be imitated by fracture, or be absent owing to the existence of ore bodies that cannot adapt themselves to parallel arrangement. "A quartzite may fracture at one place, while near at hand, without increase of depth, but under different conditions, it may flow." Position of level, age, density, and composition of rock, all influence flowage very materially: we can gather no certain criteria by which it is possible to differentiate between the results of fracture and flowage.

But rock flowage has a significance beyond the mere surface indications. Since it is supposed to originate at very considerable depths, it should supply some information on the constitution of the interior of the globe, and should either confirm or disprove inferences drawn from other sources, as earthquakes. If it be justifiable, as the author suggests, to divide the lithosphere into zones of vertical distribution, of which the lowest is the seat of rock flowage, the study of the epicentres of earthquakes should decide the depths to which such zones extend; also the behaviour and rate of travel of seismic waves should indicate whether these waves have passed through uniform and homogeneous strata or through fractured and incoherent material. Much has been learnt of late years from earthquake records and perhaps conclusions have been drawn from insufficient data, or, in the author's words, "the evidence is not always regarded as conclusive." But the discussion of the problem here does not do justice to our knowledge of earthquake phenomena, and is so sketchy and imperfect that it is impossible to follow the deductions with certainty. The argument seems to run thus: The seat of earthquake disturbance has been proved to be superficial, perhaps 12 miles below the surface, and since earthquake shock is likely to be a product of rock fracture, it is probable that the zone of fracture does not extend on the average below depths of that order. Further, as the examination of seismic records obtained at a distance of 600 miles and more from the origin betray the existence of waves of different velocities, it may be concluded that the velocity of one set is due to the vibrations travelling circumferentially through fractured rock, while the other, following the chord and passing through deeper strata, has penetrated the zone of flowage, and consequently exhibits a different velocity. Therefore on both grounds, of determined depth of epicentre and of observed wave velocity, there is evidence of change of formation at a depth of about 12 miles. If we have correctly apprehended the author, the reasoning is not satisfactory. In a solid, as the earth, we have not two, but three, waves to consider. Confining attention entirely to the waves travelling through the interior, these will be of two kinds, but will follow the same course, waves of compression and waves of distortion. Since these waves travel with different velocities, they will arrive at different times, whatever the nature of the material passed through. The evidence drawn from earthquake waves at distant stations, say from 120 deg. to 150 deg. of the earth's surface, does point to the material at great depths being more elastic and more dense than near the surface, but this is altogether a different question from that under consideration here.

The description of faults and folds, and of the typical superficial markings, is quite satisfactory, as are the instructions for field work, and for forming conclusions in doubtful cases where misinterpretation is possible. The work of the practical geologist will be facilitated by the use of this treatise, and especially the American student, since the illustrations are almost entirely taken from the United States. The use of geological maps is strongly and properly insisted upon. Here and there we find an expression which does not exhibit the same care and lucidity that mark the body of the work. For instance, we read "that the structure of the greater number of mountains is clearly the result of tangential shortening of the earth's crust." If this means that mountains are the consequence of the folding of strata due to the crust collapsing on a shrinking core, we doubt the adequacy of the explanation. More than one authority has shown that the great rock-folds encountered in the Alps and Himalayas, to say nothing of the Appalachian chain, to which the author frequently refers, cannot be explained by the contraction of a cooling globe. When the Appalachians were young they extended over a far greater length than their dwarfed descendants cover; and, moreover, if we would invoke surface or radial shrinking as a main cause, it is difficult to see why continuous chains, coinciding with a great circle, should be a frequent feature in mountain formation. The Himalayas are a product of modern geologic time, when shrinking by cooling must have seriously diminished, yet we find an elevation continuously extended in a definite direction for more than a thousand miles, with an overthrust perpetually directed from the north that cannot be regarded as accidental.

It is impossible to pursue these speculations without being brought up against the thorny subject of isostasy, or "that condition of equilibrium of figure to which gravitation tends to reduce a planetary body, irrespective of whether it be homogeneous or not." The author's account of this theory follows closely the American view; indeed, the words of Hayford, the great exponent of the theory due to Dutton, are largely quoted, but Mr. Leith does not weigh the evidence deduced from measurement in other parts of the world, especially India.

We gather, however, that the data collected by the original supporters of the theory do not convince him that the hypothesis is sufficient, though he is willing to accept it as a partial explanation. This is the attitude generally assumed, and Mr. Leith gives it just expression by saying "Unquestionably the plumb-bob deflections show the existence of some sort of isostatic compensation, the higher areas having lower density, and the lower areas having higher density; but it is questionable whether the compensation is as complete as indicated by Hayford." The determination of the density of rocks below the ocean or far below the surface of the globe's crust can possess little exactness, but the theory requires that the product of the height of any area by its mean density should be the same for all places. This implies that continental areas must be light, while the depths beneath the ocean must be heavy. Some spherical surface must be selected as the locus of complete compensation—that is, the depth at which the inequalities of gravity disappear, and if this surface be placed about 120 km. below the surface and a uniform distribution of density be assumed, the American observations of pendulum displacement and of topographical irregularities can be fairly well reconciled. "The discrepancies are so slight that Hayford has concluded that the area of the United States falls one-tenth short of complete isostatic adjustment." The only other country where sufficient data exist for testing the validity of the hypothesis on a sufficiently large scale is India, and there the attempt to explain the anomalous durations in the direction of gravity by supposed local changes in load fails. The assumption of isostatic conditions over that area is by no means supported. Since the first time the hypothesis is put on its trial a failure results, it would seem that the relation between topographical inequalities and gravity anomalies in the United States is accidental. To harmonise the geological and geodetic conditions in India, comparatively rapid and abrupt transitions are needed within a small area, and these are precisely the conditions that the general theory of isostasy fails to meet. The author presents some other very pertinent reasons for doubting the sufficiency of Captain Dutton's ingenious suggestion, and his attitude of criticism or suspended judgment is thoroughly warranted.

Gold-Dredging. By T. C. EARL. London: E. and F. N. Spon. [Price 20s. net.]

THE great strides made in the development of the gold-dredger during the last decade, and the vast amount of alluvial gold in almost every country in the world still awaiting the energies of the miner, make the volume under review an interesting one.

After dealing with the properties and utilities of gold, and describing some ancient alluvial workings in Spain, Africa, and Southern Europe, which he attributes to the Romans, and more recent races, the author proceeds more specifically with his subject. In modern times, during the early rushes to gold areas, the rich pockets and streaks were worked by various light appliances and sluices, sometimes followed by the Chinaman, who reaped rich harvests where the white man failed. Dredgers are now working tailing débris which were formerly hand-worked, and are returning good profits.

The success of gold-dredging has been practically demonstrated in many parts of the world. The amount of gold won by dredgers in California, New Zealand, Victoria, and New South Wales during the years 1898 to 1911 is shown in this volume graphically, California being the most conspicuous with over 1,500,000*l.* worth in 1911. The capital required is not large; New Zealand companies having started with 8000*l.* and under, and operated successfully. Apart from ventures in Australia and New Zealand, most of the money for dredging has been raised in London.

Many considerations which are important in the selection of dredging-ground are pointed out, and the author is of the opinion that the chances of failure, when the ground has been thoroughly sampled and the advice of an expert dredge-engineer followed, are small. Locality, transport, climate, and the availability of water-power or fuel are important factors, as all these have a direct or indirect bearing on the capital outlay.

The author goes on to deal with prospecting and testing of ground, describing the methods commonly used—*e.g.*, shaft-sinking, drilling and dredging by a small prospecting dredger, and he recommends shaft-sinking as the most satisfactory plan when the conditions will permit. The prospecting dredger is the only appliance that is of any use in fast-running streams, and when gold is present in good quantities the cost of the process may be more than defrayed by the gold recovered. This is also the only method which does not lend itself to

"salting," on account of the expense. Salting is common, and the author mentions several means used to that end, and suggests weapons by which the engineer may combat this pernicious practice.

A chapter is given to the description of the bucket-dredger and its various parts, the proper selection of a dredge is discussed, and a comparison drawn between the New Zealand and American types. The former is characterised by the line for keeping the dredger up to its work, the open-connected type of bucket-chain, tables for gold-saving, and the tray-elevator; whilst the American dredger is fitted with the "spud" for keeping it up to its work, the close-connected type of bucket-chain, riffled sluices for gold-saving, and the belt-elevator. The author favours the New Zealand type for several reasons, and cites a case, where the two types worked together under the same conditions, in support of his contention.

Dredgers in Australia, New Zealand, and California usually have hulls of timber, on account of its cheapness; they are generally built in an excavated dam, and, after floating, the machinery and equipment are fitted. The order generally followed in the course of construction and erection is given, together with a brief outline of practical methods.

The author next deals with the operation of dredgers in rivers and in paddock claims, and explains the proper distribution of tailings, so that they will not interfere with the later working of the dredger. Crews and their wages are discussed, and tables are given showing the wage rate for "winchmen," &c., in different parts, and also the numbers of crews on different dredgers under varying conditions; these show that crews vary considerably with different circumstances. A crew of four work, in one instance, a 5 cub. ft. machine, whereas in two other cases dredgers of similar capacity have crews of eight and eleven respectively, the latter being so large on account of the heavy timber encountered by the dredger. Tables of costs are also given; among the dredgers cited, one in California costs 1.2d. per cubic yard for operation, and another 2.9d., also in California.

Gold-saving appliances and their limitations are considered, and suggestions are made for the reduction of loss of gold. The importance of a steady and well-regulated water supply and the disintegration of clayey material are emphasised.

The laws in New Zealand, California, and other countries in regard to resoiling of dredged ground and the pollution of water are briefly dealt with. Anticipated modifications in these laws in California, it is thought, should bring further areas into the scope of operations. Statistics and maps are given showing the extent to which dredging operations have been carried out in New Zealand, California, and Australia, and areas partially and wholly unknown are suggested for active operations.

The concluding chapter is a brief consideration of the possibilities of the various countries from the point of view of the alluvial operator, many maps and photographs being given for the purpose. There are in all seventy-eight illustrations and seventeen maps in the book, which appears to be a record of a vast experience in the gold-dredging world, and should prove useful for reference to those actively interested in this industry.

La Construction en Béton Armé: Theorie et Pratique. By A. V. MAGNY. Avec une Preface de PAUL PIKETTY. Paris and Liége: Charles Béranger. [Price 20 francs.]

THIS is an excellent and comprehensive volume on reinforced concrete, and includes both a theoretical and a practical treatment of the subject, the latter being illustrated by several folding plates, giving the important details of construction of jobs actually carried out, both in France and in this country, on two or three of the best-known systems of design. The author of the book has had the advantage, which, unfortunately, is seldom shared by English writers on the subject, of many years' working experience in the design of reinforced-concrete structures of all types, and consequently he deals with the various points he discusses, both theoretical and practical, with a proper appreciation of their relative importance. In addition, the methods of calculation he recommends are brief and practical. M. Piketty, a well-known French designer and contractor, who writes a preface to the volume, also lays stress on this fact, and points out that in the design of reinforced concrete a series of rapid approximate calculations will achieve a better result than the application of the cumbersome official formulæ, which are only suitable for checking and verifying designs. A glance at the formulæ given in the French "Instructions Ministerielles"—or their equivalents in the new Regulations proposed by the London County Council and the Local Government Board—will convince anyone of the practical impossibility of applying these long algebraic expressions each time the stresses in the steel and concrete, or the position of the neutral axis, in a beam or slab are required.

As in most other departments of engineering, good design in reinforced concrete cannot be achieved by mere calculation; a happy union of theory and practice is needed before any high standard can be arrived at. There are, particularly in England, many systems of construction evolved by the untutored instincts of practical men, which a very little sound theoretical knowledge would show at once to be clumsy and extravagant, and there are also writers on the subject who appear to have obtained their knowledge only at second-hand and who, after having dealt (laboriously and at great length) with one or two simple and elementary questions and given a few hopelessly unpractical examples, ignore or dismiss in a few lines all complex problems in which a student might reasonably be supposed to require some assistance. M. Magny, having been for many years with large firms of specialist designers, both in England and in France, has an intimate and personal knowledge and experience of reinforced concrete, and therefore writes with a comprehensive view and a true perspective. He deals with nearly every type of structure for which reinforced concrete is suitable, and gives for each a theoretical treatment, with brief calculations, details of the arrangement of the reinforcement taken from actual examples, and photographs of finished jobs. The folding plates give details of bridges, buildings, and silos erected in France on the Hennebique, Considère, and Piketty systems; and for British examples the author has selected the Waterford Bridge, Ireland (Messrs. L. G. Mouchel and Partners), and the arch over the River Ogmore at Bridgend, Wales (the Considère Construction Company, Limited). In addition to these examples, the salient characteristics of several other systems less well known in this country are given, and also illustrations of some of the different patterns of embossed and fabricated bars.

The book is divided into eight sections, and the first part gives several very useful tables, including one of moments of inertia of different sections, and one of the bending moments realisable on beams, continuous and otherwise, and with partial, point, and distributed loads; whilst the second is devoted chiefly to the materials of construction. The author has gathered together from various sources an enormous amount of general information, the existence of which could only be known to one having a very thorough acquaintance with the subject. The properties of Portland and other cements and the methods of testing; the various useful aggregates and sands and their qualities and properties; the different machines for mixing concrete and the effect of different gaugings; the woods suitable for shuttering and shoring, with illustrations of the different methods; bending and placing the steel; surface finishing, superintendence and cost-keeping are only a few of the points which are succinctly, but clearly and usefully, dealt with in this part of the work.

Another section of the book deals with the recognised methods of calculation and includes references to the results obtained by the classic experimenters (Mörsch, Considère, Talbot, &c.), which form the basis of the modern methods of design. The fundamental principles and assumptions involved in making calculations are also stated, and the great importance of a full and proper investigation of the shearing forces in beams is urged. This is a point which is often overlooked, and, in England, it is not unusual to find every care taken by those checking designs to ascertain that the direct tensile and compression forces in the steel and concrete are within the specified limits, whilst any verification of the design of the stirrups or transverse reinforcement is entirely neglected. The fact that the first symptoms of failure in a reinforced-concrete beam are practically always indicated by diagonal shearing cracks, whilst, within limits, the exact number of pounds per square inch of tension or compression is relatively unimportant, should indicate that absolute safety against collapse is better assured by the provision of adequate reinforcement against shear than by limiting the tensile and compressive stresses to very low figures.

The author states that it is beyond the scope of the work to give all the various methods of calculation which were proposed by different engineers during the development of reinforced-concrete design, and he therefore only includes the now universally accepted formulæ of the French "Instructions Ministerielles" of 1906, which were included in the exhaustive report issued by the Government Commission after five years' deliberation and experiment. The "Instructions Ministerielles" are included in the book, and they form a pleasing contrast to the quite unnecessarily tiresome and inconsistent Regulations put forward by the London County Council and the Local Government Board. The book, if translated into English, would be an excellent one both for designers and students; but (as is not always done) the calculations and dimensions should also be put into English units, as a very long acquaintance with the metric system is needed before "kg./cm.^{2}" conveys quite the same instinctive quantitative appreciation of stress as "lbs. per sq. in.," and a quick instinct for quantity is essential to good engineering.

The Maintenance of Foreshores. By ERNEST LATHAM, A.M. Inst. C.E. With contributions by Colonel R. E. B. CROMPTON, C.B., M. Inst. C.E., and A. F. CAREY, M. Inst. C.E. London: Crosby Lockwood and Son. [Price 2s. net.]

THIS book is somewhat difficult to classify, as it is neither completely technical nor yet exactly popular. The former fact will be appreciated when we explain that it does not contain a single drawing or diagram. At the same time it comprises very much information of value to engineers, some of it being of a kind which is difficult to obtain, as it lies on the borderland between design and business. For instance, it gives a list of authorities dealing with drainage and foreshores, and generally known as Level and Sewer Commissioners. Of these there are at least twenty-one who have powers of varying kinds in relation to sea or river frontages, or both, and extending inland over all areas below a certain standard level. In the main, the work deals with foreshores in a more or less general fashion, but interspersed with much that is superficial there are very valuable hints and pieces of information drawn from the author's personal experience on many parts of the coast. The reader feels that if Mr. Latham had set out to write a bigger book, going fully into details, both of design and execution, it would have been of great assistance to engineers dealing with the subject.

The work is divided into eight sections. The first deals with the classification of coast erosion, referring to notable examples around this island. The second, contributed by Mr. A. E. Carey, M. Inst. C.E., summarises the findings of the Royal Commission on Coast Erosion. The third is devoted to the question of the protection of low-lying lands; the fourth to the drainage of low-lying lands; the fifth to the protection of high lands; and here we are glad to see that the author protests against the indiscriminate use of groynes without special consideration of the circumstances of each locality, and of the design of groyne suitable for it. The sixth section has been contributed by Colonel R. E. B. Crompton, C.B., M. Inst. C.E., and deals with the surfacing of promenades at seaside places; this subject was dealt with in our columns in the series of articles by Mr. E. R. Matthews, of Bridlington. The last two sections concern respectively considerations prior to the commencement of structural work on foreshores, and materials and construction, and are among the most valuable in the book, since they represent very largely the results of the author's observation and experience. The volume is essentially readable, and while it is far from exhaustive, it is a useful contribution to the subject which will be appreciated by many.

ANNEALING CASTINGS. — The American Society for Testing Materials recommends the following temperatures for annealing steel castings:—

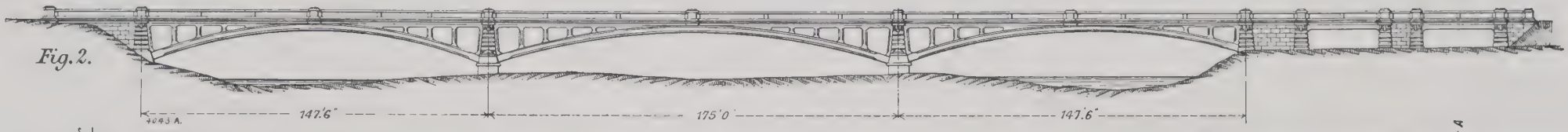
Carbon per Cent.	Deg. Cent.
Up to 0.16	925
0.16 to 0.34	875
0.35 to 0.54	850
0.55 to 0.79	830

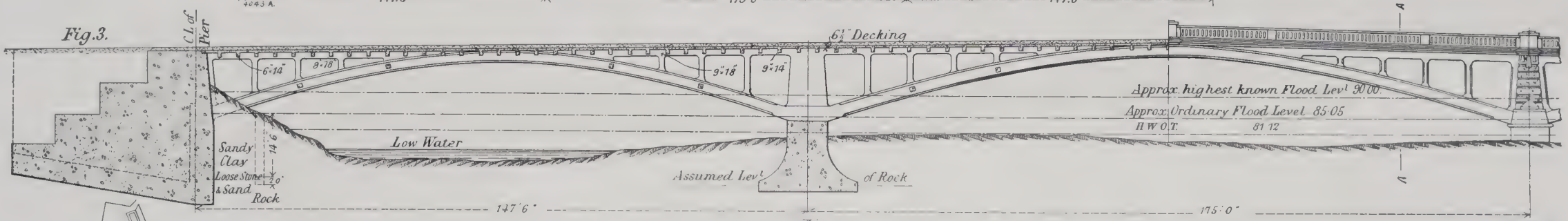
The heavier the sections of the castings, the longer must be the exposure to the temperature.

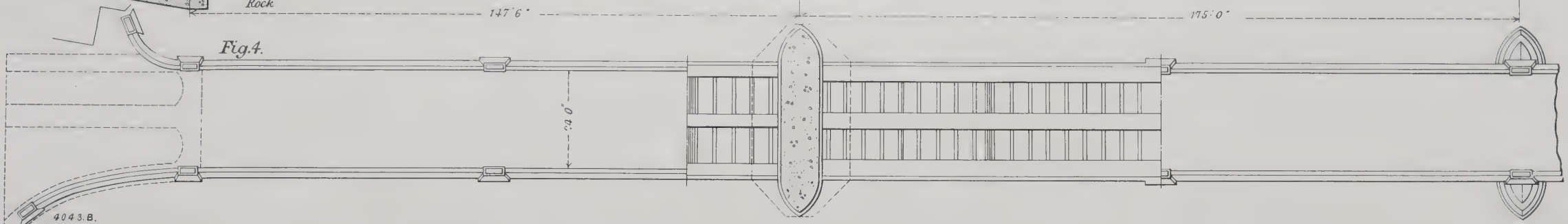
FERRO-CONCRETE BRIDGE AT LONGTOWN, CUMBERLAND.

FROM THE DESIGNS OF MESSRS. L. G. MOUCHEL AND PARTNERS, LTD., WESTMINSTER; MR. W. FINCH, ENGINEER, CARLISLE.

(*For Description, see Page* 341.)







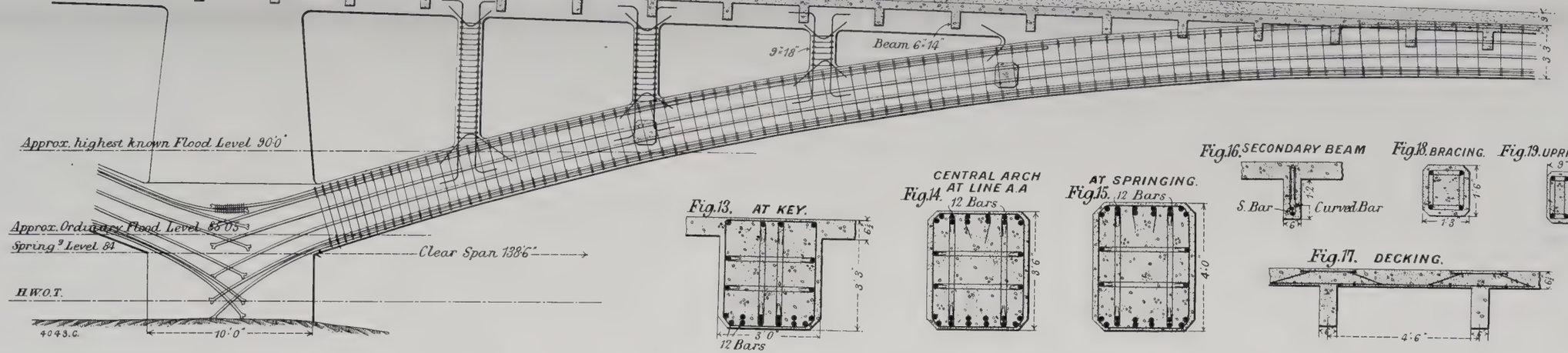
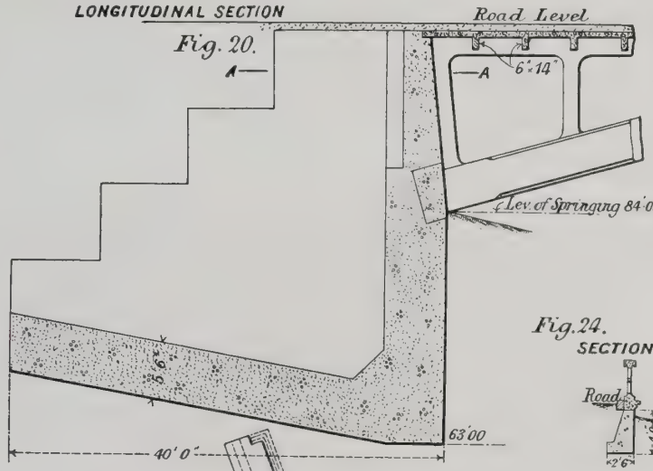

Approx. highest known Flood Level 90'0"
Approx. Ordinary Flood Level 85'05
Spring's Level 84
H.W.O.T.
Clear Span 138'6"
4043.C.
10'0"
9"x18"
Beam 6"x14"
3'3"

Fig.13. AT KEY.
6½"
3'3"
3'0"
12 Bars

CENTRAL ARCH AT LINE A.A
Fig.14. 12 Bars
3'6"
AT SPRINGING.
Fig.15. 12 Bars
4'0"

Fig.16. SECONDARY BEAM
S. Bar
Curved Bar
1'2"
6"
Fig.18. BRACING.
1'6"
1'3"
Fig.19. UPRIGHT.
9"
9"
Fig.17. DECKING.
6"
4'6"


LONGITUDINAL SECTION
Fig. 20.
Road Level
A
6"x14"
Lev. of Springing 84'00
5'6"
63'00
40'0"

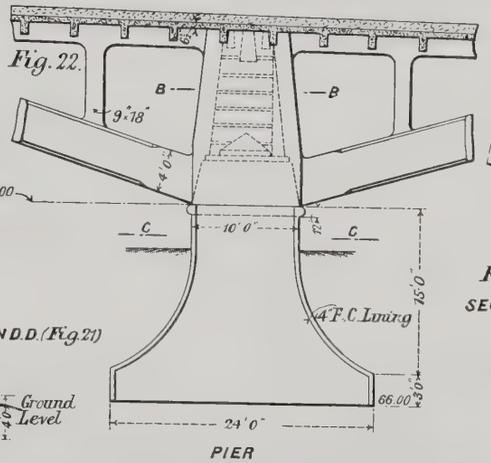


Fig. 22.
B
9"x18"
C
10'0"
4'0"
15'0"
4' F.C. Lining
66.00
3'0"
24'0"

Fig.24.
SECTION D.D. (Fig.21)
Road
Ground Level
4'0"
2'6"

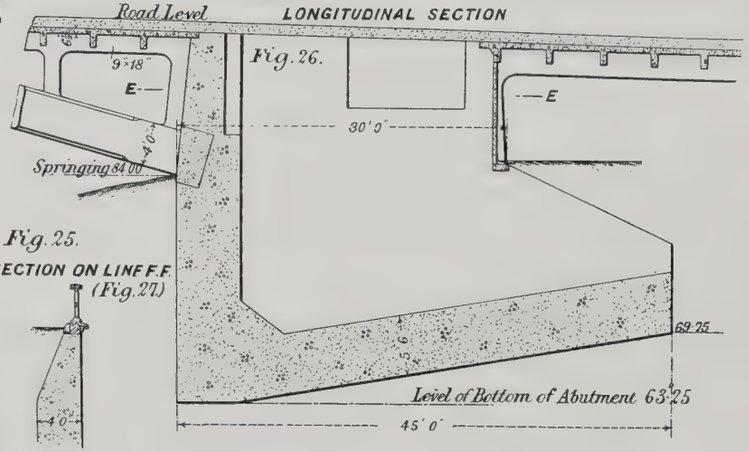

Road Level
LONGITUDINAL SECTION
Fig. 26.
9"x18"
E
30'0"
Springing 84'00
5'6"
69.25
Level of Bottom of Abutment 63.25
45'0"

Fig. 25.
SECTION ON LINE F.F.
(Fig.27)
4'0"

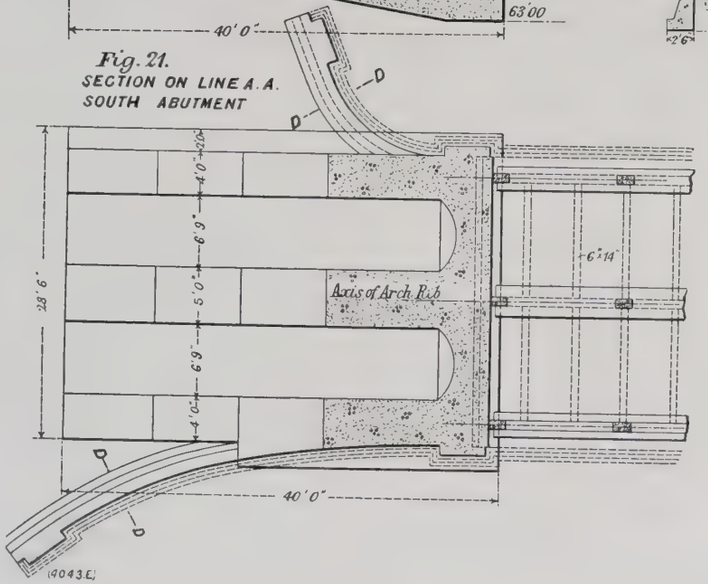
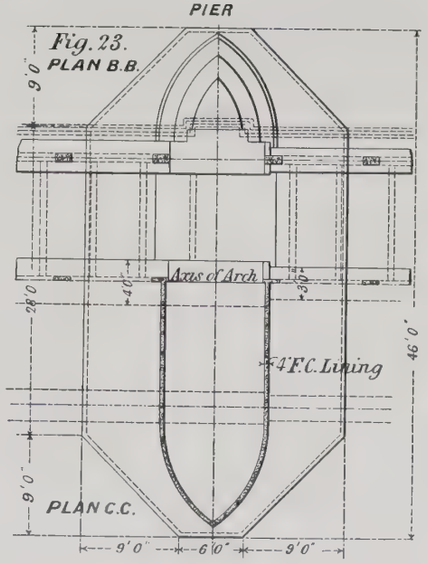


Fig. 21.
SECTION ON LINE A.A.
SOUTH ABUTMENT
D
4'0"
6'9"
5'0"
6'9"
4'0"
28'6"
6"x14"
Axis of Arch Rib
40'0"
(4043.E.)


PIER
Fig. 23.
PLAN B.B.
9'0"
Axis of Arch
4'0"
3'0"
28'0"
4' F.C. Lining
46'0"
PLAN C.C.
9'0"
6'0"
9'0"

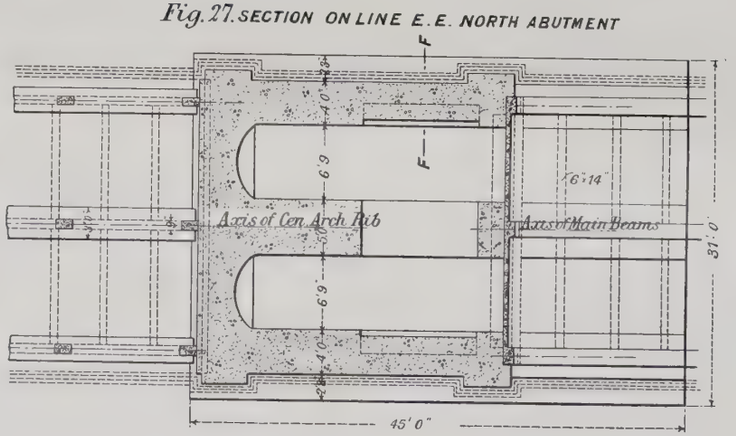


Fig.27. SECTION ON LINE E.E. NORTH ABUTMENT
F
4'0"
6'9"
6"x14"
Axis of Con. Arch Rib
Axis of Main Beams
5'6"
6'9"
4'0"
37'0"
45'0"

FERRO-CONCRETE BRIDGE AT LONGTOWN, CUMBERLAND.

THE main road from Carlisle to Glasgow crosses the River Esk at Longtown, a few miles north of Carlisle. The existing bridge is rather an interesting one, having been designed by Thomas Telford and built in the year 1820. We understand that it was originally intended for some situation elsewhere, and when erected at Longtown, in the parish of Kirk Andrews-upon-Esk, the spans were transposed, giving the bridge a very peculiar appearance. We illustrate it in Fig. 1, herewith, from which it will be seen how the road surface undulates. The gradients from the southern end—the near end in the photograph—are first 1 in 14 up, followed by 1 in 18 down; then 1 in 20 down, 1 in 40 up, and finally 1 in 20 down. This bridge, which has been known as Metal Bridge, is of cast iron. The near span in our view is 150 ft.; the other two are of 105 ft. each. The rise of the larger arch is 20 ft., and of the other two 9 ft. 8 in. The arch ribs of the main span are 3 ft. deep, and of the small spans 2 ft. 6 in. deep. They are of pierced cast iron. The spandrels are of cast iron in the form of a cross, their lower ends being let into sockets in the arches. The decking is of $\frac{3}{4}$-in. cast-iron plates, resting upon the top member of the spandrels. The abutments and piers are of masonry.

In 1911 the late county surveyor and bridge engineer for the county of Cumberland reported that the bridge was unfit for the increasing traffic making use of this important road. It was then closed to traction-engine and other heavy traffic, and the question of its replacement was considered. In 1912 plans and estimates were prepared by the present county surveyor, Mr. William Finch, to whom we are indebted for these particulars. In November, 1912, these estimates were submitted to the Highways and Bridges Committee. Three schemes were considered. One was for the construction of a stone arch bridge, a second for a steel girder bridge, and a third for a ferro-concrete structure. A ferro-concrete bridge was finally decided upon. It is being built to the specification of Mr. W. Finch, to the designs of Messrs. L. G. Mouchel and Partners, Limited, 36 to 38, Victoria-street, Westminster, S.W. The contractors are Messrs. Holloway Brothers (London), Limited, Belvedere-road, S.E., the cost being defrayed by a Local Government Board loan. On this account the Local Government Board required that the plans and calculations should be scrutinised by some independent engineer conversant with ferro-concrete construction. This was done by Messrs. D. Balfour and Sons, Newcastle-on-Tyne.

The new bridge is situated near the old, and the opportunity has been taken to divert the road slightly to get better approaches and crossing. The foundations of the existing bridge are on red freestone rock, as are also those of the new bridge. From our illustrations on Plate XXIII. with this week's issue of ENGINEERING it will be seen that the new bridge consists of three arch-spans, with two short spans in the north approach. The latter do not present any features of particular interest. The central arch-span is 175 ft. from centre to centre of piers, giving a clear span of 165 ft. The two shore-spans are each of 147 ft. 6 in. to centres of piers, or 138 ft. 6 in. clear. A general elevation of the structure is given in Fig. 2. Figs. 3 and 4, partly in section, give two spans and one abutment to a larger scale. Details of the construction of the central span are given in Figs. 5 to 11, while Figs. 12 to 19 show details of the shore spans. Figs. 16 and 17 give details of the decking which are common to all spans. The piers and abutments are illustrated in Figs. 20 to 27.

The normal rise of tide at the site is about 5 ft., and the arches are so placed that at the springing they are about 17 in. above high water of ordinary tides. The highest known flood-level reached a height no less than 6 ft. above this, and if the water should rise to such a height, it would flow above the arch-ribs in the immediate neighbourhood of the piers. In general design the new bridge is plain, but of graceful lines. The central arch has a rise of 8 ft., and the shore arches slightly less. The only ornamentation is in the chamfering of the edges of the ribs, &c., and the treatment of the balustrading and piers.

Dealing with the piers and abutments first, it will be noted from our illustrations (Figs. 22 and 23) that the mid-stream piers are supported on concrete foundations having bases 24 ft. wide by 46 ft. long in the direction of the stream. These bases rest on rock, the design providing for the full size being maintained for a height of about 3 ft. above the rock-level, after which the width is gradually brought into the pier width of 10 ft. The length is approximately maintained to the springing, for, though the piers are not actually of this length, the difference is made up by cut-waters up and down stream. The bases for the piers are of mass concrete of the proportions of 6 : 1, and have a 4-in. fine cement facing all over, ending at the top just below the springing in a coping 12 in. deep.

The abutments are monolithic and of L shape. They consist of vertical mass-concrete walls, 5 ft. 6 in. thick, facing the stream, with floors of similar thickness running back at a slope of 1 in 6 for a distance of 40 ft. in the case of the south abutment, shown in Figs. 20 and 21, and 45 ft. in the north abutment, shown in Figs. 26 and 27. This difference is accounted for by the presence on the north side of the two short approach spans, to which reference has already been made. The full width of the abutment floors is 31 ft., the area having been calculated out for a ground load of not more than 4 tons per sq. ft. Extending back from the front wall to the floor are three mass-concrete counterforts. The centre one is 5 ft. thick; the two others are 4 ft. in thickness. The south abutment is filled in with earth to road-level. At this end of the bridge the balustrading runs out into two wing-walls, ending in posts, as shown in Figs. 4 and 21, a section of the wing-wall and balustrade being given in Fig. 24. The north abutment is filled in to ground-level, and a 4-in. wall, rising from the ground to the underside of the decking of one of the approach spans, encloses the space above, as shown in Figs. 26 and 27. At this end of the bridge the balustrading is continued over the approach spans on a slight curve, and beyond them, ending in short posts similar to those capping the piers, &c.

In each of the three river spans the bridge is carried by three arch ribs of rectangular section, the edges being well chamfered. Above each rib, and connected to it by spandrel uprights, is a longitudinal main beam. The latter carry secondary beams, above which comes the decking. The arch ribs run out into the longitudinal beams and decking in the neighbourhood of the crown. Fig. 5 shows the centre rib of the central span, and the verticals and decking, &c., in section. The centre arch rib of this span has a section of 4 ft. by 4 ft. at the springing, as shown in Fig. 10, diminishing to 4 ft. by 3 ft 3 in. some distance up, and finally running out in depth to 3 ft. 3 in., inclusive of the decking, as shown in Fig. 8. The two side ribs are of the same vertical dimensions, but have a width of 3 ft. throughout, instead of 4 ft. The ribs are reinforced over the greater part of the span by twenty-four round bars distributed near the top and bottom surfaces, with two extra bars equally spaced on each side. As the ribs run out into the beams and decking, the upper twelve bars are reduced in number to six, as shown in Figs. 5 and 8. The verticals between the ribs and beams are shown in Figs. 5, 11, and 19; they are 9 in. by 18 in., and are reinforced with four bars. The bracing between the ribs is 15 in. by 18 in. in section, and is reinforced with four bars, as shown in Figs. 6 and 18. There are four braces to each span. The two shore spans of 138 ft. 6 in. are similar in design to the central arch, except that the width of the central rib is 3 ft. throughout, and of the side ribs, 2 ft. 3 in. Their depth ranges from 4 ft. at the springing to 3 ft. 3 in. inclusive at the crown. The reinforcement is shown in Figs. 12 to 15, being similar to that of the central span, except that at the centre the number of the upper bars is reduced to four. The verticals and bracing are identical with those already described.

The main beams are 18 in. deep by 9 in. in width throughout the length of the bridge. Extending between them and spaced at 4-ft. 6-in. centres are secondary beams 14 in. deep by 6 in. wide. Above is decking $6\frac{1}{2}$ in. thick, over which is laid the road-surfacing material to a depth of 9 in. at the crown. The reinforcement of the main beams consists of six bars, two of which are aligned near the bottom and two at the top. The remaining two are bent so that over the verticals they are near the top of the beam, but between them they run near the bottom. The secondary beams are similarly reinforced, but with only one straight bar near the top and bottom and one bent bar near the top at the main beams and at the bottom between them. The small spans of the north approach have longitudinals, secondary beams, and decking similar to the main spans. The balustrading is shown in section in Fig. 6, and to a larger scale in Fig. 7. It is of 4-in. concrete pierced with cross-shaped apertures. The top rail is 12 in. by 6 in. deep, and is reinforced with two bars.

FIG. 1. OLD BRIDGE AT LONGTOWN, CUMBERLAND.

OUR COAL ABROAD.—The exports of coal from the United Kingdom in the eight months ended August 31, this year (the expression "coal" including also coke and patent fuel), amounted to 46,276,159 tons, as compared with 50,396,630 tons in the corresponding period of 1913, and 41,246,156 tons in the corresponding period of 1912. Coal was also shipped from the United Kingdom for the use of steamers engaged in foreign trade to the extent of 13,249,027 tons, as compared with 13,720,560 tons and 11,608,744 tons. At this rate, in one form or another, coal left the shores of the United Kingdom in the first eight months of this year to the aggregate extent of 59,525,186 tons, as compared with 64,117,190 tons and 52,854,900 tons in the corresponding periods of 1913 and 1912 respectively.

CATALOGUES.

Hoists, Runways, Lifts, &c.—From Messrs. J. Bardell Smith and Co., of Lothair Road Works, Leicester, we have received a copy of their latest catalogue, in which particulars are given of travelling-hoists, wall-winches, crabs, jacks, pulley-blocks, hand-power lifts, and other lifting machinery. Prices are stated in all cases.

Machine-Tools.—The Judson-Jackson Company, Limited, of 50, Marsham-street, Westminster, S.W., have sent us an illustrated list of machine-tools they have on hand for immediate delivery. The list includes a large number of lathes, milling-machines, shaping-machines, drilling-machines, grinding-machines, spring-power hammers, and other tools, for all of which net cash prices are quoted.

Asbestos Goods and Engineers' Stores.—The Asbestos and Engineers' Stores Company, of 66, Bermondsey-street, S.E., have issued a useful and attractive catalogue of "Dreadnought" non-conducting coverings, jointing sheets, packings, india-rubber hose, india-rubber and balata belting, leather belting, hydraulic leathers, belt-fastenings, lubricating oils, greases, and other engineers' stores.

Air Purification by Ozone.—We have received from Ozonair, Limited, 96, Victoria-street, Westminster, S.W., a copy of their latest catalogue of ozone-generators of types and sizes suitable for purifying the air in private rooms, offices, cold stores, lavatories, hospitals, theatres, factories, &c. We understand that improvements have been made in several of the older types of generators, and that some new patterns have been recently introduced. Prices are stated and full particulars given in all cases.

Induction Motors.—The Langdon-Davies Motor Company, of 110, Cannon-street, E.C., have sent us a catalogue and price-list of single-phase and polyphase induction motors. The former are listed in sizes varying from ¼ to 100 horse-power for frequencies varying from 40 to 125 cycles, while the polyphase motors listed range from ¼ to 120 horse-power for 25-cycle and 50-cycle circuits. Both types are made with either squirrel-cage or slip-ring rotors. We have also received a price-list of "Megger" insulation-testing sets from this firm.

Suspension Bridge.—A pamphlet illustrating and describing the erection of a suspension bridge at New Hazelton, in Western Canada, has been issued by Messrs. George Cradock and Co., Limited, of Wakefield. This bridge, which was designed, constructed, and erected by the firm, was dealt with in our issue of December 12 last, on page 808, to which we must refer our readers for further particulars of it. The pamphlet is very fully illustrated, and the descriptive matter is clear and interesting, so that it will doubtless be more favourably received than a catalogue of the usual type.

Motor-Launches.—From Wolseley Motors, Limited, of Adderley Park, Birmingham, we have received an attractive catalogue of motor vessels built by this firm. The examples illustrated include standard launches, yacht tenders, cabin cruisers, yachts, and service craft for sea and river use, as well as high-speed boats for racing purposes. With regard to the latter, we notice that Wolseley boats secured no less that 33 first prizes in important races during 1912 and 1913. The catalogue is well printed, and the illustrations are distinctly above the average quality, so that it well maintains the high standard reached in previous publications of the firm.

Marine Motors and Motor-Boats.—Messrs. J. I. Thornycroft and Co., Limited, Caxton House, Westminster, S.W., have sent us a copy of their catalogue of marine motors and motor-boats. The catalogue gives full particulars of engines ranging in convenient steps from 7½ to 150 horse-power on paraffin fuel; they can, however, be run on petrol if desired. Illustrations and particulars of a number of motor-launches, yachts, cargo-boats, and other craft built by the firm are also included in the catalogue. The matter is conveniently arranged, and is fully coded to facilitate telegraphic inquiries from abroad.

Air-Compressors.—We have received from Messrs. Reavell and Co., Limited, of Ranelagh Works, Ipswich, a copy of their catalogue of three-stage air-compressors for use with Diesel engines, semi-Diesel engines, and for the auxiliary work in connection with Diesel engine installations, both on land and at sea. The general features of these compressors are too well-known to need any comment here, but they are illustrated and described in the catalogue. For land work, quadruplex compressors are listed in sixteen sizes, with piston displacements ranging from 14.2 to 138 cub. ft. per 100 revolutions, and V-type compressors in ten sizes, of which the largest has a piston displacement of 22.5 cub. ft. per 100 revolutions. Marine compressors of the quadruplex type are made in twenty-one sizes, in which the piston displacements vary from 104 to 730 cub. ft. per 100 revolutions. The catalogue also deals with hand-power compressors for filling charging bottles, auxiliary compressors, and steering compressors, the latter being driven by a lever from the crosshead of the main engine.

MILKING-MACHINES.—In the State of Victoria milking-machines are used by 2000 farmers, so it is evident that they have attained to a fair condition of efficiency. When they are used with intelligence and care they appear, from a report by Mr. R. T. Archer to the British Association, to give very satisfactory results. It is, however, difficult to persuade the average dairy farmer to exercise the necessary care in cleansing.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on the subjects dealt with can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

France (Algeria): The *Journal Officiel* (Paris) of August 19 states that a concession has been granted to the Bougie Chamber of Commerce for the construction, and control for a period of 75 years, of an outer and an inner harbour at that port. The estimated cost of the construction of the harbour is 8,000,000 francs (320,000*l.*).

Spain: The *Gaceta de Madrid* of August 21 contains a decree authorising the Ministerio de Fomento to invite plans for the construction of a railway from Estella, through Vitoria, to join up with the Durango-Zumárraga line at a convenient point between Los Mártires and Vergara. The same issue of the *Gaceta* contains a decree approving the project for the drainage of marsh land on the River Turón, in the Province of Málaga, at a total cost of 1,805,846 pesetas (about 66,883*l.*); of this amount 78,965 pesetas (about 2925*l.*) is allotted for expenditure on these works during the current year. The same issue of the *Gaceta* publishes a decree authorising the Ministerio de Fomento to make the necessary arrangements for the carrying out of irrigation works in the district of Santo Domingo de la Calzada by means of the waters of the Rio Glera, at an estimated cost of 138,052 pesetas (about 5113*l.*).

Argentina: The *Boletin Oficial* (Buenos Aires) of July 27 contains a copy of a decree, issued by the Ministry of Public Works, authorising the Dirección General de Irrigación to expend a total sum of 633,000 pesos currency (about 55,380*l.*) on irrigation works in the districts of Nonogasta, Sañogasta, and Malanzán, in the Province of La Rioja.

South Africa: The Imperial Trade Correspondent at Durban reports that the Durban Corporation's estimates of expenditure on public works for the year 1914-15 include the following items:—Hardening of roads, 20,000*l.*; municipal abattoir (completion), 17,000*l.*; infectious diseases hospital, 5000*l.*; storm-water drainage, 25,000*l.*; sewerage, 10,000*l.*; beach improvements, &c., 28,000*l.*; water works, 20,000*l.*; tramways construction, 23,000*l.*; telephone construction, 10,000*l.*; electrical work, 43,000*l.*; native brewery, buildings for use of natives, &c., 30,000*l.*

CONTRIBUTIONS TO THE HISTORY OF CORROSION.*

PART III.—COKE, CONDENSER-TUBES, AND CORROSION.

By ARNOLD PHILIP, B.Sc., F.I.C., A.M.I.E.E., Assoc. R.S.M. (Admiralty Chemist).

A NOVEL and, in the present writer's opinion, a quite erroneous departure from the views generally held on the theory of corrosion, is made by Messrs. Bengough and Jones in the second report to the Corrosion Committee of the Institute of Metals.†

The results of experiments obtained by Dr. Bengough whilst acting as an honorary investigator to the Corrosion Committee with his colleague, Mr. Jones, have led them to discard the views which, in common with most other students of corrosion, they had previously held upon what Dr. Bengough calls "a very fundamental part as regards the study of corrosion"‡—namely, upon the possibility of corrosion being caused in condenser-tube metal by contact with electro-negative particles in the presence of sea-water.

In the whole of their report the authors have only published the results of one quantitative experiment on the contact action of coke in the presence of sea-water upon the corrosion of condenser-tube material,§ and if the proof that this substance does not promote corrosion is to be understood as being demonstrated in the report, it can only be upon this slender quantitative basis, together with the description of some qualitative experiments, that their novel conclusions are founded.

The views of the authors on contact corrosion are necessarily scattered throughout a lengthy report dealing with many other matters, and on this account, and also because it is felt that in some respects their opinions have been expressed with ambiguity, the collection in the present paper of all those paragraphs in the second report which deal with contact corrosion is desirable. This course would in fact facilitate reference, and thus assist in arriving at as clear an understanding as possible of all the experiments on this subject as described by Messrs. Bengough and Jones. The exigencies of space have, however, proved prohibitive, and the reader must be referred to the second report itself as published in the Journal of the Institute of Metals, No. 2, 1913, vol. x., on the following pages:—41 to 44, 45, 49 and 50, 55 and 56, 68, 76, 78, 86, 91; and in the discussion on pages 96, 98, 102, 104, 106, 109, and 114.

From a perusal of this report the author's conclusions on the type of corrosion dealt with in the present paper may, it is considered, be fairly summarised as follow:—

Coke in firm contact with Admiralty-composition condenser-tube metal in either stagnant or running sea-water at ordinary temperatures exerts no material influence upon the amount of either general or localised corrosion, and causes no dezincification; but, on the other hand, in general slightly retards the speed of corrosion.

In summing up his views on this subject in the reply to the discussion on the second report, Dr. Bengough said (page 109):—

"Personally, in sympathy with a very large number of people, he had thought that carbon particles introduced at ordinary temperature might set up corrosion, and he had all along thought that carbon particles might cause dezincification. Until he had investigated the matter, he was persuaded that carbon particles were destructive to tubes; but he was bound to modify his opinion when he had carried out his experiments described in the report. He thought the experiments in question had served a good purpose if they only gave negative results as to the cause of corrosion. . ." And again on page 111: "Mr. Sumner seemed to adhere rather strongly to the opinion that particles had an injurious effect. Well, of course, the authors of the report could not expect the evidence in one paper would convince everybody. At the same time they thought that this matter formed a very fundamental part as regards the study of corrosion. He hoped that they would be able to add evidence to evidence until they managed to break down Mr. Sumner's scepticism on that point. It was rather difficult to know what particles to deal with. They had dealt with all the particles they could think of, and they would be glad to try experiments with any other particles that Mr. Sumner might suggest."

The views of Messrs. Bengough and Jones, as set forth above, are remarkable on many grounds, amongst which are the following:—

1. They are contrary to the investigator's previously-held views.

2. They are contrary to the general belief and experience of the very great majority of users and manufacturers of condenser-tubes, and also to the views of almost all scientific investigators.

3. They are contrary to theory as ordinarily accepted.

4. They are contrary to the view which the authors themselves, in common with most other authorities on condenser-tube corrosion, now hold, and, in fact, which they specifically support in Section III. of the report [ENGINEERING, September 5, 1913, page 341]—namely, that all relatively electro-positive metals, such as iron, steel, aluminium, and zinc, exert a protective influence over condenser-tubes with which they are in contact. For it is clear that this protective action by contact is identical in character with the corroding action produced by the contact of coke with brass.

5. They are based on the results of negative experiments, as Dr. Bengough pointed out on page 109:—"He thought the experiments in question had served a good purpose if they only gave negative results as to the cause of corrosion." To disprove a positive statement by the result of experiments yielding negative results is notoriously a matter of considerable difficulty, and in any case must necessitate a very large number of negative results.

6. The number of quantitative negative experiments which Messrs. Bengough and Jones publish in the report which are alleged to show that the contact of coke with condenser-tube metal in sea-water is not a cause which promotes corrosion, as has already been stated, amounts precisely to one. This result is given in the second report, page 43, on the second line of Table VII.

7. This single quantitative result appears to have been wrongly interpreted, or is, at any rate, of extremely doubtful validity, as will be shown later on, although possibly this may be due to a clerical error having been made.

8. It is generally admitted that localised pitting is usually most marked along the bottoms of condenser-tubes. The authors admit this on page 77, and the present writer has recently recorded the fact that in his experience 90 per cent. of the condenser-tubes which he had examined in which the piercing of the tube had occurred this piercing had taken place in the bottom of the tube. This localisation of the pitting can be readily accounted for if one admits the corroding effect of the contact of relatively electro-negative bodies at the bottom of the tubes; but if such contact corrosion does not take place, it becomes a good deal more difficult to account for.

On the above grounds alone the conclusions at which Messrs. Bengough and Jones have arrived on the effect of the contact of coke upon the corrosion of condenser tubes in sea-water appear to be open to very damaging criticism; but further than this the present writer's own experience over many years is diametrically opposed to these deductions as far as they refer to Admiralty composition tubes. In this connection the investigators make the following remark on page 20 of their report:—

"Arnold Philip has on more than one occasion emphasised his view that electro-negative particles of carbon, &c., are of special importance in promoting corrosion, but does not appear to have brought forward any detailed experimental work to support it, perhaps because it seemed to be such an eminently reasonable view."

This is a very just remark. The present writer was so convinced of the fact himself, and also so persuaded that everyone else was convinced that contact action was the generally acknowledged main cause of corrosion, that although he had made many experiments showing that the action took place with Admiralty composition tubes, and although he had no doubt whatever that it was perfectly easy to demonstrate it at any time, he had not put the results of any such experiments on paper.

As an entirely fresh view has now been put forward

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* Paper taken as read at the statutory meeting of the Institute of Metals, held on September 10, and submitted for discussion by correspondence up to September 30, 1914. Part I. appeared in ENGINEERING on January 19, 1912, and Part II. on March 14, 1913.

† Journal of the Institute of Metals, No. 2, 1913, vol. x., page 13. ENGINEERING, August 29 and September 5, 1913.

‡ *Ibid.*, page 111.

§ Vide Report, page 43, Table VII.

TABLE I.—RESULTS OF ALL THE CORROSION TESTS (TWENTY-SIX IN NUMBER) CARRIED OUT ON 70 : 30 BRASS IN SEA-WATER FOR THIRTY DAYS AS GIVEN BY MESSRS. BENGOUGH AND JONES IN SECOND REPORT TO THE CORROSION COMMITTEE OF THE INSTITUTE OF METALS.

No.	1 Length of Test-Piece in Inches.	2 Position of Test-Piece During Test.	3 Temperature at which Test was Carried out.	4 Volume of Sea-Water used, in Litres.	5 Concentration of Sea-Water Used.	6 Method of Using Sea-Water.	7 Percentage Loss of Weight by Corrosion in 30 Days.	8 Equivalent Loss of Weight in Grains per Sq. Ft. per 100 Days.	9 Reference to Second Report to Corrosion Committee, from which Results are Obtained. Figure or Table.	10 Page	11 Remarks.
1	2	Vertical near surface	Atmospheric	1.5	Normal	Stagnant in open beaker	0.18	—	Fig. 2	25	
2	2	Vertical near bottom	,,	1.5	,,	,,	0.14	—	Fig. 3	26	
3	3	Not stated	,,	1.5	,,	CO_2 bubbled through water	0.24	—	—	31	Calculated from figures given.
4	3	Horizontal	,,	1.5	,,	Stagnant in open beaker	0.24	62.48	Table IV.	35	
5	3	Vertical	,,	1.5	,,	,,	0.20	52.65	,,	35	
6	3	Horizontal	,,	4.0	,,	,,	0.21	49.99	Table V.	38	
7	3	,,	,,	4.0	,,	,,	0 22	51.39	,,	38	
8	3	,,	,,	1.5	1.5	,,	0.22	57.62	,,	38	
9	3	,,	,,	1.5	1.5	,,	0.20	53.01	,,	38	
10	3	,,	,,	1.5	2.0	,,	0.29	68.96	,,	38	
11	3	,,	,,	1.5	2.0	,,	0.33	80.42	,,	38	
12	3	,,	,,	1.5	4.0	,,	0.29	71.06	,,	38	
13	3	,,	,,	1.5	4.0	,,	0.32	81.36	,,	38	
14	2	Vertical near surface	,,	1.5	0.5	,,	0.12	—	Fig. 7	41	
15	3	Horizontal	,,	1.5	Normal	,,	0.54	134.5	Table VII.	43	Check test on the following two experiments.
16	3	,,	,,	1.5	,,	,,	0.25	64.34	,,	45	Corroded in contact with graphite and coke.
17	3	,,	,,	1.5	,,	,,	0.37	90.61	,,	43	Corroded in contact with clinker.
18	Not stated	Not stated	,,	1.5	,,	Air bubbled through	0.39	—	Fig. 8	46	
19	,,	Horizontal	,,	1.5	,,	Stagnant in open beaker	0.24	—	,,	46	
20	,,	,,	,,	4.0	,,	,,	0.22	—	,,	46	
21	,,	Vertical	,,	1.5	,,	,,	0.16	—	,,	46	
22	6	Horizontal	,,	4.0	,,	Water circulated	0.39	—	Fig. 9	47	
23	6	,,	,,	4.0	,,	,,	0.35	—	,,	47	
24	3	,,	,,	4.0	,,	Stagnant in open beaker	0.22	—	Fig. 10	53	
25	3	,,	40 deg. C.	4.0	,,	,,	0.18	—	Fig. 11	62	
26	3	,,	50 deg. C.	4.0	,,	—	0.39	—	,,	62	

formally in the Second Report to the Corrosion Committee, it is necessary to put on record what it is believed must be considered as forming a convincing proof of the correctness of the writer's views on this question. At least, in so far as it refers to 70 : 29 : 1 Admiralty alloy. But as a preliminary to describing the corrosion experiments which the present writer has himself carried out, it is desirable first to call attention in more detail to the results of the single quantitative experiment bearing upon the contact action of coke and brass which is published in the Second Report to the Corrosion Committee. This experiment, dealing with the contact action of coke and graphite on 70 : 30 brass, is described in Table VII. of the report, page 43.

With reference to this experiment, Table I., above, in the present paper shows the results of all the quantitative corrosion results of whatever character obtained by Messrs. Bengough and Jones from experiments on 70 : 30 brass in sea-water, as published in the second report, and gives all the details of these experiments arranged in a tabular form, together with references to the tables or figures in the report, and to the corresponding pages on which they are recorded. In column 7 of this table the percentage losses due to corrosion in thirty days, as calculated by the authors, are given; and in column 8 these results are recalculated into terms of loss in grains per square foot of corroded surface per 100 days in order to bring the figures into a form in which they can be compared with those obtained by the present writer, which are given later on in this paper. In some thirteen cases it has not been possible to recalculate Messrs. Bengough and Jones's figures on account of the fact that these have been taken from their curves. This remark refers to all the experiments, 1, 2, 3, 14, 18, 19, 20, 21, 22, 23, 24, 25, and 26.

Out of the whole of these twenty-six experiments there are only three which refer to corrosion by contact. These are numbered 15, 16, and 17. Number 15 gives the results of the corrosion of a piece of 70 : 30 brass by itself and without any contact with any other conducting body. This sample was intended to serve as a control or check test on experiments numbers 16 and 17, which consist of identical pieces of 70 : 30 brass, corroded in stagnant sea-water for the same period of time in contact respectively with coke and graphite in experiment 16, and with clinker and pyrites in experiment 17.

No experiments have been made by the writer of this paper upon the action of pyrites and clinker in contact with brass as affecting its corrosion in sea-water, and no further criticism need therefore now be made upon experiment No. 17. In the case, however, of experiments Nos. 15 and 16 dealing with the contact action of coke and graphite two remarkable facts must be pointed out. Firstly, the corrosion loss on the piece of tube corroded in contact with coke for thirty days in experiment No. 16—namely, 0.25 per cent.—is greater than the loss observed by the investigators on any other sample of 70 : 30 brass (with one exception) which was corroded under similar conditions—namely, in stagnant sea-water of normal composition at atmospheric temperature for thirty days; and the results of no less than nine such experiments are recorded, Nos. 1, 2, 4, 5, 6, 7, 19, 20, and 21; and yet it is upon the result of this single quantitative test on the action of coke that the investigators base their conclusion that no action takes place. The exception to this statement, which is referred to above, is experiment No. 15—namely, the check test-piece to the experiment on the effect of the contact of coke on corrosion.

Secondly, in experiment 15 the authors show the corrosion losses on the check piece of 70 : 30 brass in ordinary stagnant sea-water at atmospheric temperature, without any aeration or other special treatment, to be 0.54 per cent. by weight in thirty days, or 134.5 grains per square foot per 100 days. This corrosion loss is more than double the loss in thirty days on any other similarly corroded piece of 70 : 30 brass described in the investigator's report, and is nearly 50 per cent. greater than the corrosion loss observed by them in any of all the twenty-six experiments on 70 : 30 brass which they have described, even when they have accelerated the corrosion by aerating the water, circulating the water, using concentrated sea-water, or temperatures of either 40 deg. or 50 deg. Cent. The next highest results are, in fact, those given in the three experiments Nos. 18, 22, and 26. In each of these three, however, the corrosion loss is only 0.39 per cent. by weight in 30 days—that is to say, the most vigorous corrosion which the authors have been able to obtain by means of bubbling air rapidly through sea-water, as in experiment 18, or by circulating it rapidly at atmospheric temperatures, as in experiment 22; or by heating it to 50 deg. Cent. and aerating it as in experiment 26, was found by them to cause less than two-thirds of the corrosion which they found to occur in the check sample of 70 : 30 brass which was corroded in stagnant sea-water of normal strength in an open beaker at atmospheric temperatures for thirty days.

The above statements of fact concerning these experiments, it is considered, indicate the very high probability that a serious error—probably a clerical error—has occurred in making the determination of the corrosion loss on the check test-piece in experiment 15. If this is not the case, it is evident that any corrosion measurements of this nature must be useless in arriving at a conclusion as to the character of the real mechanism of corrosion, for the corrosion loss in thirty days in experiment No. 15 is more than 2¼ times as great as the loss found in the same time in experiment No. 4—namely, 0.24 per cent. by weight—which experiment is nevertheless identical in every respect as to the conditions of corrosion with those obtaining in experiment No. 15.

The one and only quantitative experiment upon the contact action of coke upon the corrosion of brass which Messrs. Bengough and Jones have published in the Second Report to the Corrosion Committee, and upon which they appear to have based their new theory of the unimportance of the contact of coke upon the corrosion of brass in sea-water, therefore would seem on examination to be one upon which but little reliance should be placed.

In order to demonstrate the nature of the acceleration in the corrosive action of sea-water upon brass caused by the contact of coke, the following quantitative experiments have been carried out.

Test-pieces of condenser-tube of Admiralty composition—copper 70, tin 1, and zinc 29—were prepared by cutting a 10-ft. length of tube in half longitudinally by a plane containing the axis. These lengths of tube were annealed at a low red heat, rolled flat, and cut up into test-pieces 3 in. long, which were then cleaned by means of emery, and were finally each filed to the same size, having a surface area of 6.32 sq. in. The results of the chemical analysis of this condenser tube are given in the first column of the following table:—

	Philip. Per Cent.	Bengough and Jones. Per Cent.
Copper	70.60	71.18
Tin	1.02	1.07
Lead...	0 31	0.28
Iron	0.22	0.21
Zinc, &c. (by difference)	27.85	27.26

The results of the analysis of the Admiralty composition condenser-tube used in the experiments made by Messrs. Bengough and Jones, and referred to on page 67 of the Second Report to the Corrosion Committee, are also given for comparison.

The test-pieces, prepared as described above, were stamped with identification marks, and were submitted to the action of sea-water under the following conditions:—

Series G.—Six test-pieces were placed in glass tubes in running sea-water for 60 days at atmospheric temperature in contact with coke.

Series H.—Six test-pieces were placed in glass tubes in running sea-water for 60 days at atmospheric temperature without contact with coke or any other substance, except the glass walls of the tubes.

Series K.—Six test-pieces were placed in glass tubes in running sea-water for 60 days at atmospheric temperature, in contact with pebbles of the same size as the pieces of coke used in contact with the pieces of condenser-tube in the experiments in series G.

Series M.—Six test-pieces of condenser-tube were suspended in running sea-water for 60 days in a vertical position by means of cotton threads.

The glass tubes in which the corrosion experiments in the three series, G, H, and K, were made consisted of what are known as "boiling tubes," namely, a large form of test-tube. These tubes are about 1½ in. in diameter and 7 in. long. At the bottom of each tube a circular hole of about ½ in. diameter was made by means of a blow-pipe. A sketch of one of these tubes is shown in Fig. 1, page 344.

In series H the brass test-pieces rested at their lower ends upon the bottoms of the tubes, and the tubes contained nothing but the test-pieces and sea-water.

In series G the lower ends of the test-pieces were packed round with pieces of coke of about the size of a split pea. The coke surrounded the test-pieces up to about their middle points. The coke was prepared by breaking up the ordinary material, and retaining only that portion which would pass through a sieve of ⅜-in. mesh, but which would not pass through a sieve of ⅛-in. mesh. Before use the sieved coke was well washed in Portsmouth tap-water and then in sea-water.

In series K the test-pieces were packed in the glass tubes precisely as in series G, but instead of using broken coke, the test-pieces were surrounded with pebbles which were of the same size as the coke fragments, and were packed round the test-pieces up to their middle points in precisely the same manner.

All the test-pieces in the four series G, H, K, and M were placed in the same corrosion tank, Figs. 2 and 3. This tank was made of teak, and contained 11.45 cub. ft. of sea-water, and was fed with fresh sea-water at the rate of about 8.9 cub. ft. per hour, so that the water was completely changed about eighteen times in 24 hours. The sea-water flowed into the tank in equal streams through ten pipes arranged at equal intervals along the top of one side of the tank. Each jet of water fell through the air for a distance of about 1 in. The water left the tank in eleven equal streams through openings arranged at equal intervals along the opposite side of the tank at the bottom. The positions of the openings by which the water entered and left the tank were staggered with regard to one another. By this arrangement a well-distributed current of aerated sea-water passed through the tank without the possibility of any dead spaces of stagnant water being formed. The equality of the ten streams of water flowing into the tank was adjusted by means of screw-clips on rubber tubes fitted to the nozzles of the tubes A, Figs. 2 and 3. The equality of the eleven outflowing streams of water was adjusted by bending the lead overflow pipes O, Fig. 2, higher or lower, as necessary.

The glass tubes, which contained the eighteen test-pieces forming the three series G, H, and K, were supported in teak racks fitted along that side of the tank into which the sea-water was entering. The racks were similar to large test-tube racks, but the lower ends of the glass tubes rested on the edges of circular holes in a teak board. A portion of the rack, with a tube in position, is shown in Fig. 1. These holes, although too small to permit the tube to pass through, allowed sea-water to flow freely either into or out of the holes in the bottoms of the glass tubes. The bottom openings of the tubes were about 2 in. from the bottom of the tank, whilst the upper ends or mouths of the tubes were 3 in. below the surface of the sea-water in the tank.

The test-pieces in series M were suspended vertically on cotton threads, which were tied round their middle line. They were hung from a suitable glass-rod support at a distance of about 6 in. below the surface of the water.

The sea-water which flowed through the corrosion-tank flowed by gravity into the tank from the salt-water tank over the fire-engine house in Portsmouth Dockyard. This tank has a capacity of 174,720 gallons, and is fed by a pump from the tidal basin at the rate of approximately 448,000 gallons per diem. The water is therefore Portsmouth Harbour water. No streams flow into Portsmouth

Harbour, and the water is actually of the same composition as the sea-water at Spithead.

The results of the chemical analysis of the sea-water used are as follow :—

Reaction to litmus	Alkaline
Specific gravity at 17.6 deg. Cent. ...	1.026
	Parts per 100,000.
SiO_2	0.5
Al_2O_3 and Fe_2O_3	0.5
CaO	194.0
MgO	86 47
Cl_2...	2044.0
SO_3...	225.0
Total CO_2	9.8

For comparison it may be noted that the sea-water used by Messrs. Bengough and Jones, as calculated from the results of analysis given on page 68 of the second report to the Corrosion Committee, contained 1942.9 parts of chlorine per 100,000, and possessed a specific gravity at 17.6 deg. Cent. of 1.0225. This sea-water, obtained at Formby at a point well outside the mouth of the River Mersey, was therefore about 5 per cent. weaker than that used at Portsmouth.

The test-pieces in all the four series of tests were weighed before test and the area of their surfaces measured. At the completion of the tests they were removed from the sea-water, at once rinsed under the tap, and five of the six in each series were then vigorously scrubbed with a hard nail-brush. This treatment removes all but a very thin and tightly-adhering layer of cuprous oxide. The test-pieces were then finally dried and weighed.

The numerical results obtained in those four series of tests are given on Table II., and a summary of the mean results is shown on Table III.

TABLE II.—*Corrosion Tests in Running Sea-Water at Atmospheric Temperature: Composition of Test-Pieces —Admiralty Condenser-Tube: Copper* 70, *Tin* 1, *Zinc* 29 ; *Duration of Corrosion, Sixty Days ; Area of Test-Pieces*, 6.32 *Sq. In.*

1	2	3	4	5	6	7
Description of Method of Test.	Mark on Test-Piece.	Weight of Test-Piece when Put into Tank (in Grammes)	Weight of Test-Piece when Taken out of Tank after being Cleaned (in Grammes).	Total Loss of Weight of Test-Piece Due to Corrosion (in Grammes).	Loss of Weight of Test-Piece as Percentage on Original Weight.	Loss of Weight of Test-Piece in Grains per Square Foot per 100 Days.
Series G.						
Test-pieces contained in glass tubes. The lower halves of the test-pieces being packed round with pieces of coke	G 1	15.8386	15.2558	0.5828	3.679	341.4
	G 2	16.3236	15.5197	0.8039	4.924	471.0
	G 4	15.4838	14.7228	0.7610	4.914	445.9
	G 5	15.8390	15.0606	0.7784	4.914	456.0
	G 6	15.7296	15.0760	0.6536	4.155	382.9
	Mean loss of weight on G test-pieces ..			0.7159	4.517	419.4
Series K.						
Test-pieces contained in glass tubes. The lower halves of the test-pieces being packed round with pieces of stone of the same size as pieces of coke used in experiments in Series G.	K 1	17.6386	17.6110	0.0276	0.156	16.17
	K 2	16.7622	16.7346	0.0276	0.164	16.17
	K 3	16.9020	16.8736	0.0284	0.169	16.60
	K 4	16.2755	16.2450	0.0305	0.187	17.86
	K 6	16.5895	16.5590	0.0305	0.183	17.86
	Mean loss of weight on K test-pieces ..			0.0289	0.172	16.93
Series H.						
Test-pieces contained in glass tubes similar to those used in Series G and K, but containing no coke or stones or other material.	H 1	16.1393	16.0906	0.0487	0.3017	28.53
	H 2	16.3603	16.3166	0.0437	0.2671	25.61
	H 4	16.6420	16.5918	0.0502	0.3016	29.41
	H 5	18.3225	18.2705	0.0520	0.2838	30.47
	H 6	16.1782	16.1235	0.0547	0.3381	32.05
	Mean loss of weight on H test-pieces ..			0.0498	0.2984	29.21
Series M.						
Test-pieces suspended vertical by means of cotton thread tied round longer axis of test-piece.	M 1	15.6132	15.5790	0.0382	0.244	22.39
	M 3	16.3060	16.2682	0.0378	0.232	22.15
	M 4	15.3610	15.3254	0.0356	0.232	20.85
	M 5	15.8862	15.8484	0.0378	0.237	22.15
	M 6	16.5520	16.5180	0.0340	0.205	20.33
	Mean loss of weight on M test-pieces ..			0.0367	0.230	21.59

Table IV. gives all the results of quantitative sixty-day corrosion tests made by Messrs. Bengough and Jones with Admiralty-composition condenser-tube, which they have recorded in the Second Report. These results are necessarily taken from the curves given in the report, and in each case the number of the figure and the corresponding page in the report are quoted. These results are of interest for comparison with the similarly calculated percentage sixty-day corrosion losses given in column 6 of Table II. in this paper. They are, on the whole, closely similar, but are slightly higher than the results obtained in the tests made in series H, which vary from about 0.27 per cent. to about 0.34 per cent.

It will be noticed that although six tests were made in each of the series of tests G, H, K, and M, only five results from each series appear in the Tables II. and III. This is on account of the fact that, as stated above, in each series one of the test-pieces was not cleaned after corrosion, but was merely rinsed in a stream of tap-water and then dried. The four test-pieces thus treated, one from each of the four series G, H, K, and M, have been preserved in stoppered glass bottles, and are exhibited during the reading of this paper in order to afford an ocular demonstration of what is partly shown in the photographs in Figs. 4 and 5, and partly in the numerical results in Tables II. and III.

The corroded test-pieces in series H and G are shown in the photographs, page 345. The scale of the test-pieces and also the sharpness of their focussing is indicated by the postage stamps shown in each photograph. Fig. 4 is a photograph of the six test-pieces used in series H, and the six used in series G, photographed together after corrosion for sixty days, and after they had merely been rinsed in a stream of tap-water and dried on blotting-paper. The lower six test-pieces in the line marked B are test-pieces from the series G, which have been corroded in contact with coke, and the heavy scale of corrosion products is seen adhering to the underlying metal in a thick incrustation. The upper line of test-pieces marked A are the six test-pieces from series H, which were corroded out of contact with coke or any other material except the glass walls of the tube. All these twelve test-pieces were photographed immediately after they were withdrawn from the corrosion tank after a sixty days' corrosion. Both the G and H series of test-pieces were not only corroded under precisely the same conditions as to time and method of support, but, except as limited by their method of support, they were also under precisely the same conditions as to velocity of flow and aeration of sea-water and also temperature, for they were all put into the corrosion tank on the same day and were all removed on the same day.

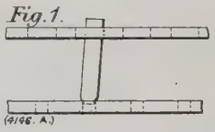


FIG. 1.—Sketch of a portion of wooden rack in corrosion tank, showing glass tube for containing samples under corrosion. Scale about one-twelfth full size.

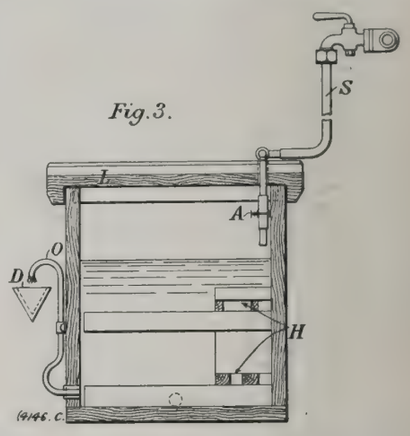


FIG. 3.—Transverse section of sea-water corrosion tank at Portsmouth Dockyard. The lettering is the same as in Fig. 2.

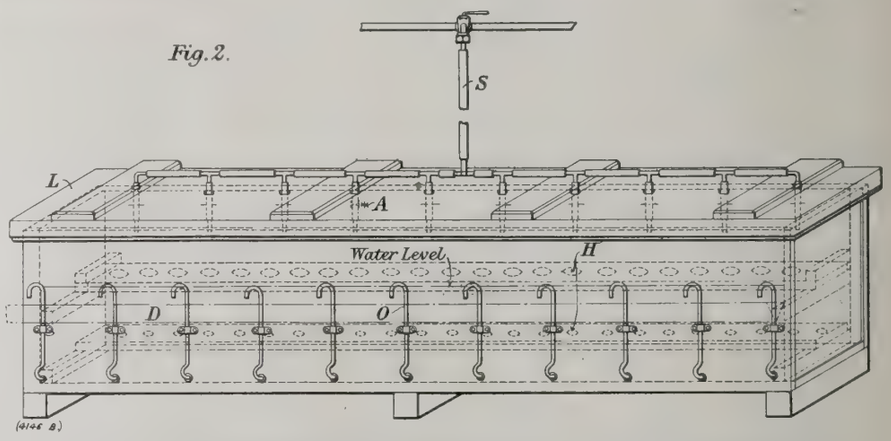


FIG. 2.—General view of sea-water corrosion tank at Portsmouth Dockyard. Scale about one-twentieth full size.

S. Salt-water supply-pipe.
L. Lid of tank.
H. Holes in wooden rack for holding glass tubes containing samples under corrosion.
O. Overflow pipes for carrying off waste sea-water.
D. Trough for carrying off overflow water.
A. Entry-pipes for sea-water controlled by screw-clips.

TABLE III.—*Summary of Means of Results of Corrosion Tests at Atmospheric Temperature in Running Sea-Water on* 70 : 1 : 29 *Condenser-Tubes Made in Series G, K, H, and M, as given on Table II.*

1	2	3	4	5
Series.	Mean Total Loss of Weight in Sixty Days in Grammes on Five Tests.	Mean Percentage Loss of Weight in Sixty Days on Five Tests.	Mean Loss of Weight Expressed in Grains per Square Foot of Surface Corroded per 100 Days on Five Tests.	Relative Corrosion Velocities.
G in glass tubes in contact with coke ..	0.7159	4.517	419.4	24.7
K in glass tubes in contact with stones	0.0289	0.172	16.93	1.0
H in glass tubes with no other material ..	0.0498	0.2984	29.21	1.7
M suspended by cotton thread	0.0367	0.230	21.57	1.3

Fig. 5 shows a photograph of five of each of the same F and G series of test-pieces as are shown in Fig. 4, but after having been scrubbed with a hard nail-brush in water. The surfaces here shown are the metal surfaces, or are, at any rate, the metal surfaces coated with a thin and tightly-adherent film of copper oxide. The entire absence of pitting of the metal in the H series of tests (in the line marked A), corroded out of contact with coke for sixty days, is easily seen ; whilst the heavy pitting which has occurred in the same time in the samples in the G series of test (in the line marked B), corroded in contact with coke, is also clearly shown.

The reason that photographs of only five samples of both Series G and H are shown in Fig. 5 is because one of each of these series was not cleaned after corrosion, but was retained for direct inspection in its condition precisely as removed from the corrosion-tank. All the samples (five in each Series G, H, K, and M), after corrosion and cleaning, have also been preserved in stoppered bottles for direct inspection.

A careful inspection of the photographs in Figs. 4 and 5, and of the actual samples themselves which are now exhibited, together with a consideration of the numerical results of corrosion losses given in Table II., must, it is considered, give convincing proof that the contact of coke with Admiralty-composition condenser-tube in running sea-water at ordinary temperatures may be the cause of extraordinary violent acceleration of corrosive action. The summary of the numerical corrosion results given in Table III. shows that the mean corrosion velocity in contact with coke, as shown by these results, is 24.7 times as great as the mean corro-

TABLE IV.—*Results of all the Corrosion Tests Carried Out on Admiralty-Composition Condenser-Tubes in Sea-Water at Atmospheric Temperature for Sixty Days, as Obtained from the Figures Published by Messrs. Bengough and Jones in the Second Report to the Corrosion Committee of the Institute of Metals.*

1	2		3	4	5	6	
No.	Length of Test-Pieces in Inches.	Position of Test-Piece.	Concentration of Sea-Water.	Method of Using Sea-Water.	Percentage Loss of Weight by Corrosion in 60 Days.	Reference to Second Report to Corrosion Committee, from which Results are Obtained.	
						Figure.	Pages
					p.c.		
1	2	Vertical, ½ in. below surface	Normal	Stagnant in open beaker	0.415	2	25
2	2	Vertical, 3 in. below surface	,,	,,	0.370	3	26
3	3	Horizontal, 1 in. below surface	,,	,,	0.360	5	36
4	2	Vertical, ½ in. below surface	0.5	,,	0.240	7	41

sion velocity of precisely similar test-pieces of condenser-tubes in Series K, which were packed in precisely similar tubes, the only difference being that, instead of the coke fragments used in Series G, small pebbles of the same size as the pieces of coke were used for packing round the lower ends of the test-pieces. These four series of experiments, in fact, demonstrate that when the condenser-tube material is corroded out of contact with coke in various ways, its mean corrosion velocity varies from 1 to 1.7, according to the freedom with which the sea-water can circulate round the test-pieces; but when corroded in contact with coke, the corrosion velocity

FIG. 4.—Samples of condenser-tube A from series H after corrosion in sea-water for thirty days, out of contact with coke, and B from series G corroded under similar conditions, but in contact with coke. These samples were merely rinsed in tap-water after corrosion, and were then dried and photographed.

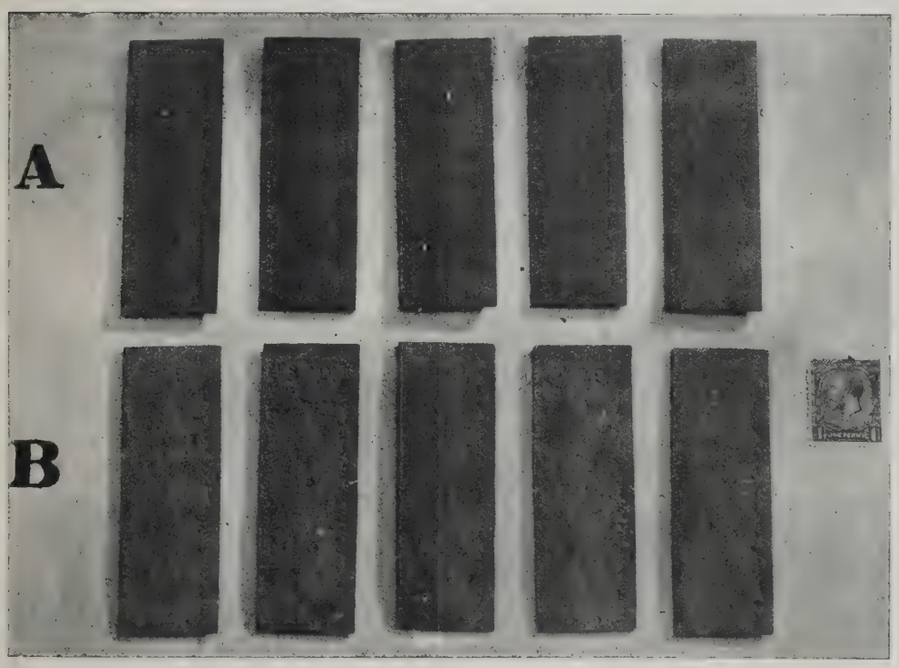


FIG. 5.—The same samples of condenser-tube as are shown in Fig. 4, but after removal of corrosion incrustation by scrubbing with a stiff brush.

at once rises to nearly 25. But further than this, many dozens of qualitative experiments have also been made with fragments of coke tied with cotton on to Admiralty-composition condenser-tube test-pieces, which have then been immersed in ordinary sea-water, both stagnant and running, and both at atmospheric temperature and at temperatures up to 50 deg. Cent., and in every case accelerated corrosion has been caused, and what appears to be dezincification has been observable within two days, even in tests carried out with sea-water at the ordinary temperature; but the action, as might be expected, is accelerated at higher temperatures.

With regard to the appearance of dezincification areas, it must be noted that when this occurs in thin layers it may be doubted whether the difference between a thin layer of copper and a thin layer of cuprous oxide, or of a layer of a mixture of the two substances, can be clearly discriminated. As far as the present writer is able to decide, a thin layer of copper is always formed within forty-eight hours when coke is in contact with Admiralty condenser-tube in sea-water at ordinary temperatures. Probably a real decision as to the difference between a thin layer of metallic copper, or a mixture of copper and cuprous oxide, and a thin layer of cuprous oxide, can only be definitely fixed by optical reflection methods of test. However, as to whether dezincification takes place or not is a side issue in the present case, and does not affect the important main conclusion, which cannot be doubted—namely, that the contact of coke with Admiralty condenser-tube material in sea-water accelerates corrosion at all temperatures, and not only accelerates it, but accelerates it far more markedly than any of the other causes of acceleration which have been pointed out in the Second Report to the Corrosion Committee.

This conclusion as to the accelerating effect of coke on corrosion is nothing new; it has been within the knowledge of all engineers dealing with corrosion, and especially with the corrosion of condenser-tubes, for very many years, and, in fact, long ago attained the status of an ancient and respected truism. But what can explain the quite contradictory results obtained by Messrs. Bengough and Jones? The temperatures are the same, the composition of the water and of the condenser-tube metal is practically the same, as far as analysis can show. In the present writer's opinion, the reason for the discrepancy must be sought in the fact that the result of only a single quantitative experiment has been used upon which to base the authors' conclusions. This single quantitative result may possibly be invalidated by some clerical error, or it may itself be correct, and the singularity of this negative result may be of interest as pointing to some unrecorded, but important, factor coming into action in this one instance. If this is so, it may prove an important matter for investigation. But in any case, whatever reason there may be for the unusual character of the single quantitative observation made by Messrs. Bengough and Jones, it is negative in its character, and it cannot in any way upset a single well-confirmed positive demonstration that the contact of coke with Admiralty condenser-tube metal in sea-water does accelerate corrosion.

In conclusion, the author would again emphasise the importance of the following points:—

1. The acceleration of corrosion in sea-water by contact with coke is a very real and important cause of trouble in condenser-tubes.

2. Experiments made to decide any point concerning corrosion should be made in large numbers. There is probably no field for investigation in which a cautious statistical method of attack is more desirable.

3. The observations obtained from engineers actually using the apparatus in which corrosion is a cause of trouble are, in general, of much importance, and should be most carefully considered. Nor should they be hastily discarded as incorrect, except after, at least, being subjected to a reasonably detailed experimental examination. It is, in fact, of much importance to enlist the interest and assistance of engineers in the elucidation of corrosion problems.

The author has much pleasure in recording his indebtedness to Mr. Wycliffe Killner for carrying out the quantitative experimental work recorded in this paper.

COMMERCIAL YEAR-BOOK, BIRMINGHAM.—We have received from the Birmingham Chamber of Commerce a copy of the fifth issue, 1914, of their year-book. It gives information on the numerous industrial resources of the city of Birmingham and the neighbouring districts. It is issued to all parts of the world—the war area omitted—and should prove invaluable for recovering trade. It contains a large amount of statistical data on our imports and exports, shipping, metallurgy, industry, agriculture, &c., a guide for patentees, a directory of Birmingham manufacturers and traders, and a quantity of carefully-illustrated advertisements.

THE MUNICIPAL TECHNICAL INSTITUTE, BELFAST.—The prospectus for 1914-15 of this Institute has reached us. Most of the evening classes will open on Monday, the 14th, as will also the "Day Engineer Apprentice Course." Other courses commence on September 28, 29, and 30, and October 5. The general course extends over three years, becoming more and more specialised. Apprentices can arrange to take part of a course on Mondays, and many employers grant leave to attend the Institute on that day. The course includes mechanical engineering, physics and electrical engineering, building and furnishing trades, textile industries, pure and applied chemistry, commerce, printing trades, and various trades.

CANADIAN RAILWAY WORKING.—At the close of June this year the Canadian Pacific Railway Company owned 2248 locomotives, 2174 first and second-class passenger cars, baggage cars, and colonist sleeping cars, 502 first-class sleeping, dining, and café cars, 96 parlour, official, and paymaster cars, 88,090 freight and cattle cars, 1427 conductors' vans, and 5850 boarding, tool, and auxiliary cars, and steam shovels. The aggregate distance run by trains in the year ended June 30, 1914, was 47,578,236 miles, as compared with 51,832,790 miles in 1912-13. Passenger trains ran 21,523,630 miles, as compared with 22,333,592 miles; freight trains, 24,164,242 miles, as compared with 27,611,103 miles; and mixed trains, 1,890,364 miles, as compared with 1,888,095 miles. The contraction observable in the train movement in 1913-14 was due to a falling off in traffic, and a consequent necessity of reducing expenses. The ratio of the working expenses to the traffic receipts in 1913-14 was 67.32 per cent., as compared with 66.82 per cent. in 1912-13. In the course of last year, 259,371 acres of the company's agricultural land were sold for 4,618,420 dols., showing an average of 17.80 dols. per acre. In view of the very considerable expenditure made for rolling-stoock in the four years ended 1912-13 the directors considered that it was advisable to spread the payments for the corresponding deliveries in 1913-14 (representing about 14,000,000 dols.) over a period of fifteen years under an ordinary equipment trust agreement. A contract was made accordingly with the Victoria Rolling-Stock and Realty Company to provide the equipment and receive payment in fifteen annual instalments with interest at the rate of 4½ per cent. per annum. The expenditure made on capital account for additions and improvements in 1913-14 amounted to 25,891,278 dols. In this aggregate Eastern lines figured for 5,881,334 dols., and Western lines for 16,409,648 dols.; the balance was principally represented by a double-track bridge over the St. Lawrence and additions to office buildings and hotels. The gross earnings on revenue account in 1913-14 were 129,814,824 dols., while the working expenses of the year were 87,588,896 dols.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

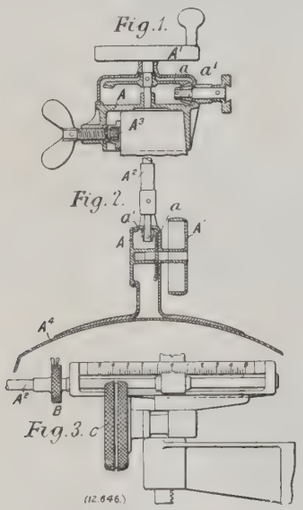
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

GUNS AND EXPLOSIVES.

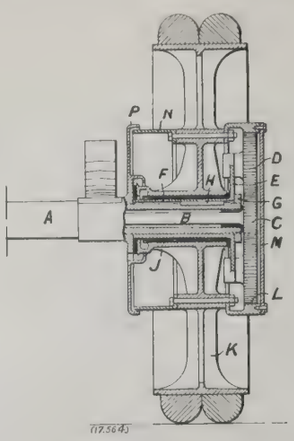
12,646/13. Sir A. T. Dawson and G. T. Buckham, London. Sighting of Ordnance. [3 *Figs.*] May 30, 1913.—This invention relates to the sighting of ordnance in which the sight is set by an independent observer, and has particular reference to those guns that are adapted to fire at high angles of elevation. In such guns it has been found difficult for the gun-layer to follow the course of the projectile, or to observe the point of impact, and at the same time to keep the sight on the object aimed at. According to this invention, the setting of the sight by the independent observer, who may be stationed in a convenient position, such that he can observe the effect of the gun-fire, is effected by means of a portable instrument having a handle or hand-wheel, which is connected to the setting mechanism of the sight by a flexible shaft or the like. The instrument comprises a casing A carrying a handle or hand-wheel A^1, which is connected, preferably through bevel-gearing *a*, a^1, to the flexible shaft A^2, which, in turn, is connected either to the deflection-setting mechanism of the sight or to the range-setting mechanism. If desired, the instrument may be provided with two handles or hand-wheels, one of which controls the deflection-setting mechanism, and the other the range-setting mechanism of the sight, so that



one observer can perform the deflecting and elevating operations. If desired, however, two separate instruments may be employed, for the use of two observers, one observer deflecting and the other elevating the sight as required; the flexible shaft A^2 may be so arranged that it can be readily disconnected either from the instrument or from the sight-setting mechanism, or from both these parts. It is to be understood that, although the observer has full control of the setting of the sight, the gun-layer can, if necessary, operate the deflection and range-setting mechanism as heretofore by means of the hand-wheels B, C respectively (Fig. 3). The amount of adjustment given to the sight may be determined by the number of turns of the hand-wheel, one turn representing a known definite correction. If the instrument is used at some little distance from the sight—*e.g.*, on an observation-post or wagon—graduations may be provided on the instruments corresponding to those on the range or deflection-scales of the sight. In the construction shown in Fig. 1, the instrument is attached by means of a clamp A^3 to the gun-carriage wheel, and in the construction shown by Fig. 2 it is attached to the observer's waist by means of a belt A^4, thus leaving one of his hands free to hold his field-glasses. (*Sealed August* 13, 1914.)

MOTOR ROAD VEHICLES.

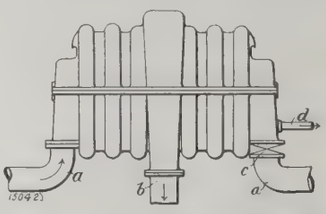
17,564/13. J. F. Henderson and Albion Motor-Car Company, Limited, Glasgow. Motor-Road Vehicles. [1 *Fig.*] July 31, 1913.—This invention relates to rear axles and driving-gear particularly intended for use in heavy motor vehicles where a great reduction in speed is required between the engine and the driving-wheels, and is of the type in which motion is transmitted to the driving-wheels from driving-shafts through the medium of toothed gearing within the driving-wheels, the invention having for its object to provide an improved combination and arrangement of such rear axles and driving gearing. The type of axle to which the invention relates specifically is that in which there is a "live" axle of the usual type having tubular fixed parts, on the opposite ends of which the two rear or driving-wheels are mounted, and through which two driving-shafts extend. These driving-shafts are connected at their inner ends to the differential gear, and at their outer ends they each carry a pinion all in known manner. This pinion gears with a series of planetary pinions turning on spindles carried by a disc or spider fixed to the tubular axle part. The disc pinions gear in turn with an internally-toothed wheel on an annular flange extending out laterally from the spokes of the driving-wheel. According to the invention, the spider referred to is fixed at the extreme outer end of the tubular axle part beyond the road-wheel hub. The road-wheel may be mounted to rotate directly upon the tubular axle part, or upon a sleeve extending inwards from the spider, and which itself is directly upborne by the tubular part—the load of the wheel being thus in either case transmitted directly to the tubular fixed axle end, and not borne either in whole or in part by the inner driving-shafts. Within the usual tubular fixed part A of a live axle is a differential or driving-shaft B having at its outer end a pinion C. This pinion gears with a series of planetary pinions D mounted on axis-pins on a spider E. The spider E has on it a sleeve F, by which it is mounted on the extended end of the part A, it being held in position by a nut G on the latter, and prevented from rotation by a feather H engaging grooves in it and the latter. Upon this sleeve F, and thus virtually upon the



extended axle, is mounted the bushed hub J of the road-wheel K. The road-wheel carries an internally-toothed ring L engaged by the planetary pinions D. Thus a non-epicyclic reduction is given between the shaft B and the road-wheel K in the ratio of the diameter of the pinion C to that of the ring L. For the exclusion of dust and to retain lubricant, a cover M is fitted to the ring L, while the usual brake-drum N, closed at its inner end by a fixed disc P, which serves to carry the brake, coacts with a central filling-web in the wheel to totally exclude dust and prevent the leakage of oil from the inner end of the hub. (*Sealed August* 13, 1914.)

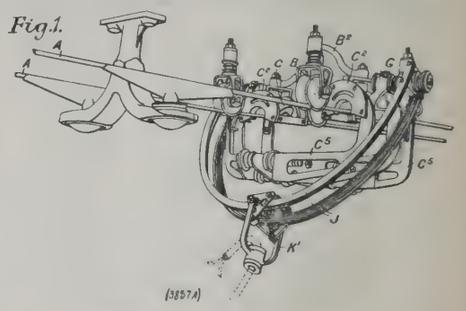
PUMPS.

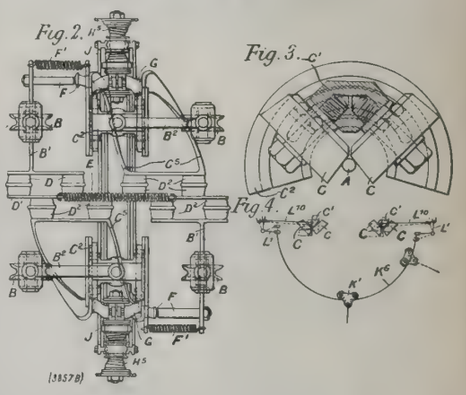
5042/14. Aktiengesellschaft Brown, Boveri et Cie., Baden, Switzerland. Turbo-Compressors. [1 *Fig.*] June 30, 1913.—This invention relates to the operation of turbo-elastic fluid-compressors or liquid pumps, hereinafter referred to as turbo-compressors. Such compressors, working with a low pressure, and delivering a large quantity of fluid, are, as a rule, double-ended—that is to say, they are provided with two suction branches and one common delivery branch. In many cases, and particularly in connection with the working of blast-furnaces, if the charge "hangs," or does not feed properly, it is necessary temporarily to increase the pressure to a considerable amount beyond the normal pressure. On such an increase in the pressure, however, without correspondingly increasing the volume delivered, turbulence occurs. For this reason one is frequently compelled also to increase the volume of air delivered as well as the pressure. This necessitates a great increase in the output, and it is therefore necessary to design the driving-engine for such an increased output. The object of the present invention is to provide a method whereby a high pressure may be obtained temporarily without involving an increased output, so that it is unnecessary to design the driving-engine with abnormal dimensions. The invention consists in increasing the pressure in double-ended turbo-compressors by wholly or in part shutting off one half of the compressor, so that it gives practically no delivery when a temporary increase of pressure is to be obtained. In the diagrammatic drawing, which illustrates one manner of carrying the invention into effect, a compressor is provided with a suction branch *a* at each end and a common delivery *b* in the middle. A damper *c* is arranged in the suction conduit *a* of one-half of the compressor. In operation, when a high pressure is to be attained, the damper *c* is closed. In that case only the other side will remain in operation. The delivery output will be reduced to one half or even to less, and as regards the shut-off end only the no-load losses occur therein. It is a well-known fact that the pressure of a working turbo-compressor is considerably higher than the pressure produced by the same when running idle—that is, under no-load. For this reason a pressure above atmospheric pressure, originating from the working half or end of the compressor, will obtain in the closed suction branch. By opening a branch conduit *d*, so that a communication is established between the closed suction branch and the atmosphere, it is possible to set up a current or circulation in the closed end or half of the blower in the opposite direction, thus removing the heat generated by running idle. (*Sealed August* 13, 1914.)



RAILWAYS AND TRAMWAYS.

3857/13. E. M. Munroe and the R.E.T. Construction Company, Limited, London. Railless Traction. [9 *Figs.*] February 14, 1913.—This invention relates to trolleys for electric-traction systems, and has particular reference to "over-running" trolleys, that is, those which rest upon and travel on top of aerial conductors, the connection between the trolley and the vehicle being usually in the form of a flexible cable coiled upon a spring paying out drum on the vehicle. An over-running trolley, according to this invention, comprises a frame having pilot-wheels which normally remain substantially vertical, and one or more other wheels or runners so mounted in the frame that they may be turned according to the position of the vehicle relatively to the line of the conductors. The overhead conductors A are supported on insulators from brackets in the usual manner. The trolley carriage is supported on the conductors by pilot-wheels B and by runners, each comprising two gripping-rollers C. The disposition of the gripping-rollers relatively to the conductor is shown in Fig. 3, where it will be also seen that the spindles upon which the rollers are mounted are screwed into a block C^1, which is capable of movement in circular guides made for it in what may be termed running-frames C^2. These trunnion-frames C^2 form part of the frame of the trolley. It will be seen that the block C^1 upon which the roller spindles are mounted is furnished at each end with a pin or stud, which projects through a slot in the trunnion plate or frame, and forms the means of attachment for operating mechanism. The plan of the trolley-frame or carriage forming Fig. 2 of the drawings illustrates the fact that the frame comprises two triangles, each supported on the conductors at three points. One triangular portion comprises the two left hand pilot-wheels B, with their supporting brackets B^1 and B^2, and one pair of gripping-rollers C, with their trunnion-frames C^2 and the arms or brackets C^5 supporting the trunnion-frames. The other triangle is precisely similar, and is constituted by the corresponding members shown on the right-hand portion of Fig. 2. Each triangular portion has necessarily to be in two parts, electrically insulated, though joined mechanically, and it will be seen that the bracket B^1 is connected through insulators D to a dead plate D^1, which, again, is joined through insulators D^2 to the bracket C^5. The two dead plates D^1 are joined by a towing-spring E, which thus serves to connect mechanically the two triangular portions of the trolley-frame. Stops F and auxiliary springs F^1 are provided, serving normally to keep the two pilot-wheels on each side and the runner between them in alignment. This construction enables the frame to open out against the tension of the springs E and F^1, and thus to facilitate the trolley-frame turning curves in the line of conductors. As a further means to the same end, and to allow for some variation in the gauge—that is, the distance separating the two conductors A—some amount of lateral play on their axes is allowed to the pilot-wheels B. Secured to the brackets C^5, or to some adjacent part of the frame, are lugs G forming a support for a sleeve. Upon this sleeve, but insulated from it by another sleeve and washers, is yet another sleeve. Sliding on the lastly-mentioned sleeve is a spherical bearing to which the end of a semi-circular frame or bridle J is attached.





The bearing is normally kept centrally in relation to the sleeve by means of volute springs H^5. It will be understood that this arrangement for the spring support for the end of the bridle is provided at each end of that member, which can thus swing practically through a hemisphere below the line of the conductors, and is also capable of limited transverse motion relatively to the conductors against the action of the volute springs H^5. The members J forming the bridle are grooved on each side to accommodate friction-rollers, which are mounted on a shackle or carriage K^1. In addition to the friction-rollers, the shackle is provided with a spindle carrying two pinions, the teeth of which engage with the teeth of racks; one of the racks is secured to one of the members J of the bridle, and the other rack is held in guides attached to the other member J, so that it can move relatively to the bridle, although it is constrained to move in a certain path. The pinion which engages with the fixed rack has more teeth than the pinion which engages with the movable rack. Thus, if the shackle or carriage K^1 be moved along the bridle J, the movable rack will be caused to move relatively to its seating one way or the other, according to the direction of motion of the carriage. This movement of the rack is caused to move the runners C in the trunnion-frames C^2 by means of mechanism diagrammatically shown in Fig. 4. On the first-mentioned sleeve is mounted a bracket L carrying at its free end a forked bell-crank lever L^1. One end of this lever engages by means of a pin with a slotted crosshead attached to the end of the movable rack K^6. The other forked end of the bell-crank lever L^1 is indirectly connected to rods L^{10}, which are connected to the ends of the blocks C^1. All the parts are mounted upon the first-mentioned sleeve carried by the bracket G, and are held rigidly together by means of a bolt and nuts. The position in full lines represents the relative positions of the parts when the shackle is central with regard to the bridle—that is, the position which it would occupy if the vehicle were running directly beneath the line of conductors. The dotted position shows the shackle drawn round nearly to the top of the right-hand side of the bridle, and the consequent movement in the opposite direction of the rack K^6. This movement of the rack turns the forked bell-crank lever L^1, and a pull is transmitted through the connecting-rods L^{10} to the block C^1, which moves round in the trunnion-frame C^2, so that the rollers C take up their new position. Naturally, as one end of the movable rack rises the other descends, and consequently the rollers C on the other side of the trolley are rotated through a similar angle. (*Sealed July* 20, 1914.)

THE DISTRIBUTION OF STRESS AND STRAIN IN A REINFORCED-CONCRETE BEAM SUBJECT TO BENDING.

By F. C. LEA, D.Sc. (Professor of Civil Engineering in the University of Birmingham), and O. H. CROWTHER, M.Sc.

THERE have been a very large number of experiments carried out to determine the breaking load of reinforced-concrete beams, slabs, and columns, and a considerable amount of data has been accumulated.

In making calculations relative to beams or columns, nearly all equations involve the relationship between the modulus of elasticity of the concrete and that of the steel in the compound structure, and the degree of confidence that can be placed in the calculations is dependent, to a certain extent, upon the accuracy of the assumed ratio.

The recent regulations of the London County Council give the modular ratio for steel and concrete as follows :—

Proportion by Volume.			Modular Ratio, m.
Cement.	Sand.	Coarse Material.	
1	2	4	15
1	1½	3	11
1	1	2	8

This is presumably for a concrete ninety days old.

Furthermore, it is generally assumed, in making the calculations, that the concrete in a beam is capable of resisting compressive stresses, and that these stresses vary uniformly from the neutral axis, but the power of concrete to resist tensile stresses in a beam is generally assumed to be so small that it can be neglected.

Fig. 1.

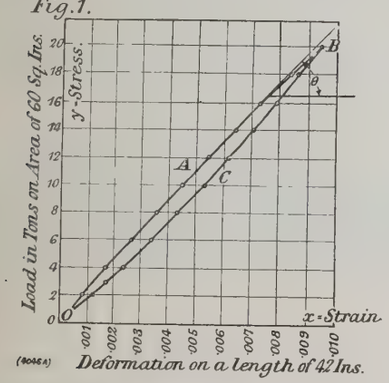
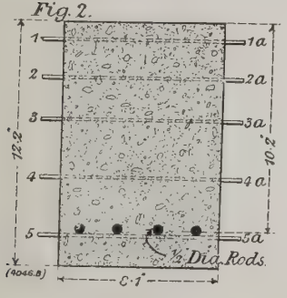


Fig. 2.



The published results on the elasticity of concrete show that it varies considerably with the richness of the mixture, the amount of water used in mixing the concrete, and also with the stress per square inch ; that is, the modulus of elasticity does not remain constant for concrete as it does for a piece of steel.

Fig. 1 shows the stress-strain curve for a plain 1 : 2 : 5 concrete column, 4 ft. long and sectional area of 60 sq in., when subjected to compression after an interval of four months from gauging. For increasing loads the stress-strain curve is O A B, and for decreasing loads B C O. The modulus of elasticity at any point is $\frac{d\,y}{d\,x} = \tan\theta$; as will be seen from the figure, this varies with the stress. For calculations it is more convenient to take the deformations caused by finite changes in load. On this basis it is equal to the change of stress per unit area divided by the change in the deformation per unit length produced by the change of stress. For this column the modulus of elasticity at a stress of 750 lb. per sq. in. based on the total deformation has a value of 3,290,000 lb. per sq. in.

As the modulus of elasticity varies with the stress, the assumption of a constant value as generally used in reinforced beams, and the assumption that the stress varies uniformly, might be considerably in error. Unfortunately, the experiments which have been carried out have been too few to settle the matter with any degree of assurance, and the experiments now to be described were undertaken in the hope that some light might be thrown on this difficult subject. The results of the experiments, which have proved interesting, are given completely, and the conclusions that may be deduced from them are discussed. They show the desirability of the work being continued, and arrangements are being made for this to be done. Further, the experiments that have been made on these beams will be repeated when the latter are six months and twelve months old respectively and the results will be made known.

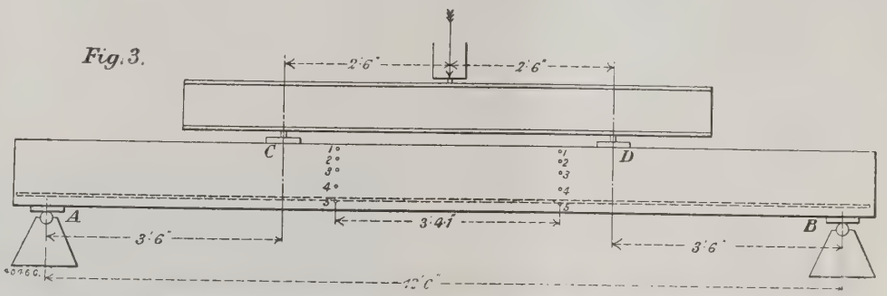
The aim of the experiments was to determine the strain, or change in length of the horizontal layers, in a concrete beam when subjected to bending. Reinforced-concrete beams of mixtures shown in Table I. and sections shown in Fig. 2 were made on the dates shown. At the same time, concrete-compression specimens about 6 in. in diameter were made, the strengths of which, after an interval of ninety days, are given in the last column of Table I.

At the points 1, 2, 3, &c., Fig. 2, were inserted thin steel transverse rods at a horizontal distance apart of 40.1 in., which projected a short distance on each side of the beam.

On the dates shown in Table I. these beams were loaded in a vertical testing-machine, as shown in Figs. 3 and 4. The beams were supported at A and B, 12 ft. apart, and loaded at the points C and D, 5 ft. apart, which were symmetrically placed with respect to A and B and the centre of the beam. The portion C D of the beam was therefore subjected to no shear and a uniform bending moment ; the stress along any horizontal plane of the beam should therefore be constant.

A special simple extensometer was devised for determining the actual changes in length between any two pins 1—1, 2—2, 3—3, &c., when the beam was loaded. The extensometer, though of such simple construction, proved a thoroughly reliable instrument, and the authors are convinced that if there are any errors in the experiments, they are not due to the simple nature of the extensometer used. These have, no doubt, registered with a considerable degree of accuracy the change in the distance apart of the pins embedded in the concrete, and if any criticism is to be offered to the results, it must be rather that these changes do not measure the true strains in the concrete than that the instruments were in error. These simple extensometers have been used during the last winter, in the laboratory of the authors, for a variety of purposes, and have proved effective and very useful. It is surprising how they can withstand illtreatment without any ill-effects resulting. They have been put in series with a Ewing extensometer on steel bars, and have proved practically as effective as the Ewing instrument for determining the coefficient of elasticity of the bar.

Fig. 3.



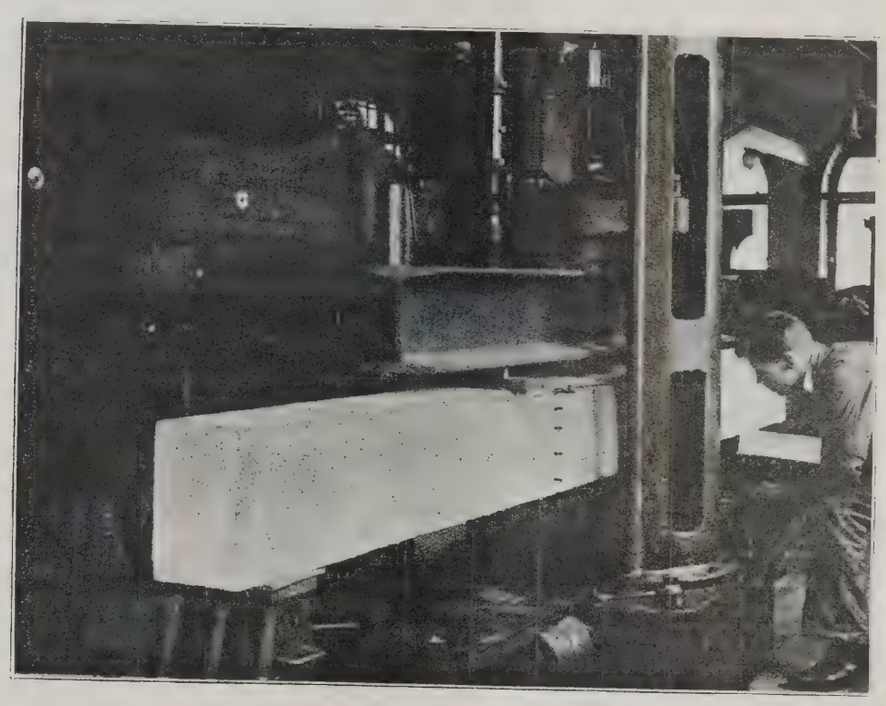


FIG. 4. VERTICAL TESTING-MACHINE.

TABLE I.

Beam.	Date Made.	Interval Before Testing.	Mixture. Cement.	Sand.	Gravel.	Compressive Strength of Concrete after 90 Days.
		days.	By weight			lb. per sq. in.
A	Nov. 25, 1913	94	1	1	2	3000
			By volume.			
			1	0.98	1.90	
			By weight.			
B	Dec. 8, 1913	90	1	1.5	3	2150
			By volume.			
			1	1.47	2.84	
			By weight.			
C	Dec. 11, 1913	90	1	2	4	1700
			By volume.			
			1	1.96	3.80	

Description of Extensometers.—The moving portion of each extensometer consisted of a small rocker, as

shown in Fig. 5. Into a small slab of brass were inserted three small hard-steel points, *a*, *b*, and *c*, while a long pointer P, made of aluminium tube, was attached to the slab, and the whole carefully balanced by the balance-piece B. To the end (1), say, of the transverse rods projecting from the beam was fixed a piece of $\frac{1}{2}$-in. square steel, as in Fig. 6. To this was fixed a thin piece of spring steel, which was rigidly attached to bar H. To the corresponding transverse rod (1) a second piece of $\frac{1}{2}$-in. square steel K was attached, on which could rest two points of the three-point rocker, while the bar H was allowed to rest on the third point. Small centre dots were made in the bar H, and the piece K, in which the points of the rocker rested. The thin spring gives the bar H a degree of freedom in a vertical plane, allowing it always to rest on the point of the rocker. Any relative motion of two points 1, 1 causes a rotation of the rocker, and the pointer P moves over the scale. It will be seen on reference to Fig. 7 that the horizontal movement of the point (*a*) about the centre (*b*) is proportional to the horizontal movement of point P, thus allowing a straight scale to be used. To calibrate the instrument the bar H was made to move a definite amount by a micrometer screw, and the reading of the pointer taken.

Fig.7.

beam in such a way as to eliminate twisting. The only explanation that can be offered is that the concrete is non-homogeneous. The experiments indicate that in calculations an allowance of at least $\frac{1}{8}$ of the mean for this discrepancy should be made. In Figs. 12, 13, and 14 are shown the strains for different loads, as deduced from the curves in Figs. 9, 10, and 11 at various distances from the compression surface of the beam. For example, taking the line E G H on Fig. 10, the ordinates of the respective curves show the strains for given loads on the beam B. In Fig. 13, the line E G H is plotted as a strain curve for an increment of 3000 lb.—*i.e.*, from 1000 lb to 4000 lb. In all cases the points plotted in Figs. 12, 13, and 14 are the means of four points on the vertical lines in Figs. 9, 10, and 11.

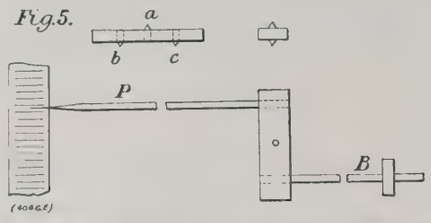


Fig.5.

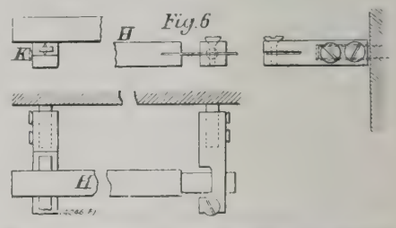


Fig.6

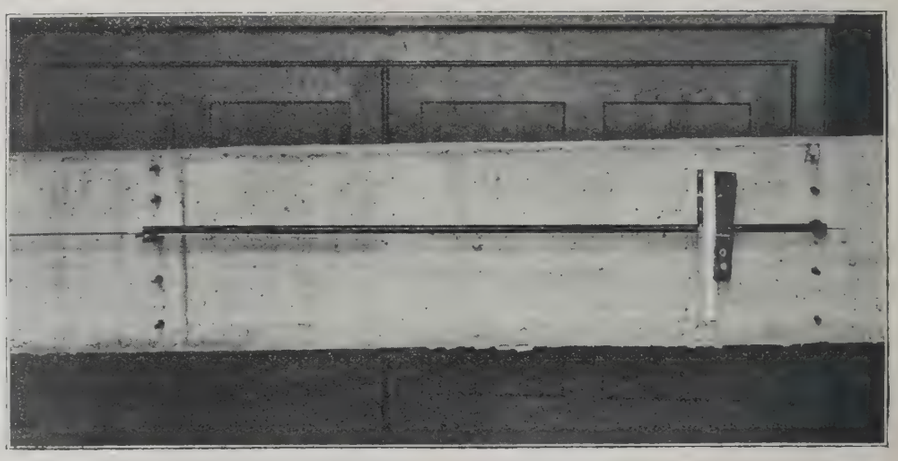


FIG. 8.

TABLE II.

	BEAM.	A. Concrete :—1 : 1 : 2. By Weight. Compressive Strength after Ninety Days = 3000 lb. per Sq. In.						B. Concrete :—1 : 1½ : 3. By Weight. Compressive Strength after Ninety Days = 2150 Lb. per Sq. In.						C. Concrete :—1 : 2 : 4. By Weight. Compressive Strength after Ninety Days = 1700 Lb. per Sq. In.					
1	Increment of load .. .. lb.	1000	2000	3000	4000	5000	6000	1000	2000	3000	4000	5000	6000	1000	2000	3000	4000	5000	6000
2	Depth of neutral axis x .. in.	4.56	4.42	4.30	4.20	4.22	4.28	3.80	3.74	3.72	3.72	3.80	3.81	3 94	3.85	3.85	3.85	3.90	3.90
3	Maximum compressive stress due to load increment lb. per sq. in.	132	264	415	565	705	835	153	310	467	622	757	917	147	300	448	598	745	898
4	Maximum strain on 40.1 in. in.	0.00196	0.00391	0.00561	0.00745	0.00900	0.01035	0.00175	0.00335	0.00480	0.00630	0.00770	0.00890	0.00195	0.00405	0.00590	0.00775	0.00935	0.01100
5	Total stress due to total load lb. per sq. in.	432	567	718	868	1008	1138	506	663	820	975	1110	1270	484	637	785	935	1082	1235
6	Modulus of elasticity of concrete E_c .. .. lb. per sq. in.	2,680,000	2,720,000	296,000	3,050,000	3,140,000	3,240,000	3,520,000	3,720,000	3,900,000	3,960,000	3,960,000	4,130,000	3,020,000	2,970,000	3,050,000	3,000,000	3,200,000	3,360,000
7	Modular ratio $E_s/E_c = m$ ratio	11.2	11.0	10.1	9.8	9.6	9.15	8.5	8.0	7.7	7.6	7.6	7.3	9.9	10.1	9.9	9.7	9.4	9.0
8	Stress in steel lb. per sq. in.	5530	11,400	16,900	22,200	27,100	31,400	7800	15,900	23,000	29,200	34,600	38,200	6500	14,200	22,600	29,000	35,000	38,900

Loading of Beam and Readings Taken.—Two extensometers were used and readings taken simultaneously on both sides of the beam and at similar distances from the compression surface. Fig. 8 shows one of the extensometers in position. Readings were taken with both increasing and decreasing loads. When the beam was first loaded and the load removed, there was some permanent set; but on again increasing and removing the load, although the extensometers did not at first return to zero, they did so completely after a time. It will be seen on reference to Figs. 9, 10, and 11, that the extensions for increasing and decreasing loads were different, forming a distinct hysteresis loop in each case, and, moreover, the strains on the two sides of the beams were in some cases very different. Taking, for example, the curves numbered 1 and 1*a* in Fig. 9, the vertical ordinates show respectively the strains on the two sides of the beam as the load is increased and then diminished. The extensions are greater for a given load as the load falls than for rising loads. In all three figures it will be noticed that there is one curve which has practically no loop. The unequal strains on the two sides of the beam, amounting in the worst case to 16½ per cent. of the mean, are not easy to explain, as the loading was put on the

To show the difference between the strains for rising and falling loads, curves *p r* and *k m*, falling on either side of the mean curve K M, are plotted in Fig. 12, while the curves *q v* and *u n* show the difference between the strains on the two sides of the beam for a given loading; these curves are displaced for clearness. All the curves in Figs. 10, 11, and 12 show that on the compression side of the neutral axis the assumption of linear distribution of stress is approximately correct. The position of the neutral axis for each of the beams varies slightly with the load on the beam, and is at a different distance from the compression surface for each beam.

On the tension side of the neutral axis the strains are considerable, and, as already remarked, the extensometers returned to zero after loading was removed, showing that the steel reinforcements pulled the concrete back into its original unstrained position.

Theory of Concrete Beams: The Modular Ratio.—Taking the ordinary assumptions :—

(*a*) That the stress varies uniformly from the neutral axis.
(*b*) That the concrete offers no resistance to tensile stresses,

the following equations are deduced and the modular ratio calculated :—

Let

A = area of tensile reinforcement.
d = depth of the beam from the upper surface of the concrete to the centre of the reinforcement.
x = distance of the neutral axis from the compressed surface of the concrete.
a = arm of resistance moment—*i.e.*, the distance from the centre of reinforcement to the centre of gravity of the concrete stress triangle = $d - \frac{x}{3}$.
b = breadth of the beam.
f_c = maximum stress per square inch in the concrete.
f_s = stress per square inch in the steel reinforcement.
E_s = modulus of elasticity for steel.
E_c = modulus of elasticity for concrete.
m = modular ratio = $\frac{E_s}{E_c}$.
M = external bending moment in inch-pounds.

Taking assumption (*a*)

$$\frac{f_c}{f_s} = \left(\frac{E_c x}{E_s (d - x)}\right) \quad . \quad . \quad (1)$$

Since the total compressive force on the section must equal the total tensile force :—

$$\tfrac{1}{2} f_c b x = f \text{ A} \quad . \quad . \quad . \quad (2)$$

The internal moment, neglecting tension in the concrete,

$$= \tfrac{1}{2} f_c b x \tfrac{2}{3} x + f_s \text{ A } (d - x)$$
$$= \tfrac{1}{2} f_c b x (d - \tfrac{1}{3} x)$$
$$= \tfrac{1}{2} f_c b x a \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Equating the internal and external moments,

$$\text{M} = \tfrac{1}{2} f_c a b x \quad . \quad . \quad . \quad . \quad . \quad (4)$$

From the method of loading it can at once be seen that

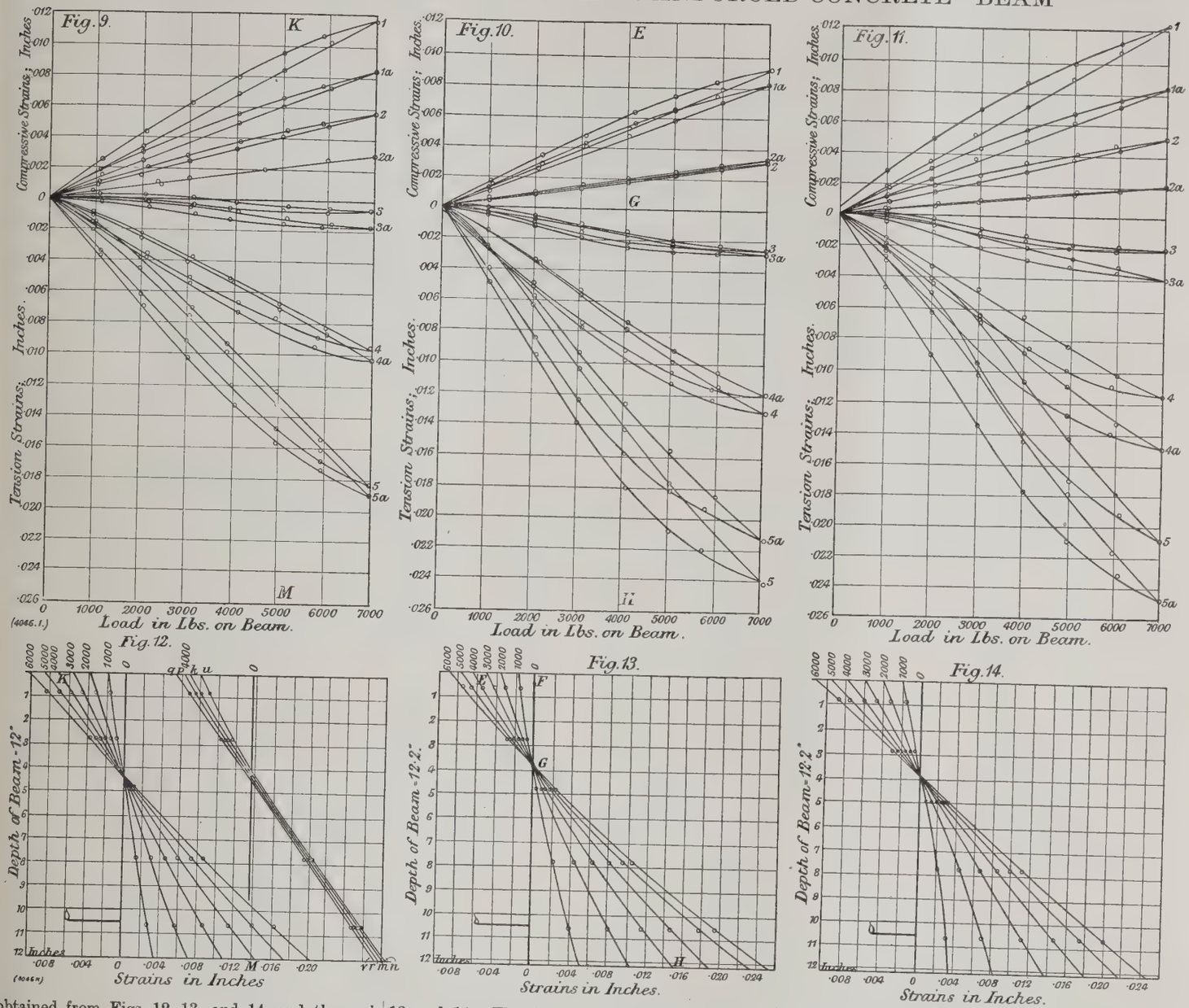
$$\text{M} = \tfrac{1}{2} \text{ W } 42 \text{ in lbs.},$$

where W is the total load on the beam, and therefore

$$42 \text{ W} = f_c a b x.$$

The position of the neutral axis in each case is

STRESSES AND STRAINS IN A REINFORCED-CONCRETE BEAM



obtained from Figs. 12, 13, and 14, and thus a b and x are known, and f_c can be calculated for each load on the beam.

The modulus of elasticity for any stress f_c is given by the formula,

$$f_c = E_c \text{ strain} \quad . \quad . \quad . \quad . \quad (5)$$

The strains were determined by experiments and are given in Table II.

As an example, Fig. 13 shows the strains on different horizontal layers in beam B for various conditions of loading. The loads are indicated at the top of the figure. The curve E G H shows the increase in the strains for an increment of load of 3000 lb., E F is the strain at the compression surface of the beam; E F = 0.0048 in.

$$\text{The strain per unit length} = \frac{0.0048}{40.1}.$$

The increase in the bending moment for the load of 3000 lb. is 3000 × 21 in.-lb. The point G is 3.71 in. from F, and a = 8.96 in.

Then from equation (4)—

$$\tfrac{1}{2} f_c 3.72,\ 8.96,\ 8.1 = 3000 \times 21,$$

or

$$F_c = 467 \text{ lb. per sq. in.}$$

From equation (5)—

$$E_c = \frac{467 \times 40.1}{0.0048} = 3{,}900{,}000 \text{ lb.}$$

Proceeding in this way, Table II. has been prepared. The values given in horizontal lines (2) and (4) are obtained from the curves in Figs. 12, 13, and 14. The figures in horizontal line 3 are calculated from equation (4), and those in (8) from the equation $f_s = E_s$ (strain at centre of reinforcement). These strains are taken from Figs. 12, 13, and 14, and E_s is taken as 3,000,000 lb. per sq. in. The experiments show that the modular ratio diminishes as the stress increases, and is slightly higher for the richest mixture than for the poorer mixtures. The evidence so far is thus opposed to the London County Council Regulations.

It is evidently desirable, as previously suggested, that the experiments should be continued.

BRIDGES OF LARGE SPAN.

In bridge-building, as in other departments of engineering, the path of progress is ordinarily achieved step by step, and it is but seldom that the engineer is called upon to prepare designs for the construction of bridges of spans much transcending his ordinary experience. The constant march of improvement in workshop methods and in the materials available is continuously increasing the economical length of span, but this advance has been so gradual that it has involved no excessive strain on the calculating and designing departments of the larger bridge-building firms, which are quite capable of dealing, on their own responsibility, with spans of very considerable magnitude. When, however, it is desired to pass from structures of the ordinary class to spans of 1700 ft. to 1800 ft., the advance involved is too great to be adequately compassed by ordinary drawing-office routine, a wider and more comprehensive analysis of the problem being needed than is generally feasible in a contractor's office, where the chief cannot generally give his exclusive attention to a single structure.

An excellent discussion of the varied factors which have then to be taken into consideration will be found in a most valuable and highly interesting paper read before the Franklin Institute by Mr. Ralph Modjeski in May, 1913, and published in the December issue of the Journal of that Society.*

The construction of a large bridge involves no small amount of mathematical work, but this, though laborious, presents little intrinsic difficulty. Other questions require very much more consideration, and the answer to these is in no way facilitated by the fact that alternative solutions are often practicable, since this circumstance generally involves a nice balancing of mutually conflicting drawbacks and advantages.

Mr. Modjeski points out that even the location of a bridge cannot always be fixed purely by engineering considerations. He mentions, for example, the case of the Celilo Bridge across the Columbia River. A bridge at Dalles, twelve miles further down, would have been cheaper to construct, but would have involved another twenty-four miles of haul for east-bound traffic, and thus the more expensive site was selected. Mathematical investigations have shown that, in general, the total

* "Design of Large Bridges, with Special Reference to the Quebec Bridge," by Ralph Modjeski, D. Eng.

cost of a bridge will be a minimum when the cost of the substructure is equal to that of the superstructure; but here again, as Mr. Modjeski points out, it is not often feasible to fix span dimensions on this basis solely. The necessity of not unduly interfering with the navigability of a waterway often makes it imperative to use longer spans than would be advisable were purely engineering considerations alone involved. In other cases, as at the Forth and at Quebec, the natural features fix the span length almost automatically. Once the site has been chosen, Mr. Modjeski emphasises the absolute necessity of thoroughly investigating the character of the strata on which the piers must rest. This advice is too frequently neglected, but a trust in providence is but a poor substitute for a sound foundation; and if, as is sometimes done, the responsibility is left to the contractor, the latter must insure his risk by adding substantially to the amount of his tender.

Natural features, again, greatly influence the character of the superstructure. Long-span arches, for example, are advisable only where natural abutments already exist. Such arches may have either two hinges or three, or may be rigid throughout. The second alternative is that which generally commends itself to the mere computer, but most practical bridge engineers are now inclined to favour the two-hinged arch as giving a more rigid structure. Here again, however, the computer has frequently been perturbed by the question of making the central connection so as to get an agreement between the actual stresses and those on which he has figured. Mr. Modjeski's solution of the problem is to treat the dead load as if the arch were three-hinged, and to make the central connections with all dead load in place, and when the temperature is about 60 deg. Fahr. For all future time there will thus be no bending moment at the central hinge when the temperature is normal and the structure is carrying its dead load only. For the live load, and for temperature stresses, the structure acts as if it were a two-hinged structure. This solution of the problem is simple and scientific, and avoids the use of hydraulic jacks or their equivalents for putting on initial strains when making the centre joints, as would be necessary were the dead load taken as in a two-hinge structure.

The simple truss span can be used up to about 700 ft., so far as commercial considerations are concerned, and Mr. Modjeski states that one of 720 ft. span has been designed for a crossing of the Ohio River. The theoretical limit of such spans is, however, about 2000 ft., if ordinary carbon steel be adopted, and 2700 ft. if nickel steel be used. If, however, the span exceeds 700 ft., the cantilever system will generally prove to provide a cheaper structure. Large simple spans must either be erected on false-work or floated into position. They are, moreover, more stressed by the wind than cantilever structures, presenting their greatest area at mid-span. In a number of large simple spans tabulated by Mr. Modjeski the ratio of length to depth ranges from 5.24 up to 5.82, the theoretical best value being, he says, about 5½. Mr. Modjeski points out that the ordinary rule, that the weight of similar spans varies, as the square of the span is only true within a limited range, which for simple truss spans lies between 100 ft. and 300 ft. Beyond this limit the weight increases much faster than as the square of the span. Some saving in the total weight of truss spans could, Mr. Modjeski states, be effected by making the panel length longer near mid-span than at the ends: but too little is thus gained to offset the advantages of the uniformity in floor beams and stringers resulting from a constant length of panel.

In discussing still larger spans, Mr. Modjeski dismisses the continuous girder somewhat slightingly. Apart from possible difficulties in providing for temperature changes, it has, however, the advantage of being stiffer than the cantilever, and on that head should be preferred; but, undoubtedly, there would be difficulty in providing for the free expansion, with temperature changes, of a very long continuous girder. Quite possibly the importance of temperature stresses is overestimated, as expansion gear has been removed from spans of fair size without any adverse effects. The belief is not uncommon that if a long bar is prevented from contracting when the temperature falls, the ensuing stress will be greater than in the case of a short bar; but this is, of course, a wholly erroneous view, the stress arising from the suppression of the contraction being independent of the length of the bar. Hence, if a large bridge, piers and foundations included, were an exact replica, on a larger scale, of a smaller structure, temperature strains should be no more serious in the large than in the small bridge.

Mr. Modjeski, though not an advocate of the continuous girder, does not re-echo the complaint against it frequently made by American engineers. Unable to deny that many continuous girders have given excellent service in practice, they complain that the stresses are indeterminate, as if this were sufficient to condemn the system. As Mr. Modjeski truly points out, the stresses can always be determined with sufficient accuracy to ensure the safety of the work. "It is," he says, "only when everything else is equal that determinate stresses should be preferred."

With this conclusion it is impossible to quarrel, but the opinion may be expressed that everything else never is equal, and that the statically indeterminate structure, if properly designed, always results in a more mechanical structure. This is certainly the case so far as moderate spans are concerned.

In this connection reference may, perhaps, be made to the Beaver Bridge across the Ohio River, of which a full description was given in our columns during the earlier half of last year. The design of this structure gave proof of a very high order of engineering ability, but it may, perhaps, be doubted whether the care taken to sub-divide up the longitudinal girders of the floor system into short independent lengths was not somewhat misplaced. M. Rabut has proved experimentally that a continuous floor may greatly augment the carrying capacity of a bridge. The floor, in fact, often acts as so much additional metal in one or the other flange, and the remarkable endurance under modern loads of bridges built in the 'sixties, or even earlier, is, he has shown, often mainly attributable to this fact. From this discovery M. Rabut has, on occasion, derived notable advantage. Thus, when it became necessary a few years ago to increase the span of the Rue Legendre Bridge at Paris from 40 m. to 48 m., M. Rabut found that the "flange effect" of the floor was so great that the actual stresses in the girders proper were very much less than had been calculated on. It therefore became practicable to make the increase in the span by simply lengthening the existing girders to the extent required, no strengthening by additional plates being requisite. There seems, therefore, no adequate reason for not allowing the floor to help the girders, thus adding, it may be, an unknown, but at any rate a very substantial, increase to the resistance of the structure.

Mr. Modjeski has been one of the engineers responsible for the new Quebec Bridge now in course of construction, and of this he gave a number of highly interesting details in his lecture. The main span is to be 1800 ft. between centres of bearings, the anchor arms being 515 ft. long, whilst the central suspended span will measure 640 ft. This was considered to be about the limit that could be successfully floated into position, although a somewhat greater length would have reduced the total weight of steel. The bridge is to take on each track two Cooper's Class E-60 engines, followed or preceded by a train-load of 5000 lb. per lineal foot of track. In addition to the actual dead weight of the structure, a load of 500 lb. per foot run was provided for on the suspended span, and of 800 lb. per foot run on the remainder of the bridge, as an allowance for the winter snows.

The wind loads provided for are 30 lb. per sq. ft.

Fig. 1. THE QUEBEC BRIDGE (NEW DESIGN)

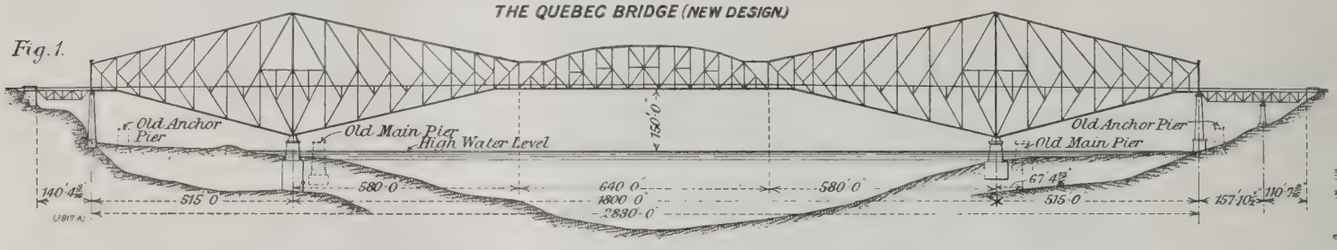


Fig. 2. QUEBEC BRIDGE (NEW DESIGN)

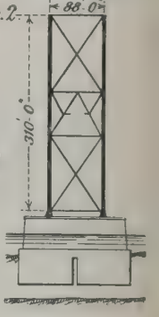


Fig. 3. QUEBEC BRIDGE, PHŒNIX BRIDGE COMPANY DESIGN.
DEFORMATION DIAGRAM. DEAD + LIVE LOAD REVERSED.
Scale of Deformation is 60 times greater than Scale of Truss.

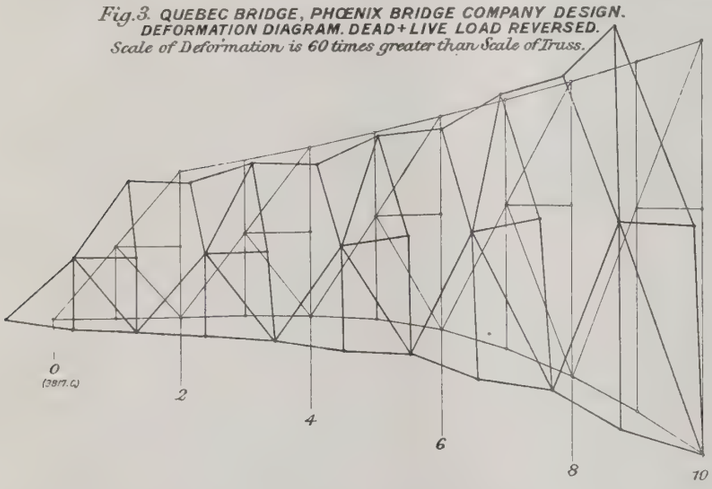
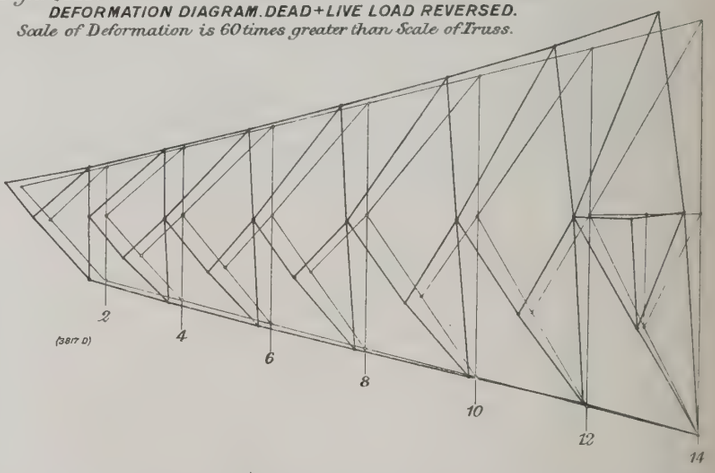


Fig. 4. QUEBEC BRIDGE. ST. LAWRENCE BRIDGE COMPANY DESIGN.
DEFORMATION DIAGRAM. DEAD + LIVE LOAD REVERSED.
Scale of Deformation is 60 times greater than Scale of Truss.



on the exposed surface of the two trusses, and on one and a half times the elevation of the floor, to which was added a wind load of 300 lb. per lineal foot on the moving load. In the direction of the axis of the bridge, the wind load assumed was 30 lb. per sq. ft. on one-half the area assumed for the transverse wind loading.

The main towers are to be 310 ft. in height. This is stated to be 20 ft. more than the most economical height with the K bracing which is to be used. It has, however, the advantage of reducing somewhat the enormous size of the chord members. As shown in Fig. 1, page 350, which we reproduce from the Journal of the Franklin Institute, both the upper and the lower cantilever chords are straight—a plan which has the advantage of transferring wind stresses to the pier as directly as possible.

The width of the bridge is to be 88 ft., as shown in Fig. 2, which represents a section over a pier. The question of splaying out the trusses at the pier level, as at the Forth, was considered, as also that of making the bridge generally wider at the piers than elsewhere. A certain economy of material could have been effected in this way, but it was considered, on the whole, that the gain possible was insufficient to offset the very considerable practical advantages pertaining to a constant width throughout the whole length of the bridge.

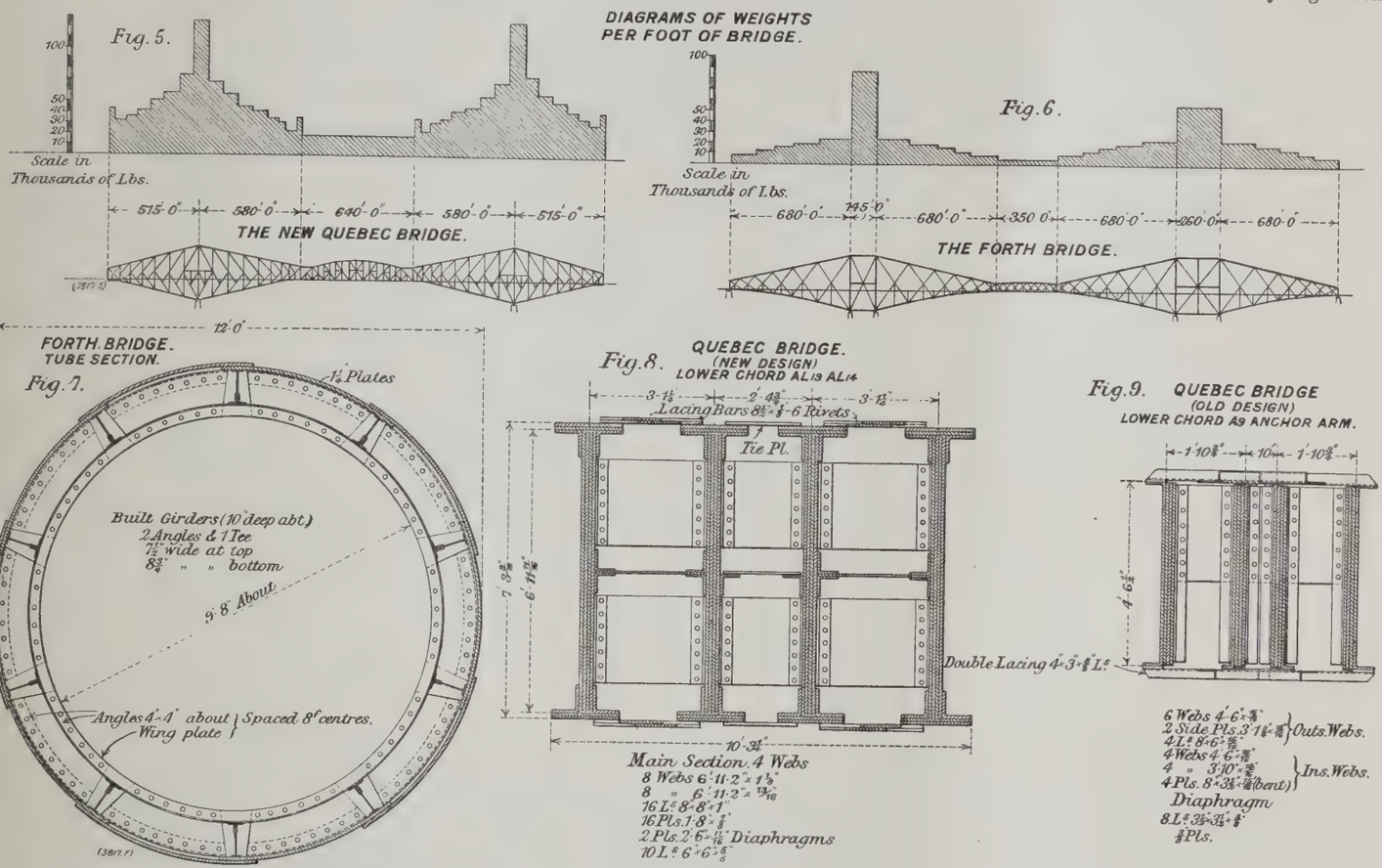
The K system of bracing was adopted as requiring a minimum of secondary members, and few, if any, temporary members during erection. It has the further advantage of subdividing the web stresses, thus making each member of a more manageable size, and comparative calculations showed that it was lighter than the alternative systems examined. Mr. Modjeski draws attention to the fact that the deformation of the truss with this system of bracing is very regular in character, and he gives Figs. 3 and 4, showing, in the first case, the character of the distortion under its load of the original Phœnix Bridge design, and, in the other diagram, that of the design finally adopted. The deformations were calculated by the Williott method, and are plotted to 60 times the scale of the truss. The large distortions in the old design arise in part from the higher unit stresses adopted, but are also affected by the fact that the chords were curved, and by the relatively large number of secondary members.

It was originally intended to construct the cantilever arms of the new bridge as riveted trusses throughout, nickel steel being used for the river arms, and carbon steel for the anchor arms. It has, however, finally been decided to use carbon-steel eye-bars for the tension chords. Mr. Modjeski claims that a better design is thus secured, and, taking a comprehensive view of all the considerations involved, this is probably true. From a purely structural standpoint, a well-designed bridge riveted throughout is probably superior to any equivalent eye-bar structure, but other considerations are involved. The ease of erection characteristic of the eye-bar system is a most important factor in the present case, where the severity of the climate precludes work in the open throughout many months in the year. Nickel steel will be used for the trusses of the suspended span, but the floor system and most laterals will be of carbon steel throughout.

The new bridge will weigh 8.7 tons per foot near the centre, and 38 tons per foot near the piers. The corresponding figures for the Forth Bridge are 2 tons and 13½ tons. The distribution of the weight in the two cases is illustrated in Figs. 5 and 6. Part of the increase in the case of the new bridge is due to its greater span, since for bridges of such dimensions the weight increases rather faster than as the cube of the span.

The design of the bottom chord at its heaviest is represented in Fig. 8, and may be compared with that of the Forth, Fig. 7, and of the old Quebec Bridge in Fig. 9. Of course, from the standpoint of theoretical mechanics, the Forth design is superior to either, but it is of a type very difficult and costly to build, and a rectangular section has therefore quite legitimately been adopted. Such a form was, in fact, practically unavoidable, in view of the conditions under which the erection will have to be carried out. This chord will have pin-joints only at the junction with the towers, where the antipathy of the American bridge engineer to possible secondary stresses has been allowed to prevail. The bracing of these large compression members is not fully shown in Fig. 8, but in view of the previous failure very full consideration has, of course, been given to the securing of a thoroughly stiff and efficient system.

In concluding his paper, Mr. Modjeski entered into a short discussion of the vexed question of secondary stresses. These, he states, were all calculated and provided for in the new design, but he expresses what we believe is a thoroughly well-founded opinion, that there is a tendency to overrate their importance. Maintenance engineers, rather than designers, are those best qualified to express an opinion on this point, and certainly their experience, based, no doubt, mainly on spans of moderate length, goes to show that bridges having large secondary stresses are more satisfactory under traffic than more loosely-assembled structures; and it is, in our view, rash to discard experience of this kind on purely theoretical speculations. It is, moreover, of no little interest to note that the type of eye-bar head usual in America involves the existence of very large secondary stresses. From the experiments of Professor Coker, which are in accord with the results of other workers, it appears that with a head of this type the maximum stress in the immediate neighbourhood of the eye may greatly exceed the mean.



CALCIUM CARBIDE AND NITROGEN PRODUCTS.

(*Continued from page* 296.)

CALCIUM CARBIDE WORKS AT ODDA.

As already indicated, the carbide factory at Odda, of the Alby United Carbide Factories, Limited, began the manufacture of calcium carbide in 1908, and since then has produced on an average 32,000 tons per annum, of which 10,000 tons was delivered to the cyanamide factory adjoining, and now belonging to Nitrogen Products and Carbide, Limited. The original factory was described in vol. lxxxvii. of ENGINEERING. At the time of installation the current utilised was approximately 20,000 horse-power, and the output of calcium carbide 32,000 tons. In 1912 it was decided to extend the factory, and six new kilns for the calcining of the limestone, and ten new electric furnaces for the fusion of limestone and carbon, have been built, while a new system of cooling the calcium carbide and other modifications have been made in the manufacturing plant. Since then, too, an addition has been made to the import and export quays in order to unload more expeditiously the limestone and anthracite coal, as well as the ordinary bituminous coal used in the gas-producers for running the kilns. The result is that the works now consume 50,000 horse-power of electric current, and the output of calcium carbide is 85,000 tons, of which 57,000 tons are delivered to the cyanamide factory, the remainder being despatched for use in

generating acetylene gas either for illumination or oxy-acetylene welding.

The general arrangement of the factory is shown on the diagram reproduced in Fig. 35, Plate XXIV., and in Fig. 36, the latter showing in perspective the whole establishment from a point corresponding to the top right-hand corner of the diagrammatic plan. The silos for the storage of material are seen in the foreground, with the lime-kilns behind them and the electric furnace-houses to the right of them again, while beyond these is the cyanamide works, with the Sorfjord in the distance. The export quay will be seen to the left of the river mouth, while the import quay is partially obscured by the fir-clad slope to the extreme right of the view.

In describing the works in detail we shall deal particularly with the new plant, because in its design there have been embodied the lessons of experience, so that still higher economy and uniformity in the contents of the calcium carbide are ensured. The raw materials, of which there is used each year 50,000 tons of anthracite and 150,000 tons of limestone, are imported. The former comes from Wales, and is selected in order to ensure low content of phosphorus and to give as small percentage as possible in ash, in order that the carbide shall give a high output of pure acetylene. This is particularly essential in carbide used for lighting purposes. The limestone is obtained from the company's own quarries on the west coast of Norway. The principal quarries now worked are at Skaftun, near Bergen, and at Oestborg, in the Trondhjem Fjord. In both quarries mechanical appliances have been extensively adopted, in order to achieve the highest efficiency in labour. There is also a quarry in the Hardanger Fjord, which gives about 20,000 tons of limestone per annum. The third important material is gas-coal or coke, which is got from the east coast of England, to the extent of about 15,000 tons per annum, but, as shall presently be explained, the new electric furnaces for the production of calcium carbide are arranged so that the waste gases can be utilised for the calcining of lime in the new kilns, and the two gas-producers specially erected for providing the gas for these new kilns are now utilised only as stand-bys. In our previous article we dealt very completely with the system of transport in the works, so that we need not enter largely into this part of the manufacturing arrangements. Originally the import quay had two jib cranes, with a lifting capacity of about 2 tons, of somewhat interesting design, fully illustrated in our previous article. This quay, which has been lengthened and a third crane added, is now entirely utilised for the importation of limestone. The combined capacity of the three cranes is over 100 metric tons per hour. The limestone is delivered into high-level hoppers, and through a bottom door in these, buckets or wagons are filled and traversed along the quay by hand, automatically to grip upon a cableway, 2000 yards long, and with a carrying capacity of about 30 tons of limestone or about 80 tons of anthracite per hour, the motive power being electricity. By this cableway the wagons travel to the silos. A new quay has been constructed for the importation of the anthracite and gas-coal or coke, having one crane capable of discharging 50 tons of coal per hour. This new quay is cut out of the rock on the shores of the fjord, whereas the other quay is built of timber. The crane is utilised for the discharge of steamers by means of grab-buckets. Here also the contents are deposited in hoppers. The new quay is connected to the old quay by a circular electric cableway 170 yards long, so that the coal-wagons are transferred to the existing cableway to the silos. This latter cableway is continuous, the route traversing the top of the anthracite, the limestone, and the gas-coal silos, and back to the quays (Fig. 35). These silos, which were fully illustrated in our former article, are divided into compartments, but have since been extended, that for limestone having a capacity now for 4000 tons, the two for anthracite holding together 5000 tons, and the one for gas-coal or coke taking 3000 tons. The three first-named silos lie in one range, and the main cableway runs direct around them all. The silos are divided into a series of large hoppers; over the top of each there is trip-gear, which, when set, causes the cableway wagon automatically to tip, its contents being discharged into any desired hopper; the bucket, emptied, continues on its circular way back to the quay. There is also a large open-air reserve store for limestone, and similar arrangements are made for the limestone to be deposited here from the wagons travelling on the cableway, which is here in the form of a loop as shown in the diagram, and having, at each end, junction with the main cableway.

The floors of the hoppers of the silos slope towards the outer boundary at an angle of 45 deg., so that the material falls by gravity to side doors near the ground level, where it is passed through shoots, with doors, into wagons travelling on an electric telpher railway. The electric telpher railway system is conceived most admirably, in order to economise the amount of labour involved. This is a matter of great importance in a factory having such a large quantity of material to transport from point to point. The means specially used for mechanical transport have been supplied by Messrs. Bleichert and Co., of Leipzig-Gohlis, and the details of the system were illustrated and described in a previous article; but in view of the extensions since made, it will be well to indicate broadly the general arrangement, although the details have not been materially modified. There are now (Fig. 35) seven separate telpher railways in the works, with a total length of 1½ miles. Each is continuous, and passes round one or other of the silos, conveying therefrom material to its prescribed destination, without any further manual control. Thus the anthracite railway encircles the anthracite silos, conveying the material to be tipped into the hopper for serving the coal-crushers adjacent to the electric furnace house. The limestone railway encompasses the limestone silos, and travels over the tops of the old or new kilns, returning thence to the limestone silos. The gas-coal or coke telpher railway, on the other hand, goes round the silo containing the gas-fuel, and thence to the hopper for serving the conveyors and elevators used for charging the gas-producer. Another railway takes the crushed anthracite, and deposits it into the electric furnaces, and so with the other circuits. In all cases the emptying of the telpher railway wagon is automatic, gear being placed over the lime-kiln, the anthracite hoppers, or other discharge stations. Unless the tipping-gear is set, the wagon moves on, so that there is no interruption to the passage from and to the silo. In the case of the limekilns, however, the tipping-gear is so arranged that it only comes into action when the wagon having the counterpart of such gear comes along. Thus each wagon is only discharged at that particular station, or into the particular kiln, for which its contents are required, and thus the correct sequence in the process of continuous charging of all the kilns proceeds, although there are eleven kilns, without any attention being required for the distribution of the limestone to the respective kilns. Each of the telpher railways uses direct current of 220 volts, and each wagon has two motors of ¾ horse-power. They take the current through a conductor overhead by means of a trolley, while the return circuit is through the suspended rail. The current-carrying conductor is divided up into sections, in order to make it possible to stop a wagon at the silo shoot where it is to be filled. Between each section and the next there is block mechanism, so arranged that each wagon cuts off current from the section immediately behind it, so that there is at least a complete unoccupied section between successive wagons. Thus there is no possibility of collision, though the wagons are automatically and continuously running around the complete circuit applicable to one or other of the materials. For the charging of the kilns the fuel-wagons require to ascend a pretty steep gradient in order to reach the charging-level. It was considered that the gradient was too steep to be overcome by a ¾-horse-power motor, and therefore at this point the wagons are automatically coupled on to a short cable line, which takes them up to the level of the charging-platform of the kilns. The coupling-gripper takes hold of the cable at one end, and releases its hold at the other end automatically, while simultaneously the current is cut off the motors. The details of the change-over from electric to cable or from cable to electric were illustrated in our previous article, and have worked most satisfactorily. Fig. 37, Plate XXV., is a view from the top charging-platform of one of the kilns. On the left will be seen in part the five kilns first built. The cableway for the ascending wagons is to be seen in the distance, while that to the left is the cableway for the descending wagons. In the centre there is observable the silos.

There are now eleven kilns at the Odda Works, each capable of producing 25 tons of burnt lime per day. The five kilns originally built were illustrated in detail in our previous article. There were two gas-generators placed under each kiln. In the building of the new kilns it was decided to construct the producers separately, and to this extent the new installation differs from the old. The two producers are built between the old and the new limekilns, as shown in the view, Fig. 38, Plate XXV., the new installation being seen to the left, and the old to the right. This view incidentally shows the telpher railway passing over the charging-platform of the limekilns, the uptake to the kiln being arranged on each side of the archway for the passage of the wagons. One of the advantages of having separate producers is that the gas-fumes are more easily carried away, and do not affect the workers engaged at the burnt-lime discharging-platform of the kilns. Moreover, separate producers were required, because, as has already been indicated, the six new kilns are to be fired with the waste gases from the new electric furnaces, and the producers will therefore only be utilised as stand-bys. The two new producers gasify 20 tons of gas-coal per day, and will be used mostly for starting up the factory or as reserves. The gas given off from the carbide electric furnaces, it may be said, is very rich in carbon monoxide and hydrogen, and sufficient is being taken off from the new furnaces to run the whole of the six new kilns. Fig. 39 shows the calcined lime discharge-platform of the new kilns, and the wagons on the telpher railway are here seen encircling the kilns. In this case the railway line is circular and traverses round the whole of the six new kilns, so that the contents of any kiln through any of its doors may be discharged into a wagon. The contents are finally tipped into a hopper either at the new or the old furnace house, where the lime is fed into crushers over the mixing-machine for use, pulverised in electric furnaces. It will be noted from the general diagram of the arrangement of the works that while separate telpher railways are arranged for the old kilns and old furnace-houses, and for the new kilns and the new furnace-houses, the two systems are connected by a loop-line, so that the supply of calcined lime may be passed from either set of kilns to either set of electric furnaces.

As the arrangement of crushing plant for the anthracite burnt lime is the same as formerly described, we may now pass to a consideration of the electric furnaces. There were originally twelve furnaces of 1400 k.v.a. capacity, each producing 7 to 8 tons of calcium carbide in 24 hours. The new installation is of ten furnaces, with electrodes of 3000 k.v.a. capacity, the production from each furnace being 16 to 18 tons per day. The temperature in the case of all furnaces is about 5722 deg. Fahr. It is not alone in size and capacity that the new furnaces differ from the old; the great experience attained in the working of the old furnaces has led to very important changes, not only in the design of the furnace itself and in the manipulation of the immense electrodes, which weigh 4 tons each in the case of the new furnaces, but also in the system of charging the furnace. In the old furnace-house the material was charged by hand, the workers being protected by gauze screens; the work was arduous. Moreover, in the old furnaces the whole of the cables in connection with the electrodes had to be moved when a new electrode was being fitted. The furnace top too was open, and smoke and other impurities filled the upper part of the furnace-house. All this has been changed. The new furnaces are charged with lime and anthracite, fed through hoppers by means of hydraulic rams, which have the further advantage that they pack the material close up to the electrodes, and ensure therefore the absorption of the maximum of heat. Naturally the space to allow the electrode to pass into the furnace is open, and through this there comes only a slight vapour. Again, the electrode is so arranged that it can be taken out and replaced by a new one in five to ten minutes without dismantling any of the wiring connections. The hot gases are carried off, and, as we have already said, are utilised in the new lime-kilns. The new electric furnace-house is illustrated in Fig. 40, Plate XXV. When this view was taken the whole of the new furnaces were in use, and it will be seen that a great success has been achieved so far as the state of the atmosphere in the shop is concerned. There is some exhalation from the top of the furnaces, but it is partly due to heat radiation. The telpher railway

THE CALCIUM CARBIDE FACTORY AT ODDA, NORWAY.

(*For Description, see Page* 351.)

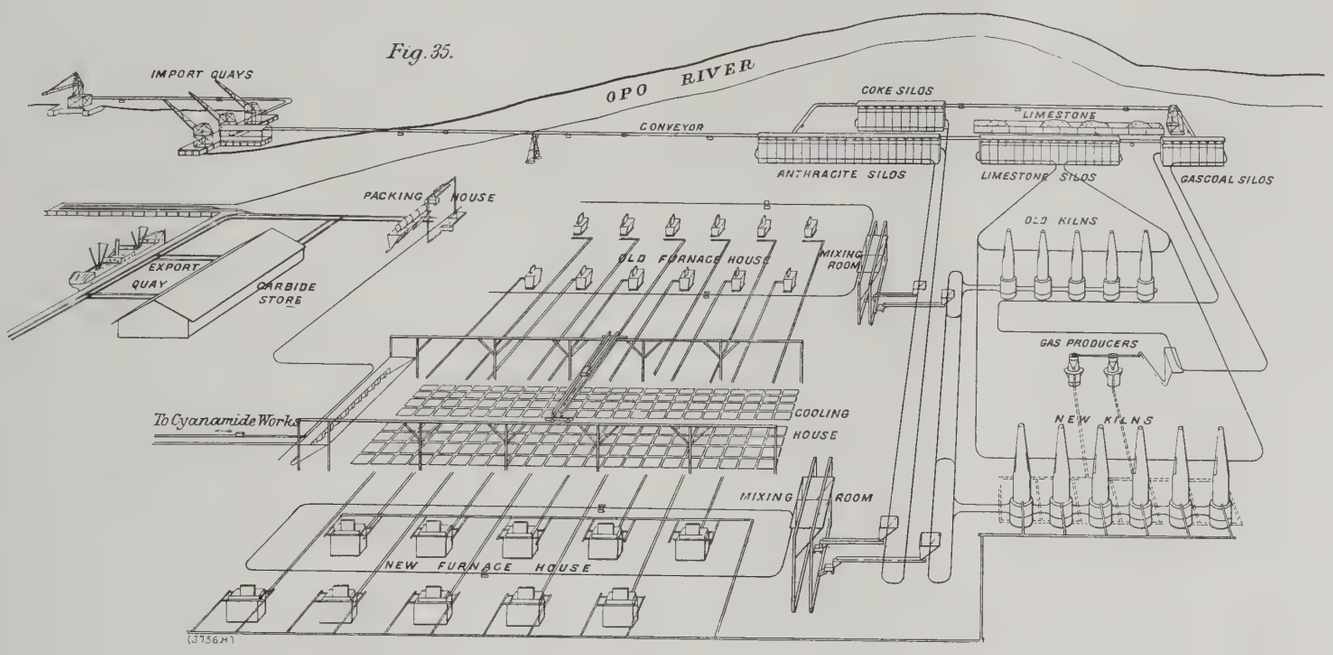


Fig. 35. Diagrammatic Plan.

Fig. 36. General View.

(*To Face Page* 352.)

THE CALCIUM CARBIDE FACTORY AT ODDA, NORWAY.

(*For Description, see Page* 351.)

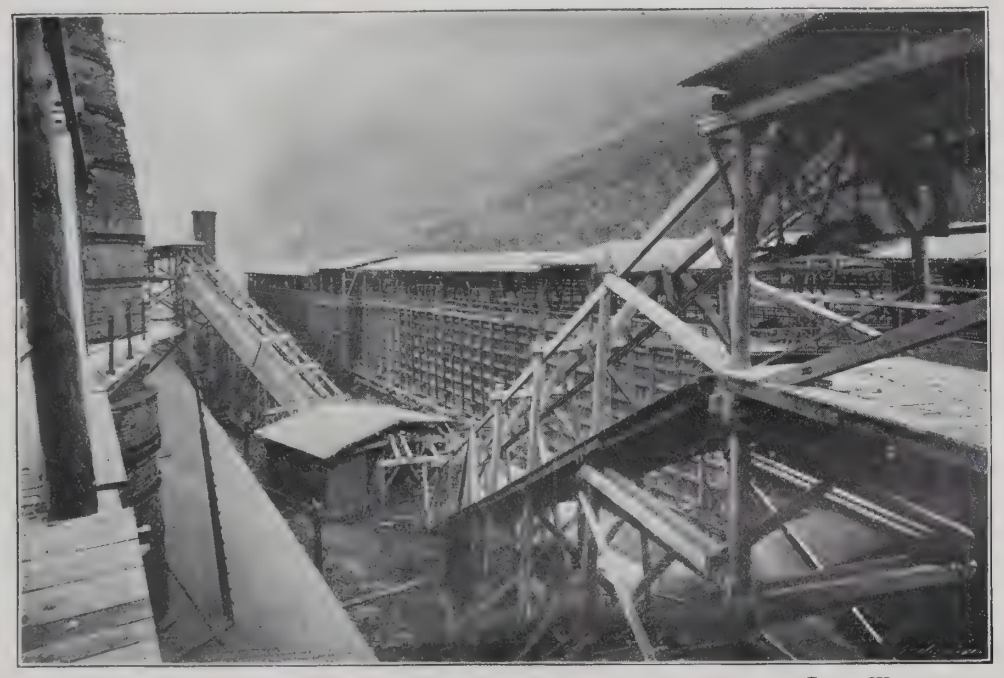


FIG 37. VIEW OF SILOS AND KILNS, WITH ELEVATING CABLEWAY FOR LIME-WAGONS.

FIG. 39. THE CALCINED LIME DISCHARGING-PLATFORM.

FIG. 38. VIEW FROM TOP OF LIME-KILNS, WITH GAS-PRODUCER IN CENTRE.

FIG. 40. THE NEW CARBIDE ELECTRIC FURNACES.

THE CALCIUM CARBIDE FACTORY AT ODDA, NORWAY.

(*For Description, see Page* 351.)

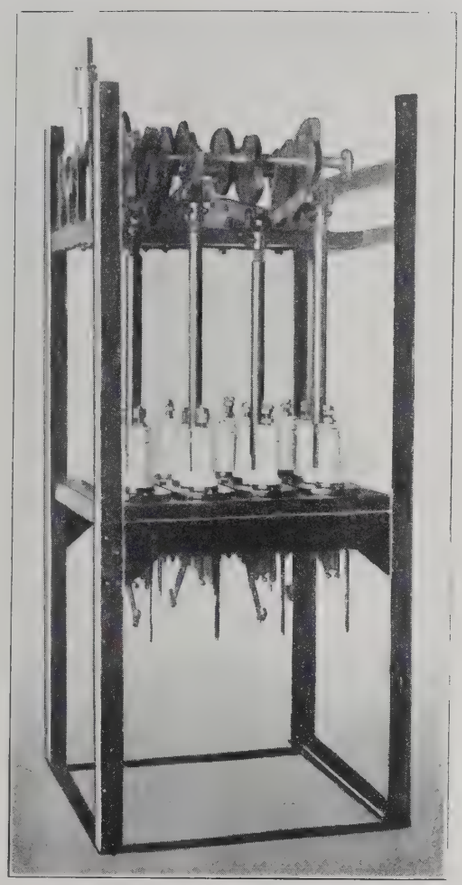
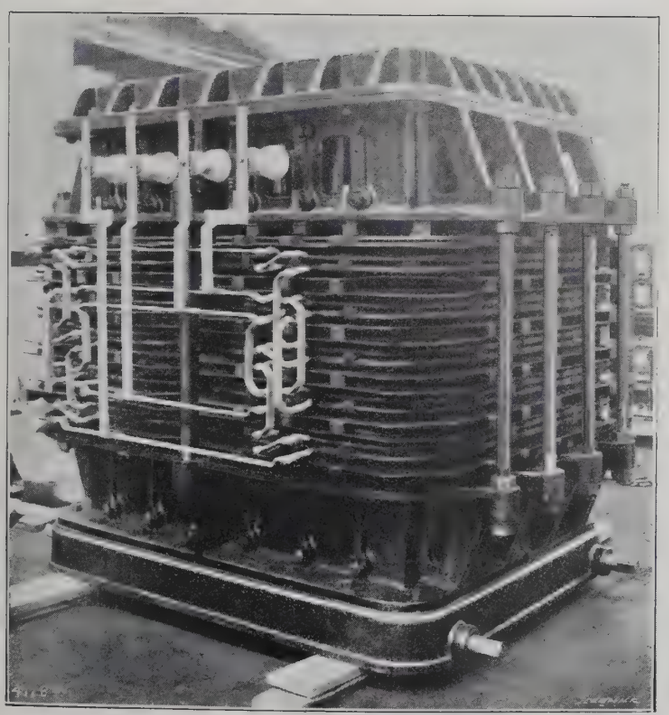
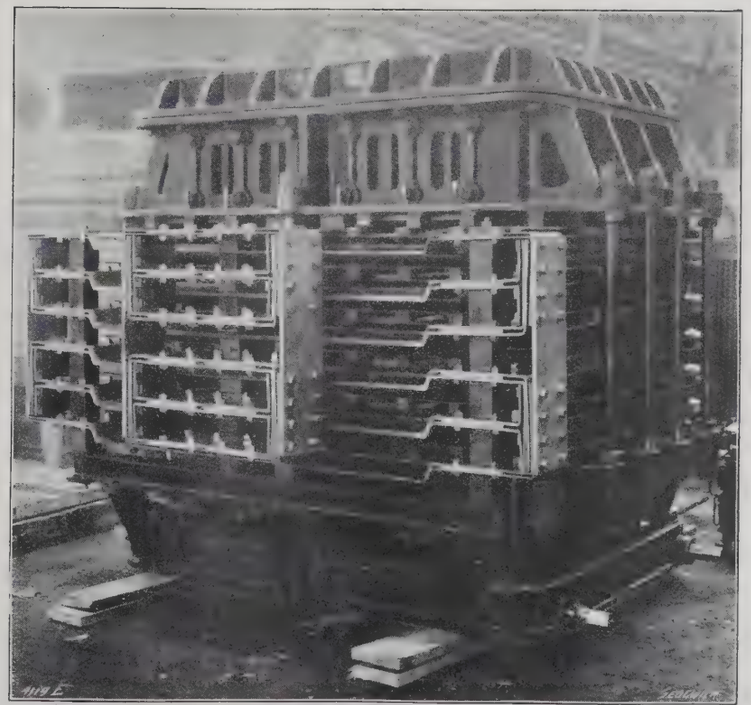


Fig. 42. Regulating Switches.

Fig. 43. Regulating Transformer.





Figs. 44 and 45. Main 3000-Kilowatt Transformer.

MILL FOR THE MANUFACTURE OF CANE SUGAR.

CONSTRUCTED BY MESSRS. DUNCAN STEWART AND COMPANY, LIMITED, ENGINEERS, GLASGOW.

(*For Description, see Page* 353.)

Fig. 1.

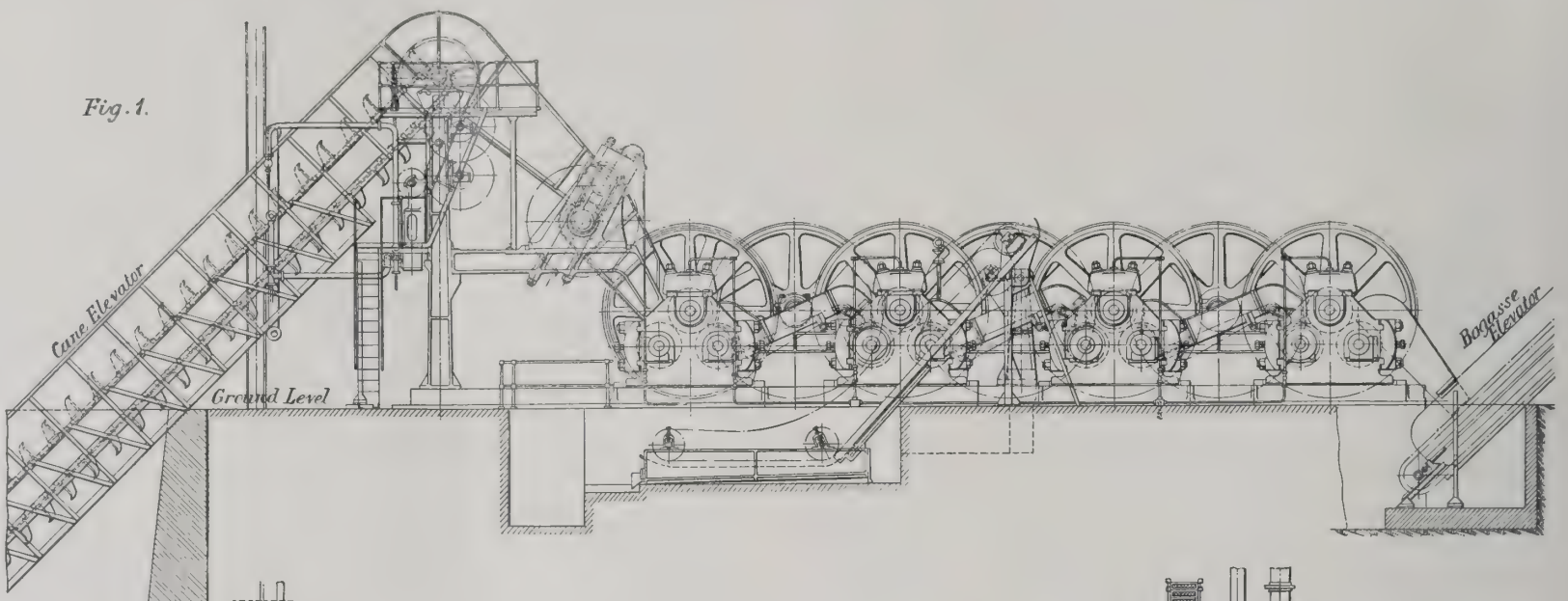


Fig. 2.

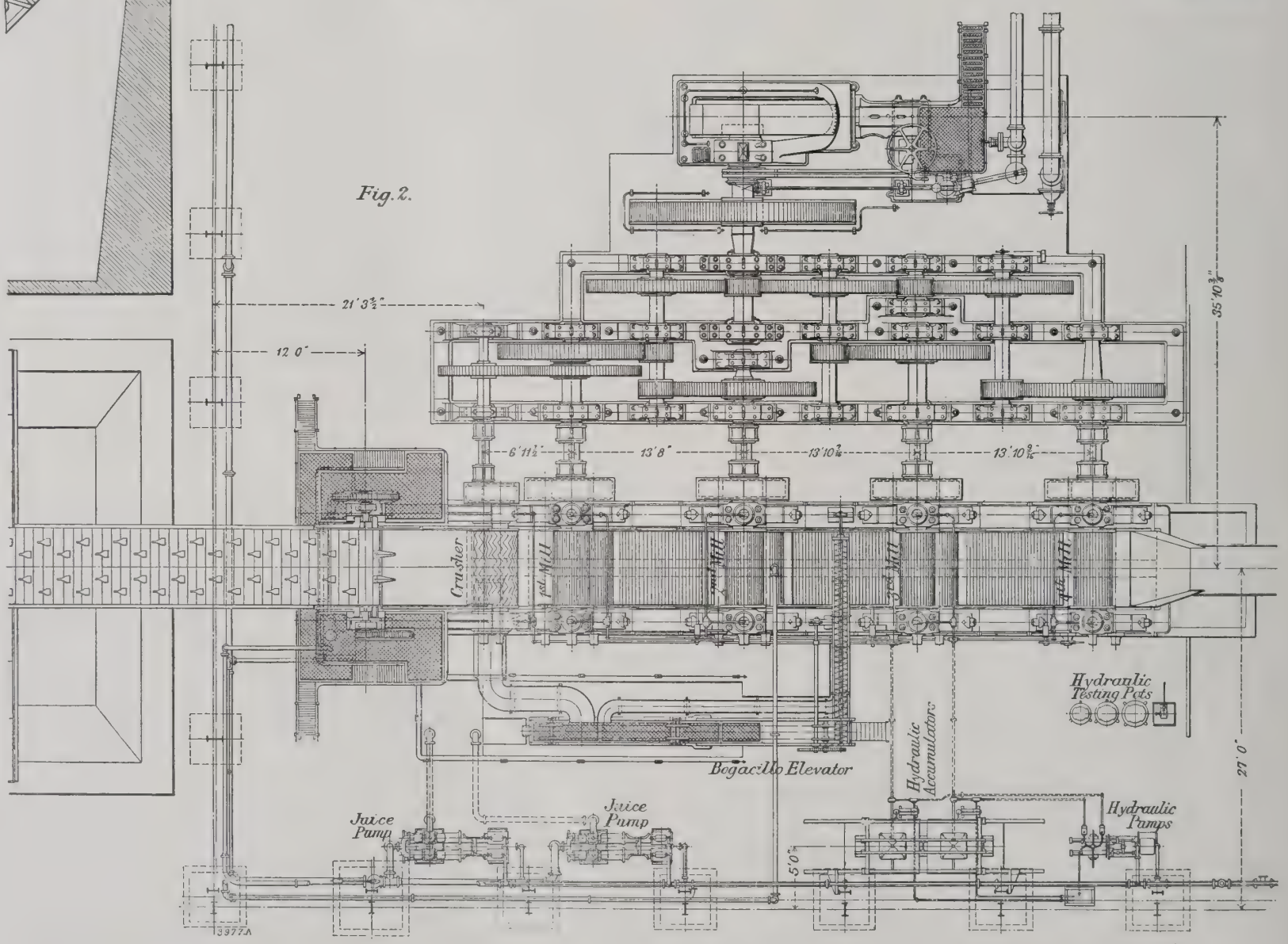
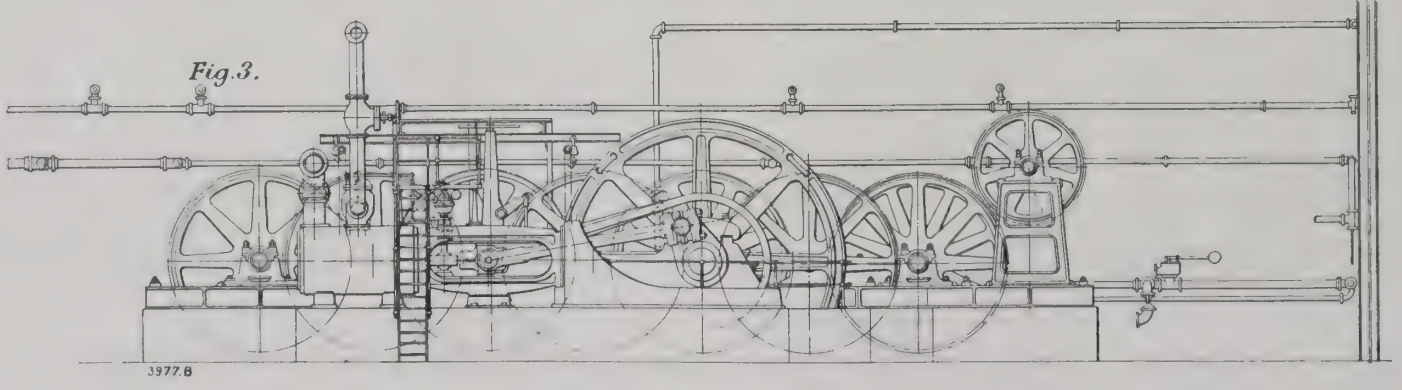


Fig. 3.

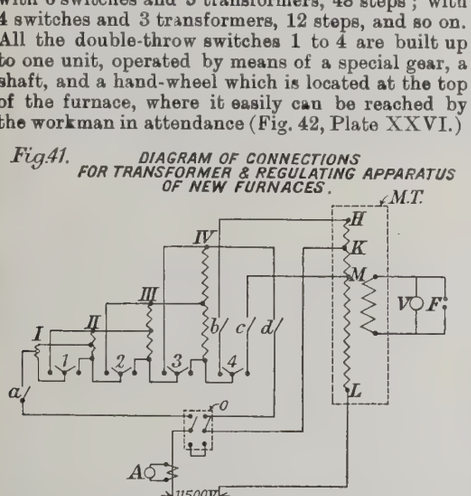


(*To Face Page* 353.)

shown above is utilised for the transport of lime and coal to the furnaces. The upper platform is arranged for work in connection with the electrodes and the electric connections. The hydraulic rams for charging the furnace are immediately below the platforms on each side of the furnace, and are manipulated from this upper platform. One can stand looking into the furnace without experiencing heat to an uncomfortable degree. Another important change which has recently been made, and one which will be greatly appreciated by tourists, is that the carrying over of the waste heat from the furnaces greatly reduces the dust and smoke liberated to the atmosphere. In other respects, too, where dust and smoke arise, the company have put in suction-fans to draw such impurities into a filtering apparatus by Messrs. Beth, of Lubeck.

The current is supplied to each one of the ten furnaces from a single-phase core-type transformer, which is air-cooled. In order to regulate the secondary tension and current in the proportion of 1 : 1.5, the primary voltage being constant, an arrangement is provided to change the transformation ratio according to the patents of the manufacturer, the Allmänna Svenska Electric Company, Vesteraas, Sweden. As the method used to accomplish this gives an unusually good solution of the intricate problem of regulating the voltage of an alternating-current system, especially when many steps are desired, and the tension has to be controlled within very wide limits, the principles may be briefly outlined. With reference to the diagram of connections for the transforming apparatus for a furnace, Fig. 41, it will be seen that the regulating device consists of four auto-transformers I., II., III., and IV., the connections of which can be changed by means of the double-throw single-pole oil-switches 1, 2, 3, and 4, which, when not operated, are always in a closed position. Any position of these four switches will give a fixed transformation ratio of the large transformer; and as 16 positions are possible, 16 different secondary voltages also can be obtained, with about equal intervals for each step. In order to indicate the great possibilities of the system, it may be said that with a number of 5 switches and 4 transformers 24 steps can be obtained; with 5 switches and 5 transformers, 32 steps; with 6 switches and 5 transformers, 48 steps; with 4 switches and 3 transformers, 12 steps, and so on. All the double-throw switches 1 to 4 are built up to one unit, operated by means of a special gear, a shaft, and a hand-wheel which is located at the top of the furnace, where it easily can be reached by the workman in attendance (Fig. 42, Plate XXVI.)

Fig. 41. DIAGRAM OF CONNECTIONS FOR TRANSFORMER & REGULATING APPARATUS OF NEW FURNACES.



M.T.=Main Transformer. I, II, III, IV=Auto Transformers.
F. = Furnace. 1,2,3,4=Double Throw Oil Switches.
A. = Ammeter. o= " " Oil Switch.
V. = Voltmeter. a,b,c,d.=Disconnecting Switches.
(4119.A.)

The gear is so designed as to allow the switches to operate only in correct order, step by step, and makes therefore an interlocking device of the switches unnecessary. The whole arrangement, being very simple and strong, does not involve much repair work, and is not very liable to get out of order. The four auto-transformers are built up to one regulating transformer, which is air-cooled and of the shell type (Fig. 43). The transforming and regulating apparatus are all located in the cellar of the furnace-house below the furnaces, which arrangement gives a very short length and low reactance of the low-tension leads. There are also a double-pole, double-throw oil-switch, marked *o* in Fig. 41, and four disconnecting switches *a*, *b*, *c*, and *d*, in order to make it possible, when the regulator is in a certain position, to take the regulating apparatus out of service without breaking the current of the main transformer for a moment. This switch is used, for instance, in case of inspection of the oil switches 1-4, which are operated very frequently. An examination of the conditions under which the switches 1-4 have to operate will show that they have to switch off and on only a small part of the total energy. The switch 4, for instance, has to break only $\frac{1}{16}$ of the whole current, and No. 1, while breaking one-half of the current, has to deal only with a small part of the full voltage. In addition to the advantages of the system already mentioned—namely, the great facilities for arranging many steps in a very convenient and comparatively cheap way, the small number and easy maintenance of the switches, the simplicity and reliability of the operating mechanism—there is the fact that all difficulties met with in hitherto known systems in distributing the regulating coils of the main transformer systematically, and in bringing out its many different taps in a convenient way, are here easily overcome, as the number of extra outlets amount only to two. The main transformer is shown in Figs. 44 and 45, Plate XXVI. The electrical equipment of the new furnaces was furnished by the Allmänna Svenska Electric Company, Vesteraas, Sweden.

The carbide is tapped from the electric furnaces into iron crucibles standing on small wagons. These are moved into the cooling-house lying between the two furnace-houses. The carbide blocks are taken out of the crucibles by overhead electric cranes, and are placed on iron plates on the floor. When cooled, the carbide is conveyed on these plates by another set of cranes running above the former, and is discharged into hoppers at the end of the cooling-house, from which the carbide is delivered to the cyanamide factory, or conveyed by the telpher railway to the crushing and packing-house, where, after being crushed and sorted into sizes convenient for the trade, as fully described and illustrated in our previous article, it is packed in drums containing 100 kg. and 50 kg. for export. These drums are made in a special department of the factory, as are also the wooden casks enclosing them. From the packing-house the drums are conveyed to the export quay. This quay has now a total length of about 300 yards, having recently been considerably enlarged. Rails for the electrical locomotive and wagons are laid down to and over the whole of the quay. The total length of these rails over the factory grounds is about $1\frac{1}{2}$ miles. The railway is also used for the transport of electrodes and other materials used in the factory. For works of the size of this factory it is necessary to have large workshops for repairing purposes; a mechanical workshop and a large foundry has, therefore, been built.

We may now refer to the electrical arrangements in the factory. The switch-house is designed for a capacity of 50,000 horse-power. From the power-station at Tysse the electrical power is conducted as three-phase current, 12,500 volts, and twenty-five periods, on twelve aluminium cables of 450 sq. mm. (6.975 sq. in.) section. These cables are arranged on two separate lines of iron poles. The six aluminium cables on each line are so designed that they may take the whole of the 50,000 horse-power when the others have to be repaired. On the way from Tysse to Odda, about 3 miles, there are placed five switch-towers, with parallel connections between the two ranges, and with cut-outs, in order to disconnect one range between two towers for repair.

The switch-house at the Odda Carbide Works has two floors. On the upper one the arriving lines are connected with four large switches, each able to break the 50,000 horse-power in case of short-circuit. Here the choking-coils are placed, further lightning-arrester, the volt and ammeter transformers, and the first bus-bars. On the first floor are the measuring instruments, all the switches for the transformers, and distributing bus-bars which form two ring systems connected with each other. Between the bus-bars on the first floor and the second floor are four connections, two of which are strong enough to take the whole of the 50,000 horse-power.

The carbide factory has about 90 different motors, with a total capacity of 2000 horse-power for 400 volts three-phase current. It is therefore necessary to have three 500-k.v.a. three-phase transformers with 4000 volts recording tension. These are placed in a special department on the first floor. In this are also placed four motor-generators—two for direct-current, 220 volts—for lighting purposes, tramways, and telpher railways. The other two transform the 400 volts 25 periods to 2000 volts 50 periods for lighting purposes in the dwelling-houses of workers, and also for the town of Odda.

The furnace transformers, already described, are placed in special transformer-channels under the furnace-house. One transformer is placed directly under each furnace. There are for the old furnace-house twelve single-phase 1400-k.v.a. transformers, and for the new ten single-phase 3000-k.v.a. transformers. All are cooled with large air-fans. From the switch-house to the transformer-chamber underground runs a cable tunnel, also used as an inlet channel for conveying a part of the cooling air. The old transformers have a secondary tension of 60 volts. By the new transformer, as already explained, the secondary tension can be changed from 60 to 90 volts in sixteen steps, without interrupting the current, arranged by the interposition of an ingenious regulating system. The controller of the regulator is so arranged that the workmen at the top of the furnace can regulate the tension as desired for the best working of the furnace.

It may be added that the extension of the calcium carbide factory has been carried out under the direction of Dr. Petersson, the managing director, assisted by Mr. Rosengrin.

(*To be continued.*)

MILLS AND EVAPORATORS FOR THE MANUFACTURE OF CANE SUGAR.

WE illustrate on Plate XXVII., and on pages 354 and 355, examples of the latest types of mills and evaporators for cane-sugar manufacture. These were constructed by Messrs. Duncan Stewart and Co., Limited, Glasgow, a firm long identified with this branch of engineering. The perspective view, Fig. 4, page 354, shows a powerful set of mills—the third made by the firm—for a factory with a capacity of 6000 tons of cane per day; while on Plate XXVII. are reproductions of drawings of another set of mills, which have a working capacity of 1400 tons per day of twenty-four hours. Excepting in size, there is little difference between the two mills. That shown in Fig. 4 consists of a crusher, with rolls 32 in. by 84 in., and four mills with rolls 36 in. by 84 in., all driven through compound gearing by a horizontal reversing steam-engine, with a cylinder 50 in. in diameter by 60 in. stroke. The first-motion wheels, with 110 teeth, $4\frac{1}{2}$-in. pitch, 17-in. face, and pinions with 23 teeth, $4\frac{1}{2}$-in. pitch, 17-in. face, have machine-cut teeth. Figs. 1 to 3 illustrate a fourteen-roller milling plant consisting of a Krajewski crusher, with rolls 32 in. in diameter by 72 in. long, and four mills with rolls 34 in. in diameter by 72 in. long, all driven through a set of compound gearing by a horizontal reversing steam-engine, having a cylinder 42 in. in diameter, with a stroke of 60 in. The transmission-gear is shown in Figs. 1 and 3.

As we have said, both mills are generally of the same design, and the detailed drawings serve to illustrate the features of both. The canes are transferred from the cane-pit or hopper to the shoot above the crusher by an elevator, which is 72 in. wide and built entirely of steel. It is seen in the distance in Fig. 4, and to the left in Figs. 1 and 2. The hooks and slats are attached to bush-roller chains at a $12\frac{1}{2}$-in. pitch, and are driven at a speed of 50 ft. per minute through suitable gearing by a two-cylinder engine fixed to the columns supporting the crusher. The crusher in front of the mills is of the usual Krajewski type—*i.e.*, the surface of each roller is composed of a series of helically-formed teeth arranged so that the two rollers gear properly one into the other. In passing between these rollers the canes are broken up and prepared for the mills. The bottom roller is driven from the main engine through the gearing tail-bar and couplings, and a pair of cast-steel crown wheels transmit the power to the top roller. The roll-casings are of cast steel, the cheeks, beams, and columns of cast iron, and the bearings of hard best-quality bronze, the top bush being arranged for water-cooling. The pressure on the top roller of the crushers is usually regulated by means of springs, but in this case Stewart's patent hydraulic attachments are fitted in the top covers. These will be described later. The cane-shoots to and from the crusher are constructed of steel plates and designed to prevent the escape of juice at any point except towards the mills.

The mills are mounted on two separate cast-iron bedplates running from end to end on each side, leaving space between them for a canal, into which all the extracted juice falls, and from which there are two outlets—one for the juice from the crusher and first mill, and the other for the juice from the other

MILLS FOR THE MANUFACTURE OF CANE-SUGAR.

CONSTRUCTED BY MESSRS. DUNCAN STEWART AND CO., LIMITED, ENGINEERS, GLASGOW.

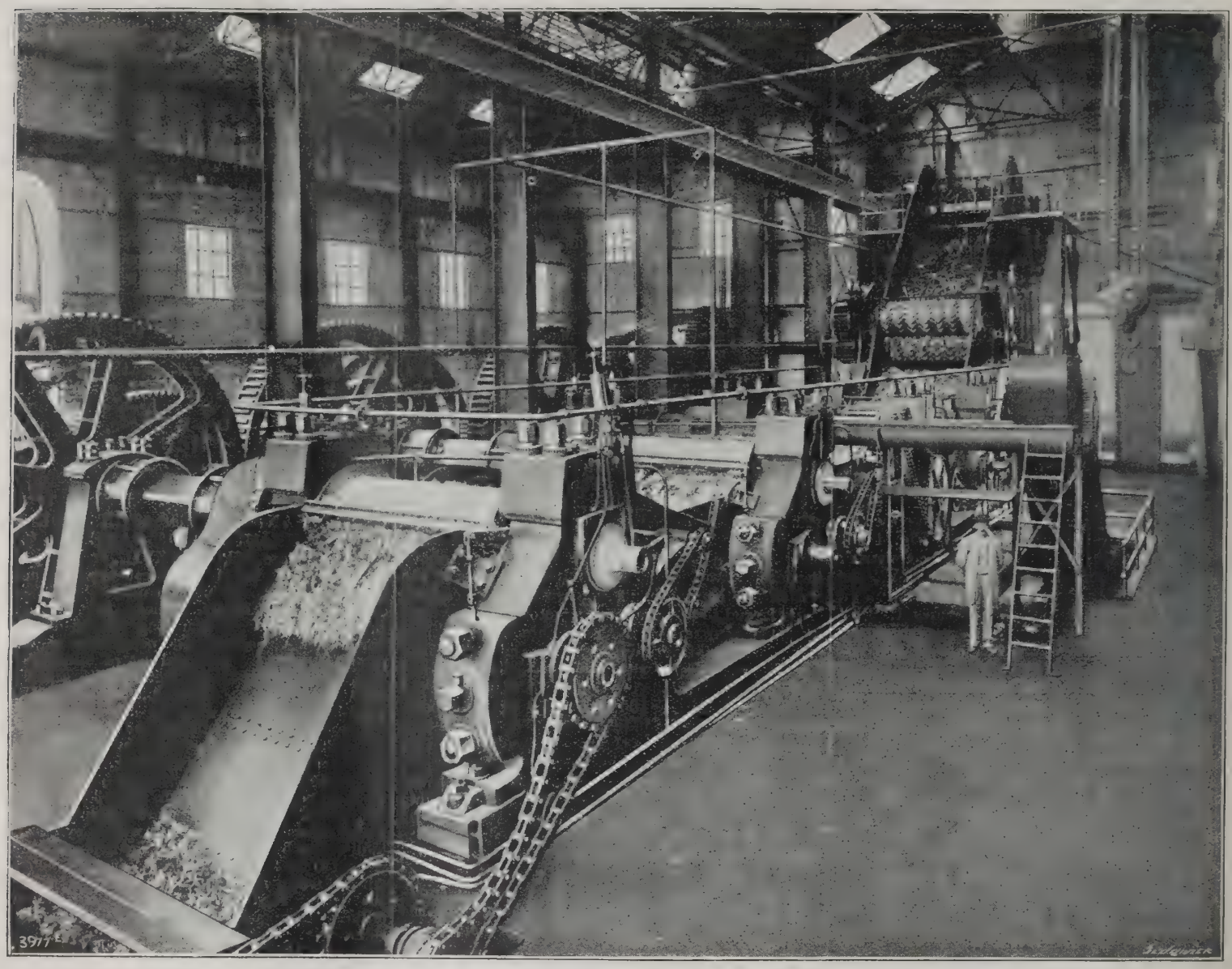


Fig. 4.

mills. The mills are designed for a maximum load of 600 tons on the top roller, and each unit is connected by tail-bar and couplings to the main gearing and engine, the power being transmitted from the top to the side rollers by means of cast-steel crown wheels. The roller-casings are made from special hard coarse-grained cast iron, and the gudgeons are of nickel steel. The cast-steel cheeks and covers are of massive proportions, and the through bolts that secure the covers are amply strong to take up the principal strains that come on the cheeks in working. The roller bearings carried in the cheeks are made from best-quality bronze, the top bushes completely surrounding their journals and the side bushes surrounding about half the surface of each journal, while they are all arranged for water cooling, and lubricated from a large central oil-box on each top cover.

The Stewart patent hydraulic attachments fitted to the top covers of the crusher and mills already referred to is illustrated by Figs. 7 to 9, on page 355. They provide a simple means of putting a constant and adjustable pressure on the top roller, irrespective of the thickness of the feed, and thereby ensure a maximum percentage of extraction, while at the same time acting as a safeguard against breakages in the event of hard substances finding their way between the rollers during the process of grinding. In the older types of mills much time was lost in the replacement of burst packing-leathers, but the essential feature of the Stewart patent attachment is that maximum efficiency in working is obtained with a minimum amount of inspection and attention. The hydraulic cylinder, containing the ram and packing-ring, is separate from the cover, and is held in position by the counterparts of a bayonet joint. Only one packing-ring is used, thereby decreasing by one-half the chances of trouble from burst leathers; should replacement become necessary, the entire cylinder can be lifted out and the spare one inserted in a few minutes. Two hydraulic accumulators—one for the crusher and one for the mills—and a steam-driven hydraulic pump are provided, as shown in Fig. 2, and the working pressure throughout the system is about 2 tons per sq. in., giving a total pressure in the case of the smaller plant of 200 tons at the crusher, 315 tons at the first mill, and 420 tons at the second, third, and fourth mills.

The canes are guided to the second pair of rollers in any mill unit by means of the trash turner, which is fixed directly below the top roller. Very different settings are required to suit the varying conditions of working and quality of canes, and both horizontal and vertical adjustment are provided for. The rocker type of turner is employed, and this consists of a strong steel body casting pivoted on trunnions, and a tough cast-iron knife secured to the body in such a way that the top working face is left perfectly smooth. After passing between the second pair of rollers, the cane, or bagasse as it is now called, falls on to an inclined intermediate carrier, which conveys it to the next mill. There are, therefore, three of these carriers in the plant. The slats are of a double curved section, so as to overlap one another, and prevent loss of bagasse. They are attached to Ewart-type chains, which are driven through suitable sprocket-wheels, shafting, and driving-chain from one of the rollers of the succeeding mill (Fig. 4). The mills are also equipped with maceration piping and pump, top-roller scrapers, and guard-rings, which prevent juice running into the bearings. Reports from the factory state that the bagasse leaving the last mill contains only 46 per cent. moisture.

The juice from the mills carries with it small particles of bagasse or bagacillo. These are removed in the mechanical strainer and elevator (Fig. 2), an apparatus which consists of a suitable arrangement of gutters covered with perforated brass sheets, through which the juice flows to the juice-pump. A light elevator is supplied, and is driven from one of the mill gudgeons, and provided with scrapers which are drawn over the strainer. The bagacillo is thus separated from the juice, and is discharged through a conveyor on to one of the intermediate carriers.

The peripheral speeds of the rollers are as follows:—Crusher, 26 ft. per minute; first mill, 18 ft. per minute; second mill, 20½ ft. per minute; third mill, 23 ft. per minute; and fourth mill, 25 ft. per minute. The gearing is compound, giving a ratio between engine and mills of about 20 to 1, and the arrangement can be readily seen by reference to Fig. 4. The wheels and pinions are all of cast steel, the former being made in halves securely bolted together, and the latter shrouded to the points of the teeth. The shafts are supported in heavy pillow blocks which are fitted with bronze bushes and sight-feed lubricators, except that the bearings for the extension of the engine crank-shaft are specially provided for lubrication by chain, and arranged for water cooling (Fig. 2).

The steam-engine is of the horizontal single-cylinder non-condensing type, with link reversing motion and balanced piston-valve. Its main features are strength and rigidity and ample bearing surfaces throughout, while the general finish is above the average for this class of work. Lubrication has been carefully attended to, and the tank and chain system employed for the crank-shaft bearings has given extremely good results in practice. The engine is controlled by a Steinle-type governor, and can develop about 700 horse-power at 50 revolutions per minute.

The quadruple-effect evaporating apparatus is shown in Figs. 5 and 6, on page 355. The first vessel receives

QUADRUPLE-EFFECT EVAPORATOR FOR THE MANUFACTURE OF CANE-SUGAR.

CONSTRUCTED BY MESSRS. DUNCAN STEWART AND CO., LIMITED, ENGINEERS, GLASGOW.

Fig. 5.

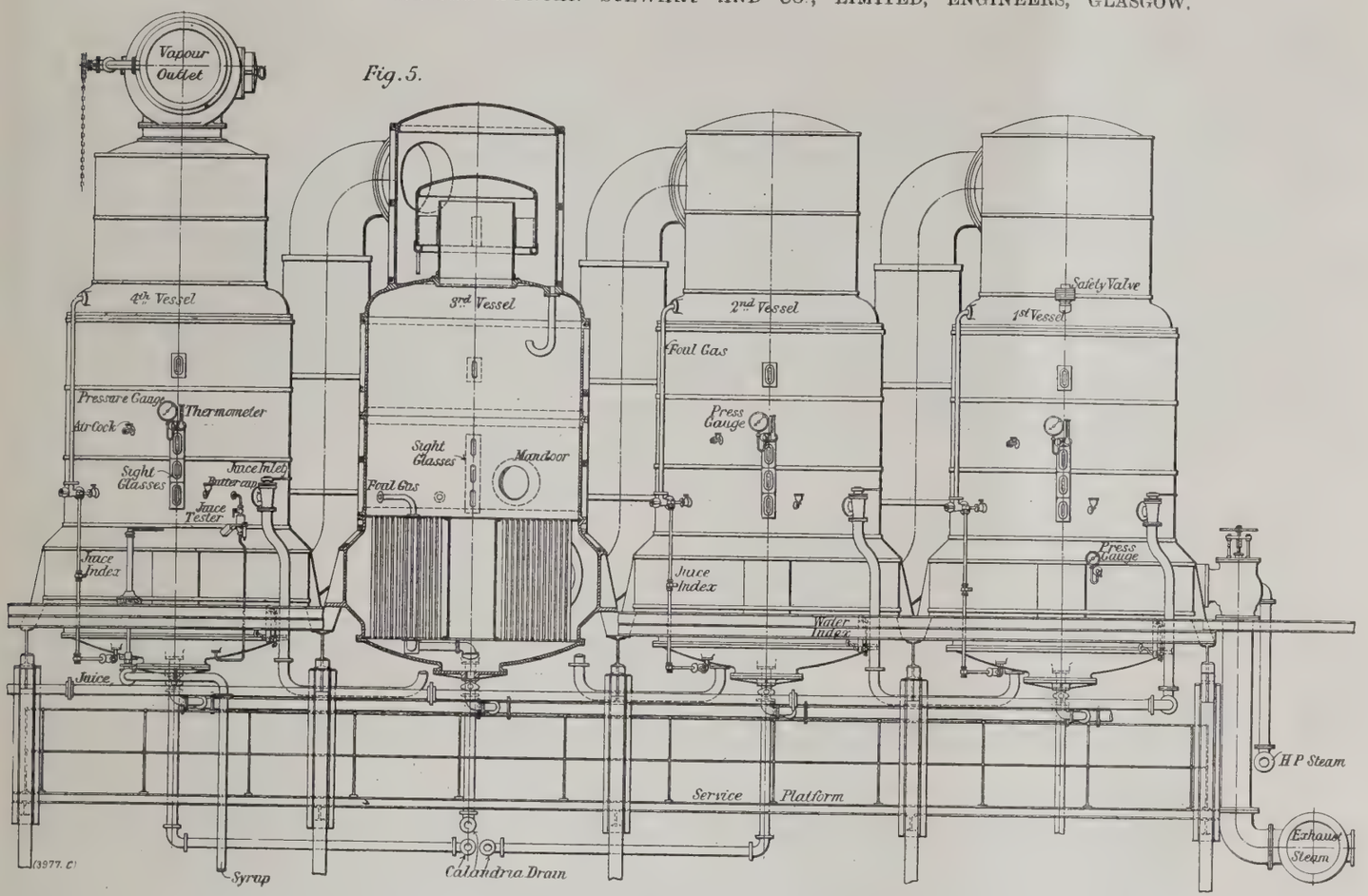


Fig. 6.

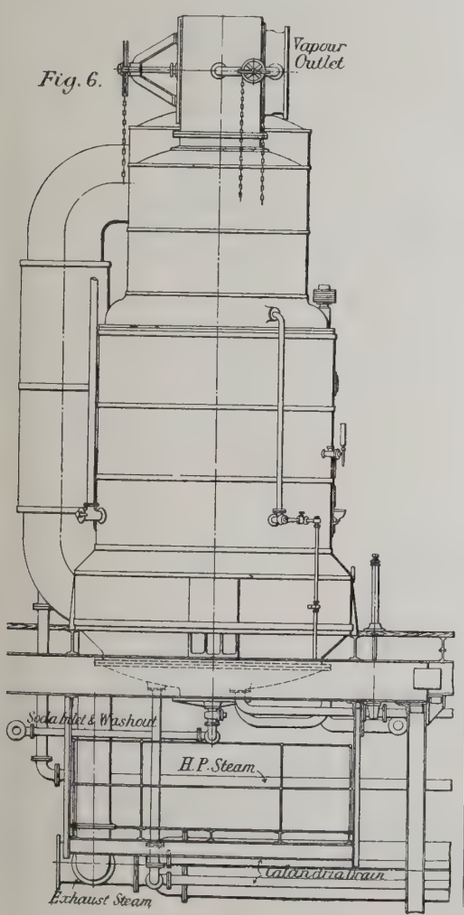


Fig. 7.

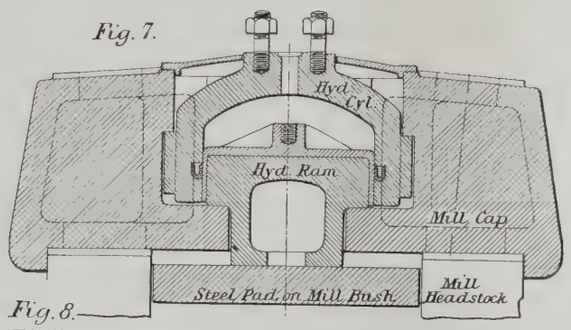


Fig. 8.

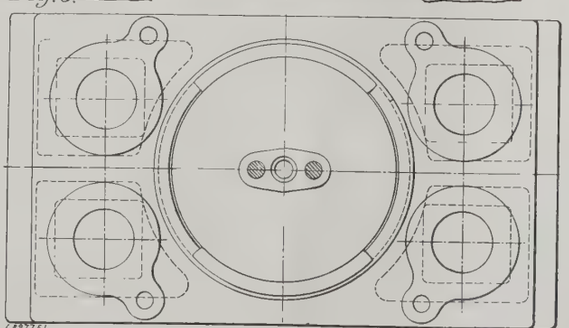


Fig. 9.

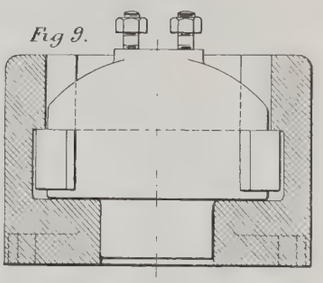
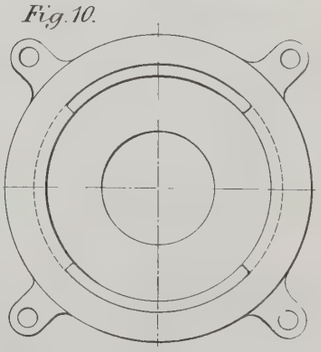


Fig. 10.



the thin juice, and is supplied with exhaust steam at about atmospheric pressure. The vapour given off from this juice is used in the second vessel further to evaporate the slightly thickened juice coming over from the first vessel, and so on it flows successively through the third to the fourth vessel, which works under a vacuum of about 27½ in., produced by the condensation of the vapours from the last vessel. The solid content of the juice entering the first vessel is from 16 to 20 per cent., and of the syrup discharged from the last vessel from 50 to 60 per cent., about 75 per cent. of the water originally contained in the juice having been evaporated.

The four vessels in the apparatus are each 11 ft. in diameter, and are built entirely of cast-iron plates. In each vessel the calandria drum has a greater diameter than the calandria itself, so as to give space all round for the uniform distribution of vapour. The tube-plates are of bronze, and the tubes of copper, 2 in. in diameter by 5 ft. long, giving a total heating surface of 12,000 sq. ft., with an evaporation of over 7 lb. of water per sq. ft. per hour. Large save-alls, made from steel plates, are provided on each vessel, and the vapour-pipes are of ample diameter to ensure an easy flow. The fittings are clearly shown in Figs. 5 and 6, and do not require enumeration; but it may be

said that they form a complete equipment for the satisfactory working of the apparatus. The vessels are covered with planished-steel sheets.

AUSTRALIAN PORTS IN RELATION TO MODERN SHIPS AND SHIPPING.*

By W. E. Adams, A.M. Inst. C E., Principal Assistant Engineer, Sydney Harbour Trust.

The enormous increase in the size of ships trading to Australia during the last fifteen years has set a problem to the port authorities of Australia that calls for careful consideration. It has become very desirable to review the position not only from the standpoint of the harbour authorities, but also from that of the local commercial interests involved. That the marine engineer can always rise to the occasion and provide for anything the shipbuilder can produce is evidenced by such works as the Suez and Panama Canals. But as engineering, practically conceived, cannot be divorced from economics, especially in a young and growing country like Australia, where much money is required for numerous lines of development, the engineer must be a rigid economist. On this account it is advisable carefully to examine the situation that is arising in its most general aspect.

Privately-owned wharfage in the chief commercial seaports of Australia has almost disappeared. Public ownership of the foreshores has been rendered necessary in order that wharfage may be planned in conjunction with other great public utilities, such as railways, tramways, roads of access, and to admit of the segregation of berthage into mail and passenger, general cargo, frozen meat, grain, coal, and other specialities.

Clearly it is necessary to separate the shipment of frozen meat and grain from coal and other dirty or noxious cargoes, while passenger and mail services should berth as close to the heart of the city as possible. Where these essentials are laid out in advance, contingent municipalities are enabled to co-operate to advantage, and private industries immediately connected with shipping can be established in the most suitable conditions.

Thus it has come about that all the Australian capital seaports except Brisbane have been placed under public trusts of various constitutions, but all aiming at the one object—namely, to provide for the shipping on a comprehensive scale and on a self-supporting basis. In the endeavour to keep pace with shipping developments the cost of the modern seaport has become, and promises to become in the future, a still more important commercial factor. Port dues already amount in many cases to 10 per cent. of the freight charges.

In ocean transport three separate interests are involved. Firstly, there is the private shipowner, who invests for personal profit; secondly, the Port Authorities, who build usually to meet expenses of maintenance, interest, and sinking fund (though sometimes more is required); and, thirdly, the merchant or shipper, who ships goods.

To Australia, which is a large exporter and importer, and, moreover, a country greatly in need of population, it is obviously important that over-sea freights, fares, and other charges should be as low as possible, on account of the immense distance from the centre of civilisation. The point of supreme interest to Australia in this connection lies in the question as to whether modern shipping developments tend to increase or to decrease the total cost of ocean transport.

It is unquestionable that cargo and passengers can be carried more cheaply in large than in small steamers —that is, the cost per ton-mile, reckoning working expenses, including coal, wages, and upkeep, are less per ton carried in large than in small steamers. By way of illustration, Sir W. White, in 1903, quoted the case of the P. and O. Company's Moldavia, 10,000 tons, stating that an increase in draught of 3 ft. would increase her freight-earning capacity by 66 per cent., while no appreciable loss of speed would ensue. This is, of course, very important to the ship-owner, but the economies of ocean transport are not affected thereby unless some at least of this saving is passed on by ship-owner to shipper, and ultimately to the producer. Naturally some reasonable advantage must be permitted to the ship-owner, otherwise he would not build large ships; but, to place the matter on a true economic basis, it has yet to be shown that the shipper and the producer share in the saving. If not, then the big ship must rely upon other grounds of justification, and, as we shall see, these may not be lacking.

The next point for consideration is the effect of big ships upon the cost of port and harbour works to accommodate them. Conditions vary so much between the ports of Australia that the total increased outlay per berth, including the necessary dredging, could only be considered for each port in detail. Thus, at Sydney and Hobart, the matter would be practically narrowed down to the actual increased cost of the new over the old class of berth, the dredging being practically a negligible quantity, whilst at Melbourne and Brisbane the deepening and dredging will be heavy items. The natural physical difficulties of these two ports must therefore exercise a limiting influence on the size of ships trading to Australia for some time to come. Brisbane being the only possible outlet for a vast and productive hinterland, will surely develop rapidly into a very large and important shipping centre, probably in time rivalling the southern ports.

To meet the increase in the size of ships the port authorities of Australia find themselves called upon to spend very large sums of money in reconstruction. Wharves and jetties that sufficed twelve or fifteen years ago are now all obsolete. Upon the cost of replacement, planned on a vastly larger scale, maintenance, interest, and sinking funds have to be provided for out of the port dues. It seems inevitable that the port dues must tend to increase. It is not overlooked that modern appliances and large vessels will allow more cargo to be handled at a berth than formerly; but, on the other hand, when a small number of very large ships replace a large number of small ones, berths are apt to have longer periods of idleness, and would, therefore, not be made the fullest use of.

The situation will be better understood by a comparison of the berths of fifteen years ago at the port of Sydney with those of to-day. Up to the year, say, 1900 the largest over-sea vessels trading to this port averaged some 6000 tons, and the interstate vessels 3000 tons. The lengths of the former ran from 430 ft. to 470 ft. by 50 ft. to 53 ft. beam, and the latter from 300 ft. to 350 ft. by 40 ft. to 46 ft. beam. For vessels of this class there were a number of berths consisting of frontage wharves and jetties from 300 ft. to 450 ft. in length. The jetties were usually from 30 ft. to 40 ft. wide, and the depths of water required ranged up to 28 ft. Several of the berths, having been built by private owners, were without shed accommodation. The average cost per berth with cargo-sheds, inclusive of value of frontage land, was 21,300*l*; but the same jetties built to-day at the higher prices would have cost 25,500*l*. per berth. The waterway between jetties varied from 90 ft. to 110 ft., but in several cases was as little as 80 ft.

The vessels now coming to Sydney have already touched the 18,400-ton mark; the largest measuring 555 ft. by 69 ft., with a loaded draught of 32 ft. Clearly it is necessary to provide for much larger vessels in the future, and it would be inadvisable to look forward to anything less than a possible 1000 ft. in length, with a loaded draught of 40 ft., though these dimensions may not be reached for many years to come.

The jetties necessary to berth the over-sea vessels at present trading to Sydney are from 500 ft. to 650 ft. in length (with provisions for extension) by 130 ft. to 250 ft. in width, and the waterway between them, to allow for handling, coaling, and transhipping, ranges from 220 ft. to 360 ft. Double-decked cargo-sheds are required to accommodate the large quantities of freight rapidly put ashore, and electric cranes, gantries, and other lifting gear are being provided. The cost of these, adding the value of frontage land, ranges from 67,000*l*. to 77,000*l*. per berth, irrespective of dredging, which, particularly in Sydney, is a small item, but in several other ports will be excessively heavy. The requirements for interstate shipping are scarcely less. Some of the vessels now engaged in this traffic measure as much as 9000 and 10,000 tons, and no doubt larger ships will be built.

It seems evident, even after making allowance for the superior earning capacity of these modern berths, that increased harbour rates will have to be charged to render such investment sound and self-supporting. This is a question that requires special investigation. Judged from a purely economical point of view, there is room for considerable doubt as to whether the advent of the large vessel has operated towards lowering the cost of sea-borne freight, including, of course, incidental charges, such as wharfage and tonnage dues, &c. The question is greatly complicated by the upward tendency of wages and materials, which not only increases the cost of ship construction, but also puts up the cost of working expenses and maintenance, which are naturally passed on by the ship-owner. There are, however, other very important considerations which must be taken into account. Pressing as the economic question is, there are distinct advantages in the employment of big ships. Higher speed can be obtained, which at this distance from Europe, is desirable for mails, passengers, and cargo. The time element is certainly of urgent importance to Australia. Greater safety, seaworthiness, steadiness, and comfort are also secured.

The class of wharf construction that will come into use in the future, though important, is very uncertain at the present time. Timber has been used almost entirely in Australia. Reinforced concrete has been dealt with very charily, but it is safe to say that if the local timbers had not proved so satisfactory from every point of view, reinforced concrete would have been largely used during the last fifteen years.

Where space is available, longshore wharves, served by low-level road and belt railway, offer the greatest facilities for handling cargo. But as this is not always possible, jetties will continue to be used to a large extent. To provide shed accommodation and low-level road access to facilitate the removal of goods, without traffic congestion, necessitates very great width of jetty. In Sydney two plans are being tried to meet such cases. In one instance the jetty is 210 ft. wide, with a sunken road down the middle, which brings the cart body to the level of the shed floor.

In another case, where the available water frontage length is restricted, a type of jetty is being built with a high and a low side, so that when a cart is on the low side the body is at the floor level of the higher side of the jetty. The high side, which extends over about three-quarters of the width of the jetty, will be used for inward cargo, which requires as much space as possible for sorting and stacking. The low side will be used for traffic and outward cargo, which goes aboard the ship as it arrives, and seldom accumulates on the wharf to the extent of more than 400 or 500 tons at a time. These jetties will have an upper deck approached by a bridge from a high-level roadway. The upper deck will be constructed with high and low levels, similar to the lower deck, but disposed on the opposite sides. Thus each side of the jetty will have a separate loading and unloading deck. On this account it will be possible to carry on the two operations together, without confusion of outward and inward cargo, and the cost of construction will be relatively low. The position of the other Australian ports will be reviewed in the same way, for the purpose of considering how far the port authorities are justified in accepting the challenge of the ship-owner.

* Abstract of paper read before Section G of the British Association in Australia, August, 1914.

THE TENSILE PROPERTIES OF COPPER AT HIGH TEMPERATURES.*

By Guy D. Bengough, M.A., D.Sc. (Lecturer in Mettallurgy, University of Liverpool), and D. Hanson, M.Sc., of the National Physical Laboratory.

The experimental work described in the present paper was designed originally as a continuation of the research carried out by one of the authors in 1911, an account of which was published at the annual general meeting of this Institute in 1912.† The discussion of that paper brought out certain criticisms and suggestions, with which the present authors now propose to deal.

In the first place, criticism was levelled at the special type of testing-machine used, on the ground that the friction of the ram would vary from time to time, and in particular with widely varying loads.

The reply to this is given in Table I., in which is recorded a series of comparative tests carried out in an ordinary tensile-testing machine, and in the machine described in the paper mentioned above. Bearing in mind the differences which are ordinarily found between duplicate tests of non-ferrous metals, the agreement afforded appears to the authors to be satisfactory, and to dispose of the criticism mentioned. It will be noticed that the metals and alloys have been selected to cover a wide range of properties. The tests were carried out precisely as described in the former paper.

Table I.—*Tests at* 18 *Deg. Cent.*

Name of Metal or Alloy.	Buckton Testing-Machine.		Special Machine.	
	Maximum Stress.	Elongation per Cent. on 2 In.	Maximum Stress.	Elongation per Cent. on 2 In.
Zinc (rolled) ..	6.4	8.9	6.2	9.1
Brass (cast) ..	12.1	39.0	12.4	37.0
Copper (rolled) ..	16.5	31.5	16.3	32.5
Muntz metal ..	27.1	32.2	27.7	36.5
Ditto ..	28.9	34.0	28.1	34.6
Nickel-copper ..	29.8	28.2	29.2	28.0
Complex brass ..	40.3	21.0	40.0	22.0

For the work now to be described, certain changes were carried out in the design of the heating furnace with a view to enabling tests to be carried out in any desired atmosphere; the new form of apparatus is shown in Fig. 1, opposite. The test-bar A, which is ½ in. in diameter and turned down parallel to ¼ in. for a length of 2½ in., is held centrally in a nichrome wound resistance furnace by means of extension pieces which are provided with ball-seatings as shown. The nichrome wire is wound on asbestos sheet wrapped round an iron tube which is closed at the lower end by a water-seal B. At the top end it is closed by a well-fitting steel plug D provided with a bayonet catch, and drilled for the entrance of gas and thermocouple. The thermocouple holes were lined with fibre. The top joint was water-cooled, as shown at C, and this enabled the plug to be kept gas-tight by a coating of "hot-neck" grease.

In view of the remarkable elongation curve recorded for B.S. copper in the earlier paper, and reproduced in Fig. 9, page 358, it seemed desirable to ascertain whether the high elongations observed between 780 deg. and 920 deg. Cent. were characteristic of all types of copper, or were dependent in any degree upon such matters as the nature of the atmosphere in which the test was carried out, the past history of the specimen, thermal and physical, and the presence of small quantities of impurities.

As a starting-point for the present research, it was decided to carry out a series of tests on well-annealed rolled electrolytic copper. The analysis of this material, as well as the analyses of other materials used in the research, is given in Table II. The copper was obtained in the form of ½-in. round rolled rods, and was turned down to ¼ in. diameter before testing.

Table II.—*Analyses of Materials Used.*

——	Electro-Copper.*	B.S. Copper.†	Arsenical Copper.
	per cent.	per cent.	per cent.
Oxygen	0.08	0.08	0.13
Arsenic	0.003	0.05	0.13
Iron	trace	trace	0.02
Lead	—	—	0.10
Sulphur	—	0.005	—
Tin	—	—	0.08

* Analysed after annealing for two hours at 750 deg. Cent. in CO_2.
† Analysed before testing.

The procedure in testing was the same as formerly, except that the rate of loading has been kept constant, as suggested by Dr. Rosenhain in the discussion of the former paper. The rate selected as most convenient with

* Paper taken as read at the statutory meeting of the Institute of Metals, held on September 10, and submitted for discussion by correspondence up to September 30, 1914.

† G. D. Bengough, "A Study of the Properties of Alloys at High Temperatures," Journal of the Institute of Metals, No. 1, 1912, vol. vii., pages 123 *et seq.* Engineering, vol. xciii., pages 90, 93, and 166.

the apparatus used was 0.5 ton per sq. in. per minute. Strictly speaking, a definite rate of straining should have been adopted, as has been pointed out by Rosenhain and Humfrey,* but this could not be carried out with the apparatus used, since only the total final strain could be measured. The adoption of a definite rate of loading leads, however, to useful results, since the mechanical treatment of the material is precisely defined and reproducible, though it is possible that the shapes of the stress-temperature and strain-temperature curves obtained by this method of testing are slightly different from those that would be obtained by adopting a definite rate of straining.

Previous to testing at the various temperatures, the electro-copper was annealed for two hours at 750 deg. Cent. in an atmosphere of CO_2. The results of the tensile tests are given in Table III., and are plotted in Figs. 2 and 3. It will be noticed at once that the curves present considerable differences from those described for B.S. copper in the earlier paper. The latter have been reproduced for comparison in Figs. 8 and 9, page 358. It will be noticed that the two maximum-stress curves are approximately of the same form, but that the critical portion of the curve occurs at a higher temperature in the case of the annealed electrolytic copper, and is not so sharply defined.

The two elongation curves present much greater differences, especially in the upper parts. The high elongations recorded in the case of B.S. copper between 750 deg. and 950 deg. were not observed in the case of the annealed electrolytic copper. Moreover, in the case of the latter metal, the maximum stress and elongation curves were of the same general shape, showing critical ranges at about 750 deg. Evidently a high elongation at high temperatures is not characteristic of all types of copper under all circumstances.

Fig.1.

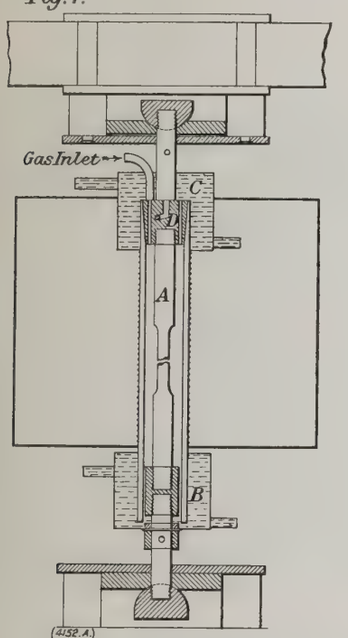


Fig.2. COPPER. ANNEALED 2 HOURS AT 750° C. IN CO_2

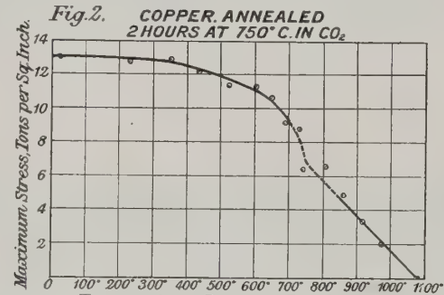


Fig.3. COPPER. ANNEALED 2 HOURS AT 750° C. IN CO_2 (BROKEN IN CO_2)

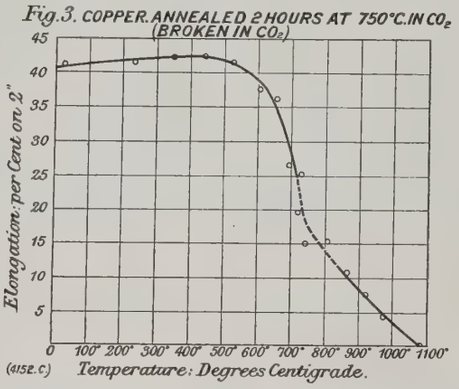


Fig.4. COPPER. ROLLED. (BROKEN IN CO_2)

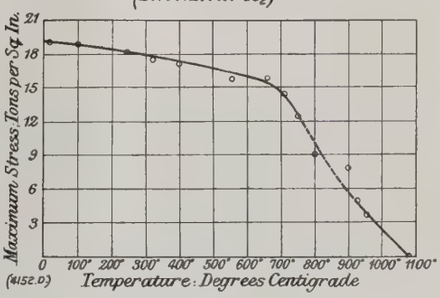


Fig.5. COPPER. ROLLED. (BROKEN IN CO_2)

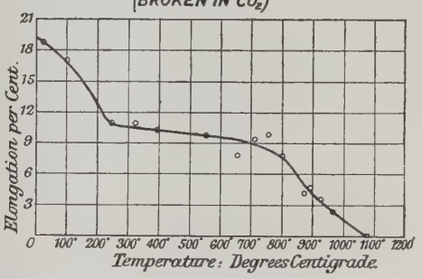


TABLE III.—*Electro-Copper, Annealed Two Hours at 750 deg. Cent. in CO_2.*

No. of Bar.	Temperature.	Maximum Stress.	Elongation per Cent. on 2 In.
	deg. Cent.	tons per sq. in.	
D. 5	22	13.0	40.6
D. 11	233	12.7	41.4
D. 24	350	12.8	42.2
D. 10	434	12.2	42.2
D. 6	522	11.4	41.4
D. 23	605	11.2	37.5
D. 18	650	10.5	35.9
D. 16	692	9.2	26.5
D. 19	719	7.4	19.5
D. 17	730	8.8	25.5
D. 15	740	6.3	14.8
D. 25	804	6.5	15.6
D. 22	863	4.9	10.8
D. 20	918	3.4	7.9
D. 21	975	2.0	4.25

It seemed desirable next to ascertain whether the high elongation shown in the case of B.S. copper at high temperatures was due to the nature of the atmosphere (in this case, air) in which the bars were tested. Unfortunately, none of the original B.S. copper was available for a direct test. But two bars of the annealed electro-copper were tested in air at 800 deg. and 850 deg.—*i.e.*, in the high elongation range of the B.S. copper. The results are given in Table IV., and it will be seen that the elongation in air is three or four times that of the same metal in CO_2, though it is not nearly as high as was the case with B.S. copper. Part of the difference may perhaps be due to the rather slower rate of loading in the older tests, and part to the differences in the two types of copper. The interesting point about these results is the demonstration of the great effect of the atmosphere upon the ductility of commercially pure copper bars. It is a somewhat surprising fact that an oxidising atmosphere should confer greater ductility than a neutral atmosphere; a possible explanation will be discussed later.

It has now become clear that in any discussion of the tensile properties of copper at high temperatures from the point of view of physical constitution, it is necessary to deal first with tests carried out in a neutral atmosphere, since reducing gases such as hydrogen are known to influence the properties of copper at high temperatures at least as seriously as oxygen.

As far as the authors are aware, a complete series of tests in a neutral atmosphere ranging from atmospheric temperatures to approximately the melting-point of a pure thoroughly-annealed metal has never before been published, so that it is not possible to say whether the curves now presented are of typical form. The experiments of Rosenhain and Humfrey on steel are not available for direct comparison, since the shapes of the curves obtained for that material were much modified by the occurrence of allotropic changes, and probably by the presence of carbon. Nevertheless, in view of the theories that have recently been put forward in a series of papers by Rosenhain and his associates, it may be interesting to discuss the curves now published in the light of those views.

In the former paper by one of the authors the view was put forward that the mechanical properties of metals and alloys at high temperatures might be accounted for by supposing "that the individual crystals in a pure metal are normally bound to one another by some substance stronger than the crystals themselves," and that this substance was "arranged in a thin continuous layer round the crystals." This substance was then supposed to be an amorphous material similar to that discovered by Beilby, but formed during the process of crystallisation. It was supposed, further, that it could be crystallised by long annealing at high temperatures. In the discussion on that paper, Rosenhain outlined a modification of this theory that was a distinct improvement in the number of particulars on that suggested in the paper, and he has since developed his views with great skill upon a basis of actual experiment. For the purposes of the present paper Rosenhain's theory may be briefly stated as follows:—

Metals in general consist of crystalline aggregates surrounded by elastic envelopes of primary cement formed during solidification. At low temperatures the cement accommodates itself to stresses in virtue of its elasticity, but the crystals do so by plastic deformation. At low temperatures the cement is stronger than the crystals, and fracture under stress passes through the crystals. As the temperature rises, the cement weakens more rapidly than the crystals, and its elasticity falls off. Finally, the cement is as weak as, or even weaker than, the crystals, and its elasticity has disappeared. Fracture will then be intercrystalline, and permanent elongation will result under the action of very small stresses owing to the deformation of the cement, which will allow the crystals to slide over one another.

The final elongation observed in a tensile test will depend on the rate of straining, and rapid straining will give low elongation.

The results obtained in the tests on annealed copper will now be reviewed in the light of this theory. Turning first to the tensile curve given in Fig. 2, it will be observed that the maximum stress corresponding to the rate of loading adopted falls off slowly, but regularly, up to a temperature of about 700 deg. Cent. Between 700 deg. and 800 deg. Cent. the strength falls off more rapidly. In this region it is difficult to get closely concordant results, and the curve has been shown dotted. Above 800 deg. Cent. the rate of fall of strength with temperature becomes less, and the curve approximates to a straight line.

TABLE IV.—*Electro-Copper (as Rolled). Tested in CO_2.*

No. of Bar.	Temperature.	Maximum Stress.	Elongation per Cent. on 2 In.
	deg. Cent.	tons per sq. in.	
D. 29	21	19.3	18.7
D. 39	100	18.9	17.0
D. 30	245	18.3	10.9
D. 28	320	17.6	10.9
D 27	396	17.4	10.2
D. 31	555	15.8	9.8
D. 32	660	15.9	7.8
D. 33	710	14.5	9.3
D. 34	760	12.5	9.8
D. 35	800	8.9	7.8
D. 36	896	7.9	4.7
D. 37	927	4.9	3.5
D. 38	954	3.6	2.5
	Tested in Air.		
D. 42	800	2.6	27.3
D. 43	850	2.4	30.6

On Rosenhain's theory, this curve may be interpreted as follows:—At all temperatures below about 700 deg. Cent. the strength of the cement is greater than that of the crystals, and fracture will take place through the body of the crystals. Between 700 deg. and 800 deg. Cent. the strength of the cement and the crystals will be approximately equal, and fracture may pass through either, though the tendency at the higher temperatures will be for it to pass through the cement, and at the lower through the crystals. In this range of temperature there is a certain degree of instability of structure throughout the metal; hence the difficulty of obtaining closely agreeing results.

At temperatures above 800 deg. Cent. fracture should pass wholly through the cement, which has become weaker than the crystals. Apparently the strength of the cement in this region of temperature is inversely proportional to the temperature.

These predictions could obviously be tested by microscopic observations of the fractures of the test-bars. In order to preserve the actual edge of the fractures during polishing it was necessary to plate the edges of the test-bars by a supporting metal, as was originally pointed out by Rosenhain. Copper-plating was not satisfactory, since it exhibited preferential etching. Finally a thin coating of nickel was used, which was afterwards covered with a thick deposit of copper. The method adopted was as follows:—

The fracture was cleaned in potassium cyanide to remove tarnish, and covered by a coating of nickel by electrolysing a saturated solution of nickel-ammonium sulphate. The specimen was rotated during deposition and a current of 0.2 ampere used. The deposition of nickel occupied two to three hours, and the specimen was then transferred to an "acid sulphate" copper bath until a thick coating of copper had been deposited. The specimen was then cut and polished in the usual way.

Etching was a matter of considerable difficulty, but eventually satisfactory results were obtained with a 10

* Journal of the Iron and Steel Institute, 1913, No. 1, page 244.

per cent. solution of ammonium persulphate containing excess of ammonia. Figs. 10 to 19, on the opposite page, illustrate some of the structures observed. Figs. 10 and 11 show the original structure of the metal before testing, both before and after annealing. Figs. 12 and 13 show examples of the low-temperature type of fracture, which passes through the crystals. The crystals are greatly elongated in the direction of fracture, though the engravings do not show this quite as clearly as could be wished. These severely strained structures were exceedingly difficult to etch, though neighbouring parts further away from the fracture, but less severely strained, etched up readily.

Figs. 16 and 17 show the fractures of bars broken at 896 deg. and 719 deg. Cent. The fractures are clearly intercrystalline. For all temperatures between 720 deg. and the melting-point the metal shows great intercrystalline weakness, and cracks can be found passing between the crystals for distances as much as an inch from the actual point of fracture. Such intercrystalline cracks are clearly shown in Figs. 14, 15, and 17. It is particularly to be noticed that there is no distortion of the crystals in this type of fracture.

These results are remarkable. Previously this type of fracture has only been observed at temperatures within a few degrees of the melting-points of metals,* whereas it has now been found to occur at a temperature as much as 350 deg. Cent. below the melting-point, and first becomes observable where the stress-temperature curve begins to flatten. It should be stated that bar 19, which was broken at 719 deg. Cent., showed signs, in a few places, of fracture passing through the crystals, though characteristically it passes between them, as shown in the microphotograph. Thus it seems clear that the strength of cement and crystals are nearly equal at 719 deg. Cent., with the crystals slightly the stronger even at this temperature. At 710 deg. Cent. the crystals were decidedly weaker than the cement, and showed plastic deformation by slip (see Fig. 12). With the exception of bars tested at about 719 deg. Cent., all the bars were perfect examples of either one type of fracture or the other. It is interesting to notice that the intercrystalline type of fracture never takes place along a twin boundary (see Fig. 15), thus proving the prediction that a cementing material exists at a twin boundary.

Fig. 19 shows the low-temperature type of deformation which was found at some distance away from the centre—*i.e.*, the hottest part—of a highly heated bar (D. 36).

Turning now to the elongation curve obtained from the same series of tests, it is interesting to note that the ductility begins to fall off at a lower temperature than the maximum stress. From the atmospheric temperature up to 600 deg. Cent. the bars show a considerable elongation, which takes place by plastic deformation—*i.e.*, by slipping in the crystals. Thereafter the ductility falls off rapidly, though the most noticeable reduction in strength only takes place at a temperature higher by 50 deg. Cent. The explanation of this phenomenon is not easy to see.

At higher temperatures the reduction in the elongation must be supposed to be due to the loss of strength of the cement through which the fracture passes before any great extension has taken place by the yielding of the cement. The engravings (Figs. 14 and 16) show that no plastic deformation of the crystals occurs in this region of temperature, though at temperatures below about 720 deg. Cent. a certain amount of plastic deformation can take place. At temperatures above about 800 deg. Cent. any ductility that the bars may possess must be due to the sliding of the crystals bodily over one another.

Looking at the results as a whole it would appear that the Rosenhain theory of the physical constitution of metals will fit the experimental facts observed for a pure annealed metal quite satisfactorily except in the one particular mentioned. In the last connection it is interesting to note that Longbottom and Campion† have observed a loss of ductility at a lower temperature than strength in the case of Admiralty bronze alloys of the composition: copper, 87.96; tin, 9.77; zinc, 1.94; so the phenomenon probably has an important significance. They put forward the view that the cement loses its ductility before its strength as an explanation. This hardly seems satisfactory to the authors, since at the comparatively low temperatures under consideration the characteristic property of the cement is elasticity rather than true ductility. That the cement does not lose its elasticity is shown by the fact that fracture still passes through the crystals in this region of temperature; consequently the cement can accommodate itself to stresses.

Effect of Mechanical Work.—It will now be interesting to consider the results obtained from the same sample of copper used in the last experiments, but tested in the unannealed rolled condition. It was thought that the two sets of results might throw some light on the question of the identity or resemblance between the "primary cement" formed during the crystallisation of a metal from the molten state and what may be termed the "secondary cement" of Beilby which is formed by "work." The results of the tests are given in Table IV. and plotted in Figs. 4 and 5, page 357. In the first place, it should be noticed that the heat treatment in the furnace while the tensile test was being carried out was too short to produce a complete, or nearly complete, annealing effect at any temperature below 1000 deg. Cent.; in other words, the tensile curve for rolled copper lies wholly above the same curve for annealed copper. This would seem to indicate that the secondary cement has considerable powers of persistence at high temperatures, though it cannot survive two hours' annealing at 750 deg. Cent. The general forms of the curves are similar, though the range of temperature in which the most rapid diminution of strength occurs is apparently slightly higher in the case of the rolled copper.

The most interesting and important differences are seen when the two elongation-temperature curves are examined. In the case of the rolled metal there is a rapid diminution in ductility at quite low temperatures, which is not observable in the case of the annealed metal. Previous workers, including Le Chatelier, Huntington, and one of the authors, have observed a loss of ductility in copper at low temperatures. Except in the case of Huntington's experiments,* the drop has only been observed in unannealed rolled or worked metal. Huntington observed it in annealed electrolytic copper. The temperature at which it occurs seems to vary considerably, but minimum ductility is usually observed between the limits 300 deg. to 450 deg. Cent. Looking at the results as a whole, the explanation that naturally suggests itself is that low ductility is observed in the temperature range over which the amorphous material formed by "work" is recrystallising most actively. There are two objections to this view. The first is that a region of low ductility was found by Huntington in the case of annealed electrocopper. Since, however, at the date of his experiments (1906) there was no reason to suppose that drastic annealing was specially important, it may be suggested that the heat treatment was incomplete, at any rate pending an authoritative statement to the contrary by Professor Huntington. The second objection is that there is very little sign of any corresponding fall in the maximum stress curve, which would certainly be expected if the view suggested were correct. All that can be said at present is that the fall of ductility at low temperatures, such as 250 deg. to 450 deg. Cent., is possibly connected with the general properties of the "secondary" or amorphous cement of Beilby. If this prediction should be verified by future work, it will suggest that there are important differences in properties between the primary and secondary cement—a view which commends itself to the authors, though Longbottom and Campion have recently adopted the view that they are identical. Special experiments are necessary for the further elucidation of this matter.

Effect of Chemical Composition.—The results of tests described above have been obtained on material which may be considered as commercially pure metal. The effect of the introduction of an impurity may now be discussed, and in this connection oxygen introduced into the bar by testing it in air may be regarded as an impurity.

The great increase in ductility due to the presence of an oxidising atmosphere has already been noticed. Comparing the rolled B.S. copper with the rolled electrolytic, it is also noticeable that the latter has the higher tensile strength, and it preserves this characteristic even at temperatures as high as 900 deg. Cent. The B.S. copper was tested in oxygen. Thus oxygen as an impurity seems to confer high ductility and low tensile strength, especially at high temperatures. A quantitative expression for this result cannot be given, since the estimation of the real amount of oxygen, which penetrated into the bar during a test, could not be carried out accurately owing to the small section of the bars, the thick external scale of oxide formed, and the irregular distribution of the oxide in the bar itself. Microscopic examination showed that the amount was considerable.

Fig. 6. ARSENICAL COPPER. ROLLED. (BROKEN IN AIR.)

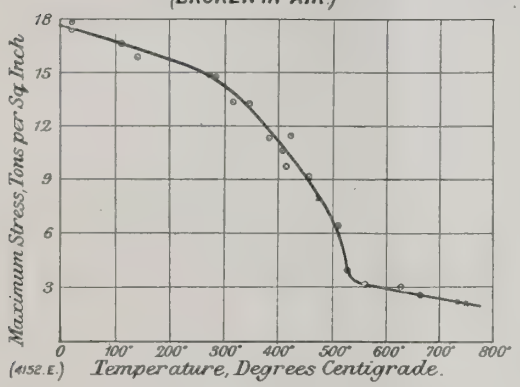


Fig. 7. ARSENICAL COPPER. ROLLED. (BROKEN IN HYDROGEN.)

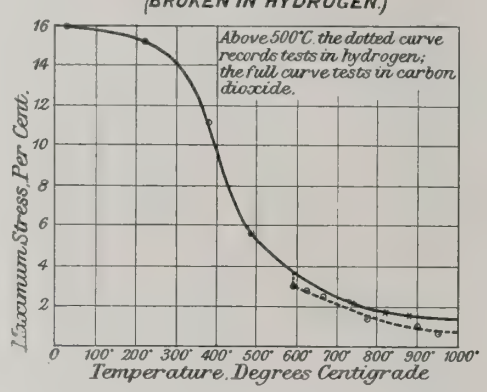


Fig. 8. COPPER.

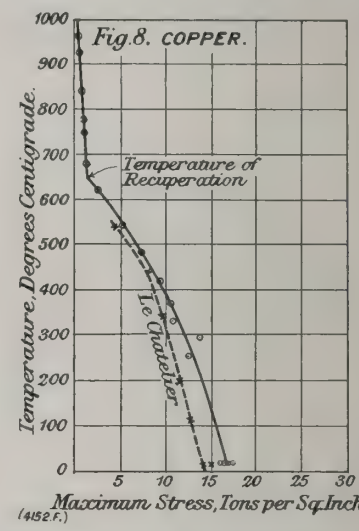


Fig. 9. COPPER.

TABLE V.—*Arsenical Copper (as Rolled). Tested in Air.*

Temperature.	Maximum Stress.	Elongation per Cent. on 2 In.
deg. Cent.	tons per sq. in.	
18	17.5	21.0
18	17.9	23.0
110	16.7	10.5
138	15.9	10.0
216	15.7	7.8
226	15.7	8.0
270	14.9	9.0
280	14.8	8.5
316	13.3	9.0
340	13.2	6.0
378	11.4	4.0
408	10.7	4.0
410	9.75	4.0
420	11.5	4.8
455	9.2	9.0
505	6.5	7.0
526	4.0	12.5
562	3.2	14.0
622	3.1	16.0
665	2.67	11.1

TABLE VI.—*Arsenical Copper (as Rolled). Tested in Hydrogen.*

18	17.9	23.0
220	15.3	10.0
385	11.2	4.5
490	4.85	11.3
595	2.95	8.0
625	2.75	8.0
690	2.55	11.0
780	1.47	9.4
900	1.00	12.5
950	0.84	12.0
Test in Carbon Dioxide.		
650	3.00	9.0
735	2.20	10.0
740	2.15	17.0
820	1.75	16.0
880	1.60	13.5

Turning now to the effect of arsenic on the mechanical properties of copper, the results of two sets of tests on arsenical copper (of the composition given in Table II.) are shown in Tables V. and VI. and plotted in Figs. 6 and 7. Three sets of tests were carried out, one in air,

* Rosenhain and Ewen, Journal of the Institute of Metals, No 2, 1913, vol. x., pages 119 to 140. ENGINEERING, vol. xcvi., pages 314 and 370.

† Journal of the Institute of Engineers and Shipbuilders in Scotland, July, 1914.

* Journal of the Institute of Metals, No. 2, 1912, vol. viii., pages 126 to 144. ENGINEERING, vol. xciv., pages 434 and 437.

another in hydrogen, and a third set in carbon dioxide. These last tests are plotted on the curves for the other two sets, but are distinguished by being shown as crosses.

The tensile curve for tests in air somewhat resembles that for B.S. copper in air, though the change in the direction of the curve takes place at a slightly lower temperature. The curve for the tests in hydrogen resembles the two mentioned, though there are signs that at temperatures of 600 deg. Cent. and above the bars tested in hydrogen were weaker by about half a ton per square inch. This is probably connected with the well-known cracking of copper in hydrogen, which becomes evident at about 700 deg. Cent., but may somewhat impair its properties at somewhat lower temperatures. In this connection it is interesting to compare the results of tests in carbon dioxide, which lie on an extension of the hydrogen curve above 720 deg. Cent.

Looking at the set of curves for bars tested in air as a whole, from the point of view of Rosenhain's theory, the explanation that naturally occurs is that the presence of either arsenic or oxygen in copper causes a softening of the cement, and that the effect of the presence of both together is not appreciably greater than either singly. The softening of the cement results in a low tensile strength. It would also be expected to lead to a high ductility, and this prediction is verified in the case of the B.S. copper, which has a high ductility over the whole temperature range of the tests, except in the narrow zone in the neighbourhood of 300 deg. Cent., which has already been discussed.

In the case of arsenical copper this range of low ductility is much more extensive, and extends to 500 deg. Cent., above which a range of considerable ductility occurs, and the arsenical bars show greater elongation than the rolled electro-copper bars broken in CO_2. Thus the view that both oxygen and arsenic cause a softening of the primary cement affords a satisfactory explanation of the whole series of curves, with the exception of a zone of low ductility which occurs in the case of all the unannealed "impure" bars. Further tests are necessary to determine the meaning of the results obtained in this region.

The main conclusions that have been reached as a result of this research may be briefly stated as follow :—

1. The nature of the atmosphere in which the tests

FIG. 10.—Electrolytic copper (as rolled). Magnified 200 diameters.

FIG. 11.—Electrolytic copper, annealed for two hours at 750 deg. C. Magnified 200 diameters.

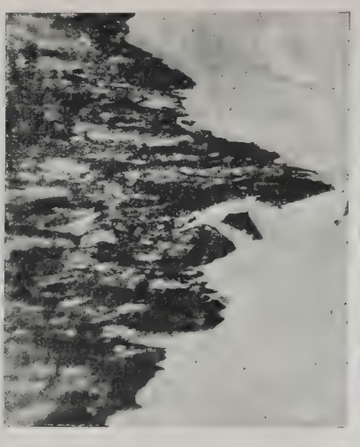


FIG. 12.—Rolled electro-copper bar (D. 33) broken at 710 deg. C. Shows elongation of crystals at fracture. Magnified 400 diameters.

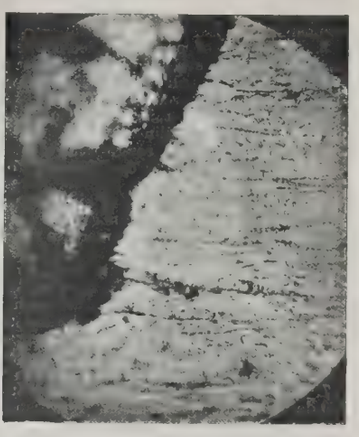


FIG. 13.—Annealed electro-copper bar (D. 24) broken at 350 deg. C. Shows elongation of crystals at fracture. Magnified 400 diameters.

FIG. 14.—Electro-copper bar (as rolled) (D. 36) broken at 896 deg. C. Shows intercrystalline cracks. Magnified 600 diameters.

FIG. 15.—Annealed electro-copper bar (D. 19) broken at 719 deg. C. Shows intercrystalline cracks near fracture. Magnified 600 diameters.

FIG. 16.—Annealed electro-copper bar (D. 19) broken at 719 deg. C. Shows intercrystalline fracture. Magnified 600 diameters.

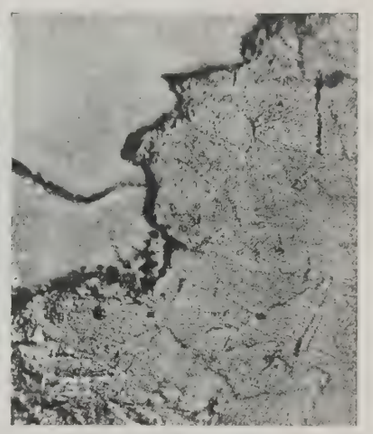


FIG. 17.—Rolled electro-copper bar (D. 36) broken at 896 deg. C. Shows intercrystalline fracture. Magnified 600 diameters.

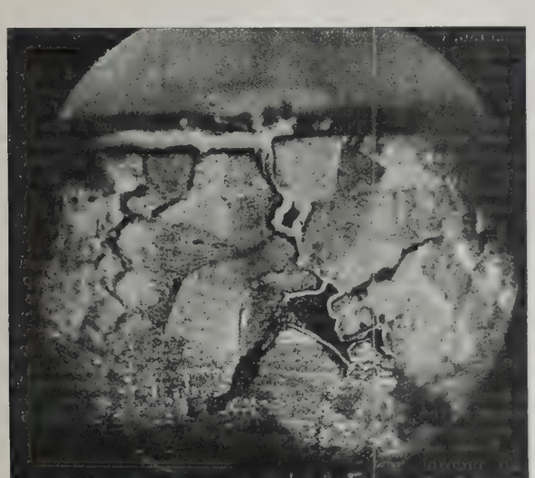


FIG. 18.—Annealed electro-copper bar (D. 20) broken at 918 deg. C. Shows intercrystalline cracks and fissures. The white lining to fissures is deposited nickel. Magnified 600 diameters.

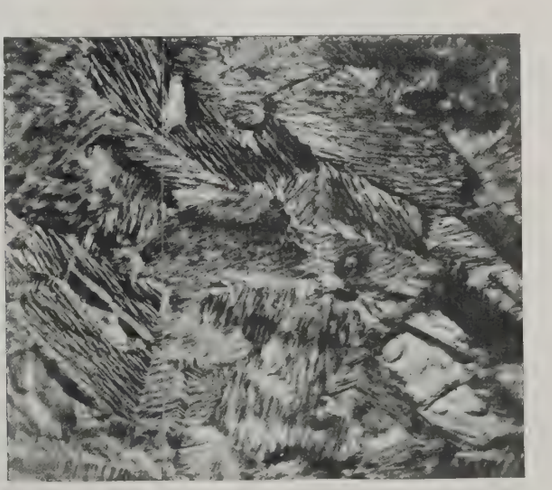


FIG. 19.—Rolled electro-copper bar (D. 36) broken at 896 deg. C. Not near fracture. Shows slip-bands, *i.e.*, low temperature type of deformation, owing to fall of temperature along the bar. Magnified 1000 diameters.

ALL SPECIMENS ETCHED WITH A 10 PER CENT. SOLUTION OF AMMONIUM PERSULPHATE, TO WHICH AN EXCESS OF AMMONIA HAD BEEN ADDED.

2. The main conclusions that have been reached as a result of this research may be briefly stated as follow :—

were carried out has a most important effect upon the results obtained. An oxidising atmosphere at high temperatures gives high ductility.

2. Pure unannealed rolled copper maintains its superior strength over annealed copper at all temperatures from atmospheric to 1000 deg. Cent. Annealed copper preserves its superior ductility to approximately the same temperatures. These results were obtained in a neutral atmosphere.

3. In the case of pure annealed copper, fracture passes through the crystals at all temperatures below about 700 deg. Cent. At all temperatures above about 750 deg. Cent. it passes between the crystals. At intermediate temperatures it may take either course, though preferentially it is intercrystalline.

4. The existence of a range of low ductility at temperatures in the neighbourhood of 250 deg. to 450 deg. Cent. is confirmed.

5. The effect of introducing either oxygen or arsenic in small quantities into copper is to lower the tensile strength at high temperatures. An increase in ductility is also observed.

6. The results of the tensile tests, as a whole, can be satisfactorily explained on the basis of Rosenhain's theory of the existence of a cement surrounding the crystals, which cement is stronger than the crystals at low temperatures, but weaker at high temperatures. Two points of interest must, however, be excepted from this statement at present.

7. Bars tested in hydrogen at temperatures above about 720 deg. Cent. are weaker than bars tested in an oxidising or neutral atmosphere by about half a ton per square inch. This is due probably to reduction of copper oxide, which may result in weakening and finally cracking the bars.

The authors desire to express their indebtedness to the Director of the National Physical Laboratory for granting facilities for the carrying out of the microscopic work in the laboratory under his charge; to Dr. Rosenhain for numerous suggestions; and to Mr. T. G. Bamford, M.Sc., for carrying out some of the tests on arsenical copper.

AUTOMOBILE ASSOCIATION MEMBERS AND WAR SERVICES.

WE have been requested by the Automobile Association and Motor Union to publish the following report:—

The magnificent response by the members of the Automobile Association to the recent appeal for cars and motor-cycles has enabled the Automobile Association to play a very important part in the work of assisting the authorities.

The numerous military duties undertaken have been of a varied description, from taking generals to the different military centres to carrying inspectors on observation in connection with bridges and sentry-posts, also the appointment of members with their cars for permanent duty at the various commands. Various recruiting dépôts around London have been supplied with cars. Recruiting tours comprising batches of cars are at work in different parts of the country. In London and other centres members' cars are being used for collecting recruits and bringing them to the stations. Cars have been provided for officers superintending the shipment of aeroplanes, &c. Other useful work includes assisting refugees, the Navy League, the National Service League, and Red Cross work. On occasions fleets of fifty cars have been in attendance at given stations in connection with Red Cross work. Other organisations which have received assistance are the Local Government Board, Central Committee Women's Employment, Young Men's Christian Association, the Prince of Wales' Fund, &c. Motorists who are willing to convert their cars into ambulance vehicles at a reasonable cost are earnestly requested to communicate with the Secretary, Automobile Association and Motor Union, Fanum House, Whitcomb-street, London, W.

PERSONAL.—We have been informed that the Mordey-Fricker Electricity Meter Company, Limited, having sold its patents and business to the British Insulated and Helsby Cables, Limited, have gone into voluntary liquidation simply to wind up the business. The advertised meeting of creditors was called only to comply with a legal formality, there being no creditors.

GERMANY'S EXPORTS OF SEWING AND KNITTING-MACHINES.—A Board of Trade bulletin, recently issued, shows that Germany exports sewing and knitting-machines, and parts thereof, to a value of about 2,840,250*l.* per annum, while our exports are valued at 2,367,800*l.* The distribution is peculiar. We have the best of the Indian market, in which our sales amount to 128,550*l.*, compared with Germany's 44,500*l.* To the Netherlands, German sales are valued at 78,300*l.*, compared with ours at 26,100*l.* In Sweden our respective sales are almost exactly reversed. In Belgium, Germany disposes of 117,200*l.* worth of these machines and parts; we sell there only 42,950*l.* worth. However, the tables are almost exactly turned in our favour in Spain, which buys from us to the value of 108,700*l.*, and from Germany to the amount of 50,000*l.* Then, again, in Russia we have a greater trade with sales amounting to 831,700*l.*, compared with Germany's 399,300*l.*; but in Italy, Brazil and the Argentine our business is much smaller than Germany's, as it is also in France, although in the latter country our sales amount to the considerable figure of 218,300*l.* Germany sends us machines and parts to the value of 136,200*l.* German machines find a ready sale in many countries, such as the United States, Mexico, Morocco, Bulgaria, Ecuador, &c., which markets seem to be scarcely touched by our manufacturers.

AN ENGINEERING SOCIETIES' BATTALION.

A CIRCULAR to the following effect has been issued separately by the Institutions of Civil, of Mechanical, and of Electrical Engineers, and signed by the respective Presidents. The one reproduced was issued by the Institution of Mechanical Engineers:—

DEAR SIR,—Many members, graduates, and students of the Institutions of Civil, Mechanical, and Electrical Engineers having expressed a desire to serve in the army now being raised, the formation of an Engineering Societies' Battalion was recently contemplated; but the following opportunity for engineers to serve together, under conditions in which their professional qualifications will be of advantage, has now occurred.

The three Institutions have been invited by the Lords Commissioners of the Admiralty to assist in obtaining picked men for the divisional engineer units and signal company of the Royal Naval Division recently formed by the First Lord of the Admiralty, and referred to in the daily Press of 7th inst.

It is understood that these units will be raised on the lines of the undermentioned units of the military forces:—

One divisional headquarters, R.E.
Two field companies, R.E.
One signal company, R.E.

The division is being raised under the Admiralty with a view to its employment in the field.

The engineer units, for which recruits are now being asked, will be employed on duties similar to those on which Royal Engineer units are employed.

A camp is under preparation near Martin Mill Station, Kent, and is now ready to take a first batch of 160 recruits, with provision for rapid increase to the authorised strength, totalling some 500 men, with 18 officers, in addition to the commanding Royal Engineer and a medical officer.

It is expected that a considerable number of the officers will be selected from among the recruits.

The terms of enlistment will be for the duration of the war, but not in any case exceeding three years.

Pay is under consideration, but will not be less than the army rates, and the conditions of service will be similar to those in the army. (Information as to army pay and conditions of service may be obtained at any recruiting office.)

Applications are invited from members of all classes of the Institution between the ages of 19 and 35. Application may be made in person on or after Wednesday, the 16th inst. (between 10 a.m. and 2 p.m.), at the special recruiting office, 2, Savoy-hill, Victoria Embankment, London, W.C.; the enclosed form may be filled in and returned by post to the Secretary of the Institution, after which the applicant must present himself for interview and medical examination.

As President of the Institution of Mechanical Engineers, I venture to express the hope that those of the younger members and graduates of the Institution who have not otherwise placed their services at their country's disposal will promptly avail themselves of this favourable opportunity of doing so.

I am, dear Sir, yours very truly,
H. F. DONALDSON, President.

"BRITISH PATENTS AND FOREIGN PATENTEES."

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to your footnote to my letter published in last week's issue of ENGINEERING, the suspension of the patentee's right to prevent every one else from making, using, exercising or vending the patented invention is, of course, different from the granting of a licence to one or more applicants to do these things, for, in the first case, the monopoly is temporarily destroyed, whilst, in the second, only a limited number of persons—namely, the licensees—are protected from any infringement proceedings which the patentee might take.

Such a general suspension would be almost valueless, since it would allow of the patented invention being adopted by all and sundry, and would not confer any distinctive advantage on those persons who applied for, and secured, suspension at their own expense. Avoidance is open to the same objection.

There seems to be an alternative procedure, however—namely, that the patentee's rights should only be suspended against the successful applicants for suspension; they would then still hold good against all others, and the suspension would have practically the same effect as a licence.

As a matter of fact, there is no special form of application to obtain a licence under the provisions of the two Acts; the only form provided relates to avoidance or suspension, and, as I remarked last week, I was advised that the suspension and licence would probably go together, one being merely the counterpart of the other.

The position, however, is very obscure, for with the exception of an exclusive licensee, there is no one capable of instituting infringement proceedings whilst the war lasts; the patentee cannot, because he is an enemy; the ordinary licensee cannot without the participation of the patentee. How this position will be remedied remains to be seen.

Yours truly,
H. FOTHERGILL AND CO., A. L. ANNISON,
Chartered Patent Agents.
3, Central-buildings, Westminster, September 16, 1914.

"STATIC TORQUE EXPERIMENTS ON A PELTON WHEEL:" ERRATUM.—In the article bearing this title in our last issue, line 15 from the end (on page 337), for "$=10.4$ ft.-lb." read "-10.4 ft.-lb."

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with a weak tone, and sellers of Cleveland warrants quoted 51s. 2½d. cash, 51s. 6d. one month, and 52s. 1d. three months. There were no transactions. In the afternoon Cleveland warrants were again easier, and 3500 tons were dealt in at 51s. 1d. and 51s. cash and from 51s. 11d. to 51s. 10d. three months. At the close sellers named 51s. 1d. cash, 51s. 4½d. one month, and 51s. 10½d. three months. On Friday morning the market was quite idle, and Cleveland warrants were quoted without change at 51s. 1d. cash and 51s. 4½d. one month sellers. In the afternoon business was quiet, and consisted of 500 tons of Cleveland warrants at 51s. cash, with sellers over at 51s. 1d. cash and 51s. 4½d. one month. The three months position was again neglected. On Monday morning, although quotations were the turn firmer, no dealings of any kind were recorded. Sellers of Cleveland warrants quoted 51s. 3d. cash, 51s. 6½d. one month, and 52s. three months. The afternoon session was also quite idle, and quotations were a shade easier, with sellers of Cleveland warrants quoting 51s. 2½d. cash, 51s. 6d. one month, and 52s. three months. Tuesday was another blank as regards business, and in the morning sellers made no change in their quotations for Cleveland warrants. Buyers were easier, however, and named 50s. 10½d. cash, 51s. 2d. one month, and 51s. 7d. three months. In the afternoon sellers' prices were again unchanged, but buyers of Cleveland warrants increased their rates to 51s. 0½d. cash, 51s. 4d. one month, and 51s. 10d. three months. When the market opened to-day (Wednesday) the tone was dull, and only one lot of Cleveland warrants was put through at 51s. 11d. three months, with sellers over at 51s. 1½d. cash, 51s. 5d. one month, and 52s. three months. The afternoon session was quiet, and 2000 tons of Cleveland warrants were done at 51s. cash, and 51s. 10½d. three months. At the close sellers quoted 51s. 1½d. cash, 51s. 5d. one month, and 51s. 11½d. three months.

Sulphate of Ammonia.—The demand for sulphate of ammonia has lately been very poor, and the current price for prompt lots is round 10*l.* 11s. 3d. per ton—Glasgow or Leith. The inquiry for shipment during the first month or two of next year is very poor and is only of a half-hearted nature.

Scotch Steel Trade.—The position of things in the Scotch steel trade has not materially altered of late, and business is in fact still somewhat quiet. Any improvement is bound to be slow in coming, but it is sure to come, nevertheless, and the present outlook is certainly very promising indeed. A steady tone prevails in the local and general home markets, and a moderate amount of dealing is being done, but, although many new schemes have been curtailed and held back temporarily, there are good prospects of these being gone on with in the near future. The demand for ship-plates is very moderate, and the same may also be said about sections, while for general structural material there has been a decided decline in the demand. Makers of heavy-gauge sheets are fairly busy, but there is little doing in the thinner sizes, and galvanisers are very quiet. Export trade is confined within narrow limits at present, and nearly all buyers are restricting their engagements.

Malleable-Iron Trade.—The West of Scotland malleable-iron trade has improved considerably, and quite a number of the works are getting a full week's employment. The orders on hand are fairly satisfactory, but raw material is dear, and thus fresh business is none too easily secured.

Scotch Pig-Iron Trade.—The past week has not witnessed any notable change in the demand for Scotch pig-iron, although certain brands are in fairly good request. The war has most assuredly put a damper on business, not only at home, but also in many other parts of the world, with the result that it will probably be some little time before things open out again. The ordinary qualities of Scotch pig-iron are sure to be in demand at no very distant date, as they, and the English and American makes, will be required to make up the deficiency caused by the stoppage of the supplies from the Continent. In the meantime the inquiries from abroad are not very heavy, but with the prospects of improved shipping facilities an early expansion in business is anticipated. Hematite iron is in rather better request by the local steel-makers, and quite a respectable amount of business is going through. The following are the market quotations for makers' (No. 1) iron:—Clyde, 69s. 6d.; Calder, Gartsherrie, Summerlee, 70s.; and Langloan, 72s. (all shipped at Glasgow); Glengarnock (at Ardrossan), 71s.; Shotts (at Leith), 70s. 6d.; and Carron (at Grangemouth), 70s. 6d.

GERMANY'S EXPORTS OF PHOTOGRAPHIC MATERIALS.—The value of the exports of photographic materials from Germany amounted in 1912 to 1,843,600*l.* The most important classes of goods dealt with were lenses, films, and chemicals. Sensitised paper and dry-plates were also exported in considerable, but lesser, quantities. Of photographic chemicals Germany exported to the United States 72,900*l.* worth; to Russia, 79,950*l.*; and to England, 45,650*l.* Her largest exports of films were to France, which bought to the value of 110,550*l.*, England taking 40,350*l.* worth. Next to Russia, we are Germany's largest customer for sensitised papers, taking nearly 40,000*l.* worth. The most important market for German optical glasses and lenses has been England, which took goods of this class to the value of 104,900*l.* Altogether, Germany sends us about 232,000*l.* worth of photographic goods in the year.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The demand for house coal is on a larger scale. Both at the dépôts and at the collieries a better inquiry has been experienced, and prices have hardened. Hard steams are firm. The tendency of values is upward. After a brief check, due to floating-mine disasters, the shipping trade continues its recent expansion. Though the gross tonnage sent from South Yorkshire is less than at this time last year, it is considerably larger than at any period since the outbreak of war. In view of the early closing of the Baltic ports, a big inquiry prevails for best hards for shipment to Archangel. Sweden and Denmark are also making substantial demands upon the district output, and merchants anticipate a fair business with the north French ports. The demand for local industrial consumption is maintained at a satisfactory level. Now that the Board of Agriculture and Fisheries, in co-operation with the English Forestry Association, are taking steps to stimulate the marketing of home-grown timber, less anxiety is felt respecting the continued scarcity of pit props. A fair tonnage of gas fuels is being sent inland and to the ports. Slacks move irregularly. Special lots are available at cheap rates. There is a strong demand for blast-furnace coke at previous rates. Quotations:—Best branch hand-picked, 15s. 6d. to 16s.; Barnsley best Silkstone, 12s. to 13s.; Derbyshire best brights, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 10s. 3d. to 11s. 3d.; small nuts, 9s. to 10s.; Yorkshire hards, 10s. to 11s.; Derbyshire hards, 10s. to 10s. 3d.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.; smalls, 2s. to 3s.

Iron and Steel.—Conditions in the local raw material market vary considerably. After a record run on common irons, the demand has tapered off, the inflated character of values having acted as a brake on forward business. The chief decline is in foundry iron, but Lincolnshire makers are still asking 60s. 8d., and Derbyshire makers 59s. 3d. for present delivery. The greater activity at local forges has upheld the inquiry for the class of common iron which they require, and sales are freely made at the listed rates of 59s. 8d. for Lincolnshire sorts and 56s. for Derbyshire sorts, though numerous cases of underquoting are reported. A brisk tone is maintained in the hematite iron trade. The outlook is better in every respect. A greatly increased business in West Coast brands has prompted producers to increase their output, the whole of which is going into immediate consumption. Present and future delivery rates stand respectively at 82s. and 83s. Activity in East Coast brands is less pronounced, though makers have advanced their quotations for future delivery by 6d. to 79s. Spot buying centres round the listed figure of 77s. 3d. A slump in ordinary business at the bar mills has minimised the benefit derived indirectly from War Office orders, but there is evidence of a slight improvement in the export demand. A more hopeful outlook obtains in the general steel trades. This has been primarily brought about by a small but decided improvement in business with foreign and neutral markets as a result of more regular overseas communication between buyers and exporters. The results of the campaign against German and Austrian commerce are being more widely felt, and substantial orders from customers abroad which have been held up since the beginning of August are now being worked upon. New orders have also been booked for big tonnages of steel for shipment to Freemantle, the United States, and South Africa. These include supplementary orders for special shoes and dies for use in the South African gold-mining industry. The armament factories are very busily engaged, and in order to preserve the magnitude of their present output, Lord Kitchener has addressed a note to employees eligible for enlistment, assuring them that they are rendering equally valuable service to the country by continuing their present occupation. Makers of basic billets and basic steel have as many orders on hand as they can promptly deal with.

TRADE WITH ALGIERS.—His Majesty's Consul at Algiers reports that articles hitherto imported from Germany and Austria, and for which the British substitute would probably now find a good opening, include tools and metal goods and scientific instruments and apparatus.

NORTHAMPTON POLYTECHNIC INSTITUTE.—We have received from this Institute, the address of which is St. John-street, Clerkenwell, E.C., a copy of their recently-issued educational and social announcements for the ensuing session. Full particulars are given of day and evening courses in civil, mechanical, and electrical engineering, technical optics, horology, and artistic crafts. The engineering courses include subsections in automobile work, aeronautics, and radio-telegraphy, and there are also evening courses in electro-chemistry and metallurgy. The classes of the day courses begin on the 28th inst., while the evening courses will commence on the 21st inst.; enrolments for the latter commenced on Monday last. The equipment in the various departments of the Institute has been extended in many directions during the past year. For instance, a two-stage air-compressor, specially designed for experimental work, has been added to the mechanical engineering laboratory. In the evening classes in engineering, the courses of lectures by specialists in their various subjects are to be developed. There will be two series of advanced lectures on transformer design, and another on electrical instruments and switch-gear. Lectures on aerial propellers, aero engines, and aeroplane construction will also be delivered in the mechanical engineering department.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is very little new to report concerning the northern iron trade. Extreme quietness characterises the Cleveland market, buyers and sellers alike hesitating to commit themselves to any extent, and what business is passing in pig-iron is almost entirely confined to transactions in very small lots for early delivery. Negotiations with firms abroad are very limited, financial difficulties still crippling foreign trade, demand for cash in this country before shipment checking business. At the same time the position is somewhat better than it has been. Fairly large negotiations with firms in Scandinavia are reported. No. 3 g.m.b. Cleveland pig is 51s. 3d. f.o.b.; No. 1 is 53s. 9d.; No. 4 foundry, 51s.; No. 4 forge, 50s. 9d.; mottled, 50s. 6d.; and white, 50s. 3d. East Coast hematite pig is much weaker. Both makers and merchants offer Nos. 1, 2, and 3 at 67s. The latter are keen sellers at the figure, and doubtless some of them would make contracts at an even lower price. Buyers, most of whom have satisfied their requirements, consider the market quotation still too high. Makers are believed to have rather large stocks of hematite, and the production may shortly be reduced by the blowing-out of furnaces. Values of foreign ore are falling, but quotations are still above what consumers think they should be. Sellers are a good deal in evidence, and are ready enough to make concessions to meet the views of buyers. So far as is ascertainable, however, there is no business passing. Sellers quote on the basis of 18s. 9d. ex-ship Tees for Rubio of 50 per cent. quality, but would doubtless entertain offers on lower terms. Freights, Bilbao-Middlesbrough, are round about 4s. 7½d. Imports of foreign ore are not large, but under present circumstances they must be considered satisfactory. To date this month imports to the Tees are returned at 76,345 tons. There is rather more coke offering, and local demand shows some falling off. Prices, though hardly quotably lowered, are easier. Durham beehive blast-furnace coke of average quality is put at 18s. delivered at Tees-side works.

Stocks and Shipments.—The stock of Cleveland pig-iron in the public warrant stores now stands at 97,724 tons. Since the beginning of the month the stock has been increased by 3021 tons. Shipments of pig-iron from the Tees show a considerable improvement, as compared with those of last month, but they fall short of normal September clearances. To date this month they average 2225 tons per working day, the total despatches being returned at 31,157 tons, 27,857 tons of which have gone from Middlesbrough and 3300 tons from Skinningrove. To the same date last month the loadings were given at 9954 tons, or a daily average of 711 tons, and for the corresponding part of September, a year ago, the clearances reached 48,125 tons, or an average of 3437 tons per working day.

Manufactured Iron and Steel.—Nearly all departments of the manufactured iron and steel industries are well employed, and a few new orders keep coming in. Producers of shipbuilding material are turning out a good deal of work. Joist-makers and rail manufacturers are also busy. Prices all round are very firm. Principal market quotations stand:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 10s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 8*l.*; iron ship-rivets, 9*l.*; iron girder-plates, 7*l.* 5s.; steel bars (basic), 6*l.* 15s.; steel bars (Siemens), 6*l.* 15s.; steel ship-plates, 7*l.* 5s.; steel ship-angles, 7*l.*; steel boiler-plates, 8*l.* 5s.; steel joists, 7*l.* 2s. 6d. to 7*l.* 5s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 15s.—all less the customary 2½ per cent. discount; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 15s.; steel railway sleepers, 7*l.* 15s.—all net at works.

Jarrow Iron and Steel Works.—A scheme is on foot to modernise the huge Tyneside works of the Palmer Company. A circular has been issued to the debenture holders describing the suggested improvements, and intimating that the cost thereof will amount to 250,000*l.*, which it is proposed to spread over two years. The circular states that the company's bankers have expressed willingness to extend the loan account for the amount required, taking as first charge all the assets of the company ranking in priority to the first debenture stock. The scheme includes the installation of new gas-engines at the furnaces, and the complete electrification of the shipyard and general works.

Ironstone Mines Closing.—The Grinkle ironstone mines in Cleveland are closing for a short period for alterations and repairs to the surface machinery.

MANUFACTURES FOR SPAIN AND PORTUGAL.—The Commercial Intelligence Branch of the Board of Trade has issued a statement to the effect that His Majesty's Consuls at Seville, Oporto, and Lisbon report that there is a good opening in Spain and Portugal for British goods of a class recently supplied by Germany. From Seville it is reported that articles usually imported from Germany include machinery, rails, pipes, steel cables, cutlery, brass ware, electrical fittings, cement, bicycles, lubricating oils, tin-plates, &c. From Oporto it is stated that the usual German trade comprises hardware, cement, iron, cutlery, cycles, sewing-machines, motor-cars, locomotives, electrical machines, &c. The Lisbon report states that Germany usually supplies electric fans, sewing-machines, sanitary fittings, rifles, &c., aluminium ware, telephones, cutlery, lathes, and other machine-tools, agricultural implements, electrical plant and fittings, &c. In some of these cases there are, however, large stocks on hand.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has been quiet, buyers not showing any eagerness and holding back in the hope of easier conditions later on. One consideration which they urge is that British naval coal requirements are falling off. In consequence of the unsettled state of foreign affairs, coal-owners have been showing an increased disposition to insist upon cash payments. The shrinkage which has been observable in production is still serious, but the quietness of the general demand has prevented the falling-off having much effect at present. House coal has shown little change. The best Admiralty large steam coal has been quoted at 21s. 6d. to 22s. 6d.; best secondary qualities at 19s. 6d. to 20s. 6d.; other secondary descriptions at 19s. to 19s. 6d.; best bunker smalls, 7s. 3d. to 7s. 6d.; and cargo smalls at 5s. to 7s. per ton. The best household coal has brought 19s. to 20s.; good households have made 17s. to 18s.; No. 2 Rhondda large has realised 13s. to 13s. 9d.; and No. 2 smalls have brought 6s. 6d. to 7s. 6d. per ton. Special foundry coke has made 27s. 6d. to 30s.; good foundry coke, 21s. to 25s.; and furnace coke, 18s. to 20s. per ton. As regards iron ore, Rubio has been quoted at 18s. 6d. to 19s. per ton upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Powell-Duffryn Coal.—The Powell-Duffryn Colliery has had a remarkable career. In 1864 its output was 400,000 tons, and in 1880 an aggregate of 500,000 tons per annum was reached. Ten years later the production was carried to 1,305,000 tons; in 1900 it had reached 1,942,000 tons; and, in 1910, 3,319,000 tons. Last year it stood at 3,874,000 tons, and it is expected that this year it will exceed 4,000,000 tons. The company had many early vicissitudes and struggles, and in 1894 the dividend did not exceed 5 per cent. In 1895-6 it went still lower—viz., to 1½ per cent. Between 1899 and 1906 a steady 7 per cent. per annum was distributed; since 1907 the dividends have ranged between 15 and 20 per cent. per annum.

Welsh Coal for Egypt.—The administration of the Egyptian State Railways have invited tenders for 360,000 tons of South Wales screened coal. The announcement has been received with interest, as it is the first notice of the kind relating to any substantial delivery of coal over next year. The coal required is ordinary secondary Admiralty and best Monmouthshire. Deliveries are to be made between December 1, 1914, and July 31, 1915—for the first two months at the rate of 30,000 tons per month, and for the subsequent six months at the rate of 50,000 tons per month.

The Swansea Valley.—The outlook for the steel trade is rather more satisfactory, there being two furnaces in full operation at the Duffryn works and three at the Forest works. Stocks of steel ingots are heavy.

TRADE OPENINGS IN ITALY.—We are informed by the Commercial Intelligence Branch of the Board of Trade that His Majesty's Consul at Milan telegraphs that local firms there are making inquiries with a view to the purchase, among others, of the following goods of British manufacture:—Glass tubes, glass gauges, wood pulp, pens, machinery, dynamos, bicycles, iron and steel, motors, carburettors, motor-cycles, cutlery, and kitchen utensils.

THE MERCHANT VENTURERS' TECHNICAL COLLEGE AND BELGIAN AND FRENCH STUDENTS.—The Merchant Venturers have decided to offer to engineering students of Belgian universities, or of the university of Lille, free places in the faculty of engineering of the University of Bristol, which is provided and maintained in their college. Of course, many of these students are at present serving with the respective armies; but it is hoped that any students who were unable to serve, and who are at present in England, will avail themselves of this offer.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—The question of the course of action to be pursued by the Institution of Automobile Engineers during the forthcoming session, in view of the situation brought about by the war, has been very carefully considered by the Council, and as a result, they have decided that, in spite of the absence of a number of officers and other members in the service of His Majesty and of the difficulties with which a number of firms are faced, it will be to the best interests of the industry generally, and of the Institution, to proceed with the normal work of the session, and to hold the usual monthly meetings. They propose that, as far as possible, the papers to be read shall deal with the special difficulties which have been imposed upon the automobile engineer by the war, such, for instance, as those connected with labour, finance, the reduction in the demand for pleasure cars, and the impossibility of obtaining parts from abroad. Papers have already been promised on these lines. It is hoped that by means of the papers and the ensuing discussions, valuable information may be elicited as to how these difficulties may be overcome or reduced, so that the Institution may be able to perform its prime duty of being of real assistance to the automobile engineer. The Council therefore make a confident appeal to the members to assist them to an even greater extent than hitherto by attending all the meetings and to the Press to support them as they have always so readily done in the past. By this co-operation it is hoped that the interests of the automobile industry may be promoted to the utmost, and that the Institution may be enabled to continue its work throughout what must, without doubt, be a period of great difficulty.

INSTRUMENTS FOR TESTING GAS.

CONSTRUCTED BY MESSRS. ALEX WRIGHT AND CO., LIMITED, ENGINEERS, WESTMINSTER.

Fig. 1.

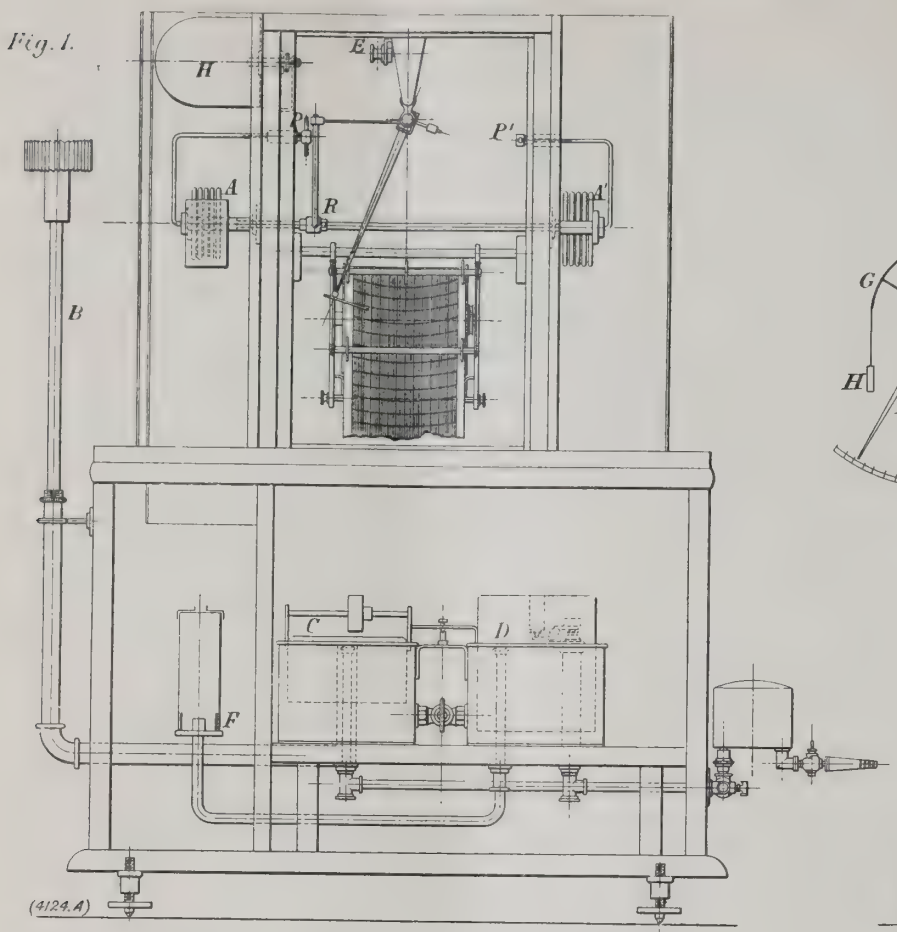


Fig. 3.

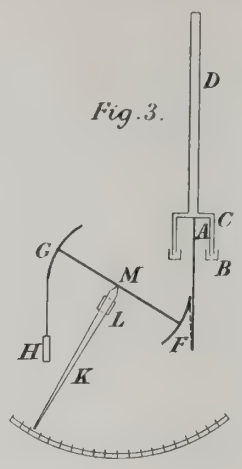


Fig. 2.

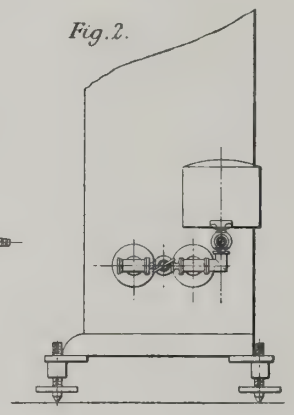
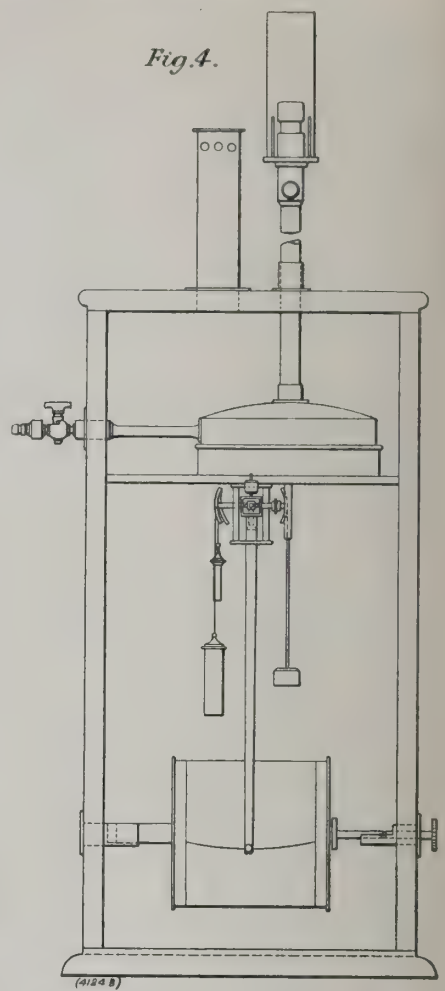


Fig. 4.



At the Munich Gas Exhibition, Messrs. Alex. Wright and Co., 1, Westminster Palace Gardens, London, S.W., showed instruments for testing gas, two of which—the caligraph and the gravitometer—we illustrate on this page. The caligraph, which attracted much attention, is an instrument by means of which the calorific value of a gas is automatically recorded.

The principle on which it operates may be described as follows:—A constant volume of gas is burnt. The heat from this combustion is caused to warm a certain quantity of air which then passes over one diaphragm of a differential thermometer, the other diaphragm being affected only by the room temperature. The indication of the differential thermometer, which is thus a measure of the heat given off from the gas on combustion, is marked by means of a pen, actuated by suitable link-work, on a chart passing over a clock-drum.

Referring to Figs 1 and 2, the constant consumption of gas is obtained by means of a governor consisting of two bells C and D, which are connected together and swing on needle-points. The gas passes through a dry governor (to take up any sudden variation in pressure) into the right-hand bell D by means of a valve. The extent of opening of this valve is determined by the position of the bells. The gas passes out of the bell D through a gold nipple of standard size to the burner F, where it is consumed. At the same time the gas can also pass from the dry governor into the left-hand bell C by means of a by-pass cock. This gas passes out of the bell C through a tube B, at the top of which it is consumed by a small flame. This is prevented, by means of a special burner, from heating the gas in the tube. Any variation in specific gravity of the gas will obviously cause a difference in weight of the column of gas in the tube B, and will thus alter the pressure in the left-hand bell C. This alteration in pressure will cause the bells to move and actuate the gas-admission valve. In this way a constant supply of gas to the burner F is assured, no matter what the gravity of the gas may be.

The differential thermometer consists of two metal diaphragm boxes A and A^1 filled with air, one at each end of a glass rod R. Any movement of this rod is recorded, by means of a pen actuated by link-work, on a chart wrapped round a revolving drum, which is driven by clock-work. As the temperatures of the diaphragms vary, the air in them will expand or contract, thus causing a movement of the glass rod, and as the right-hand diaphragm is affected by the room temperature only, while the left-hand one is affected by the heat from the flame as well as by that from the room temperature, the movement of the rod, being the difference of the two effects, is proportional to the heat obtained from the combustion of the gas at F. It will be observed that any alteration in temperature and in atmospheric pressure will affect the air being heated in the same way as the gas burnt, thus automatically compensating for any change in the number of the tables of constants which are used in connection with the instrument.

The essential principle of the gravitometer is illustrated in Figs. 3 and 4. The instrument is essentially a gas-balance, in which the specific gravity of the gas under test is compared with that of the surrounding air. This is accomplished differentially, the weight of a column of gas and the weight of an equal column of air being arranged to act on opposite sides of what is virtually a scale-pan, and the difference in weight registered.

The bell of the gravitometer may be considered as a scale-pan on which the pressure below is due to the pressure of the atmosphere on the lower surface, and the pressure above to the pressure of a column of gas added to the pressure of the atmosphere at the top of that column, the aggregate being less, in the case of coal-gas, than that of the atmospheric pressure below the bell. Gas is always passing up the tube to supply the burner at the top, and under these conditions is under absolutely the same conditions of temperature and pressure as that of the surrounding air. It will thus be seen that the pointer of the gravitometer indicates the weight of that column of gas of a height equal to that of the tube. For example, with a bell of 6 in. diameter and a height of tube of 30 in., the weight of gas of, say, 0.9 specific gravity is 15.9 grammes.

The pressure or weight on the top of the bell is in direct proportion to the specific gravity of the gas in the tube, and is, in addition, proportional to the height of the tube. Thus, if the tube were 60 in. in height instead of 30 in., the pressure on the bell, due to the weight of the gas, would be 30.38 grammes, and the movement of the pointer across the scale would be twice that in the case of the 30-in. tube. Mechanical considerations constitute the only reason for not using a longer scale; indeed, by employing tubes of sufficient height, it is possible to measure specific gravity to any required degree of accuracy.

Referring to Fig. 3, which shows diagrammatically the action of the gravitometer, A represents a light aluminium bell, sealed in oil contained in the annular tank B. The bell is covered by a shell C, which is not in contact with it. The top of the shell carries a tube D. The bell is free to move up and down, and is carried by a vertical support connected to the end of the balance-beam G by a hanging chain. The other end of the beam carries a hanging weight H. The chains connected to both H and A pass over circular arcs. A pointer K and a gravity-control weight L complete the essentials of the instrument. On a stream of gas passing slowly over the bell A and up the tube D, the pressure on the top of the bell is diminished and the pointer K swings into a new position of equilibrium. The scale over which the pointer moves is graduated to read or to record specific gravity directly.

Tests of 3000-Kilowatt Oerlikon Turbo-Generators.—Two 3000-kilowatt turbo-generators supplying three-phase current, and running at 3000 revolutions per minute, were recently installed at the Richmond-street Station of the Marylebone Electricity Supply Company by the Maschinenfabrik Oerlikon, for whom Mr. G. Wüthrich, of Oswaldestre House, Norfolk-street, Strand, is the British representative. These machines have now been thoroughly tested, and have yielded results much better than the guarantees. The generators have, moreover, run so cool that the makers have agreed to a substantial increase in the overload capacity, and have also permitted an increase of 100 deg. Fahr. in the superheat for which the turbines were originally designed. The generators supply three-phase current at a periodicity of 50 and at 6660 volts. The normal designed load is 3000 kw., with a temperature rise of not more than 54 deg. Fahr. after a six hours' run. The designed overload capacity is 4200 kw., with a temperature rise not exceeding 81 deg. Fahr. after a six hours' run. The turbines were designed to work with steam at 190 lb. per sq. in. and at a temperature of 485 deg. Fahr., and with a vacuum of 95 per cent. The test figures reduced to these conditions are tabulated below, whilst the third column shows the steam consumption guaranteed.

Steam Consumption in Pounds per Kilowatt-Hour.

—	On Test.		Guarantee.
	Turbine No. 1.	Turbine No. 2.	
Full load	12.88	12.92	13.27
Three-quarter load	13.04	13.21	13.73
Half-load	14.00	14.06	14.70

We may add that in spite of the mobilisation made to ensure the neutrality of Switzerland, the Oerlikon works are managing to keep in operation with half the men and half the staff on half time. Contracts in hand are making good progress, and new orders are being booked, since facilities for export still exist.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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Thick ,,	£1	16	0 ($8.75)
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Thin paper copies	£1	16	0
Thick ,,	£2	0	6

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Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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With Three One-Page Plates of the CALCIUM CARBIDE FACTORY AT ODDA, NORWAY, and One One-Page Plate of a MILL FOR THE MANUFACTURE OF CANE-SUGAR.

NOTICE OF MEETING.

THE INSTITUTE OF MARINE ENGINEERS.—Monday, September 21, at 7.30 p.m. Demonstration of metal jointing by the Amalgaline process.

NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to some Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, SEPTEMBER 18, 1914.

LESSONS FROM LOCOMOTIVE-TESTING PLANTS.

THE regret has often been voiced that we have, in this country, no testing plant for locomotives on which general research work can be carried out. The only plant of the type over here is, as is well known, that at the Swindon works of the Great Western Railway Company. All the published data derived from plants of this character come to us from the United States, where, in a most commendable public spirit, much valuable information has been made freely available. Apologists for our deficiencies have not infrequently contended that little or nothing is to be learnt from these testing plants for locomotives. They speak of them with contempt, asserting that the complexities of service can have no relation to the uniformity of test conditions, and no indications of value in the former can be obtained from the latter. We have even heard a bolder line taken, to wit, that it is not really an economical locomotive that is wanted, but one capable of moving the traffic. The movement of traffic is, of course, the main purpose of a railway, but no engineer worth his salt would rest satisfied with performing that duty inefficiently. It is the privilege of the engineer, not only in railway, but in other work, to face complicated problems and to resolve them on economical lines. That is his excuse for existence.

In the case of locomotives, the testing plant does not pretend to provide the equivalent of road tests or service performance, but it, nevertheless, occupies a very important field. It is an accepted principle in research work that as few variables as possible should be altered at one time when an investigation is being carried on over a certain range. It is only by restricting changes in this way that effects can be traced to their proper causes. In railway service the variables are numerous, and in special road tests are nearly equally so. They embrace all sorts of questions relating to the proportioning of the machines, and the effect on this of various operating factors, such as loads, speeds, grades, &c. The weather also often renders valueless for comparative purposes the best laid plans for tests of this kind. A testing plant properly run cuts out at once many of the influences, which, in road-work, mask points on which information is sought. By removing these outside influences the performance may be reduced to steady speeds and loads, a series of tests showing results over any desired range. This form of treatment clearly lends itself much better to analysis, and if the work be conducted on an ample scale, the effect of modifications in design can be traced and valuable lessons learnt therefrom. In locomotive operation, steam consumption and engine output, cut-off, draught, back pressure, superheat, steam production and rate of firing, &c., are all interdependent. It might be thought that here were certainly variables enough to study, without the additional complication in any single test of changes in load and speed. Road tests give merely a flat average, from which the effect of possible modification in design can only be inferred with difficulty and then with scant accuracy; but on a testing plant any particular conditions can be simulated and a range of results is obtainable showing how loads, speeds, &c., affect performance, from which it can be deduced what influence some change in design is likely to have.

We have so often referred to them that we need hardly remind our readers of the investigations carried out over a long series of years at Purdue, whose locomotive laboratory has been made famous in the railway world through the able work of Dr. W. F. M. Goss, now of the University of Illinois. This work covered an immense amount of virgin ground. Some of it was conducted with the co-operation of the American Railway Master Mechanics' Association, and the reports to that body, with the subsequent discussions at its conventions, have done much to disseminate knowledge on the matters worked up. The investigations on front ends, on cylinder performance, boiler efficiency, the effect of high pressures, of superheated steam, &c., are all of intense interest, and furnished the first data we had of this class, much of it having been confirmed by later work elsewhere. The plant belongs to a public institution, as does also, of course, that erected last year at Urbana (Ill.). The work of such institutions is naturally published, to the joint honour of the college and its staff. There is less reason, but still greater credit, for freely placing at the disposal of all the results obtained on private plants. Such a broad-minded policy on the part of the Pennsylvania Railroad Company has had the effect of placing in the hands of engineers an enormous mass of valuable information on modern high-powered locomotives.

Readers will doubtless remember the notable exhibit of the Pennsylvania Railroad at the Louisiana Purchase Exposition of 1904. This exhibit included the most complete locomotive-testing plant till then erected, which was worked under an advisory committee of engineers, representing the company, the American Society of Mechanical Engineers, the American Railway Master Mechanics' Association, &c. The data of the tests so conducted were embodied in a volume which has become one of the classics of the locomotive engineering library. At the close of the exhibition, the plant was re-erected at Altoona, and has continued to prove a fruitful source of information, a great deal of which has been given to the engineering world at large. Many of the recent investigations carried out by Mr. C. D. Young, Engineer of Tests, under the superintendence of Mr. J. T. Wallis, General Superintendent of Motive Power, have been of a very complete character. The particulars of several have been published in a series of bulletins, and have added greatly to our fund of data on many points. Naturally, as in other classes of research by commercial concerns, conclusions are not reached in some of the many directions in which these reports arouse interest. They are noteworthy, however, as having been convincing enough to influence design, and this, too, on a system like the Pennsylvania, which has always been one of the foremost railways in America in the matter of standardisation. The strong desire to retain existing standards would not have been foregone unless these changes were thoroughly justified. Their adoption is testimony of the value of the testing plant.

For many years this company has been developing the 4-4-2 type of locomotive, for which the system furnishes a large amount of suitable express passenger traffic. Subsequent to the re-erection of the testing plant at Altoona, one of the earlier designs of this class was put through its paces. The data were published in a bulletin, in which its performance was compared with that of a four-cylinder balanced compound of the New York Central and Hudson River Railroad, the tests of which had been previously conducted at St. Louis and published in the report above referred to. A fine development of this type appeared in the form of a saturated-steam locomotive in 1910. A further advance was made in 1912 by adding a superheater to the 1910 type. In their 1912 form the engines had cylinders 22 in. by 26 in., and a load of 141,000 lb. on the coupled wheels, which were 80 in. in diameter, the boiler being fitted, as stated, with a superheater and with a brick arch. These engines were notable in American practice for the shortness of their tubes, which had a length of only 13 ft. 9 in. A combustion chamber projected from the fire-box some distance down the barrel. The tests of an engine of this class have been frequently referred to in our columns. From a study of cylinder performance it was clear that the locomotive was most economical when working at about 20 per cent. cut off, but that maximum power was only developed with a later cut off. Engines of this class handle heavy trains on fast timing, so that they are called upon to work near maximum capacity for a large proportion of their time. It was therefore argued that the cylinders should be enlarged from the 22 in. by 26 in. used on the original

saturated-steam engine of this pattern to a size suitable for working the superheater engine at an economical cut off. Such a modification was, we pointed out in an article appearing on page 493 of vol. xcvii. of ENGINEERING, perfectly rational, and we note the latest model, of which there is already a large number in service, has cylinders 23½ in. in diameter, compared with the original 22 in., the 80-in driving-wheels being retained. A corresponding recommendation was made with regard to a class of 4-6-2 engines. In this case it was found that the utilisation of the full capacity of the engine required a cut-off of about 50 per cent. An enlargement of the cylinders was recommended in order to bring the cut-off down to something like 30 per cent. at maximum output.

Another point on which serviceable information has been deduced has reference to boiler performance. The short-tube boiler with the combustion-chamber, of the 4-4-2 design above referred to, proved a very free steamer. The combustion-chamber adds virtually to the fire-box heating surface and volume, a neighbourhood in which the heat transmission to the water is most active, and where such an addition is proportionately valuable. The boiler-tubes in this case were found to be so short that the smoke-box temperatures were high, and as a result of the tests it was suggested that they should be lengthened from a ratio of length to diameter of 94 to 103, giving an increase in heating surface of about 8 per cent. The proposed length of 15 ft. would standardise with other classes and could be secured by redesign at either the back or front-tube sheet. In the latest model this alteration is made in accordance with the report. The extra length has been secured, as a matter of fact, at the expense of the combustion-chamber, by pushing the tube-plate back towards the fire-box in spite of the manifest advantage of surface of this character.

In all locomotive boilers the length of the tubes must be a compromise between great activity of combustion and evaporation, and efficiency. It is sometimes held that if smoke-box temperatures vary considerably on the road, the boiler is deficient in tube length, and that all boilers should have such a length of tube as to provide a margin of surface to take care of the additional heat towards the tube ends when the boiler is forced. In long-tube boilers the smoke-box temperatures are fairly uniform over a wide range, and the efficiency is good, and better maintained than in a short-tube boiler. The long-tube type, however, has two disadvantages—viz., excess of weight, and the need of much higher draught, which is prejudicial to the free working of the cylinders. Since the latter is of vital importance in express work, conditions are probably best met by a moderate tube length. If the waste-gas feed-heater should in time meet with more general approval, its addition to the short-tube boiler would greatly improve the efficiency, while, weight for weight, such a combination would have a greater capacity than the long-tube boiler, owing to the effectiveness of series heating, compared with the low efficiency of the smoke-box end of long boiler-tubes.

In contrast with the 4-4-2 class of engine with tubes about 13 ft. 9 in. long, the Pennsylvania Railroad has a class of the 4-6-2 type, with tubes 21 ft. long, but of 2¼ in. diameter, compared with the 2 in. of the shorter tube. The efficiency of this long-tube boiler has been found, on the testing plant, to be very good, but, comparatively speaking, the evaporation was sluggish. With 5-in. draught at the front tube-plate the evaporation per square foot of heating surface was 9.8 lb. per hour, the efficiency being 70 per cent. Under like conditions the short-tube boiler evaporated 13 lb. of water per square foot per hour, but the efficiency was only 61.5 per cent. The rapidity of evaporation and greater activity of the short-tube boiler was noticeable over the whole range.

The much higher draught required for equal rates of evaporation suggested that the greater total output of the long boiler was being too dearly purchased. Better results and even greater output appeared probable with some reduction in tube length, and this was recommended. The new standard design has a tube length of 19 ft., or 114 diameters, the fire-box tube sheet having been pushed some distance up the barrel by the interposition between it and the fire-box of a length of valuable combustion-chamber. The new boiler should be distinctly freer as regards steaming, and should respond more readily to varying demands. It is to be noted that these investigations confirm the conclusions drawn from the early work, on a much smaller scale, of M. Henri, of the Paris, Lyons and Mediterranean Railway. The new boiler, with 19-ft. tubes, is now adopted as standard for 4-6-2 and for 2-8 2-type engines.

An investigation of the action of the blast has led to the adoption of a rectangular blast-pipe top, instead of a circular one. The niceties of screw-reversing gear, long appreciated over here, have been more clearly recognised, it seems, on the testing plant. The design of piston-valves has been considered in the light of data so obtained, and, instead of a variety of sizes, a standard 12-in. piston-valve has been introduced on many classes, and found satisfactory. At the recent Master Mechanics' Convention the Pennsylvania Railroad had three of its latest types of locomotives on view. Each one was the direct product, so far as design went, in these and many other points, of the work on the testing plant and in the laboratory. Finally we may refer to an investigation on the form and size of superheating elements, referred to in these columns on page 17 *ante*.

The public-spirited action of the Pennsylvania Railroad in placing all these data so freely before the profession cannot be too strongly commended. We have several times discussed, and sometimes criticised, points made in the report. We have never done so by way of depreciation, but always in the hope that the comments might contribute to the general advance of knowledge. We can only regret that in this country we have not the means of studying English locomotive practice in the systematic way in which the Pennsylvania Railroad has set to work. A company of its commanding position can, of course, incur much better the expense of running such a plant than could individual systems of this country; but, as we have before pointed out, combined effort might easily result in the provision here of a plant on the lines of those at Urbana or Purdue. Naval architects have now a public plant in the William Froude Tank at the National Physical Laboratory, which, Mr. Baker assures us, has several times led to savings in working expenses. In locomotive work the saving on individual machines might be small, but in the aggregate would probably be considerable, while other lessons bearing on design, standardisation, &c., would all prove valuable, and, in many cases, more easily come by than by tedious trial and error on the road, where effects and their causes are easily confused.

THE IRON AND STEEL TRADES AND THE WAR.

No great manufacturing industry will be so profoundly affected by this terrible war as the steel trade. While the world's demand for nearly all classes of iron, steel, and engineering products will be increased rather than decreased by the war, the second largest producer and chief exporter, Germany, ceases for some indefinite period to be a serious competitor in the world's markets. The Belgian, French, Austrian and Russian steel industries are also dislocated. Thus an enormous amount of new business stands to be shared between Britain and America. Out of the world's total iron and steel export trade of about 20,000,000 tons a year, 10,000,000 tons has been supplied lately by European Continental countries involved in the war—6,000,000 tons a year by Germany alone. Even if the war were ended to-morrow, the credit and bounty systems under which Germany has fostered her export trade would remain crippled for years. In these circumstances the question arises: Can the United Kingdom or the United States produce and ship steel goods the cheaper, and so secure the larger share of the business?

In the matters of geographical situation and shipping accommodation Britain is in the better position for the conduct of export trade. We are nearer to the majority of the world's markets than our United States rivals, we have about ten times as many ships, and all our works are within short distances of our shipping ports. In these respects we hold unique advantages over all our foreign competitors. We have coal and iron supplies, blast-furnaces and steel mills, shipyards and docks, all practically side by side in this compact little country. Taking our country through, the average haul for iron-making materials from mines to furnaces, and for finished goods from mills to ports, is less than 30 miles. On the Continent of Europe it is 150 miles, and in America 500 miles.

In spite of our natural favours, we have fallen behind in the race. In the last 25 years, or thereabouts, the world's consumption of iron, steel, and machinery, per head of the population, has increased by 150 per cent. While that has been so, the United Kingdom, with its slowly-growing population, has failed to increase its *per capita* production of iron by even 1 per cent. We have merely marked time while others have gone rapidly ahead. The Germans, with a large growth of population, have increased their output of iron from 4,631,000 metric tons in 1891 to 17,617,000 tons in 1912. The Americans (U.S.) have increased theirs from 8,280,000 tons in 1891 to 29,727,000 tons in 1912. We have been rapidly relegated from first to third position in production, and to second place even in exportation. America has lately been producing between 25,000,000 and 30,000,000 tons a year, and Germany has been making from 16,000,000 to 18,000,000 tons a year, against our 9,000,000 or 10,000,000 tons. Of course, those countries have bigger populations than we have; but when it comes to the question of exportation, population is not the chief consideration. We ought to be first in exports, as we always were until these late years. As a matter of fact, we ought to export more iron and steel than any other two or three countries put together, because we have the best shipping facilities, we have the most Colonies requiring manufactures, we have the most money invested in foreign railways and similar undertakings needing steel, and we should export an abnormal quantity of manufactures, such as those of steel, to balance our abnormal food imports. But we have actually allowed ourselves to be overtaken in this line. In the first six months of this year Germany exported nearly 1,000,000 tons more iron and steel than we did. As an outcome of this war we have to regain and retain the lead.

Now the probability is that America, instead of Germany, will be our greatest competitor. Here we find ourselves at one serious disadvantage. Our iron and steel works capacity is not large enough. With the certainty that a vastly increased volume of business will soon be available, we are without either mills or men enough to enable us to take that great lead in exports to which we are entitled by virtue of our natural resources, geographical situation, shipping facilities, manufacturing skill, and our economic dependence upon an immense trade in manufactured exports to balance our enormous importations of agricultural produce. On the other hand, America is exceptionally well situated in the matter of works capacity. In the United States they have increased their productive capacity far beyond consumptive requirements these last few years. Roughly, our American rivals have a capacity equal to 30,000,000 tons of steel ingots a year, whereas their home demand scarcely exceeds 20,000,000 tons a year, and their exports of iron and steel have seldom accounted for more than 2,000,000 tons, against Britain and Germany's 4,000,000 to 6,000,000 tons a year.

Here, then, we have America with more than enough works to take practically all the iron and steel export trade hitherto done by Germany, but labouring under geographical disadvantages. On the other hand, Britain, with all the resources and favours that can be desired in convenient supplies of raw materials, conveniently situated manufacturing plants and shipping ports, has done very little to increase her works capacity for nearly a generation, and if she taxes all her furnaces and mills to the uttermost she cannot produce on a sufficiently large scale to take half the trade that Germany stands to lose. The fact is that far too much capital that should have been employed to build new works at home has gone into investments abroad. But that by the way. We are in a position to take a very considerable portion of the trade that Germany is losing, and we must see to it forthwith that our capacity is increased.

There remains now the question of competition between ourselves and the Americans. Which country can sell steel the cheaper — Britain or America? The problem of trade is primarily the problem of cheap production. We have often been told by the highest authorities that the United States can produce the cheapest steel. That may have been true at one time; it is not true to-day. Fifteen years ago the investigations of the United States Industrial Commissioners, coupled with those of eminent English authorities,

showed that pig-iron was being produced nearly 20s. per ton cheaper in America than in Britain, and steel rails about 29s. cheaper. It was admitted that the general cost of production in the American steel trade was at a level that defied competition, and it was thought that our rivals had only to increase their capacity sufficiently in order to beat us in the export trade. But it is a remarkable circumstance that while the American steel-makers have been adding to the number and capacity of their plants, their costs of production have gone up. The recent calculations of the Ways and Means Committee charged with the revision of the American tariff, and the estimates of the Inland Taxation authorities, prove that since 1899 the net cost of producing steel-making pig-iron has increased by 24s. per ton, and of steel rails by 27s. per ton in the United States. Since the late 'nineties mining royalties have risen enormously, and the costs of mining, on account of the increasing depths, have advanced, while the iron yield of the ore has diminished; costs of coal and coke have gone up; more ore and fuel are now needed to produce a ton of pig-iron; transit charges have increased; therefore it is not possible to make iron or steel anything like so cheaply now as it was some dozen or fifteen years ago. On the other hand, there has been no corresponding rise in our costs of production. We have not experienced any serious deterioration in the quality of our ore, and the advances that have been made in the prices of our coal, &c., have been pretty nearly offset by improved processes of manufacture. The net result is that it has paid our American rivals better to let many of their plants stand idle these last few years rather than undersell us and the Germans in neutral markets. Now, with German competition suspended, and with prices rising to a height that will be unusually profitable, the best and the most of the export business will have to be divided between Britain and America. Recently, with the competition of Germany, backed by extremely generous credits and lavish export bounties, real cost of production has not been the vital point in the problem of trade rivalry. Now cost will be the all-important matter, and it is on this point that it is necessary to observe that America is in a much weaker competitive position than is generally assumed.

The great handicap on the United States exportation of steel is that the coal-mines are mostly a thousand miles from the iron-ore deposits, and that the smelting-furnaces and rolling-mills are generally between four and five hundred miles from a port of shipment, besides which America, as a country, is at least a few thousand miles from most of the world's neutral markets.

BRITISH RAILWAY ACCIDENTS.

AT the present moment the mind is in most cases occupied with the great struggle in which our nation is engaged, and in view of the long lists of casualties which we are prepared to expect in the course of the next few months, it seems almost trifling to embark upon a discussion of the loss of life which occurs on our railways. Its real proportion is well illustrated by the fact that the recently-issued annual Board of Trade report on railway accidents was either ignored by the daily Press, or given at the most an inconspicuous paragraph.

We have all felt some degree of pride in the fact that our forces have been mobilised and sent to the front without loss through any railway accident. In reality we had almost a right to expect as much from a railway organisation such as this country boasts of. What the actual movement of troops has been none but the officials know, but our usual average loss of life among railway passengers is so low that the chance of accident was probably small, although the rapidity with which the movement was carried out added risks of an extraordinary kind. Earlier in the year* we recorded the principal figures relating to British railway accidents in 1913. In that year life was lost in passenger trains in only eight accidents, which figure, when compared with the total number of passenger-train movements in a year, will be recognised as extremely small. The fatalities, which amounted to thirty-two in 1913, were more numerous than usual and compared with an average of nineteen for the previous ten years. The actual loss of life in such circumstances is more or less fortuitous.

* See ENGINEERING, vol. xcvii., page 746.

No one regrets more than we do that casualties of this kind occur, but we believe that through the persistent habit of a section of the daily Press they are generally viewed in altogether exaggerated perspective. At the time of the loss of the Empress of Ireland the *Morning Post* had a calm and dignified leading article in which it was pointed out that "newspapers abuse their functions when they encourage or facilitate a heated controversy on questions with regard to which ordinary people cannot have full and accurate knowledge, and on which they cannot hope to form a sound and final judgment. . . Instead of urging the need of a suspension of judgment until all the facts have been collected and examined by an unbiassed and expert tribunal, it (the Press) too often fosters wild speculation and rash criticism by publishing *ex parte* statements, and by circulating any wild theories or rumours that may have been floated." We might add to the extract, but we doubt if we could improve upon the comments thus made. Written in connection with a serious disaster at sea, the words might equally well be applied to the disproportionate treatment accorded to what are, comparatively speaking, small accidents on our railways. Ostensibly the case always is, of course, that the public must be protected; but if the matter were followed up at all consistently, people would find plenty of evidence that the railways are very far from being callous of human life. Confirmation of this has been forthcoming recently.

The series of accidents in 1912 and 1913 led the inspecting officers of the Board of Trade to formulate certain recommendations with the object of urging upon the railway companies action along certain lines. Track-circuiting, for instance, was recommended where it would afford protection in connection with dense or frequent express traffic. By the end of 1913 track-circuiting had been installed in 1500 places, and was about to be adopted in 700 more. The companies were also urged to experiment with cab signalling and automatic stops. At the Paris meeting of the Institution of Mechanical Engineers, held last July, Mr. J. A. F. Aspinall remarked that such experiments were being conducted. In this country we are apt to lay considerable stress on the effect of the introduction of a more or less imperfect mechanical check on the morale of the men on the foot-plate. We take more trouble in training these men than is done in many other countries. They are brought up to a sense of their responsibilities, and, on the whole, prove themselves thoroughly reliable as a class. A point worthy of notice was brought out by Mr. Aspinall. In the case of cab signalling and automatic stops, the safety ensured by these long years of responsible training is replaced by the none too satisfactory substitute of the skill of an electrician whose ordinary work is not calculated to develop this sense of responsibility to nearly the same degree.

During recent agitations we have heard complaints that the railways do not adequately protect their employees. Statistics certainly show an increase of accidents in some cases, but in proportion to the number employed there seems to have been little change. A departmental committee was appointed in May last to inquire into this matter. Evidence given before it by Colonel von Donop was very favourable to the railway companies. He stated that 80 per cent. of the recommendations made to the companies under the Act of 1900 were adopted, and where they were not adopted the companies showed them to be unsuitable and had attained the desired end in some other way. He went on to say that often the matter was more one for the men to attend to than for the companies. This is in accordance with the views frequently expressed by us and shown by statistics to be sound. If the men would exercise a reasonable amount of care, the casualties to railway employees would rapidly shrink in number. To add point to this we may again refer to remarks made by Mr. Aspinall at the Paris meeting. Speaking of the loss of life among permanent-way men, he said that when they provided look-outs for these men their sense of responsibility went. The number of accidents had increased since look-outs had been adopted. Previously all the men of a gang had had an eye for their safety. A fatal accident which occurred on the North-Eastern Railway last May shows how difficult it is, even after most serious warning, to ensure the exercise of a reasonable amount of care by men of the class from which some of the railway employees are recruited. On a perfectly clear morning, with signals clearly in view in both directions, three permanent-way men were at work near Harrogate. Two were dressing ballast in the 4-ft. and 6-ft. way when a train approached from one direction. Without looking the men crossed over and stood in the other 4-ft. way, where they were caught by another train. Both men were experienced, with records of long service, but what was more extraordinary was that one of them had actually been knocked down by a passenger-train under similar circumstances about six months previously. It might have been thought that one such accident would have made a man cautious for the rest of his life.

With carelessness of this kind in the ranks how can the railway systems be expected to show a clean sheet. The companies are no more responsible for many of the accidents which happen to their servants than they are for the loss of life sustained by trespassers and by the suicides who choose railway premises for their misdeeds. The habit of listing all casualties on railway premises together as railway accidents has led to the misuse of the figures. Last year there were 458 trespassers and suicides killed and 132 injured on our railways. For these no blame can possibly attach to the railway companies, and they should be separately listed. Indeed, it is quite legitimate to ask if suicides can be termed accidents at all. They are usually deliberate acts. It would be well if the classification could be improved. The returns are issued for the information of the public. What the public really wants is some idea of the extent of the accidents for which the railways ought to be held responsible, so that, if possible, the situation may be improved. Both for this reason and in justice to the railways the classification might well be changed.

THE LATE MR. EDWARD RILEY.

WE regret to have to announce the death, which occurred on Saturday last, the 12th inst., at his residence, Marlow, Bucks, of Mr. Edward Riley, F.C.S., F.I.C. Mr. Riley was eighty-three years of age.

As our readers will remember, and as we recorded at the time (see ENGINEERING, vol. xcvii., page 642), Mr. Riley was awarded the Bessemer Medal at the last spring meeting of the Iron and Steel Institute. On making the presentation, Dr. Greiner, the President, stated that Mr. Riley was "an old and honoured member of the Institute—he was elected a member of that Institute as early as 1873." Dr. Greiner said also that Mr. Riley's name was associated with the two most important advances in modern times in the manufacture of steel. In 1853 the deceased joined the staff of the Dowlais Iron Works as their chemist, and at those works, in 1857, he carried out the first experiments with the Bessemer process. The first blow was made in a converter built like a chimney, two tuyeres formed of a 1-in. pipe being used on each side, and about 2 cwt. to 3 cwt. of foundry pig being blown with the cupola blast. The first piece of Bessemer steel ever forged was made in that installation, and that piece of steel is now in the possession of the Iron and Steel Institute. The experiments above referred to led to the making of further trials, using different classes of forge pig; but owing to the high percentage of phosphorus and sulphur in the pig the results were not satisfactory. Notwithstanding the poor results obtained, however, these early experiments proved most valuable, in that they led to the determination of the essential conditions for the success of the Bessemer process.

Two years later, in 1859, Mr. Riley resigned his position at the Dowlais Works, and started in private practice as a consulting and analytical chemist in London, when Sir Henry Bessemer (then Mr. Bessemer), who had recognised his ability, entrusted to him the greater part of the analytical work required in connection with the practical development of his process.

For a short time afterwards Mr. Riley resided at Leeds, where he carried out experiments with titaniferous iron ores, but after a period of two or three years he abandoned these experiments, and in 1869 he returned to London, where his firm, under the style of Edward Riley and Harbord, acquired a great practice as consulting metallurgists and analytical chemists.

The development of the Bessemer process made it necessary to obtain spiegeleisen and ferro-manganese; Mr. Riley, in conjunction with Mr.

Henderson, gave his attention to the production of these metals, and his efforts in this connection led him to carry out a large amount of analytical work, which brought him in contact with both the importers and the users of manganese ores. Owing to his reputation for thoroughness and accuracy he was soon regarded as the acknowledged authority with reference to the analysing of these and other ores used in metallurgy.

Mr. Riley made a study of both the Bessemer and the basic converter processes, and in 1881 he was associated with Messrs. Thomas and Gilchrist in their patents covering basic converter linings; he was able to introduce a number of important improvements in the composition and manufacture of such linings. He also took part in the formation of the North-Eastern Steel Company, Ltd., and of Messrs. Alfred Hickman, Ltd., of which companies he became a director.

But to revert to his earlier activities, we may state that in the earlier 'fifties of last century, when Mr. Riley was commencing his practice as a metallurgical chemist, the accurate methods of analysis now used for determining the constituents of raw materials and of finished-iron and steel products were almost unknown. In this connection Mr. Riley carried out pioneer work, and established new methods of analysis; some of these methods originated by him have been modified, following upon the experience gained in research, but others are still accepted as standard methods. He read at different times various papers before the Chemical Society and the Iron and Steel Institute. During his connection with this latter Institute he read the following papers:—"Chromium Pig-Iron Made by the Tasmanian Iron Company," "The Estimation of Manganese in Spiegeleisen and of Manganese and Iron in Manganiferous Iron Ores," "A Ready Means of Moulding Lime and Making Lime or Basic Bricks and Linings for Furnaces, Converters, &c.," and "Iron-Making Resources of Our Colonies." References under his name in the volumes of Proceedings of the Institute and dealing with his life's work in metallurgy are very numerous, and the iron and steel industry owe him a great debt of gratitude for his untiring and painstaking efforts in furthering that industry in all its phases.

When Dr. Greiner handed him, as recorded above, the Bessemer Medal, the highest award in the gift of the Iron and Steel Institute, he concluded his remarks by stating that "though he had retired from the active prosecution of his scientific work, the members would note that Mr. Riley's connection with metallurgy had been one of fully sixty years' duration, fifty years of which had been spent in energetic and industrious labour in the science of metallurgical chemistry."

These words of the sympathetic President of the Institute give a vivid *résumé* of the services rendered by the deceased. It only remains for us to state that Mr. Riley was educated at King's College School, London, and at the Putney Civil Engineering College, a college which has long ceased to exist. Later he became a student under Dr. Lyon Playfair (afterwards Lord Playfair) at the laboratory of the Board of Health. He then became Dr. Playfair's assistant at the Jermyn-street Laboratory, where he remained until the early 'fifties, when, on the recommendation of Sir Henry de la Beche, President of the Geological Survey of England, he was appointed chemist to the Dowlais Works, as above stated.

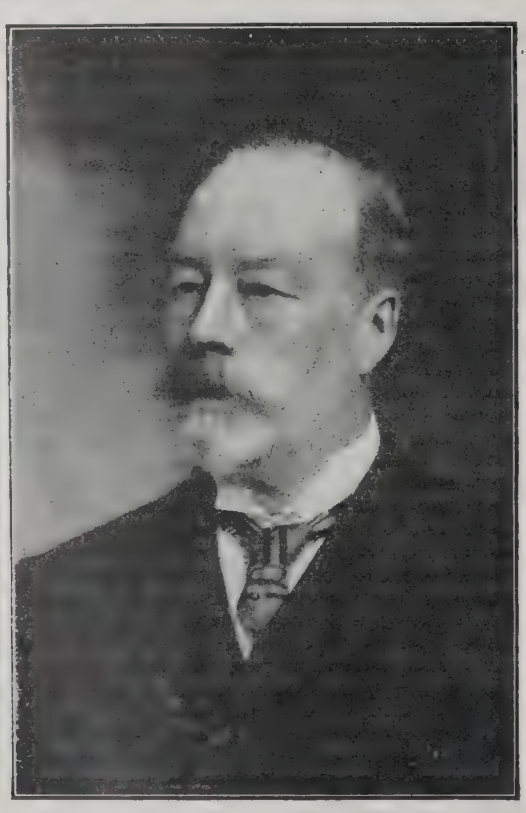
Mr. Riley down to the time of his death was in the enjoyment of all his faculties, and, with memory unimpaired, he still followed technical matters with the keenest attention. He had resided at Marlow for the last twenty-six years, and always took great interest in all matters connected with the welfare of the town.

THE LATE MR. WALTER HUNTER.

It is with much regret we report the death, which occurred on the 9th inst., of Mr. Walter Hunter, the well-known civil engineer, and senior partner in the firm of Messrs. Hunter, Duff and Middleton, of 17, Victoria-street, Westminster.

Mr. Walter Hunter was the eldest son of the late Mr. James Hunter, and was born in 1840, at Bow, Middlesex. He served a pupilage of five years, from 1856 to 1861, under his father, at the works of Messrs. Hunter and English, engineers and millwrights, Bow, London, E., and after completing his period of apprenticeship, he was engaged for thirty-six years in designing and constructing engines and machinery of various kinds, embracing dredging and excavating machinery, rice-dressing and flour-mill machinery, sluices, lock-gates, hydraulic cranes, lifts for gas works, distillery and brewery plant, &c., to the value of over 1,000,000*l*., for the Admiralty, the Crown Agents for the Colonies, the India Office, Trinity House, and several of the water, gas and dock companies of London. For a long period he was the senior partner of the above-named firm, and during later years became the managing director of the business.

Early in life Mr. Hunter took a strong interest in public work, and while living at the East End of London he served on the vestries of St. Mary's, Stratford; Bow; and Bromley St. Leonards, as well as on the Poplar Board of Works. In 1889 he was elected as the representative of the Bow and Bromley division on the London County Council, and for three years he held the position of vice-chairman of the Bridges Committee of that Council. He also acted as the representative of the Council on the Lee Conservancy Committee. As vice-chairman of the Bridges Committee, Mr. Hunter



Elliott and Fry, Ltd.

The late Mr. Walter Hunter.

exercised an important influence in securing the sanction of the Council to the carrying out of the Blackwall Tunnel scheme, and he was further largely responsible for the reconstruction, on much improved lines, of the bridge by which the Barking-road is carried over Bow Creek.

On leaving Bow, Mr. Hunter became engineer, and, later, engineer-director of the Grand Junction Water Company, London, a position which he held until the formation of the Metropolitan Water Board in 1903. During this period he designed and built pumping-engines, filter beds, and water mains at a total cost of about 250,000*l*., his efforts having for effect to reduce the water consumption in the company's district from 49 to 35 gallons per head per day.

Whilst engineer-director to the Grand Junction Water Company, Mr. Hunter originated the Staines reservoirs scheme of water storage, which, through his untiring energy and perseverance, became fully developed, and was ultimately adopted by three of the Metropolitan water companies. Mr. Hunter was joint engineer with Mr. R. E. Middleton for the first instalment of those works, which cost about 1,250,000*l*. The scheme has since been taken up for the whole of the water supply of London.

From 1903 down to the time of his death Mr. Hunter practised as consulting engineer in partnership with Mr. R. E. Middleton and Mr. M. B. Duff, and the firm have jointly carried out many water-works and sewage schemes. In 1903 Mr. Hunter was appointed by the Crown Agents for the Colonies, acting for the Colonial Government, to visit South Africa and inquire into the means of providing an adequate water supply to Johannesburg and the Rand mines, the report made by him being subsequently adopted by the Rand Water Board. Later on Mr. Hunter also visited the West Coast of Africa, and, acting upon the instructions of the Colonial Office, reported upon the question of water supplies for various parts of the Gold Coast Colony. As a result his firm have since designed works for the supply of the towns of Accra and Seccondee, and these works are being carried out at a cost of upwards of 500,000*l*.

More recently Mr. Hunter was instructed by the Rand Water Board to give evidence at Johannesburg in the arbitration between that body and the Johannesburg Water Works Company, involving a claim of 4,500,000*l*., and resulting in an award of 1,281,500*l*. He also appeared before Committees of Parliament in support of, and in opposition to, a large number of water and other Bills, and further was called in at different times to advise various British provincial water companies on their water supplies. He also acted as arbitrator in a number of cases.

Mr. Hunter was elected an associate member of the Institution of Civil Engineers in 1865, and a full member in 1878, while since 1906 he has been a Member of the Council, and at the last annual general meeting he was elected a Vice-President. He was also a member of the Institution of Mechanical Engineers (elected in 1877) and of the Institution of Water Engineers. He was also a J.P. for London and Middlesex, and chairman and director of several companies.

Mr. Hunter was a most energetic and conscientious worker, and all matters which he took in hand, whether of a professional or public character, were dealt with in a most thorough way. For the past year he had been in failing health, and during the present summer his condition had given cause for grave anxiety, but he continued to devote himself to his work, and his last fatal attack took place at his office last Monday week. His state was then so serious that he could only be moved to the Westminster Hospital close by, where he died, as we have said, on Wednesday, the 9th inst. His loss will be deeply regretted by a wide circle of friends, whose regard and respect he had earned, and who will sympathise most heartily with his family under their bereavement.

NOTES.

Trade in Russia.

The Minister for Foreign Affairs in the Russian Government, M. Sazonoff, has authorised the publication of a statement which should be a good incentive to British manufacturers in their endeavour to increase trade with the great Russian Empire. In this communication, which is published through the medium of *The Times*, he truly states that there is presented at the present moment an opportunity for trade and commerce with Russia which, to England and America, may mean more in decades to come than it is easy to realise. There is an enormous and lucrative market for machinery, chemicals, and all sorts of manufactured goods. The avenues of supply across the frontier have been cut, and it is the business of the British and American nations to pave new ways for the importation into the Czar's dominions of the corresponding products. The importations from Germany are said to have amounted to 60 million pounds sterling per annum, and M. Sazonoff quotes one of the sayings of Pascal to the effect that to govern is to foresee, applying this to trade relations as well as to politics and to affairs of government. It is our business to "foresee" the situation commercially in Russia, if we are to obtain the fullest advantage from the present state of affairs, and we are glad to realise that already there are being cultivated direct trade relations between the houses of business in Petrograd and our manufacturers. M. Sazonoff pleads for the sending of experts to Russia, even while the war is in progress, in order to ascertain the requirements of the country, and to study the means whereby these can be fully and acceptably met. Instead of calmly resting on past achievements, and trusting to collective or Government aid in the propagandist movement, which promises to yield such large and

immediate results, the manufacturers ought to arouse themselves immediately, deal firmly with the financial and other retarding forces, and adopt direct and personal effort towards the establishment of close relationship with potential markets, so that they may acquire full knowledge of the needs, and establish means of meeting such needs. Fortune helps those who help themselves, and it would be a mistake for our manufacturers to rely solely on Government or other collective effort; these are welcome, but only as supplementary to individual enterprise.

Competition with Germany in Steel Plates, Rails, &c.

Pursuing its policy of furnishing information regarding markets in which British products should now find a ready sale, the Commercial Intelligence Branch of the Board of Trade has recently issued, among others referred to elsewhere, three bulletins dealing respectively with German and Austrian exports of steel plates and sheets, railway material, and nails, bolts, &c. All are well aware that in recent years Germany has captured many contracts for the supply of these materials, to the disappointment of this country. Not only has this been the case in markets in which we usually have a good chance, but it has even happened at home, by reason either of questions of cost or time of delivery. In 1912 Germany exported steel and iron plates and sheets (other than tinned or galvanised) to the value of 3.523,000*l.*; Austria's exports are of the value of about 183,650*l.*; our own in 1913 were valued at 2,813,000*l.* We purchased from Germany to the extent of 527,300*l.*, the bulk of this being sheets of over 5 mm. in thickness. Germany's most important market is the Netherlands, which took sheets to the value of 852,800*l.* in 1912. To no less than eleven countries her exports are valued at over 100,000*l.*, while we only send to four countries goods of such a value. In Australia the United Kingdom's share of this business tends to decline. In India, in 1913, Germany's share was nearly equal to our own. In Japan, while our trade about doubled between 1910 and 1912, Germany's was nearly trebled. In Egypt the principal competitor of Great Britain is Belgium, though Germany's trade increases. In the matter of rails, steel sleepers, fish-plates, springs, &c., Germany's exports are very important, totalling an annual value of about 4,531,200*l.* Austria's, on the other hand, are comparatively small—viz., 37,470*l.* Our own are valued at about 5,189,600*l.* The export of such materials from Germany to the United Kingdom amounted in 1912 to a value of about 179,400*l.*, of which the bulk was made up by rails for railways or tramways. Germany sends exports of rails to a value of over 100,000*l.* to twelve countries, her largest purchasers in 1912 being the Dutch East Indies, Sweden, Argentina, the Netherlands, Turkey, Brazil, &c. The exports to these countries range from 155,300*l.* to Brazil, to 289,400*l.* to the Dutch East Indies. To no country does Germany export to the extent that we do to Argentina, Australia, India, &c. In 1913 Australia purchased rails from us to the amount of 897,200*l.*, and India to the value of 810,600*l.*, chairs and sleepers to the latter country being responsible for another 540,100*l.* From South Africa recent orders for railway material have gone to Germany on the matter of price. While our exports to Japan have risen from 5400*l.* worth in 1910 to 56,613*l.* in 1913, Germany's have increased from 79,800*l.* to 122,105*l.* in the same period. To many of Germany's best Continental customers we do not export material of this class at all. The exports of screws, nails and bolts from Germany are of an annual value of 1,241,150*l.* Austria exports also these goods to a value of about 86,200*l.* We export goods of this type to the value of 1,201,400*l.* As in railway materials, while we export heavily to a few markets abroad and in small quantities to others, Germany's trade is much more evenly distributed. For instance, Australia and India buy from us each to the value of about 240,000*l.* Germany's principal customer, the Netherlands, buys to the value of only 98,200*l.* She sends, however, exports valued at over 10,000*l.* to no less than twenty-three countries, compared with our fifteen, from which it will be clear that there are many markets where we might do more business. The principal Austrian markets are her neighbours—viz., Italy, Bulgaria, Roumania, Turkey, &c. In many of these south-easterly European countries our trade is small. In Japan Germany has a strong footing in the market for nails, disposing of goods to about the value of ten times the amount we do. In South Africa German trade has been assisted by agents who buy samples of goods enjoying a satisfactory sale, for the purpose of sending them home to be copied, the market being supplied a few months subsequently with a similar but cheaper German article.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. III

By Frederick William Lanchester, M. Inst. C.E.

The Aeroplane as an Auxiliary to Tactical Operations.

The aeroplane in its employment in connection with tactical operations finds itself under conditions entirely different from those discussed in the preceding section; its duties are of a more varied character, and involve flying at lower altitudes than are compatible with security. It is likely to be almost continuously under fire, and, according to some of the experiences of the present war, it has almost as much to fear in this respect from its friends as its foes. Whereas the strategic reconnaissance machine is able to perform all its most useful work at high altitude, and will avoid as far as possible the attention of, or actual contact with, the enemy, and evade pursuit by flight. The tactical machine acting under the divisional command, whether engaged in local reconnaissance or in locating or directing gun-fire, or in other duties, must be prepared at once to tackle the enemy, and, in brief, to interfere as much as possible with the hostile aeroplane service. Under certain circumstances the instructions will undoubtedly be to make the aircraft of the enemy the first objective.

It is more than probable that it is in connection with the varied duties that in the future must fall to the Fourth Arm in its tactical usage, that differentiation of type and specialisation will eventually become the most marked. At present practically no attempt in the direction of specialisation has taken place. It is true the different machines in service vary considerably, and those responsible for the construction and specification of Service aeroplanes have already begun to talk of "reconnaissance machines" and "fighting machines;" but the distinction is one that has scarcely yet penetrated to the field of operations. When all has been said, differentiation of type must, from the Service standpoint, be looked upon as an evil, only to be justified when, and to the extent that, service conditions prove it to be necessary. So far even the broad distinction between machines for strategic reconnaissance and for tactical operations has scarcely been drawn or received recognition. The military aeroplane of to-day is something like the frontiersman's knife—made for nothing in particular, used for everything in general.

For the purpose of directing artillery fire the experience of the present war has shown the aeroplane to be effective almost beyond the most sanguine expectation. For this purpose it appears to have established its utility beyond question. Its duties in this respect may be regarded as a special branch of local reconnaissance, its function being to locate the objective and signal its whereabouts to the gun batteries to which it is attached; further to report and correct inaccuracies of fire. The exact mode or modes of signalling adopted do not so far appear to have been definitely disclosed. Some reports give the aeroplane as turning sharply when over the enemy's position; according to other accounts a smoke bomb of some kind is let fall to indicate the position to be attacked; other reports, again, mention lights as being used. It appears that lamps of sufficient power to be visible in daylight are actually being employed by the German aircraft. Possibly all these methods are in use experimentally, or different kinds of signals may be used for different purposes, to indicate initially the position, and subsequently to give corrections, either as to direction or range. Whatever the methods employed may be (and the details do not much concern us at the moment), they seem to be quite effective, and, it may be presumed, very considerably increase the fighting value of the guns. More than this, the value of aeroplane work will be relatively greater the longer the range; in fact, it may in future be found possible to employ heavy artillery of long range under conditions in which, without the help of the aeroplane, it would be comparatively useless. As an illustration, there is nothing to-day to prevent a long-range battery, well served by its aeroplanes, from effectively shelling an enemy without knowing in the least the character of its objective—*i. e.*, whether an infantry force or position, a body of cavalry, or the enemy's guns. In the present war the aeroplane appears to have been utilised by the German army, as a matter of regular routine, as an auxiliary to the artillery in the manner indicated. It has been reported again and again that the appearance of an aeroplane overhead has been the immediate prelude to the bursting of shrapnel, frequently the very first shell being so accurately placed as to indicate that the method of signalling, and, in fact, the whole performance, must have been well thought out and equally well rehearsed.

It is well understood that the determination of the distance of an aeroplane of *known size* with approximate accuracy is a matter of perfect simplicity. Thus, if the aeroplane be flying fairly overhead, or directly towards or away from the observer, and the span be a known dimension, then by measuring the optical angle presented by the span, the distance or range is given by simple proportion. For example, holding a foot-rule square in front of one at arm's length—approximately 20 in. from the eye—the span, known to be, say, 36 ft., subtends an angle represented by, say, $\frac{1}{2}$ in. on the scale; the distance is $\frac{20 \times 36}{0.5} = 1440$ ft. Using such rough-and-ready "apparatus," the degree of accuracy to be expected is not great; however, the writer has found it quite sufficient to determine the altitude of a machine to within 5 or 6 per cent. of the truth. If for the observer's arm and foot-rule we substitute a low-powered telescope or binocular of, say, 2 or 3 diameters magnification, with micrometer cross-wires, with which to follow up the apparent reduction in span of a receding aeroplane, until some prearranged signal is given, the range could undoubtedly be determined easily to within 2 or 3 per cent. At 1 mile distance this means a degree of accuracy represented by a maximum error of about 40 yards, or sufficient to enable shrapnel to be dropped right on the mark. Parenthetically, it may be pointed out that the same method will enable the range of a hostile aeroplane to be determined, provided the type be identified, and its leading dimensions are known; it also suggests the importance of not flying exactly towards or away from, or exactly broadside to, any position of the enemy guarded by aeroplane (or balloon) artillery; flying end-on to the enemy is also to be deprecated on the ground of fixity of direction.

Attack by Gun-Fire.

An aeroplane operating in a hostile country is liable to attack by rifle and machine-gun fire, also by shell-fire from special aeroplane artillery. It has comparatively little to fear from field artillery owing to the want of handiness of the ordinary field-gun. The "laying" of a field-piece is far too clumsy a business to permit of its effective use on so small and rapidly moving a target as presented by an aeroplane in flight, though it may be effective when used against a dirigible. With regard to rifle or machine-gun (small bore) fire, calculation shows that aircraft is absolutely safe at an altitude of somewhat over 7000 ft.; it is in that region that the top of the trajectory lies for vertical shooting.

The duties of a strategic scout on long-distance work would, without doubt, permit of flying at such a high altitude, and it may be added that, although absolute immunity is not reached at less than about 7000 ft., a solitary aeroplane can only present a very unprofitable target at far lower altitudes. In fact, it may be taken that at, say, 5000 ft. or 6000 ft., the amount of small-arm ammunition that would be wasted in bringing down an aeroplane would be enormous. Not only would the velocity become so reduced as to render a "hit" capable of but little mischief, but the time of flight of the bullet, rising vertically to this altitude, would be about 8 or 9 seconds, and the distance moved by the aeroplane 1000 ft., more or less. Therefore it would be necessary to fire into quite a different part of the heavens from that in which the aeroplane was seen, something akin to sighting into the Great Bear to hit the Pole Star. Beyond this the gyroscopic drift of a bullet fired vertically is nil, against some 30 ft. or 40 ft. under normal conditions;* also the error due to

* The normal sighting of a rifle is arranged partially to correct for the gyroscopic drift.

the earth's rotation is a matter of about 30 ft. westward, and cannot be allowed for without taking reference to the compass bearing. Taking all these things into account, it is evident that for the infantryman or gunner not specially trained, the task of bringing down an aeroplane flying at high altitude is no light one, especially when we recall the fact that for every inclination and bearing of the line of sight the conditions differ. In designing the mounting of aeroplane-stopping artillery or machine-guns, it would be possible to render the sighting corrections for such items as gyroscopic drift and earth's rotation automatic; this could be done without difficulty, and would mean the elimination of errors whose combined value may amount to something like 60 ft. at 6000 ft. altitude—*i.e.*, an angular magnitude represented roughly by the apparent diameter of the sun or moon.

The height to which aircraft artillery will carry is by no means subject to the same limitation as that of the small-bore machine-gun or rifle, the resistance of the air being many times greater than that due to gravity. Thus the ordinary rifle bullet, at 2000 foot-seconds muzzle velocity, would carry to a height of over 60,000 ft. *in vacuo*, instead of approximately 7000 ft. actual. If we take the case of a 1-pounder having the same velocity, its effective vertical range is well over 12,000 ft., and from that calibre upwards the range will, in practice, be more a question of the shell being properly directed than whether it will attain the height. At the best, firing from the ground at an aeroplane at high altitude will require skilful gunnery, and when near the limit of the trajectory nothing but sheer good luck will render a hit effective. The angle of "lead" it is necessary to give to allow for the velocity of flight, as already stated, is one of the difficulties of high-altitude shooting. This angle is only constant so long as the velocity of the projectile is constant, assuming (as fairly represents the conditions) the flight speed not to vary; at extreme heights the velocity of the projectile has fallen so low that a very slight error in range-finding will be fatal to accuracy. The solution of this difficulty may be found in the employment of guns of about 3-in. bore (as already in use for airship defence)—*i.e.*, a 12-pounder or 15-pounder, with the concurrent advantage of a full shrapnel charge, and, in shot-gun terminology, a larger killing circle. The obvious disadvantages, however, of artillery, in place of a machine or other light automatic gun, lie in its want of portability and its unhandiness, difficulties that doubtless may, be overcome, to some extent, in course of time.

All things considered, it would appear probable that attack on aeroplanes at high altitude from the ground may be found impracticable, or at least uncommercial. Not only have we to reckon with the various considerations above discussed, but also with the fact that, in our climate at least, not more than one day in four is sufficiently clear to render high-altitude shooting possible, and though it is true that an aeroplane, to make observation, cannot remain above or in the clouds, it presents but a poor mark under bad weather conditions.

An aeroplane operating at high altitude will probably need to be hunted and driven off or destroyed by armed machines of its own kind.

Defence from Gun-Fire.

It is manifestly not possible for an aeroplane to perform all the duties required of it, in connection with tactical operations at high altitude,* and whenever it descends below 5000 ft., or thereabouts, it is liable to attack from beneath; in fact, at such moderate altitudes it must be considered as being under fire—mainly from machine-gun and rifle—the whole time it is over or within range of the enemy's lines. Protection from the rifle bullet may be obtained in either of two ways: the most vital portions of the machine, including the motor, the pilot, and gunner, can only be effectively protected by armour-plate; the remainder of the machine, including the wing members, the tail members, and portions of the fusilage not protected by armour, also the controls, struts, and the propeller, can be so constructed as to be *transparent* to rifle fire—that is to say, all these parts should be so designed that bullets will pass through without doing more than local injury and without serious effect on the strength or flying power of the machine as a whole; in certain cases components will require to be duplicated in order to realise this intention. It is important to understand clearly that any intermediate course is fatal. Either the bullet must be definitely resisted and stopped, or it must be let through with the least possible resistance; it is for the designer to decide in respect of each component which policy he will adopt. The thickness of the armour required will depend very much upon the minimum altitude at which, in the presence of the enemy, it is desired to fly; also upon the particular type of rifle and ammunition brought to bear. There is a great deal of difference in penetrative power, for example, between the round-nosed and pointed bullets used in an otherwise identical cartridge.

If it were not for the consideration of the weight of armour, there is no doubt that an altitude of about 1000 ft. would be found very well suited for most of the ordinary tactical duties of the aeroplane. At such an altitude, however, the thickness of steel plate necessary becomes too serious an item for the present-day machine, even allowing for the very excellent and highly efficient bullet-proof treated steel that is now available; at the altitude in question the minimum thickness that will stop a 0.303 Mark VI. round-nose bullet is 3 mm. ($\frac{1}{8}$ in.), but, if attacked by the modern pointed-nose Mauser, nothing short of 5 mm. or 6 mm. is of avail. If we compromise somewhat in the matter of altitude and prescribe 2000 ft. as the minimum height for which protection is to be given, the figures become 2 mm. (about 14 S.W. gauge) for the 0.303 round-nosed bullet, and for the pointed Mauser 3 mm. or slightly over; at present it is not expected that it will pay to armour a machine for the duties in question more heavily; thus we may take 2000 ft. as representing the lower altitude limit of ordinary military flying. Anything less than this will be referred to in the present series of articles as low-altitude flying. On this question of armour it cannot be too strongly insisted upon that anything less than the necessary thickness definitely to stop the projectile is worse than useless; a "mushroomed" bullet, possibly accompanied by a few detached fragments of steel, is infinitely more disagreeable and dangerous than a bullet that has not been upset.

An aeroplane armoured in all its vitals with 3-mm. steel, and otherwise designed on the lines indicated, flying at not less than 2000 ft. altitude, will be extremely difficult to bring down; so much so, that unless its exposed structural members be literally riddled and shattered by rifle and machine-gun, or unless a gun of larger calibre be brought to bear, it will be virtually impossible to effect its capture by gun-fire alone.

* For military purposes we may take the term "high altitude" as defined by the effective vertical range of small-arm fire—in other words, as denoting an altitude of 5000 ft. or 6000 ft. or more.

INDUSTRIAL NOTES.

The Director of the Department of Labour Statistics states that the effect of the war on employment in August was obscured by the fact that certain industries—notably, cotton—were already affected by the more or less general decline in employment, owing to purely trade causes, which had been noticed for some months past. The holiday season, especially in the North, also considerably curtails employment in August, every year. The general effect of all causes was to increase the percentage unemployed in trade unions making returns from 2.8 at the end of July to 7.1 at the end of August—a figure which has frequently been exceeded in periods of bad trade, and which is much lower than that recorded during the national coal strike of 1912, when the percentage rose to 11.3. It should be stated, however, that many employers endeavoured to avoid discharging a portion of their workpeople by putting the whole staff on reduced time.

As compared with July there was a general decline in all industries except in shipbuilding, which benefited by increased activity on Government work. The contraction in employment was especially noticeable at tinplate works, and in the textile, furnishing, and wood-working and pottery trades.

As compared with a year ago there was a general decline, in addition to that which might have been expected as the result of the downward trend in employment already referred to.

The changes in rates of wages taking effect in August affected 55,000 workpeople, of whom 19,000 received increases and 36,000 sustained decreases, the net result of all the changes being a decrease of nearly 200*l.* per week. None of the changes were due to the effects of the war, all the decreases being the result of a fall in the selling prices of iron and steel before the outbreak of hostilities. The principal increases affected 9000 labourers, &c., in engineering works, and 1800 spring-knife-grinders, &c., at Sheffield, and considerable bodies of building-trade operatives at Liverpool, Nottingham, Exeter, and Bristol. Amongst those whose wages have been reduced were 2500 ironstone quarrymen and blastfurnacemen in Lincolnshire, 3130 steel-melters, &c., in various parts of Great Britain, 20,000 ironworkers in the Midlands, and 5850 steel workers in West Scotland.

The number of disputes beginning in August was 15, and the total number of workpeople involved in all disputes in progress was 49,804, as compared with 98,112 in the previous month and 80,626 in August, 1913. The estimated total aggregate duration of all disputes during the month was 526,900 working days, as compared with 1,327,800 in July, 1914, and 801,600 in August, 1913.

At the end of August the number of disputes in progress was only 20, and the total number of workpeople involved was 9000.

Cases dealt with during the month under the Conciliation Act include steel-workers, Cambuslang; printers (women), Glasgow; packing-case makers, East London; masons, Montacute (Somerset); and joiners, Helensburgh. Matters have been dealt with by independent chairmen under the Railway Conciliation Scheme.

The average weekly number of vacancies notified to all Labour Exchanges for the four weeks ended August 14, 1914, was 26,874, as compared with 26,043 in the previous five weeks, and with 22,314 in the four weeks ended August 15, 1913. The average weekly numbers of vacancies filled for the same periods were 21,162, 19,488, and 17,070 respectively.

The Right Hon. Austen Chamberlain has received from Mr. Walter Runciman, the President of the Board of Trade, and has transmitted to the Birmingham Chamber of Commerce for publication, the following letter, which deals, as will be seen, with brass and copper exports from this country. The letter is dated the 7th inst.:—

"The present position as regards the prohibition of the export of brass and copper is that fully manufactured articles of brass and copper may be exported without any restriction whatever, but that absolutely unwrought copper and brass in ingots are altogether prohibited from exportation. Certain semi-manufactured articles are assimilated to unwrought copper and brass, in so far as they are technically prohibited. The Admiralty, however, agreed on the 4th inst. that, so long as applications for license were made in each case, these applications would in general be favourably considered if the destination of the consignment was satisfactory—*i.e.*, if there were no risk of it getting to the enemy. The object of requiring a license (apart from the question of destination) is to keep touch with the amount exported, and in certain cases to restrain any very large consignments.

"The goods which may go under license are: plates, sheets and discs, rods and solid-drawn tubes. This requirement does not extend to brazed tubes, nor to cased tubes. The latter (which are iron tubes cased in brass) are those mainly used in the manufacture of 'brass' bedsteads.

"Step by step the limitation of export is being relaxed. It will be seen that it has already been found possible to grade the manufactures into classes, and I hope that the arrangements made with regard to licenses will prevent any substantial hardship to the trade."

We read in the *Sheffield Daily Telegraph* that in the Sheffield district the Government requirements are providing the bulk of the work, and while many firms are unable to meet the demand, others, whose trade is general, are finding it difficult to keep going. The home demand for steel and steel products is extremely poor, as users are keeping down their orders to the narrowest limits. The export trade is mending, but steel leaves much to be desired, and recent happenings in the North Sea have had the effect of checking shipments of goods in that direction. More orders for material previously supplied from the Continent have been booked, but much of this possible trade is still in the inquiry stage. Many of the buyers want to obtain their material at German prices, and this, of course, is out of the question. When the last-named fact is fully realised, probably orders will come in more freely. Makers of basic billets and basic steel in various forms are working at full pressure. There is also a better inquiry for wire, although more could be done in best qualities. A constantly expanding demand for cold-rolled strip is reported. The rolling-mills are only moderately employed, except as regards material for the cutlery trade, which cannot be delivered quickly enough. Some works are feeling the effects of the recent boom in recruiting, and are now short-handed. The supply of Swedish iron and steel appears to suffice to meet the demand, which is much below what it was before the war, and stocks have been replenished. The current rates for freight are, however, forcing up prices.

According to the same journal further very large orders for shoes and dies for mining work have been placed in Sheffield, this time from South Africa. Much work of this kind goes to Sheffield regularly from that quarter, but it is understood that, as in the case of recent orders from Fremantle, some of the present orders represent trade diverted from Germany. One firm has booked a good hardware order for Penang, and another is to make a large quantity of saws for Calcutta. Steel contracts have come in very well, important tonnages now being in hand for Genoa, Victoria (B.C.), Auckland, Chicago, New York, Montreal, Quebec, and the United States. An inquiry from Fremantle for anvil-blocks has resulted in a big order being booked in Sheffield. In two cases, at least, considerable contracts for high-class razors, which formerly went to German makers, have been secured. The War Office is about to place an emergency contract for 400 dozen hand-saws of various kinds for delivery to Woolwich Arsenal. The Department has for some time past been buying up all available supplies of heavy hammers, axes, engineers' tools, spades, shovels, and picks. Large quantities of entrenching tools are required, and the demand for such goods is likely to continue for the duration of the war.

The demand for military cutlery increases by leaps and bounds, whereas the local sources of production remain practically stationary, with the result that Sheffield is utterly unable to supply the goods by the time they are needed. The requirements of the War Office are on an unprecedentedly large scale; but, in addition, orders are pouring in from every newly-formed corps throughout the country. Never before have so many razors been wanted. The regulation pattern is being ignored for the time being, and all stocks of the cheaper goods have been completely cleared out. Although every shop, big and little, which is laid out for the particular kinds of cutlery required for the Army, is working night and day on table knives and forks, pocket-knives, razors, and spoons, the output is quite inadequate. The ordinary run of the cutlery trade is, on the contrary, in an extremely depressed state, more especially in London and the provinces. Australian, American, and Indian buying is almost normal, and instructions are being received to forward many of the suspended Canadian orders. When the stocks of German cutlery are exhausted, Canada will have to buy heavily in this country; but financial stringency is holding business back just now. Cutlery makers in the United States are hoping to sell more of their goods in the Dominion markets; but it is probable that their resources will be fully taxed in meeting the home demand, in view of the withdrawal of German cutlery. Orders are coming into Sheffield from buyers of German ordinary and safety razors, and a substantial growth of this trade is regarded as a certainty. As regards the cheap safety razors, Germany had the bulk of the trade.

A Central News telegram from Petrograd says the Russian Minister of Commerce and Industry has despatched a commission of engineers to the town of Stryi, in Galicia, which has been recently occupied by Russia, with the view of studying the resources of petroleum in Austria, to meet any shortage of naphtha in Russia.

On Sunday last, the 13th inst., the coal-trimmers and teemers at Blyth reached an important decision with regard to working hours at week-ends. Owing to an abnormal demand for coal at Russian ports, the North of England Shipowners' Association, local chambers of commerce, and the North-Eastern Railway Company had been pressing the men at north-east coast ports to extend their working hours on Saturdays. On the 13th inst. the men agreed to work until eight o'clock on Saturday nights, with a view to deal with coal for Russia only. The decision is likely to extend to all north-east coast ports.

Information reaches us from Glasgow to the effect that Scotch manufacturers of jute-bags, &c., have just booked very large orders on behalf of the army, and that firms who thus specialise are full up. Other firms with Government contracts are also large buyers, some individual orders being worth from 10,000*l.* to 50,000*l.* It is stated further that contracts for a second million yards of khaki for the British Army have been given out. The Lord Mayor of Bradford has received a telegram from the War Office placing with him an order for 100,000 blankets. No particular quality being specified, the Lord Mayor (Alderman Arnold) has asked for further instructions, pending the receipt of which no action will be taken in the matter. Dewsbury and other manufacturers in the heavy woollen district have been busy for some time with orders for army blankets.

As an example of the schemes which are being put forward throughout the country for the relief of unemployment we may mention the reclamation of the waste lands of South Staffordshire. This scheme was advocated by Mr. John R. Cooper, ex-Town Clerk of Walsall, in the course of an address which he delivered on Friday last, the 11th inst., at the Friends' Library, Birmingham.

In the course of his address Mr. Cooper said it was the duty of all patriotic men and women to do what they could for the country. It was important that some schemes should be carried out in order to give employment to those thrown out of work owing to the war, and it was also important that such schemes should be of lasting benefit to the community. He suggested that a scheme should be carried out for the reclamation of the waste lands in South Staffordshire, of which there were about 14,000 acres. The waste lands in question consisted largely of pit mounds and mining areas. That such a scheme was practicable had been demonstrated by the action of many local authorities in South Staffordshire and by the Midland Reafforestation Association. The main difficulty was in regard to means, but possibly such a difficulty would be removed by financial assistance from the Development Commissioners and the acquisition of the waste lands by the State. The land could be leased to local authorities, who would utilise it for small holdings, allotments, or open spaces. Men out of employment would thus be enabled to engage in remunerative work. Many local authorities had carried out works of a similar nature.

On the motion of the Rev. H. C. Colville, seconded by the Rev. M. M. Connor, a resolution was passed urging upon the Association of Midland Local Authorities the desirability of making representation to the Development Commissioners in favour of action being taken by them by grants of money to local authorities or by the acquisition of suitable waste lands, thus providing employment for persons thrown out of work owing to the war, and increasing the national food supply by bringing such waste lands into a condition fit for cultivation.

Satisfactory news is to hand from Hull, where, it is stated, a large number of dock workers are now finding employment. There are forty vessels in the Alexandra Dock, of which nine are loading coal and a dozen are unloading cargoes of grain and timber. At the Victoria Dock vessels are unloading timber; other docks are busier than they have been for the last fortnight. A good number of seamen are signing on. Prospects at the fish dock are brighter; good supplies of fish are arriving, and there is a better demand.

In their last report, dated the 8th inst., the Steam-Engine Makers' Society make the following remarks:—

"Too long have the working classes of this country been chloroformed and deluded by a false, fallacious, and sloppy sentiment as to the love and brotherhood of the German nation. Have we not heard of it after the all too numerous junketings that at least some of our 'leaders' have been in the habit of taking from time to time in the vicinity of Berlin? We now find we have been housing hundreds, if not thousands, of spies in our very midst, and we now know only too well the value of the so-called German culture, also what has been the preaching and teaching of its professors and philosophers. We see this culture in practice and with objects that would have disgraced the barbarians of old. It would have been good indeed for us, as trade unionists, in a body, to have looked patent and obvious facts in the face long since, so vividly and concisely as they have been put before us in season and out of season, and this for many a day. . . . Upon the result of the struggle in which we are unfortunately engaged depends our very existence as a world-wide Empire, whose foundations are built upon justice, freedom, and right, as opposed to a military autocracy and despotism which young and old, according to their measure of ability and capacity, have to smash once and for all or perish in the attempt. There can only be one result, however long it may be to attain it—a fight to a finish, and no looking back until victory is achieved . . ."

The same report contains the statement of income and expenditure for the half year to May, 1914. The number of members is given as 17,059, the total funds at the half-year being 133,336*l.*

The report for the present month of the United Society of Boiler-Makers and Iron and Steel Shipbuilders places the total membership, including apprentices, at 68,032. The accounts showed a balance on July 4 last of 304,778*l.*, and on January 10 last of 281,182*l.*, giving a net increase for the half-year of 23,596*l.*

The executive council of the Amalgamated Society of Engineers issued a few days ago the following voting returns:—

In favour of a 6d. levy for the contingent fund:—For, 9343; against, 190—majority for, 9153.

In favour of a 3d. levy for the legal defence fund:—For, 8754: against, 361—majority for, 8393.

In favour of accepting provision for avoiding disputes:—For, 19,497; against, 8056—majority for, 11,441.

In favour of authorising the executive council to negotiate with the Engineering Employers' Federation with the view to arriving at an agreement in substitution of the agreement of 1907 and the premium bonus agreement, subject to the ratification of the members: For, 20,051; against, 7677—majority for, 12,374.

The membership of the Society is now 171,656.

As is now generally known, there is a good demand in this country for all classes of timber used at collieries. The sorts most affected by the temporary stoppage from the Baltic are pit-props in the round (3 in. in diameter and upwards), small pit-sleepers, and "crown" trees. Crown trees vary in length, and are sawn into sections about 5 in. by 2½ in. They can best be procured, and are most economically cut, from comparatively small trees (for example, from those having a quarter-girth of about 5 in to 8 in. at breast height). They can also be sawn from the smaller and top cuts of large trees, the butts of which can be used for other purposes, such as pit-baulks of 8-in. by 5-in. section, or railway sleepers.

In this connection there are good business prospects for owners of woodlands, and good chances of work for a part of the British unemployed.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, September 2.

INTEREST in iron and steel centres around export probabilities. Domestic demand is ominously quiet. The chief reason assigned is that the banks are pursuing a policy of restriction of accommodations to unavoidable necessities. How long they may feel obliged to pursue this course it is impossible to say. For the present, numerous steel-consuming projects are held up, and current demand is unimportant. Present requirements employ mills to about 65 per cent. of maximum capacity. Inquiries for steel from abroad are rather alarming in their magnitude. One recent inquiry is for 50,000 tons of billets, sheet bars, and other material for Sheffield, England. Billets are 21 dols., Pittsburg, and 24 20 dols., New York. Sheet bars, 22 dols. and 25.50 dols. respectively. Glasgow wants 10,000 tons of billets, and another concern the same amount. Total inquiries from abroad now amount to 150,000 tons; half this amount has been booked, but every day brings fresh news. Canada is urging delivery of sheets, Australia wants rails to fill wants placed in Europe; South America is also urgent for steel. The railroads are not buying. Efforts are being renewed to obtain permission to get better rates. The roads are anxious to buy, but they want time, as the banks have refused to extend help until a reorganisation is effected under the new reserve banking law. Not for years have so many opposing influences converged at one time in the steel situation. With an enormous trans-ocean demand in sight, to all present appearances, local demand is poor, and prices advance only fractionally. Consumption continues at its high level.

AUSTRIAN AND GERMAN FOREIGN TRADE IN LUBRICATING OILS AND GREASES.—The Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, E.C., has compiled a bulletin giving particulars of the foreign trade of Austria-Hungary and of Germany in lubricating oils and greases. This trade, in the case of the former, amounts to 860,380*l.* per annum, and for the latter country to 487,350*l.* Austria's chief exports are to Sweden (75,100*l.*), Belgium (67,400*l.*), the United Kingdom (46,700*l.*), Switzerland (45,700*l.*), Denmark (43,200*l.*). These are of mineral oils, Austria's exports of grease being small. On the other hand, Germany exports fats and grease to the value of 110,600*l.*, but the classification adopted in the two countries appears to differ somewhat. We purchase from Germany grease to the value of 15,250*l.* per annum, and mineral oils to the value of 43,550*l.* Germany's largest buyer, however, of oils is India, which takes 83,300*l.* worth. Italy is another good purchaser, her requirements being valued at 21,750*l.*

THE SPECIAL FIRE-SERVICE FORCE.—The special fire-service force organised by the British Fire-Prevention Committee has been duly inaugurated with a nucleus of 300 fire surveyors, fire-brigade officers, patrol inspectors and firemen. Fire-survey parties can be despatched for fire survey, pulling-down and dangerous structure work, at short call; a number of fire patrols, comprising skilled patrol men, can be put on either night work or permanent watches, and several complete fire-service sections, comprising fire-brigade officers and firemen with equipment complete, can be immediately mobilised to take up regular duty wherever requisitioned by public departments or other authorities requiring assistance in the national interest. Besides organising the special fire-service force, the British Fire-Prevention Committee has been acting as a clearing-house for all manner of queries from public authorities, &c., in the matter of special safeguards arising out of the state of war. All applications to render personal service and all inquiries should be addressed in writing to the Registrar, the British Fire-Prevention Committee, 8, Waterloo-place, London, S.W.

CATALOGUES.

Bolt-Screwing Machines.—We have received from Messrs. Joshua Heap and Co., Limited, Ashton-under-Lyne, a catalogue section relating to their patent automatic bolt-screwing machines. The illustrations show single-head machines for bolts ranging from ¼ in. to 4 in. in diameter, and double-head machines for bolts up to 2 in. in diameter; a complete general description of the machines is also included. It will be remembered that the firm specialise in bolt and pipe-threading machines; the latter are, however, dealt with in a separate catalogue.

Locomotives.—Record No. 78 from the Baldwin Locomotive Works, of Philadelphia, Pa., U.S.A., gives descriptions and illustrations of twenty-six locomotives of the tank and tender types, designed and constructed for contractors' work or for industrial service. The examples selected represent seven different wheel arrangements and cover a wide range of gauges and hauling capacities; the latter vary from 285 to 4445 tons (of 2000 lb.) on the level. The class of work for which each type of engine is best suited is explained in an introductory chapter, which adds considerably to the utility of the publication.

Machine-Tools.—The Selson Engineering Company, Limited, 83 to 85, Queen Victoria-street, E.C., have sent us a copy of a small catalogue they have issued showing a selection of machine-tools regularly stocked at their London address. These include shaping-machines, milling-machines, gear-cutting machines, rounding-machines for gear-wheel teeth, key-seaters, broaching-machines, shaping-machines, slotting-machines, lathes, boring and turning-mills, horizontal boring-machines, automatic screw-making machines, radial and other drills, and grinding-machines in many different types. The tools listed are all either made by the firm at their Coventry or Halifax works, or else by manufacturers for whom they are the sole agents in this country.

Oxy-Acetylene Welding and Cutting Outfits.—From Messrs. Charles Churchill and Co., Limited, of St. Simon-street, Salford, Manchester, we have received a very attractive catalogue of apparatus for welding and cutting metals by means of the oxy-acetylene blow-pipe. Automatic acetylene generators are first dealt with, particulars being given of several different sizes capable of taking charges of carbide varying from 6 lb. to 6 cwt. Blow-pipes for cutting and welding work are listed, and particulars are also given of a tube-cutting machine, a rail-piercing machine, and of various accessories and supplies for cutting and welding work; acetylene flare-lamps for contractors' work are also included in the catalogue.

Repairing Broken Castings.—A pamphlet illustrating examples of castings and iron and steel machine parts repaired by the "Castolin" welding process, has reached us from the Castolin Company of Great Britain, Clock House, Arundel-street, Strand, W.C. It is claimed that castings repaired by this process are stronger than the original metal, and test results quoted in support of this statement show that the joints will withstand a tensile stress of over 10 tons per sq. in. in the case of cast iron. With steel the breaking stress of a "Castolin" welded joint was 26 77 tons per sq. in. in one of the tests. The examples illustrated range from type-writer parts to castings weighing several tons, and include such articles as twist-drills, axles, machine-frames, pulleys, motor-car engine cylinders, electric motor casings, &c. A number of testimonials from users are also printed.

Driving-Chains.—We have received from the Link Belt Company, of Chicago, Illinois, U.S.A., a book of data relating to their silent driving-chains for power transmission. The book, which contains 112 pages bound in limp red covers, gives full particulars, with prices, of the various sizes made, which range from ⅜ in. to 2½ in. pitch, and also states prices for cut cast-iron wheels. Tables showing the power transmitted at different speeds, and the length of chain required, are given, so that the user can find the total cost of any particular drive with the minimum of trouble. Much other information relating to the construction and use of the chains is given, and numerous examples of drives are illustrated by reproductions from photographs. The book is well printed and clearly illustrated, and its general arrangement is excellent, so that we have no doubt that it will be highly appreciated by engineers.

Drilling-Machines.—Messrs. J. Archdale and Co., Limited, of Ledsam-street, Birmingham, have sent us a copy of an attractive sectional catalogue of their high-speed drilling-machines. This catalogue gives full particulars of high-speed radial drills, which are made in several different sizes, ranging from 2 ft. 6 in. to 7 ft. in radius; the radius can, however, be extended 6 in. in all sizes except the largest, which can be extended to 8 ft. This tool is capable of drilling holes up to 4 in. in diameter in cast iron, and of tapping up to 2¼ in. Whitworth; it admits work up to 13 ft 3 in. in diameter when extended to 8 ft. radius. Full particulars are also given of combined sensitive and radial drills, high-speed vertical drills, a pipe-flange drilling and facing-machine, and of various accessories for drilling-machines. We notice that all the machines are now gear-driven, cone pulleys being entirely dispensed with.

Water-Filters.—We have received from Messrs. Bell Brothers, of Calder Iron Works, Ravensthorpe, Yorkshire, a catalogue of their mechanical filters and other plant for the purification of water. The firm's filters are too well known to need any description here, but their construction is illustrated and fully described in the catalogue. They are used for the general purification of water, as well as for removing bacteria, peaty and other discolorations, plumbo solvency, and iron, in connection with the water supply of towns, villages, and large industrial concerns. A large number of important installations are illustrated, and the chemical and bacteriological results obtained are given in nearly every case. The catalogue also deals with water-softening plant, apparatus for purifying and reheating water for swimming-baths, plant for extracting grease from boiler feed-water, and small filters for villages and large country-houses.

Fire-Extinguishers.—From the Valor Company, Limited, of Aston Cross, Birmingham, we have received some particulars of their "New Era" chemical fire-extinguisher, which is specially suitable for use in engineering and other works. The extinguisher consists of a cylindrical tank, with a capacity of 30 gallons, mounted on two wheels, and provided with 50 ft. of hose, from which a jet can be thrown a distance of 60 ft. vertically, and 80 ft. horizontally. The chemical nature of the fluid used is such that it effectively extinguishes fires of petrol, oil, paint, rubber, naphtha, and other highly inflammable materials, on which water has little or no effect. This appliance has been designed to supply the need for some more powerful means of dealing with an outbreak than is afforded by the ordinary hand extinguisher, and the makers claim that to instal them, in conjunction with the latter, is practically equivalent to having a fire-brigade on the premises.

Foundry Plant and Requisites.—Messrs. J. W. Jackman and Co., Limited, of Caxton House, Westminster, S.W., have sent us a copy of their new general catalogue of foundry plant and requisites. This is certainly the most comprehensive catalogue of its kind that we have seen, and to mention all the appliances included in it would occupy more space than we can spare. We may, however, indicate the nature of its contents by saying that in turning over its pages we noticed cupolas, pig-breakers, fans and blowers, ladles, sand-preparing plant, moulding-machines, core-making machines, core-ovens, sand-blasting machines, crucible furnaces, git-cutters, tumbling-barrels, magnetic separators, air-compressors, hydraulic pumps and accumulators, hardness-testing machines, metallographic microscopes, and sundries of all descriptions. Many of the appliances dealt with have been illustrated and described in our columns in the recently-concluded series of articles on foundry plant.

Gas-Valves, &c.—A copy of their latest catalogue of valves and other appliances for use in gas works has come to hand from the Bryan Donkin Company, Limited, of Chesterfield. It will be remembered that the Donkin gas-valve is of the internal rack-and-pinion type, and that the door of the valve has a sharp edge which clears tar and other matter from the faces as it slides over them. When the door is nearly closed, wedges placed round its circumference come into contact with similar wedges on the body of the valve, thus pressing the two faces together with great force. These valves are made with bores ranging from 2 in. to 72 in. in diameter, and full particulars, with prices, are given of the smaller sizes. Particulars are also given of valves of the internal rack and worm type, as well as of high-pressure gas-valves, plug-cocks, valve columns, hydraulic-main valves, screw-down disc valves, and many other types of valves for special purposes. Some examples of gas-exhausting plant, pressure-regulators, &c., are also illustrated.

Ice-Making and Refrigerating Machinery.—Messrs. William Douglas and Sons, Limited, Douglas Wharf, Putney, S.W., have sent us a copy of their latest catalogue of Douglas-Conroy and Douglas refrigerating-machines. These machines, it will be remembered, use sulphur dioxide as the refrigerating agent, and the catalogue first points out the advantages of this agent over ammonia and carbon dioxide. Particulars are then given of compressors and condensers capable of making from 4½ cwt. to 15 tons of ice in twenty-four hours, or of cooling cold stores with capacities up to 140,000 cub. ft. The application of the plants to ice-making and cold storage is next dealt with, and afterwards a number of cold-storage installations suitable for butchers and provision merchants are illustrated. The next part of the catalogue relates to milk-cooling plant and other applications of refrigerating machinery in dairy-work, while the remainder deals with refrigeration in abattoirs and bacon factories, marine and experimental plants, and miscellaneous applications. The catalogue is fully illustrated, and is an interesting and useful publication.

Forging-Hammers, Drop-Stamps, &c.—From the Alldays and Onions Pneumatic Engineering Company, Limited, of Great Western Works, Birmingham, a catalogue of pneumatic power hammers, drop-stamps, and other forging machinery has come to hand. Pneumatic forging-hammers are first dealt with, full particulars, with prices, being given for hammers in which the weight of the moving parts varies from ½ cwt. to 10 cwt. These hammers are now fitted with a form of valve-gear which enables single dead blows to be struck from the top of the stroke without first lowering the tup on to the work. This feature, it is pointed out, effects a very considerable saving of time, and greatly extends their sphere of usefulness. Planishing-hammers, riveting-hammers, olivers, spring-power hammers, and friction-drop stamps are also listed. The latter are made with stamps varying from 3 cwt. to 20 cwt. in weight, and examples of the class of work done by each size are illustrated in order to assist clients to select the one best suited to their requirements. Particulars of power presses for trimming stampings are also included in the catalogue.

Chain-Drives in Textile-Mills.—Messrs. Hans Renold, Limited, of Brook-street, Manchester, have sent us copies of two pamphets relating to the use of their driving-chains for power transmission in textile-mills. One of these pamphlets deals with the advantages resulting from the replacement of rope-driving from a mill-engine by electric driving with chain transmission in a Yorkshire woollen factory, and illustrates by means of tachograph diagrams the remarkably uniform turning obtained on the latter system. The other pamphlet refers to the driving of carders and scribblers by means of chains. It shows how the power consumption, in one particular case, was reduced from 29 horse-power with belts to 17 horse-power with chains, the production being at the same time increased by 5 per cent., and the average number of broken ends in a period of five hours being reduced from 15 to 2. The quality of the work was also greatly improved, so that the output of the mules was increased by 10 per cent. It is stated that the chief reason for the great improvement effected in this case is that chains are not affected by "fly," which causes much trouble with belts.

Electric Mine Winding-Gear.—We have received from Messrs. Crompton and Co., Limited, of Chelmsford, a pamphlet relating to electric winding machinery for mines. The firm's "C.M.B." system of control is briefly described and several installations on this system are illustrated. It is impossible to describe the system fully in the small space at our disposal, but an idea of its method of working will be gathered if we say that it employs a motor generator, or rotary converter, to supply current to the main motor, and the equipment is accelerated and decelerated by varying the fields of the machines. Voltage and current curves show that the usual peak load at starting is absent, the arrangements being such that the current reaches its maximum value as soon as switched on, and remains steady during the whole of the wind. The voltage, however, gradually rises, reaching its maximum when the cage is running at full speed. The demand on the supply system, being the product of the current and voltage, thus gradually rises as the speed increases. Braking is effected by regeneration, which not only returns energy to the system, but effects considerable saving in wear and tear of brake-blocks, since the mechanical brakes are only necessary to hold the load during the changing period. Among many other advantages claimed for the system, it is mentioned that the motor may be run at crawling speed for long periods for shaft inspection, since there are no series resistances to heat up; also it is impossible to overload the plant by operating the controller too rapidly. Another point mentioned is that if the normal full load on the cage is exceeded, the effect is simply to increase the time required for a wind, and not to increase the power taken from the supply system. Several other special features are referred to in the pamphlet, which should prove interesting and useful to colliery managers contemplating the installation of electric winding plant.

The New Army.—Up to September 11, 118 men from the works and offices of the Westinghouse Brake Company, Limited, had joined the Colours, representing upwards of 28 per cent. of the normal establishment. The Westinghouse Brake Company, Limited, is paying these men half-rate wages, and has agreed that all who return to them on the expiration of such service will find their places open for them.—Of the employees of Messrs. D. Napier and Son, Limited, both at the Works, Acton, London, W., and at 14, New Burlington-street, up to September 10 no less than 205 members had joined the New Army, and recruiting was still going actively on, so that the number will be largely augmented in the near future. The firm are paying 10s. per week to the wife of each of the married men who have joined the Colours, and in every case the men's positions will be kept open for them.—The employees of Siemens Brothers Dynamo Works have responded with great enthusiasm to the call to arms. A large number of men from their works and offices at Stafford, amounting in all to about 400, have already joined the Forces, and, together with the reservists and volunteers from their head office, branch offices, and other departments, the total amounts to over 520. The firm is arranging to keep the posts of all these men open, and ample provision is being made for all the dependants of those who have gone to serve.—From the firm of Messrs. W. and T. Avery, Limited, Weighing, Testing, and Computing-Machine Makers, Soho Foundry, 165 men from both works and offices have joined the Colours. From the same company's 133 branches throughout the British Isles 69 men are now on active service. It is satisfactory to know that all these men's situations are being kept open for them, and that the company is making up their military pay and allowances to their full average earnings before the war.—A special committee of the Engineers' Club, Manchester, are at present busily enrolling names of men who will form a special battalion to be attached to the infantry battalions at present being formed at Manchester, and known as "Pals" battalions. All the men enrolled will be connected with engineering, either in the shop or the offices, and it is felt that a greater sense of comradeship will be secured than in the case of a battalion in which the men have wide and varying working interests. Already, even though the engineering works of Manchester and district have contributed large bodies of men to the forces, over 300 names have been enrolled, and there is no doubt that the full battalion of 1300 men will be secured. An analysis of the occupations of the men coming forward is interesting. There are a great number of turners and fitters who are out of work, although their former employers are busily engaged. Comparatively few men have come forward from the textile machinists, although this industry is probably hit harder than any other in Lancashire. A number of moulders are out of employment, and a consequent proportionate number of pattern-makers.

IRRIGATION WORKS IN ITALY.*

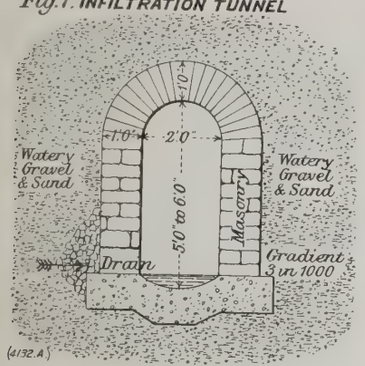
By Professor LUIGI LUIGGI, D.Sc., M. Inst. C.E., President of the Italian Society of Civil Engineers.

1. GENERALITIES.

THE average tourist who visits Italy and admires the splendid orange groves round Sicily and Calabria, the industrial flower cultivations of the Ligurian Riviera, the luxurious vegetable gardens and orchards of Tuscany and Campania, or the extensive meadows of exuberant trefoil and lucerne, green all the year round, of Lombardy and Lower Piedmont. If he has any tinge of poetry in his veins, he will be apt to raise a hymn of praise to Providence for bestowing upon Italy such great blessings, and will grumble against its inhabitants, wrongly accused of the sins of *dolce far niente*.

And really Providence has been very good in giving Italy a mild climate, with plenty of sunshine—on the average 2900 hours in the year—and even too much in some parts. But apart from this, Providence has not done much more for Italy than for any other nation of Southern Europe, except that it has given her a very hardy race of people, full of resources, very thrifty, content with little, and ready to till the land cheerfully from dawn to dusk in the hope of getting good crops, notwithstanding the numerous drawbacks of a rather poor soil and of a very irregular rainfall—in excess during the winter months, when it causes inundations, and nearly absent for five to seven months in summer, during which a fierce sun scorches the land and would dry up all vegetation if the industry of the Italian agriculturist did not overcome these natural drawbacks by a rational system of irrigation.

Fig. 1. INFILTRATION TUNNEL



Importance of Irrigation.—In fact, the prosperity of agriculture in the regions just mentioned, which are the most prosperous in Italy, is due exclusively to the incessant work of men who, far from enjoying much *dolce far niente*, have applied, and are extending continually, the art of irrigation, which in Italy dates back from the time of the Etruscans and the Romans, and has reached indeed a great perfection in our days.

Without irrigation, the marvellous orange-groves, the beautiful orchards and vegetable gardens, which give such valuable products for exportation in Central Europe and even in North America, would produce but a scanty revenue to their owners; the luxurious and extensive meadows of the valley of the Po—intensely green all the year round, and which give even seven or eight crops of fodder per year—could not exist. Barely one, or at most two, cuttings of grass during wet years could be raised, because the land during the five to seven months of the hot season remains generally without any rain to speak of, and the vegetation is exposed to a pitiless sun that scorches up everything; whilst during the winter months the rain would flood many regions of Italy if the water was not impounded in artificial lakes, or restrained between training dykes.

It is the art of the hydraulic engineer, and the intelligence and perseverance of the agriculturist, by regulating the natural water-courses, impounding the floods into reservoirs formed by high dams, or raising the water from the subsoil or from the natural streams, and then distributing this water intelligently over the land, at the proper time and in the necessary proportion for the different crops—that is, by scientific irrigation—that the waste sandy plains of Piedmont and Lombardy were transformed into the most prosperous meadows and rice fields, and the orange groves around the Thyrrenean coasts are so abundant and beautiful as to induce Goethe to give to Italy the name of "The land where the orange blooms."

How the Italian Experience can be Useful to Australia.—From this it can be seen that the climatic conditions of Italy are very similar to those of Australia; so it may be of interest—and, it is hoped, of use also—to the citizens of the Commonwealth to know how Italians manage to get the best of the natural conditions of their native land, which, having practically no mines or other natural resources to speak of, but depending entirely on the products of the soil as its principal source of revenue, has brought agriculture, combined with irrigation, to a very advanced state of progress.

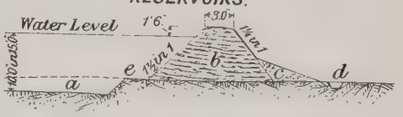
Importance of Italian Irrigation.—The whole surface of Italy can be divided thus:—

	Sq. Km.	Per Cent.
Mountains	103,649	38
	Very poor agriculture	
Hills	122,174	43
	Middling	
Plains...	60,859	21
	Fairly good	
Total surface ...	285,682	102

Of the plains, or flat lands along the valleys, about 14,000 sq. km. are irrigated, and of these 12,000 sq. km. are in the valley of the River Po, in Northern Italy, between the Alps and Apennines, which feed abundantly the irrigating canals; and the other 2000 sq. km. are in Southern Italy, where water is very scarce, and is derived mainly from underground or from reservoirs.

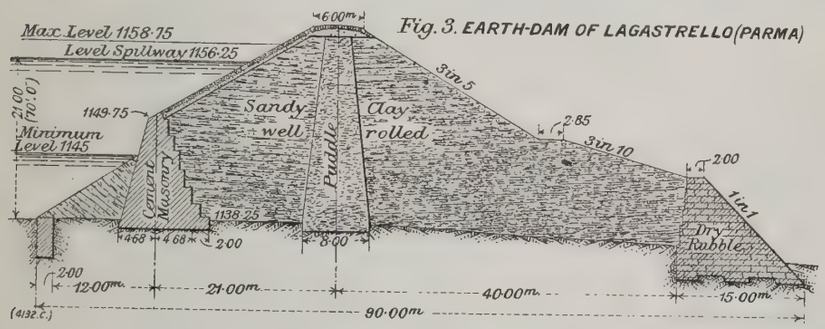
In this way agriculture, with the subsidy of irrigation, even if applied to a poor soil, leaves a fair margin of profit, sufficient to be invested in further improvements of the land or of the towns, or in other works of comfort or of beauty; and this process, repeated almost continuously for twenty-five centuries—that is, from the time of the Etruscan and the Romans up to our days—has made Italy what she is now, the land of arts, of music, of monuments, notwithstanding all the wars and vicissitudes she has gone through.

Fig. 2 DYKE FOR SMALL IMPOUNDING RESERVOIRS.



a = Excavation for Dyke
b = Dyke made of selected material well rammed in curved layers.
c = Reinforcement made with material not good for dyke.
d = Small ditch to deviate surface water
e = Berm 10·0 to 20·0 wide
(4132 B)

Fig. 3. EARTH-DAM OF LAGASTRELLO (PARMA)



And, as irrigation is the principal factor in the success of Italian agriculture and in the present progress of the nation, let us see how the water is provided, how it is distributed over the land, and the results, technical and economical, that irrigation gives.

II. HOW THE WATER FOR IRRIGATION IS PROVIDED.

(*a*) *Underground Water Raised from Wells.*—When only small quantities of water are required—as for industrial flower-gardens, or for orange-groves, or similar cultivations whose products are of high commercial value—the water is generally derived from wells dug in the sandy subsoil at the foot of the hills and round the coasts, and is raised either by very primitive means, such as water-buckets (*cicogne, altalena*), very similar to the Egyptian shadouf, moved by men, that can lift the water 2 to 4 metres high; or with norias or rosary pumps moved by animals, raising the water up to 5 or 6 metres, and sometimes up to 10 to 12 metres, and these are very common in South Italy; or by small, but very modern, centrifugal pumps moved by oil or electric motors, generally of about 2 to 5 horse-power, lifting the water 10 to 12 metres, and in rare cases up to 40 metres, and these can be seen often along the Ligurian Riviera and in many parts of the valley of the Po, where hydro-electric plants are very common.

The cost of the water raised by manual labour varies from 0.10 to 0.15 franc per cub. m. for lifts between 2 and 4 metres; if raised by norias moved by animals, the cost varies from 0.04 to 0.10 franc per cub. m, according to the lift from 6 to 12 metres; and by oil-motors the average is 0.04 franc, and by electric motors 0.02 franc per cub. m.; this is for lifts up to 10 to 12 metres, or 0.10 to 0.15 franc up to 40 metres. (One cub. m. = 220 gals.)

Although the cost of the water is so great—and it is not rare to pay also from 0.25 to 0.30 franc per cub. m., and sometimes even 0.40 franc per cub. m.—still the irrigation is done with such great care and economy that only from 2000 cub. m. to 3000 cub. m. are required per year per hectare, and the products grown in this way, such as flowers, oranges, early vegetables, special classes of prime fruit, &c., realise such high prices that this expenditure is fully justified, and leaves a very fair profit to the growers of all these delicacies, which find a ready market in Central and Northern Europe, especially during the winter months. The yearly revenue of a good orange-grove of Sicily varies from 1500 to 2000 francs, and sometimes up to 3000 francs per hectare (30*l.* to 54*l.* per acre) per year, whilst the same land not irrigated and cultivated with vines, olives, &c., can only pay rent ranging from about 160 to 250 francs per hectare; and all the good plots of land from Taggia to San Remo, in the Ligurian Riviera, cultivated with violets, roses, and especially *garofani* (carnations), gives a net yearly revenue of from 5000 to 12,000 francs per hectare. But these are specially favoured strips of land, where there is perpetual spring, and the ground produces all the year round, and the gardeners are most skilful and untiring in their works. (One hectare = 2.47 acres.)

(*b*) *Water Derived from Infiltration Tunnels.*—There are some regions, especially in Sicily and Calabria, with large valleys filled with deep deposits of alluvium, that during the rainy season become saturated with water, forming almost an underground reservoir, and this water afterwards escapes slowly in the form of drainage. In such cases it is usual to drive a small oblique tunnel* in such a way as to intercept this underflow, and collect the water which, taking advantage of the altimetric conditions and of a fall generally of 3 in 1000, flows naturally to the surface, and can be distributed on the fields at a lower level without any need of pumping. These *gallerie filtranti*† are often several hundred yards long (Fig. 1), have a net internal section of 1.80 metres by 0.60 metre, sufficient for a man to pass through, and are lined with porous masonry, but with an impermeable bottom of concrete. Their cost varies from 75 to 100 francs (3*l.* to 4*l.*) per lineal metre. The total cost of such tunnels varies from about 20,000 to 40,000 francs each, and one can give from 1000 to 2500 cubic metres of water per day; thus the cubic metre of water costs only a fraction of that raised by electric power or manual labour.

One of these infiltration tunnels at Mazzara‡ gives 100 litres (22 gallons) per second, and serves to irrigate some 220 hectares (about 500 acres) of orange-groves and vegetable gardens; and another, the largest in Sicily, at Zappulla, gives nearly double this quantity. As its total cost was 150,000 francs (6000*l.*), so the actual cost of the water is very small indeed; that is to say, it is only the interest on the capital and expenses of maintenance of the tunnel, which, even reckoned at 10 per cent. a year, the cost of the water comes out at about 0.005 franc per cubic metre (0.226 pence per 1000 gals.).

In some cases of narrow gorge a sort of underground dam of puddled clay is built across the bed of the torrent so as to stop the underflow; thus the water rises to the surface, and can be utilised for irrigation with less cost than for a tunnel. A good example of these subterranean dams (*dighe subalvee*) is at Trabia,§ in Sicily.

Also in some parts of Lombardy, and in the province of Modena, there are large volumes of water flowing underground from the lakes of the mountains to the River Po; and the altimetric conditions of the ground are such that the water can easily be tapped by ordinary wells some 20 ft. or 30 ft. diameter, and conveyed to the surface of the fields at a lower level, thus forming a sort of artificial spring, almost, but not, an artesian well, called a *fontanile*.‖ Some of these *fontanili* give water enough to irrigate several hundred acres of meadow land, called *marcite*, which are considered the most valuable in Italy. As these underground waters have a temperature of about 56 deg. to 60 deg. Fahr. in winter time, when the land sometimes is covered with snow, the meadows, or marcite, irrigated with this water are intensely green, forming a striking contrast in the landscape.

Thus these special meadows can give regularly seven and even eight cuttings of grass per year—that is, from 80 to 100 tons of lucerne grass per year per hectare of marcite.

(*c*) *Storage of Rain-Water in Small Reservoirs* (Bacini a Corona).—The irrigations above mentioned are possible only in especially favoured localities, but, except in a few cases, the amount of water is generally very small. So when larger quantities of water are required, it is better to store up the rain-water, which during the winter months falls, on the average, from 36 in. in the north of Italy to 20 in. in the south. These impounding reservoirs may vary from the modest cistern of some few hundred cubic metres capacity, built of solid masonry, to small ponds, called *serbatoi a corona*, of some 20,000 to 100,000 cubic metres, up to large reservoirs or artificial lakes of many million cubic metres capacity. One of

* Paper read before Section G of the British Association at the meeting in Australia.

* See Bionda, "Le Gallerie Filtranti della Provincia di Messina," Rome, 1908.

† Torricelli, "Gallerie Filtranti Longitudinali," Rome, 1888; Luiggi, "I Pozzi Allacciati dell'Isola di Cipro," *Giornale Genio Civile*, 1880.

‡ See Mayer, "L'acqua per Irrigazione," Naples, 1914, page 204.

§ See Capito, "Dighe Subalvee," *Giornale Genio Civile*, Rome, 1883.

‖ See Ottavi, "I Fontanili della Lombardia," Casal Monferrato, 1909.

them, for instance, now in construction on the River Tirso, with a dam 55 m. (185 ft.), will contain 350 million cubic metres of water, and will for the time being be the largest in Europe; but will be surpassed by three similar reservoirs soon to be commenced on the Bradano (dam 60 m., or 200 ft. high), and Fortore (dam 75 m., or 250 ft. high), in Apulia, and on the Simeto (dam 50 m., or 170 ft. high), in Sicily, which will be able to store up respectively 410 million, 390 million, and 360 million cubic metres of rain-water. The dams will prevent the winter floods of those regions, and extend the irrigations on the plains traversed by these rivers, which are now almost a curse, but which when regulated will be a blessing to the farmers.

The small artificial ponds, or *serbatoi a corona*,* are especially popular in the province of Piacenza. They are formed by utilising natural depressions of very bad clayey land, and surrounding them, by means of earth dykes (Fig. 2) 12 ft. to 16 ft. high, 1 or even 2 miles long, enterprises by granting a subsidy that in some cases is 3 per cent. per year during the first ten years, 2 per cent. and 1 per cent. per year during the following decades. This, at the rate of 5 per cent. interest, makes an initial grant of 35 per cent. on the capital invested. This subsidy is given on condition that the water for irrigation is not charged more than 0.01 franc per cubic metre. However, generally it is sold at much less, otherwise the farmers could not afford the expense.

Just now a law is before Parliament in order to increase this subsidy to 3000 francs per annum per fifty years for each million of cubic metres of water capacity of the lake. At the end of sixty years the reservoir and distributing canals become the property of the State.

The other type of dam which is coming into favour in Italy, because of its low cost and resistance even to earthquakes—not infrequent in Southern Italy—is the rockfill dam.* There are already three examples of these rockfill dams, built recently, at Lago d'Alpone (Mont with accessories, and the volume of the reservoir being 5,600,000 cub. m., the cost is 0.14 franc per cub. m. capacity of the reservoir.

Another dam, very daring in design, with a cross-section very similar to the Australian dams built by Mr. Wade, is that of Corfino, in the province of Lucca (Fig. 7). It is really an arch dam, 35 metres high, with a radius of 23 metres, and central angle of 140 deg. Its thickness on crest is only 1.50 m. (5 ft.) and at the base is 7 m. (23 ft.). It was built in sixty-five days, by pouring Portland cement concrete, 1 : 2 : 4, rather wet, into the wooden moulds; it gave very good results, both technically and financially. As its cost was 150,000 francs, the water capacity of reservoir 800,000 cub. m., so the unit cost is 0.20 franc per cub. m.

Another important group of five dams, just finished, on the River Gorzente, near Genova, includes the Badana dam, 56 metres high, at present the highest in Italy (Fig. 8). It is 215 metres long on the crest, has a volume

Fig. 4 VIEW OF ROCK-FILL DAM ON DEVERO (DOMODOSSOLA)

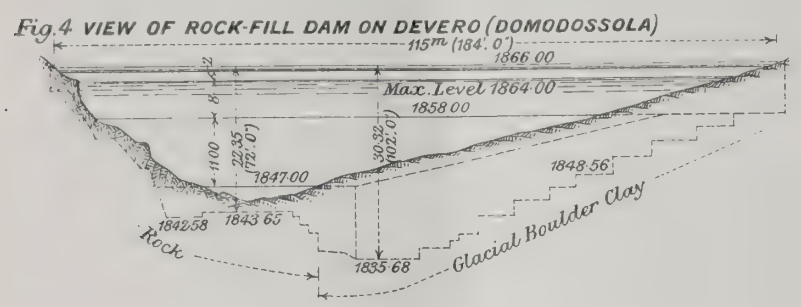
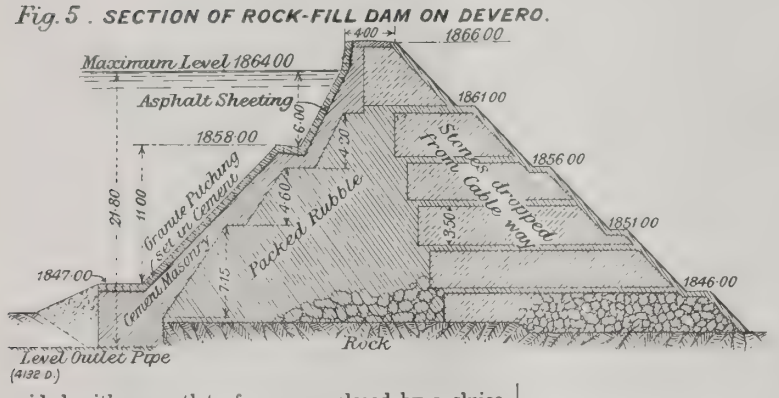


Fig. 5. SECTION OF ROCK-FILL DAM ON DEVERO.



provided with an outlet of masonry closed by a sluice-gate. Usually they cover an area from 4 to 5 hectares (about 9 to 11 acres) with water 2.50 m. to 350 m. (8 ft. to 12 ft.) deep, sufficient to irrigate about 8 to 9 hectares (17 to 20 acres) of meadows, at the rate of about 7000 cub. m. of water per hectare, which gives a height of water of about 0.7 m. (28 in.), distributed over the land during the five to seven months of dry season. This water is applied in "rotations" about every 12 to 14 days, and the cost of irrigation is from about 90 to 100 francs per hectare per year (1*l.* 15s. to 1*l.* 18s. per acre), or at the rate of 0.012 franc per cubic metre, which is notably less than that of the water raised from underground or derived from infiltration tunnels.

Some of these artificial ponds are even larger; that of Temavasio, for example, is 20 hectares in surface, and stores water, 5 m. deep, sufficient to irrigate, very sparingly, during six to seven months, about 50 hectares of meadows.

The cost of these ponds per cubic metre of water stored is about 0 20 to 0.25 franc, including all expenses, and the cost of the water distributed over the land comes to be from about 0.012 to 0.015 franc per cubic metre. This price is, however, still too high for irrigation on a very large scale, and, besides, the quantity of water thus stored is still very small, and during the hottest months the grass suffers somewhat from the drought.

(*d*) *Water from Large Artificial Lakes.*—Thus larger reservoirs, or real artificial lakes, of many million cubic metres capacity have been formed in several valleys of the Alps or of the Appennines by high dams, built either of earth, rockfill, or masonry, the latter being generally preferred.

In fact, except for the small reservoirs, called *serbotoi a corona*, just described, earth dams are not popular in Italy, and are rarely built higher than 30 ft. to 40 ft. The only high earth dam is at Lagastrello, in the Province of Parma (Fig. 3). It is 21 metres high, 170 metres long in crest, and forms a reservoir of three millions cubic metres capacity. In reality, it can be filled about four times a year by the exceptional rains of the region, so really it acts as if its volume was nine to twelve millions cubic metres capacity, so the unit cost of the impounding capacity of the reservoir is much smaller. Its total cost was 620,000 francs, so the cost of a cubic metre of water impounded is about 0.20 franc. The water is drawn at the rate of 1 cub. m. per second, and utilised first for an hydro-electric installation of about 10,000 horse-power, and then used for irrigation.

It may be well here to add that all the water from the large reservoirs of Italy serves first for hydro-electric power, and subsidiary for irrigation, otherwise it would not be possible to pay the interest on the capital invested; and even then the State has to encourage these

* Raineri, "I Serbatoi a Corona, Federazione Agricola Italiana," Piacenza, 1907.

Fig. 6. CROSS SECTION OF BRASIMONE DAM, BOLOGNA. BUILT OF CEMENT MORTAR MASONRY.

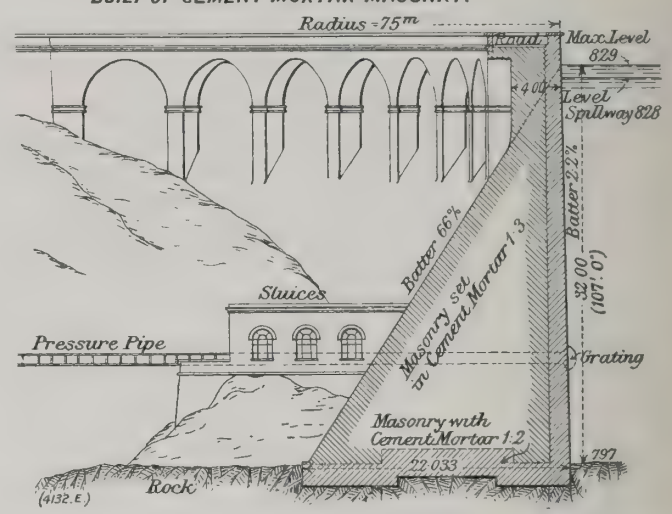


Fig. 8.

CROSS SECTION OF THE BADANA DAM (GENOA) BUILT WITH LIME AND POZZUOLANA MORTAR.

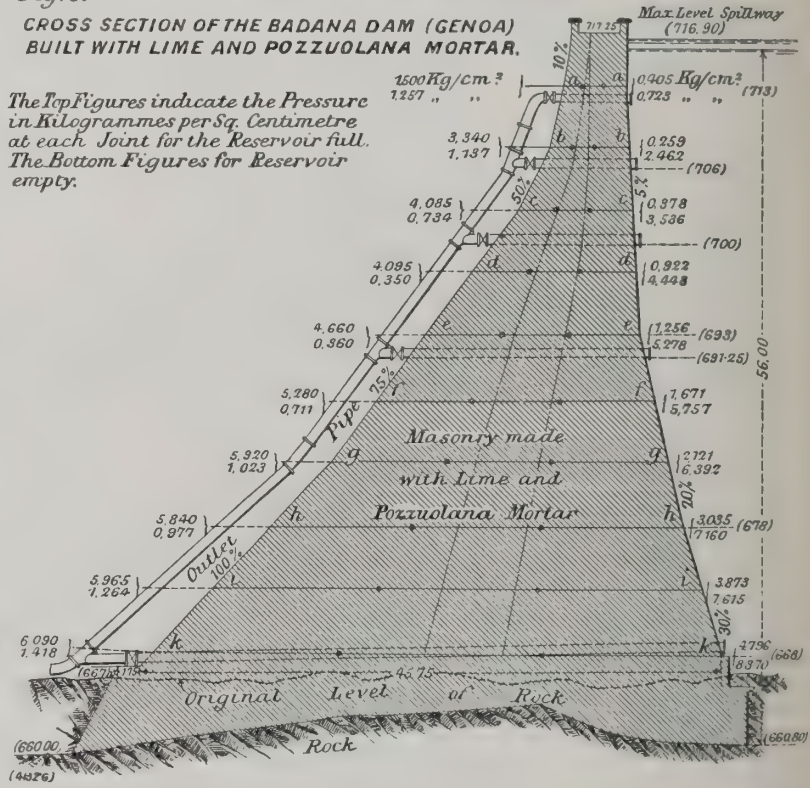
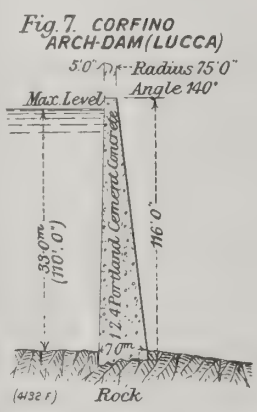


Fig. 7. CORFINO ARCH-DAM (LUCCA)



provided with an outlet of masonry closed by a sluice-gate. Usually they cover an area from 4 to 5 hectares (about 9 to 11 acres) with water 2.50 m. to 350 m. (8 ft. to 12 ft.) deep, sufficient to irrigate about 8 to 9 hectares (17 to 20 acres) of meadows, at the rate of about 7000 cub. m. of water per hectare, which gives a height of water of about 0.7 m. (28 in.), distributed over the land during the five to seven months of dry season. This water is applied in "rotations" about every 12 to 14 days, and the cost of irrigation is from about 90 to 100 francs per hectare per year (1*l.* 15s. to 1*l.* 18s. per acre), or at the rate of 0.012 franc per cubic metre, which is notably less than that of the water raised from underground or derived from infiltration tunnels.

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The Brasimone dam (Fig. 7). in the province of Bologna, is one of the best type of Italian masonry dams, and the Tirso, Bradano, and Fortoma dams are planned on the same lines, Fig. 5. It is 34 metres high, 158 metres long on crest, and has a volume of 40,000 cub. m. of masonry. It is calculated as a gravity dam, but for greater safety it is very arched in plan, following a radius of 75 metres, with an angle at centre of 126 deg. Its section is considered quite modern, combining the maximum of safety with proper economy; its cost was 800,000 francs,

* See Luiggi, "Le Dighe di Scogliera (rockfill dams) par le Regioni Simische," Rome, 1914.

of masonry of 100,000 cub. m., and its cost was 2,352,000 francs. It forms a lake of 4,500,000 cub. m. capacity; thus the unit cost of the water impounded is 0.49 franc per cub. m. A speciality of the dams of this group is that the storm outlet is not formed by the usual spillway or overflow, but by a battery of six automatic siphons, for the Badana dam, with a flow of 90 cub. m. per second (Figs. 9 and 10); and of ten for the Layolunga dam, with a discharge of 150 cub. m. of water per second.*

However, the most important reservoir, as already said, is now in construction on the River Tirso, Sardinia, with the triple object of regulating the floods of this torrential river, which has a maximum discharge of nearly 1300 cub. m. of water per second; of using the impounded water for a 12,000-horse-power electric installation; and of using its 20 cub. m. flow per second during summer, for the irrigation of about 30,000 hectares of the plains round Oristano.

The dam is 55 metres high, and will impound 350 million cub. m. of water at a cost, including electric

* See Luiggi, "Dighe recentemente costrutte in Italia," Rome, *Giornale Genio Civile*, 1914.

plant and irrigating canals, of 25 million francs (one million sterling). The State contributes a lump sum of 3 million francs and also 150,000 francs per year during fifty years, on condition that the price of the irrigation water will not be more than 0.005 franc per cub. m. At the lapse of sixty years all the works become the property of the State.

As already said, the water from all these artificial lakes is always used first for motive power in some of the hydro-electric installations, which in Northern Italy are very numerous. This helps much in lowering the price of the irrigation water, which thus afterwards can be distributed by means of canals to the different farms at prices varying from about 0.005 to 0.01 franc per cub. m. (from ¼d. to ½d. per 1000 gallons), or at the "lump sum" or "annual rate" of from 80 to 120 francs per hectare of land (*li.* 10s. to 2*l.* 10s. per acre per annum).

(*e*) *Water Derived from Rivers.*—These prices, although quite convenient in semi-arid regions like Apulia, Calabria, Sicily, Sardinia, where two or three irrigations, during the period from March 15 to May 15 can save the crops from total failure, and fully repay the expenditure for the water, and may later give another crop of maize, are, however, still too high for ordinary irrigations, especially of meadows, which form the most important feature of the plains of Lombardy and Piedmont. Besides, for very large extensions of land, the quantity of water that can be impounded in an artificial lake is always comparatively rather small, from a few cubic metres per second to 20 cub. m. per second in the Tirso district, and to 44 cub. m. in the Fortore valley, which are exceptional cases.

When large quantities are required at very low price, it is necessary to obtain the water from rivers, fed, if possible, by some natural lake, like the Rivers Ticino, Adda, Oglio, Mincio, which have waters comparatively warm, or by glaciers which, melting in the summer season, act practically like lakes of frozen water. In this condition are the Rivers Tanaro, Po, down to Turin, Dora, Sesia, Orco, Adige, and many others, whose waters, being rather cold, are not so efficient as the waters from reservoirs or lakes.

The engineering works at the intake of these canals, called *deriva zioni*, consist, in general, of a submerged dam of a very substantial masonry built across the river and capable of raising the level of the water above that of the country to be irrigated; of controlling sluices at the canal-head (*edificio di presa*), that may be as many as twenty; of another group of sluices adjacent (*disarenatore*), arranged in such a way as to cause a strong current across the entrance of the canal, and thus scour away the solid matter that has a tendency to deposit in front of the main sluices, and then invade the canal, with the danger of silting it up. Then follows the main canal, with a fall from 0.15 to 0.50 metre in 1000 metres, according to the size of the canal, in order to keep the velocity of the water between at least 0.50 metre per second, so as to prevent silting, and not exceed 0.80 metre per second in ordinary cuttings, so as not to erode the banks, otherwise they must be heavily revetted. In aqueducts, inverted siphons, and such constructions of masonry, the velocity varies from 1.5 to 2 metres per second, and in exceptional cases even 3 to 4 metres; but then the masonry is laid with cement mortar instead of the usual hydraulic lime mortar.

The main canal is provided with controlling works, such as overflows, outlets, and regulating weirs at the entrance of the secondary canals. These latter have a fall of from 1 to 2 metres per 1000 metres, and feed the private, or distributing, ditches, which are provided at their intake with some means for measuring the water to be delivered. Generally a submerged orifice, or a Cipolletti weir, or some such over-fall "notch" is used, provided it gives an accuracy of 98 per cent. of the total water to be measured. No mechanical meters are adopted, except in very rare cases and for very small deliveries.

Many of these irrigation canals date back from the Middle Ages, and are used also for inland navigation; in fact, this is a feature of the Italian canals, called *navigli*, to serve both for irrigation and navigation purposes.

The oldest is the Navligio Grand, of Milan, built in the 12th century; it is about 50 miles long, and has a capacity of 65 cub. m. (2275 cub. ft.) per second. In order of date comes the Muzza, from Adda, with 60 cub. m.; then the Naviglio of Cremona, from Oglio, with 30 cub. m., all from five to six centuries old, and several hundreds of smaller canals, ranging from 20 to 5 cub. m. per second down to thousands with a fraction of 1 cub. m. per second.

Fig. 9.
SECTION OF BATTERY OF AUTOMATIC SYPHONS FOR STORM WATER AT BADANA DAM. SECTION A.B.

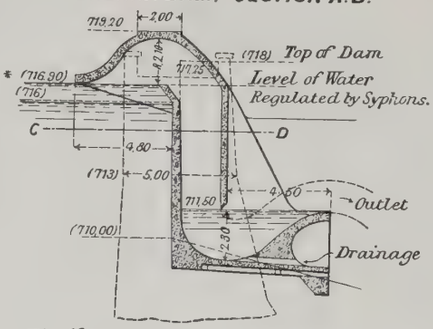
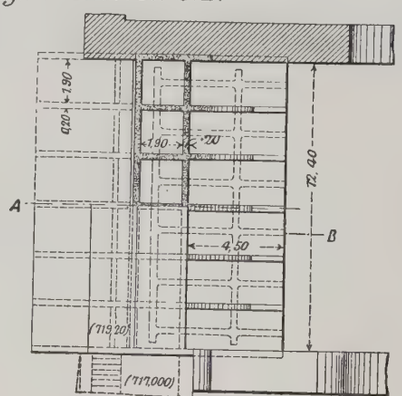


Fig. 10. SECTION C.D.



* *This Stratum of Water of 400000 c.m. was gained by replacing the usual spillway by a battery of 6 automtic syphons of 90 c.m. sec. discharge.*
(4432 H)

Another large canal is about to be started soon, called the Emiliano, from Piacenza to Bologna and Rimini, 300 km. long, with 200 cub. m. per second capacity, at a cost of about 250 million francs (10 millions sterling).

And a still larger canal is now in course of construction near Grosseto, in Central Italy, of 600 cub. m. per second (21,000 cub. ft. per second), which will be in working order in 1915.* It will utilise the muddy waters of the River Ombrone, which, in flood, carry as much as 10 per cent. of solid matter, in order to silt up some large marshes and transform them into excellent arable land, as has been done on a large scale, and with very good results both from a sanitary and agricultural point of view, round Ravenna, Grosseto, Caserta, and other provinces. When the level of the land has been raised some 2 ft. or 3 ft. above the natural water-plane of the district—or when the *colmata*, as it is called, is complete—then the head works of the canal will be slightly transformed, in order to prevent too much silt coming in, and will then be used during the irrigation season, when the water is much clearer, both for irrigation and navigation.

This is probably one of the largest canals in the world, as those derived from the Ganges and Euphrates carry only about one-third and three-fifths of the water of the Ombrone Canal, and this is surpassed only by the Ibrahimieh Canal from the Nile, with a capacity of about 900 cub. m. per second.

The water from the State canals is sold generally at 25 francs (*li.*) per 1 litre-second per year, which corresponds to about 30,000 cub. m. per annum, discounting the time when the canals are dry for ordinary repairs. Thus the cost of the water comes to be about 0.83 franc per 1000 cub. m. This one litre-second is what corresponds in Northern Italy for the irrigation of 1 hectare of land.

As, however, the irrigation is necessary only during the five to seven months of dry season, so only 15,000 cub. m. to 20,000 cub. m. of water are really used; the rest is lost. Thus the cost of the water is actually from 1.66 to 1.02 francs per 1000 cub. m.—that is, on the average, one-fifth of what it would be if taken from the Tirso Reservoir, which is the cheapest reservoir water in Italy, or from one-tenth to one-twentieth of that of the water taken from ordinary artificial lakes or underground supplies (*fontanili*), not to speak of the cost of water when it has to be raised artificially.

While water can be had at such low rates as from the State canals, or even at nearly double this price, as from the Villoresi, Marzano, and other great canals belonging to private corporations, irrigation repays amply all its cost, even for comparatively poor crops, like grass, and pays better still for richer crops, like rice, indian corn, tomatoes, &c. Then farming becomes very profitable, which explains the comparative wealth of the farmers of Northern Italy, when they apply irrigation to their fields, and why they clamour always for more water.

It would be too long and tedious to describe, even

Fig. 11. SUBMERGIBLE-DAM ACROSS RIVER CERNO. (Foundations by Compressed Air)

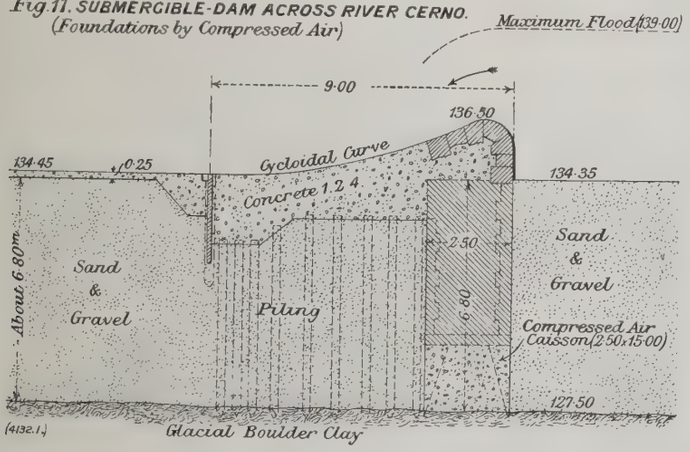
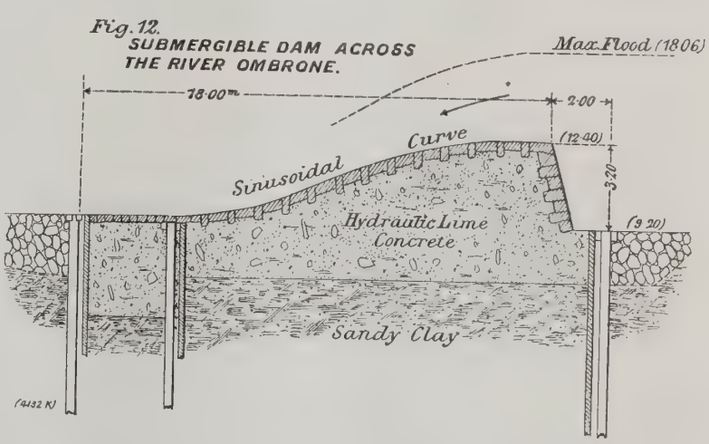


Fig. 12.
SUBMERGIBLE DAM ACROSS THE RIVER OMBRONE.



The canals of modern times—that is, built during the last fifty years, since Italy was united in one State—are the most interesting. The largest and longest of all is the Cavour, with a discharge of 110 cub. m. per second (3850 cub. ft.), a development of about 90 miles of main canals and about 950 miles of secondary canals and distributing ditches—that is, a total of about 1040 miles. It was built in 1855-66, by a private company that failed, and was bought over and finished by the State, at a cost of about 100 million francs (4,000,000*l.*). This canal, still the most important in Europe, was the means of transforming an almost barren region of Piedmont, of 250,000 acres of sand and gravel, useful only for growing stunted timber and bushes, that gave a gross revenue of 20 to 25 francs per hectare per year, into the most fertile rice-fields and meadow-land of Italy, that give net revenues of from 200 to 300 francs per hectare, and where the best butter, parmesan, and gorgonzola cheeses are produced.

Then, in degree of importance, and also from the point of view of their engineering features, follow the Villoresi canal, with 44 cub. m. per second; the Marzano, with 30 cub. m. per second; the Veronese, with 50 cub. m. per second; and the Tagliamento, with 17.5 cub. m. per second. They are all excellent models of their kind, both for the important hydraulic works along their courses and the perfection of their administration, so much so that hydraulic engineers and agriculturists from all parts of the world come to visit and study them.

rapidly, the very interesting and important engineering features of these canals, especially of the Villoresi and Marzano, which, being the latest, are the most perfect. It would certainly be most interesting for engineers to examine their majestic head-works, the inverted siphons and aqueducts that convey the water under or over the different streams and roads crossed by the canal, and all the smaller, but ingenious artifices for the delivery and the best use of the water.

It will be sufficient to refer to the plans of some of the most typical works—that is, the head-works of the Farini Canal—a feeder of the Cavour—of 70 cub. m. per second capacity. The submerged dams of Cerno and Ombrone (Figs. 11 and 12); the inverted siphon of masonry under the River Sesia, with a discharge of 110 cub. m. per second; the inverted siphon of ferro-concrete under the Ombrone of 600 cub. m. (20,500 cub. ft.) per second; the aqueduct of the Cavour over the dock and the Marzano Canal over the Oglio, of 30 cub. m., &c.; the cross-sections of the main Cavour Canal (Figs. 13 and 14), and those of the Ombrone Canal, with earth sides (Fig. 15) and with masonry walls (Fig. 16).

All these works, except Ombrone, can be easily inspected during a journey of a week between Turin, Milan,

* Luiggi, "La derivazione dell' Ombrone di 600 cub. m. per second," *Giornale Genio Civile*, Rome, 1914.

Cremona, Mantova, and Venice, which will amply repay anyone interested in irrigation.

Thus he will be able to see not only the engineering features of the canal, but also their beneficial effects. The land in those provinces was transformed—almost created—from barren sandy and gravel plains into the most fertile vegetable land by the silt deposited by the irrigation water; and where, about fifty years ago, there was a very poor agriculture and a miserable population, now farming is carried on with great success, and the country people enjoy comparative welfare, and are contented, at least as far as farmers can be so They only grumble now when it rains out of season; because, contrary to ordinary conditions of agriculture, when irrigation is adopted the best crops are produced when there is constant sunshine.

Thus Australia, like Italy, offers ideal conditions for successful irrigation.

Preparation of the Land to be Irrigated.—However, to apply irrigation with success and get from the water and the soil the maximum benefit, it is necessary to prepare the surface of the land—that is, it must be properly levelled, or, better still, laid with a slight inclination from the irrigation ditches towards the drainage one, in order to prevent water-logging; then all the ditches have to be prepared and the intercepting sluices put in place.

All this, in the best cases, costs 200 to 300 francs per hectare; but where the natural ground is rather irregular, even 800 to 1000 francs may be required.

In some cases, where the surface falls towards the north, it is even convenient to tilt it towards the south, with an inclination from 3 deg. to 5 deg. in order to get the full benefit of the sunshine. For this purpose the top layer of vegetable soil is stripped off and laid by, the subsoil arranged with the proper gradients, and then the top layer is re-deposited on the surface. And when a marcita, or a super-irrigated, meadow is to be prepared, then all the field is arranged in plots (Fig. 17), about 6 m. (20 ft.) wide, 60 m. to 70 m. long (200 ft. to 250 ft.), with a lateral fall of 0.15 metre (6 in.), and sloping alternately, like flat roofs laid all alongside each other. On the top ridge of two adjacent plots runs the irrigating ditch; the water overflowing from this ditch runs slowly down the two slopes of each plot, and the surplus is collected by the draining-ditch. This being slightly higher than the next plot, the run-off water can flow along to the next irrigating ditch, and overflow on two more sloping plots, and in this way all the water is fully utilised.

All this requires labour and capital. In Northern Italy, where irrigation has been practised since time immemorial, the capital is easily obtained and paid off in some 30 to 50 years; but in the south, where irrigation is rather modern, and, besides, capital is very scarce, the State comes to the aid of the farmer, lending the money at 2 to 2½ per cent., to be repaid in 40 to 50 years. The farmer, with the advice of some Government official appointed with this object, prepares and presents a plan of what he intends to do; this plan has to be approved, then the State lends out the capital in instalments, in proportion to the advance of the work, and at the same time a mortgage is put on the land.

This arrangement works pretty well, especially in the Roman Campania, which is being rapidly transformed from an almost waste land, very thinly populated by poor nomadic peasants, into good cornfields and meadows, with proper farm buildings and a settled population. Now some parts of it can vie with the best districts of Lombardy, thanks also to a more fertile soil of volcanic origin and a larger amount of sunshine.

Thus irrigation begins to have a beneficial social influence round Rome, in a region of about 450,000 acres, that was considered almost beyond redemption, and where malaria fever reigned supreme. Thanks to irrigation and cultivation on a proper scale, malaria is abating rapidly, and soon Rome will be again surrounded by beautiful fields, as it was in olden times, when sixty-four large villages, some with most luxurious villas, were flourishing in that region, and of these villas we find the remains when the plough cuts again the long-abandoned fields.

Quantity of Water and Economical Results from Irrigation.—Where the land can be super-irrigated, as in the marcita, and the water coming from underground has an almost a constant temperature of 56 deg. to 60 deg. Fahr., irrigation can be practised also during the winter months: some 15,000 to 20,000 cubic metres are required per hectare, at a cost of 25 to 50 francs (1*l.* to 2*l.*) per hectare. The water is applied in "rotations" every fifteen to twenty days, at the rate of 800 to 1000 cubic metres each hectare, corresponding to a stratum of water 8 cm. to 10 cm. high (3 in. to 4 in.) for each rotation.

The marcita can produce seven to eight cuttings of lucerne or trefoil per year, at the rate of at least 500 to 600 quintals per hectare—and in the best marcita even 800 to 1000 quintals—sufficient to feed two cows, which produce 26 to 30 quintals of milk. This is sold at 13 to 16 francs a quintal for dairy purposes and gives a gross revenue of about 350 to 400 francs (14*l.* to 16*l.*) per hectare, against an expenditure of 100 to 120 francs per hectare (2*l.* to 2*l.* 10*s.* per acre), leaving a very large profit.

In the usual irrigated meadows where water is applied only at the rate of 12,000 to 15,000 cubic metres per hectare during the five to seven warm months, the benefit is smaller, as the cuttings are only five to six, with a total weight of grass of from 400 to 500 quintals. A good non-irrigated meadow is let at 150 to 200 francs per hectare (2.5*l.* to 3 2*l.* per acre), but when irrigated it can be let at 250 to 300 francs (4*l.* to 5*l.* an acre), thus nearly doubling the income. (One quintal = 220 lb.)

In the Roman Campania, where the land is less permeable than in Lombardy, the water necessary during the dry season for irrigated meadows varies from 7000 to 9000 cubic metres per hectare, applied at the rate of 500 to 600 cubic metres every ten to twelve days. The rent paid by the farmer to the landlord when the land is not far from Rome varies from 100 to 150 francs per hectare; but when irrigated the rent is 200 to 300 francs (3.2*l.* to 5*l.* per acre). This is because Rome consumes a large amount of milk, sold by the farmer at 22 to 24 francs a quintal, and so meadow land produces a very good rent, and irrigation is being applied rapidly to that district.

In the southern provinces, especially in Apulia, where owing to the scarcity of rain, cereals are cultivated on a large scale in preference to grass, the usual product in ordinary years is 8 to 10 quintals of wheat per hectare. In excellent years, when rain falls to a depth of 180 mm. to 200 mm., and during the period in which the plants are in full growth—that is, between March 15 and May 15—the product is from 16 to 18 quintals of wheat; but in dry years only 4 to 5 quintals, and in poor soil the crops may be lost completely.

With irrigation, even at the very low proportion of 2000 to 2500 cubic metres of water per hectare, but applied in four rotations during the two months mentioned, when the wheat is in full development, a product of 16 to 18 quintals of wheat per hectare is assured, instead of the usual average of 8 to 10 quintals in land not irrigated. Thus, even paying for water at the very high price of 0.03 to 0.04 franc per cub. m.—as it costs in Apulia where water is scarce—that is, with an expenditure of 80 to 100 francs per hectare (1*l.* 6*s.* to 1*l.* 12*s.* per acre)—a larger crop, valued at about 140 to 180 francs, is assured, leaving an average benefit of 70 francs (about 3*l.*), so that irrigation not only pays amply for the water, and guarantees always a good crop, but also leaves a fair surplus benefit.

After the cereals have been gathered, some other plants of rapid growth, like tomatoes, water-melons, cabbages, &c., are laid down, and well irrigated, and thus, thanks to irrigation and abundance of sunshine, two crops can be gathered in one year.

This explains why the farmers of Apulia, Sicily and Sardinia clamour for irrigation; because they know by experience that water applied at the proper moment defends the crops from the greatest calamity they dread—that is, lack of rain. By assuring the proper degree of moisture in the soil and in the necessary quantity for the different crops, at the very moment when it can give the best results, it makes certain a good harvest.

Instead of suffering the fluctuations of one or two good years, four or five middling, and one or two bad, the harvest is good every year, and occasionally it can be very good, when the season has been especially favourable.

For the cultivation of Indian corn, potatoes, tomatoes, and kitchen vegetables, the water required varies from 7000 to 8000 cub. m. per hectare, applied in "rotations" of ten to twelve days at the rate of 400 to 500 cub. m. each time, and in all cases the cost of the water is still more amply repaid and the benefit higher.

These examples, that may have a direct application to Australian agricultural conditions, are sufficient to give an idea of the quantity of water required for the staple cultivation—grass, cereals, and ordinary vegetables—and of the financial results, besides proving the fact that irrigation gives agriculture an almost certain revenue, saving it from great fluctuations and avoiding completely the losses of bad years. Thus, from the point of view of the farmer, irrigation is decidedly a success.

Financial Aspect of Canal Construction.—Unfortunately the same cannot be said for the Canal Administration. Except for small irrigation plants, an irrigation canal pays only working expenses and leaves a very little margin (1 to 2 per cent.) for the capital invested, unless hydro-electric power can be combined with irrigation. The reason is that it is not sufficient to build a canal carrying a large volume of water, it is also necessary to sell this water—that is, find the farmers ready to use it. As mentioned before, in order to use the water, it is necessary to prepare the distributing ditches and to level properly the fields; then the farmers must learn how to apply the water to the land, at the moment and in the proportion most convenient, and decide which crops are the most profitable. Besides, where the land is not very permeable, it is also necessary to prepare drainage ditches in order to get rid of the surplus water that otherwise might damage the vegetation or produce an excess of parasitic plants or cause water-logging of the land.

All this requires experience, time, and capital, and thus the Canal Administration is not in a position to sell all its water for very many years. In the best cases it takes from 20 to 30 years, and sometimes even more, to dispose of all the water of a large canal.

The Marzano crosses the province of Cremona, where irrigation has been adopted since the Middle Ages; all the distributing ditches were already in service when the main canal was built; in fact, its function is only that of increasing the flow of the older irrigat on canals. It took fully thirty years before all the 30 cub. m. per second of water were disposed of, and yet the conditions were most favourable. The Villoresi, also in a region where irrigation has been very well developed since the 12th century, has not yet disposed of all its water, after forty years of existence, and the financial conditions of its administration are far from being prosperous.

Necessity of National Aid for Irrigation Canals.—This is the reason why the State considers it is its duty to help all these undertakings. Irrigation puts under cultivation large tracts of land of very little value or almost sterile, and part of the population that now emigrates can thus find profitable employment in the cultivation of this land, otherwise nearly useless, and this increases the national wealth.

Italy has an increase of population of almost one million inhabitants per year, and about 500,000 are obliged to emigrate: some 300,000 go to North America, 100,000 to Central Europe, while some 80,000 go to Argentina, and 20,000 to other countries or round the Mediterranean.

To moderate this exodus, which is not beneficial to the country, the State encourages irrigation by granting a substantial subsidy, already mentioned, of 3 per cent. per year for a period of ten years, on the capital spent in the construction of the main canal and its principal branches, 2 per cent. for the following ten years, and 1 per cent. for another period of ten years; then the subsidy ceases. But if the canal is arranged in such a way as to help to control the flood-water of rivers, as when an impounding reservoir is also built, then another subsidy is granted for this purpose in the proportion of 15 to 30 per cent. of the capital expenditure. For instance, for the Tirso reservoir and canal, estimated at about 20 million francs (800,000*l.*), the State, besides the usual annual grants, pays three million francs for the benefit accruing to the *régime* of the river. After sixty years all the works become the property of the State. On these lines the Canal Administration can obtain a proper return from their enterprise.

Conclusion.—The conclusion, based on Italian experience, is that irrigation avoids the risk most dreaded by the farmer—that is, a complete loss of the crops in years of drought. By irrigation a crop sufficient to pay all expenses, and leave even a small profit, is sure in all cases, also in years of drought.

But then in normal years it affords a very substantial benefit to the farmer, who cultivates meadow lands, when he can get the water at the rate of 25 to 30 francs

Fig. 13. CAVOUR CANAL. SECTION IN EARTH.
(Longitudinal Gradient 0·25 m in 1000 Metres)
(Discharge 110 Cubic Metres per Second) (3850 c.ft.)

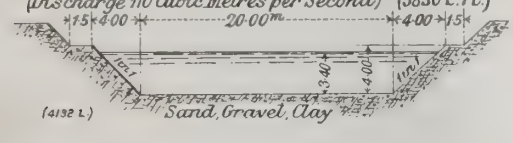


Fig. 14. CAVOUR CANAL. AQUEDUCT OVER RIVER DORA.
(Longitudinal Gradient 0·40 m in 1000 m.)
(Discharge 110 Cubic Meters per Second)

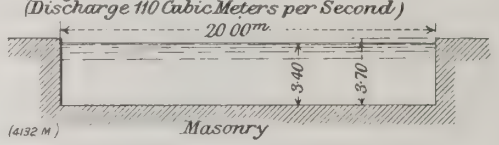


Fig. 16. "OMBRONE" CANAL, SECTION WITH SIDE WALLS.
Discharge 600 Cub. Metres per Second. (20,500 c.ft.)

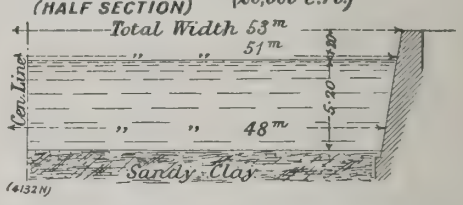


Fig. 15. "OMBRONE" CANAL, SECTION IN EARTH.
Discharge 600 Cub. Metres per Second.

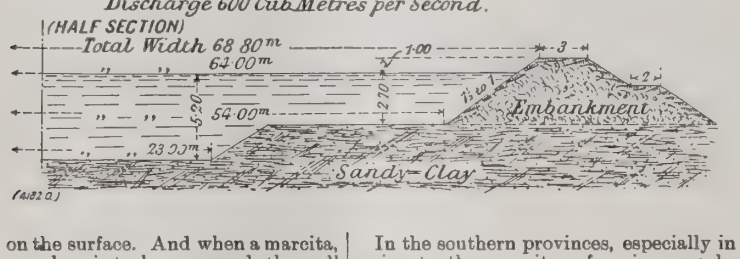
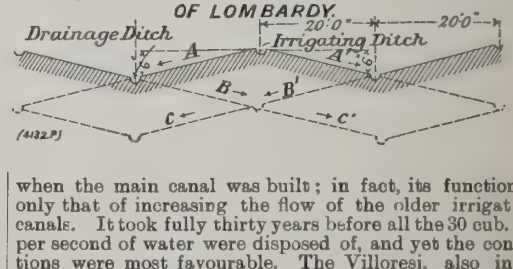


Fig. 17. DIAGRAM OF CROSS SECTION OF SUPER-IRRIGATED MEADOW ("MARCITA") OF LOMBARDY.



per hectare per year (8s. to 9.5s. per acre); but where he can cultivate cereals, even with water at 70 to 100 francs per hectare (24s. to 32s. per acre), there is still a good profit, besides other advantages. On the other hand, irrigation is not profitable to the Administration of the canal, during at least the first twenty to thirty years; so these undertakings require great help from the State during this trying period. In the meantime the State, in the form of taxation and in the increased welfare of its citizens, reaps from these works many benefits, financial and social, which amply repay all the sacrifices made for this purpose.

Without irrigation Italy would not be able to feed a large proportion of its present population; as it is, with its extensive network of irrigating canals, it has become the "Garden of Europe."

Now the State is busy preparing to extend irrigation to the southern provinces in order to be able, in thirty or forty years, to feed a population of from 50 to 60 million inhabitants.

These are the miracles accomplished by scientific irrigation, and this explains also the reason why the Italian State encourages and helps with all possible means, including financially, all such undertakings.

HEAT INSULATION FOR REFRIGERATING ROOMS.*

By Professor W. M. THORNTON, Armstrong College, Newcastle-on-Tyne.

1. THE value of a material as a heat insulator is inversely proportional to its thermal conductivity. The latter is defined as the number of heat units which pass steadily in unit time through a material when the gradient of temperature in it is unity. If the flow of heat is not steady, the temperature at any point in the thickness varies later with it. In order, therefore, that the material should be everywhere under the same thermal conditions, it is necessary that the gradient—the number of degrees rise or fall in unit thickness—should be the same at every point. This is the more important in the testing of materials whose conductivity may change with temperature. There are no direct observations recorded in any of the standard tables of reference upon the variation of thermal conductivity of bad conductors of the kind considered here, and the purpose of the present paper is to call attention to the practical importance of this variation in the choice of insulating material for refrigerating rooms.

Measurements have no doubt been made frequently by manufacturers and engineers for their own use, but they are not readily available. The classical work of Lees† was mostly carried out—so far as it touches the present question—at relatively high temperatures, and the measurements of Lamb and Wilson‡ were made by heating the interior of an insulated chamber by electric lamps.

In America the ice-box method has been used, and in certain other cases conductivity has been estimated from the cooling curves of insulated boxes containing hot water, a method which is complicated by the question of specific heats. In many of these cases the comparisons of conductivity were made at temperatures very different from those at which the insulators were to be used, and in the case of the method by cooling, the temperature gradient was constantly changing. The effect of these differences will be evident from the following measurements, made on a large scale—under industrial conditions as far as possible—upon samples of common insulating materials.

2. The first trials were by a slab method—that is, the flow of heat was arranged to be as nearly as possible the same in intensity everywhere through large flat slabs of the material under test. For this purpose, thin galvanised-iron boxes were made, 6 in. wide, 28 in. broad, and 36 in. deep. In the centre of these were suspended flat electric heaters, consisting of fine "Eureka" wire wound on a thin electrically-insulating sheet. The heat-insulating material was packed between the heater and the sides of the box. The cork used was in solid slabs, built up of irregular pieces of waste cork about half an inch cube, heated under pressure, and at a temperature such that the material changes colour. When this occurs, the pieces become slightly cemented together by the gummy matter given off by the breaking down of the cell walls, and the mass adhered in a solid block of fair mechanical strength. Such a material is a better insulator than untreated cork, and the further the process is continued, short of carbonisation, the lower its conductivity becomes. Microscopic examination shows that the cell-walls are collapsed and have lost their stiffness, so that the material transmits heat badly, in the same way that a layer of slack-air cushions would fail to transmit sound, for nearly three-quarters of cork is air, and heat passes through it largely by the movement of air in the cells.

The slabs were made to fit tightly into the box, and there was similar insulation at the top and bottom. The other materials—slagwool, granulated cork, and charcoal—were packed in tightly to the extent usual in cold-storage work. The boxes were then immersed in a large cast-iron tank up to the rim, and the temperatures observed by thermometers next to the heater and on the outside of the box in the water. The duration of the tests was at least three days in each case, for it was found that the temperatures did not reach a final steady state in less time. In the case of cork the tests were continued longer, but three to four days is found to be sufficient to give a steady flow, even in 6 in. of cork. The thickness of insulation here was 3 in. (7.6 cm.), and the effective area of the insulation on both sides together 976 sq. in. (6300 sq. cm.). The results were as follow; the temperatures are in degrees Centigrade:—

TABLE I.

Material.	Temperatures. Inside.	Temperatures. Outside.	Difference.	Watts in Heater.	Conductivity. C.G.S.	Conductivity. B.T.U.	Duration of Test.
							hrs.
Slagwool: 1st quality..	98.0	16.7	81.3	27.4	.000098	.0767	52
2nd quality	94.5	16.7	77.8	27.5	.00010	.0785	52
3rd quality	79.0	10.4	68.6	29.4	.000124	.097	42
Baked cork slab: Dark ..	71.0	11.0	60.0	28.2	.000136	.1065	110
Light ..	71.0	11.0	60.0	29.17	.000141	.1105	110
Granulated cork.. ..	82.2	13.2	69.0	28.7	.000121	.0945	48
Charcoal in small lumps	35.0	10.4	24.6	17.75	.000269	.1635	47

These may be compared with the following C.G.S. values, taken from Kaye and Laby's tables:—

Cotton-wool	0.00004
Felt...	0.00009
Flannel	0.00023
Cork	0.00013
Sand	0.00013
Slagwool	0.00019
Air at 0 deg.	0.000052

Fig.1. ICE MELTED PER DAY IN FIRST COOLING OF COLD BOXES.

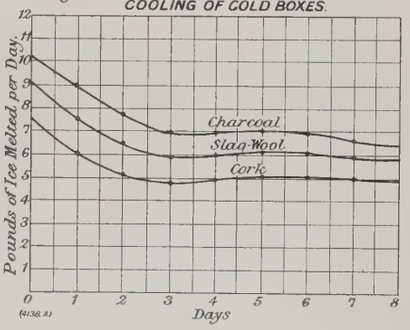
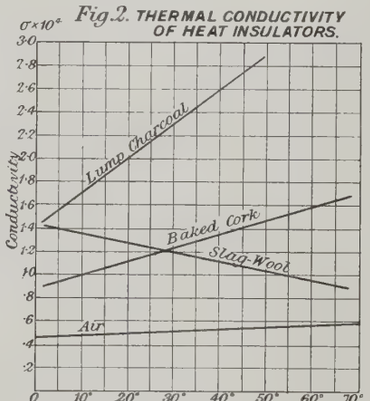


Fig.2. THERMAL CONDUCTIVITY OF HEAT INSULATORS.



The C.G.S. conductivity is the number of grammes of water heated 1 deg. Cent. a second per square centimetre of surface per degree per centimetre thickness gradient. The B.T.U. conductivity is the number of pounds of water heated 1 deg. Fahr. an hour per square foot of surface per degree Fahrenheit per foot thickness of insulation.

3. Although the conditions of these measurements were in every way satisfactory, the relatively high conductivity of cork was not in accordance with previous work. The new values for cork agree very well with those quoted in the tables, but the slagwool has a lower conductivity, and approaches felt in its insulating qualities. In order to examine this difference further, a second set of tests was made at the melting-point of ice. Three insulating boxes were made 40 in. cube outside. Two of them were lined with $\frac{3}{4}$-in. deal, and were surrounded by a 6-in. space, the outer covering being also $\frac{3}{4}$-in. wood. Between the two coverings there were 6-in. by 2-in. joists for framing the boxes and to imitate practical conditions. The insulating material was packed into this space. The third box was built up of cork slabs to a thickness of 6 in. without any additional framing or covering, and was finished outside and inside with a smooth cement, which is not a heat-insulator. The boxes were supported about 2 ft. from the floor on wooden trestles in a large room facing north. For receiving the ice, zinc tanks were made, each having a drain-pipe in the centre, communicating by means of a well-insulated siphon with the outside, for the purpose of removing the water formed as the ice melted by the flow of heat through the walls. The pipe had a break of continuity at one point to avoid as far as possible any loss by conduction of heat along it. The boxes having been cooled by standing full of ice for eight days, during which the ice melted at the rate shown in Fig. 1, the trials were started by the withdrawal of this charge and the introduction of a weighed quantity of ice, 99.6 lb. being placed in each box. The temperatures were noted and the boxes closed. The water which drained away was collected and weighed from day to day. After fourteen days the boxes were opened, the ice remaining weighed, and the final temperatures taken; the loss of weight was greater than the sum of the water collected in the proportion 0.87. This difference is caused by evaporation in the drip-pipe and from the containing vessel, and may be the cause of a large error in the ice-box method, unless checked by weighing the total ice melted. The results were as follow:—

TABLE II.

Material.	Total Ice Melted.	Ice per 24 Hours.	Temperature, C. Room	Temperature, C. Box.	Temperature, C. Difference.	Conductivity. C.G.S.	Conductivity. B.T.U.
Cork, dark	74.7	5.34	15.2	6.5	8.7	.000101	.078
Slagwool ..	87.4	6.24	15.2	7.8	7.4	.000136	.107
Charcoal ..	96.5	6.88	15.2	8.9	6.3	.000177	.139

Cork now appears as the best insulator, as shown in Fig. 2. In the calculation of conductivity from these figures the mean area is not quite the mean of the inner and outer surfaces, for the flow of heat is converging sufficiently to affect the gradient.

Let q be the heat passing per second through unit area at a distance x from the inner surface. By definition $q = \sigma\, d\,\theta/d\,x$, where σ is the conductivity and θ the temperature at that point. At the inner surface of area A_1 $q = q_1$, and since there is no other leakage $q = q_1 \frac{A}{A_1}$, A being the total area of flow at x.

Now $A = A_1 + x\,\frac{A_2 - A_1}{T}$, A_2 being the outer surface.

Thus

$$q = q_1 \left\{1 + \frac{x}{T}\left(\frac{A_2}{A_1} - 1\right)\right\} = \sigma \frac{d\,\theta}{d\,x} \quad . \quad (1)$$

and

$$\theta = \frac{q_1}{\sigma}\int \left\{1 + \frac{x}{T}\left(\frac{A_2}{A_1} - 1\right)\right\} d\,x$$

$$= \frac{q_1\,x}{\sigma} + \frac{q_1\,x^2}{2\,\sigma\,T}\left(\frac{A_2}{A_1} - 1\right) + C \quad . \quad (2)$$

When $x = 0$, $\theta = \theta_1$, the temperature inside the box, and $C = \theta_1$.

The mean value of

$$\theta = \frac{1}{T}\int_0^T \frac{q_1\,x}{\sigma} \cdot d\,x + \frac{1}{T}\int_0^T \frac{q_1}{\sigma\,T}\left(\frac{A_2}{A_1} - 1\right)\frac{x^2}{2} \cdot d\,x + \theta_1$$

$$= \frac{q_1}{\sigma\,T}\left\{\frac{T^2}{2} + \frac{T^2}{6}\left(\frac{A_2}{A_1} - 1\right)\right\} + \theta_1.$$

Thus

$$\overline{\theta} = \frac{q_1\,T}{3\,\sigma}\left(1 + \frac{1}{2}\,\frac{A_2}{A_1}\right) + \theta_1.$$

To find the distance x at which this occurs, substitute this value of $\overline{\theta}$ for θ in (2); then

$$\frac{q_1\,x^2}{2\sigma\,T}\left(\frac{A_2}{A_1} - 1\right) + \frac{q_1\,x}{\sigma} = \frac{q_1\,T}{3\,\sigma}\left(1 + \frac{1}{2}\,\frac{A_2}{A_1}\right).$$

From which

$$x = \frac{T}{(A_2/A_1 - 1)}\left[-1 \pm \left\{1 + \tfrac{2}{3}\,(A_2/A_1 - 1)\right.\right.$$
$$\left.\left.(A_2/2\,A_1 - 1)\right\}^{\frac{1}{2}}\right].$$

The inside effective area was 3900 sq. in., the outer area 8460 sq. in. Thus $A_2/A_1 = 2.215$, and T is 6 in., so that

$$x = 4.93\,(-1 \pm 1.643) = 3.17 \text{ in.}$$

The surface of mean temperature is 6102 sq. in., or 39,500 sq. cm.

The latent heat of ice is 79.77 gramme-calories per gramme, or 36,250 per pound. The thickness of effective insulation was 6 in. in each case, or 15.24 cm. The conductivity is, therefore, in centimetre measure:—

$$\sigma = \frac{W}{\theta_2 - \theta_1}\,\frac{36{,}250 \times 15.24}{39{,}500 \times 86{,}400} = 0.000162\,\frac{W}{\theta_2 - \theta_1},$$

where W is the mass in pounds melted in twenty-four hours (86,400 seconds).

4. After eight days preliminary cooling and under conditions of steady flow, the values found for the conductivity are found to differ both between themselves and one another from those of Table I. Both sets of experiments were made on a large scale, with times allowed for reaching the steady state longer than usual, and the quantities could all be readily measured. The differences would therefore appear to be real, and not arising from the methods. In all the materials the transmission of heat by the enclosed air must play some part, though the change of conductivity of air alone, calculated from the change of viscosity and specific heat, is not so great in itself. But if the mechanism of conduction in these materials is largely by air, one might expect the conductivity to change in the same ratio as that of air. For the latter we have:—

Temperature. Deg.	Conductivity.
0	4.7×10^{-5}
15.0	4.97
99.6	6.07
302.0	8.21

* Paper read before Section G of the British Association in Australia.

† Philosophical Transactions of the Royal Society, 1892-1898.

‡ Proceedings of the Royal Society, pages 65, 283, 1899.

Between 10 deg. and 25 deg. air changes in the ratio 1.065; charcoal, 1.225; and cork, 1.175. The change of conductivity of air is not alone sufficient to account for the difference.

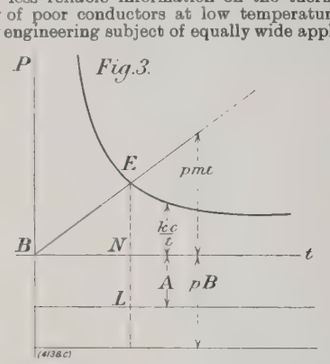
Slagwool has a negative temperature coefficient. This is a very excellent characteristic for a heat insulator to be used at high temperature, and, as shown by Fig. 2, it is superior to air at the temperature of boiler insulations. At low temperatures it is inferior to cork, though better than charcoal. Why slagwool should not follow the same law as the others is not at once evident, but silica is a peculiar substance, with many metallic properties, and the thermal conductivity of most pure metals decreases with rise of temperature.

For the insulation of rooms in which the external conditions may change from zero Cent. to 24 deg. Cent. (32 to 75 deg. Fahr.), baked cork is the best insulator of all those which can be profitably employed, and it has the advantage of economy of space and of remaining in the same condition for an indefinite time. Relative costs are not here considered.

These measurements bring out clearly two points which are of the first importance in heat insulation:—(1) In order to find with any accuracy the insulating properties of a material to be employed in the insulation of refrigerating-rooms, and of boilers, it is necessary that the measurements should be made at a range of temperature agreeing as nearly as possible with those at which the room is to be worked. (2) In the choice of material the variation of its thermal conductivity with temperature should be known if the external temperatures are to change, as they do, for example, on board ship.

The subject is of engineering importance, and there is probably less reliable information on the thermal conductivity of poor conductors at low temperatures than upon any engineering subject of equally wide application.

Fig. 3.



The present work was begun as a test of the first method which appeared to be capable of high accuracy, and was suggested by the use of the woven-wire resistances now in common use. It would be possible to use a flat hollow space filled with brine as a sink of heat in such a method, but the conditions would be difficult to control.

5. *The Specific Heat of Heat-Insulators in Bulk.*—At the start of the ice-melting trials, before the ice was put in, the box was at the same temperature inside and out. After the first enclosure of ice, the inside temperature fell rapidly, and the rate of melting of the ice also fell to a steady state. The quantity of heat corresponding to the mean height of the curve of Fig. 1, in the first few days, above the steady value is all taken from the insulation in cooling it to the steady state, and is therefore available for the calculation of its specific heat.

The mean drop of temperature is half of the maximum fall inside the box, since the outside remains at the same temperature throughout. The final temperatures are: for cork, 4.5 deg. Cent.; for slagwool, 5.57 deg.; and for charcoal, 6.0 deg. inside. Outside the temperature was nearly constant at 15.2 deg. Cent. The volume V of active insulation was in each case 640,000 cub. cm. The mean density ρ of the cork was 0.224, of the slagwool 0.40, and of the charcoal 0.30. Thus, since

$$Q = V_\rho S (\theta_2 - \theta_1),$$

the following values are found for the specific heat S, Q being corrected for evaporation :—

Material.	Q in Small Calories.	M in Kilograms.	$\frac{\theta_2 - \theta_1}{2}$	Specific Heat. C.G.S.
Cork	1.16×10^5	143	5.3	0.153
Slagwool	1.45×10^5	256	4.8	0.118
Charcoal	1.70×10^5	192	4.6	0.192

These values are small because of the relatively large proportion of included air.

The lower the specific heat the quicker the temperature of the insulation rises or falls. The insulation of a refrigerating room should have a high specific heat, so as to prevent too sudden a variation of load on the cooling machinery when the external temperature rises. The thermal capacity of the insulation is, in fact, the heat fly-wheel of the system.

6. *The Most Economical Thickness of Insulation.*—The product of the thickness of insulation t and the heat Q passing through it in a given time is nearly constant; write $Q\,t = C$. In a steady state the cost of cooling the room is proportional to the heat to be absorbed, together with the standing charges. Let the cost be £H per year, when $H = A + \frac{k\,c}{t}$, in which A is the standing charge. The cost of the insulation is directly proportional to its thickness, and there is a term corresponding to the cost of erection, which is nearly constant. We may then write the cost of $£I = B + m\,t$. The total cost per year of maintaining the room cooled is therefore:—

$$P = A + \frac{k\,c}{t} + p\,B + p\,m\,t,$$

where p is the interest and depreciation on the insulation. The most economical thickness is when $d\,P/d\,t = 0$. That is when

$$p\,m = \frac{k\,c}{t^2},\ t = \sqrt{\frac{c}{m}} \text{ or } p\,m\,t = \frac{k\,c}{t}.$$

This can be shown graphically as in Fig. 3. E is the intersection of the lines $p\,m\,t$ and $k\,c/t$, and D N is the correct thickness to be used.

This determines at once both the thickness of insulation to be used and the size of machine to deal with the heat leaking through the walls, for the height E L gives the heat-units to be absorbed per year.

The author is indebted to Messrs. Fk. Jones and Co., of Middlesbro, for kindly supplying the slagwool; and to Messrs. Newalls Insulation Company, of Newcastle-on-Tyne, for the "Nonpareil" cork slabs used in the tests, and the construction of the cooling-boxes for the second method.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on the subjects dealt with can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

New Zealand: The Borough Council of Masterton proposes to take a poll of the ratepayers for the raising of a loan of 29,000*l.* for drainage and sewerage works. A number of cheese and butter factories in the Wairarapa district intend next season to instal plants for the manufacture of whey butter. Names and addresses of dairy, butter and cheese factories in the district mentioned may be obtained by United Kingdom manufacturers of dairy plant on application to the Commercial Intelligence Branch.

Ecuador: The *Registro Oficial*, Quito, of July 4 announces that a contract has been entered into between the Ecuadorian Government and Señor Don Pablo Gonzembach for the extension of the mole at Manta, and the construction of an extension of the railway from Manta to Santa Ana. The length of the new portion of the mole is to be 200 metres. The new portion of the railway is to extend from the 66th kilometre of the existing line between Manta and Santa Ana, as far as the town of Pajan, passing through Jipijapa. The *Registro* of July 9 announces that a contract has been granted by the Municipal Council of Babahoyo to Mr. Alfred Maurry for the construction of the Los Rios Railway. Copies of the *Registro* containing the conditions of these contracts may be seen by United Kingdom manufacturers and contractors at the Commercial Intelligence Branch.

Colombia: The *Diario Oficial*, Bogotá, of June 23 publishes the text of a contract entered into between the Colombian Government and Messrs. S. Pearson and Son, Limited, for the drawing up of plans for the improvement and sanitation of Cartagena. The works at present contemplated include the construction of an approach channel to the port, the construction and dredging of an inner harbour, the erection of a sanitary station and administration buildings, the laying of a sewerage system, and the electric lighting of the town. The company undertakes to present the necessary plans and specifications to the Government within a period of one year from June 23 last.

France: The *Journal Officiel*, Paris, of August 25 publishes a decree granting to Messrs. Giros and Loucheur, 69, Rue de Miromesnil, Paris, concessions for the construction and working of a system of electric and steam railways in the Departments of Tarn and Haute-Garonne. The total length of the line will be 164 km. (about 102 miles), and the estimated cost 10,461,000 francs (418,440*l.*). The *Journal* containing the text of the concession (in French), together with the specifications of the lines to be constructed, may be seen by United Kingdom manufacturers and contractors at the Commercial Intelligence Branch. The *Journal* of August 26 publishes a decree authorising the Havre Chamber of Commerce to negotiate a loan of 625,000 francs (25,000*l.*) with a view to the acquisition of two grain-elevators.

Spain: The *Gaceta de Madrid* of August 28 notifies that the municipal authorities of Salamanca invite tenders, up to a period of sixty days from that date, for the supply and distribution of electric power for the lighting of the town. The same issue of the *Gaceta* notifies that tenders will be received by the Municipality of Barcelona, up to 11 a.m. on October 9, for the carrying out of street-paving works in that city at a total estimated cost of 699,999 pesetas (about 25,550*l.*). The *Gaceta* containing the conditions of tender and particulars regarding the sand, cement, paving-stone, &c., required may be seen by United Kingdom contractors at the Commercial Intelligence Branch. The foregoing contracts will doubtless be awarded to Spanish firms, but the carrying out of the works may involve the purchase of materials outside Spain. The *Gaceta* of August 29 announces that tenders will be opened at noon on September 26 at the Direccion General de Obras Publicas, Ministerio de Fomento, Madrid, for the carrying out of the first part of the harbour works scheme at Villagarcia (see page 671 of the *Board of Trade Journal* of June 18 last), at an estimated cost of 1,587,760 pesetas (about 58,800*l.*). The time allowed for the completion of the contract is twelve years. A preliminary deposit of 15,878 pesetas (about 588*l.*) is required to qualify any tender. The conditions of contract contain clauses to the effect that at the first competition materials to be used will be confined, with certain exceptions, to products of Spanish manufacture, but that in the event of no decision being arrived at, a second competition, in which foreign products may be accepted, will then take place. In the latter event Spanish products will have a 10 per cent. margin of preference over foreign. The *Gaceta* containing the conditions of contract may be seen by United Kingdom contractors at the Commercial Intelligence Branch.

Egypt: The Egyptian *Journal Officiel* of August 19 notifies that tenders are invited by the Egyptian Ministry of the Interior for the installation of a drinking-water system at Mattaria-Manzala. Copies of the plans, *cahier des charges*, &c., may be obtained, on payment of 250 piastres (2*l.* 11s.), from the Section des Municipalités et Commissions Locales, Ministère de l'Intérieur, Cairo, by whom also tenders will be received at a date which will be announced later. The original date for the receipt of tenders was October 10, but it has now been postponed. A provisional deposit equal to 2 per cent., or a bank guarantee of 10 per cent, of the value of the offer must accompany each tender. Legal domicile in Egypt is necessary for the contractor. For conditions under which temporary legal domicile may be obtained by British firms at the British Consulate at Cairo, see page 176 of the *Board of Trade Journal* of January 26, 1911, and page 176 of the issue of April 25, 1912.

Essen.—On March 1 the population of Essen, the town containing the Krupp Steel Works, was 323,259, an increase of 172 per cent. over the figures for 1900. In the period 1900-10 the death rate decreased from 25.85 to 12.35 per 1000.

Our Locomotive Exports.—The exports of locomotives from the United Kingdom experienced a check in August, which, in consequence of the war, was a setback month for a good many national industries. The value of the engines shipped from the United Kingdom during the month was 210,260*l.*, as compared with 301,100*l.* in August, 1913, and 115,375*l.* in August, 1912. Depression in Argentina has greatly reduced the demand for our locomotives in that quarter, and engines to the value of only 9092*l.* were shipped in August, as compared with 90,031*l.* and 23,991*l.* There was a good demand for British locomotives in Australia in August, but the value of the engines despatched to British India during the month declined to 49,765*l.*, as compared with 99,606*l.* in August, 1913. The aggregate value of the locomotives exported to August 31, this year, was 2,641,584*l.*, as compared with 1,788,211*l.* in the first eight months of 1913, and 1,325,309*l.* in the first eight months of 1912. Argentina took British locomotives to August 31, this year, to the value of 596,565*l.*, as compared with 439,299*l.* and 306,854*l.* The Colonial demand moved on as follows in the first eight months of each of the last three years:—

Colonial Group.	1914. £	1913. £	1912. £
British South Africa ..	51,278	74,194	146,969
British India	1,108,322	653,411	252,751
Australia	400,663	236,882	222,229

It will be observed that South Africa has shown some weakness, but that a compensation has been more than found in a substantially increased demand for British locomotives for India and Australia. It is to be feared that the last four months of 1914 will be a troubled period in our export locomotive history, but it appears probable that the complete year will exhibit favourable results.

German and Austrian Competition in the Printing-Machinery Trades.—Among the valuable series of White Papers now being issued by the Commercial Intelligence Branch of the Board of Trade is one dealing with the German and Austro-Hungarian exports of printing and lithographic machinery. This is a trade in which Germany in particular has established an important position, her total exports during 1912 being valued at 1,042,250*l.* It is not possible to give any corresponding figure for the United Kingdom, since such machinery is not separately distinguished in our trade returns. The total exports of Austria-Hungary in 1913 were valued at 16,440*l.* Of the German exports in 1912, machinery to the value of 59,300*l.* was sent to the United Kingdom, of 156,750*l.* to Russia, of 61,600*l.* to France, 59,650*l.* to Italy, 57,700*l.* to Brazil, 51,950*l.* to Scandinavia, 41,050*l.* to Spain, and 36,000*l.* to Argentina. These countries should all form possible fields for exploitation by British manufacturers at the present time. German competition in machinery of this class is met in our colonies, but the imports of Germany are, in general, considerably below those of the United States. Machines for printing, typesetting, type-casting, and machinery for ruling, folding, binding, embossing and creasing paper were supplied from the United States to Canada in 1912-13 to the value of 1,435,633 dols. The figure for Germany was little over 1 per cent. of this, and that for the United Kingdom between 5 and 6 per cent. In South Africa our position is better, our imports being of a value of 33,668*l.* in 1913, as compared with 5035*l.* for Germany and 6547*l.* for the United States. In Australia, of a total figure for all countries of 182,070*l.* in 1912, the United Kingdom supplied 43 per cent., as compared with 61 per cent. two years earlier. Our loss was mainly owing to competition from the United States and Germany. Much the same state of affairs exists in New Zealand. It is clear that in any new trade available in these countries, owing to the inability of Germany to export material, the United States is likely to be an important competitor, but it should be possible to obtain some of the trade for this country.

BENDING STRESSES IN HOOKS AND OTHER CURVED PIECES.

By ARTHUR MORLEY.

(*Concluded from page* 322.)

8. *Experimental Tests of the Formulæ.*—Several series of experiments have been made to test the formulæ, these consisting of measurements of the opening of a hook or jaw under the influence of gradually increasing measured loads. The deviation of the strain, from proportionality to the load, is taken to indicate that the material at the intrados has reached the stress at the proportional limit, or at the yield-point, as separately determined by a tensile test of the same material. (As the stresses are direct, with no transverse shear, no question arises here as to the rival theories of the criterion of elastic failure.) If the proportional limit and the yield-point differ sensibly in the tensile test, the writer is of opinion that in all published experiments the deviation from proportionality in the hook tests should be taken to correspond to the yield-point of the tension test. For in the bending of even a straight bar, the very marked tensile yield-point of a very mild steel is so masked by unequal distribution of the stress that the declination from proportionality is very gradual, and consequently an earlier slight deviation from proportionality at the tension edge of a section is, in its effect on the general bending strain, inappreciable by ordinary measuring instruments. This applies in a still greater degree to the bending of a

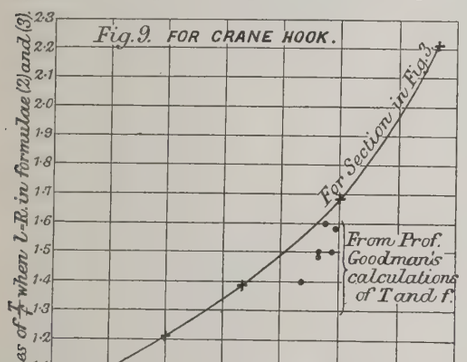


Fig. 9. FOR CRANE HOOK.
Values of T when I-R in formulae (2) and (3).
For Section in Fig. 3.
From Prof. Goodman's calculations of T and f.
(3719. I.)
Values of n (= yt/R).

curved hook across the section of which the distribution of bending stress is still more unequal, and also when the section is of a rounded form, so that only a very small fraction of the section is at first affected by an increased rate of straining.

The attempt is being made to measure stress intensity optically, but so far as the writer is aware, the method is not yet capable of giving greater accuracy in the case of a hook than is obtainable by extensometer methods.

9. *Correction of Published Results.*—In view of the serious errors involved, it is desirable to correct previously-published experimental confirmations or otherwise of the hook formulæ.

(*a*) *Experiments of Mr. Andrews.*—The memoir previously referred to, in its first two sections, points out a defect in Winkler's formula, and proceeds to develop a corrected analysis; but it is perhaps remarkable that in the deductions from the experiments no comparison is made with Winkler's results, but only with the more obviously unsuitable beam formula (1). Table II. gives the

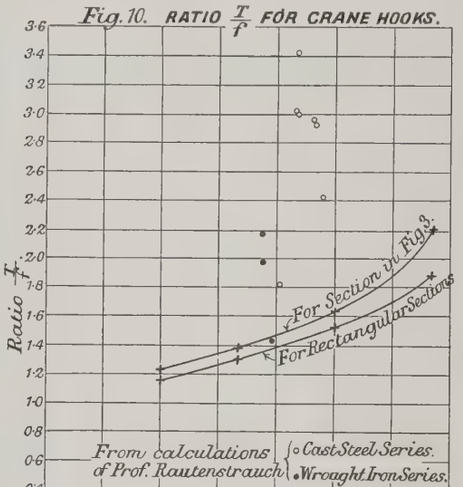
TABLE II.—*Andrews's Rectangular Section Hook Tests.*

Taken or Deduced from the Andrews-Pearson Memoir.				Corrected Values.		Winkler's Values.	
Test No.	$\frac{y_t}{R}$	$\frac{T}{f}\left(=\frac{\beta}{\alpha}\right)$	Stress T at "Elastic Limit."	$\frac{T}{f}$	Stress T at "Elastic Limit."	$\frac{T'}{f}$	Stress T′ at "Elastic Limit."
			lb. per sq. in.		lb. per sq. in.		lb. per sq. in.
2	0.34	1.16	29,200	1.31	33,000	1.27	32,300
3	0.368	1.16	30,500	1.34	35,200	1.30	34,200
4	0.20	1.093	28,500	1.165	30,400	1.145	29,900

published and the corrected results, and the results as calculated by Winkler's formula (2). The average "elastic limit" as given for the tensile tests, which is the limit of proportionality of strain to stress, is 30,000 lb. per sq. in., but the stress at the yield-point was about 31,000 lb. per sq. in. The average values of T (corrected), viz., 32,900, or of T′, viz., 32,100, in Table II., is over 31,000, as is to be expected in accordance with the remarks in the preceding section on Tests of Formulæ.

Having regard to the difficulty in detecting the slight declination from proportionality, these tests may be taken as very satisfactory, and (with ordinary extensometers) as representing about the limit of experimental discrimination of yield-point stress. They are insufficiently delicate to test conclusively the Andrews-Pearson formula as against Winkler's, but, so far as they go, they support Winkler's formula as being the more correct. The same is true of Mr. Andrews's experiment on a coupling-hook. The calculated stress at the limit of proportionality in the hook test is given as 23,000 lb. per sq. in. (If this may be corrected by the similar, but not identical, type of section, in Fig. 4 (page 321 *ante*), it would be about 23,800.)

With the extreme curvature of $\frac{y_t}{R} = 0.65$, Winkler's result is about 9 per cent. lower, which



brings it into very close agreement with the tensile limit, given as 21,000 lb. per sq. in.

(*b*) *Professor Goodman's Experiments.*—In working out the results of six crane-hook tests (second set) in the paper previously referred to, Professor Goodman, using the graphical method of Andrews and Pearson, obtained results which are shown plotted in Fig. 9. It is evident that these are not in agreement with the curve for Fig. 3 (page 321 *ante*); an inspection of Fig. 5 (page 322 *ante*) shows how comparatively little the results in this form differ for quite different sections, and it is probable that for sections so similar as those of different crane-hooks the differences are quite insignificant; in any case the points shown for a series of similar hooks are inconsistent one with another by some 10 per cent., and this shows the unreliability of the Andrews-Pearson graphical method even in capable hands.

(*c*) *Experiments by Professor Walter Rautenstrauch.*—The values of T and f for loads at the limit of proportionality of strain to load for a series of crane-hooks of similar section were worked out graphically by Professor Rautenstrauch.* The ratio of T to f for such a series is, of course, independent of the load, but must vary continuously with the function n or $\frac{y_t}{R}$. The values of the ratio are shown plotted in Fig. 10 in comparison with the curves for the section shown in Fig. 3, and for a rectangular section, which are the outside limits of Table I. and Fig. 5. It is obvious from Fig. 5 that the values shown in Fig. 10 are not only incorrect by large amounts as compared with the curves, but are in similar extreme disagreement among themselves. Also the values given for γ_1 and γ_2 in the paper are quite impossible in their relations one to another; in several cases they are such as would necessitate a value of γ_3 less than unity, which is impossible. The extraordinary fact about these results is that in spite of this disagreement by such large amounts, these values of T were found to be in very close agreement with the unit stresses at the limit of proportionality for the simple tension tests of the material, although these unit stresses varied for cast steel in different hooks between the remarkable limits of 28,500 lb. to 62,750 lb. per sq. in. Fig. 10 shows clearly what extraordinary results may be obtained by graphical constructions.

(*d*) *Experiments of Professor Lewis Jenkin.**—In the published accounts of these experiments on cast-iron punch-frames, the values of R, the radius of curvature of the centroid axis of the cross-sections at the principal section, and of n, are not given in sufficient detail to allow the writer to test the consistency of the values of the ratio $\frac{T}{f}$. Several of the frames had an unsymmetrical I-section with the intrados on the thicker and wider flange; the values of n are high, and as given in the paper the values of $\frac{T}{f}$ are very high. Even the values of $\frac{T}{T'}$ are 1.95 in some cases, and $\frac{T-1}{f-1}$ would be still higher. These figures seem difficult to reconcile with those in the first line of Table I.

10. *Empirical Results.*—Use may be made of the foregoing results to find the maximum tensile unit stresses in a curved piece of any given type of section by means of an approximate empirical straight-line formula. The designer may easily construct his own formula from graphs of Table I. or use a graph directly. In the former case the errors involved may over a given range of n be made a minimum positive or negative amount, or may be made always positive for safety.

Examples: Crane-Hook.—n = from 0.4 to 0.5.

Maximum tensile unit stress by Andrews-Pearson formula:—

$$T = \frac{W}{A}\left\{1 + \frac{y_t\, l}{k^2}(0.56+2.5\,n)\right\} \quad . \quad . \quad (4)$$

And for the maximum bending stress only, resulting from a bending moment M, say, this would be:—

$$\frac{M\, y_t}{I}(0.56 + 2.5\,n) \quad . \quad . \quad . \quad . \quad (5)$$

If l = R, we may alternatively write from Fig. 9, maximum unit tension:—

$$T = f\,(0.695 + 1.85\,n) = \frac{W \cdot y_t \cdot R}{I}(0.695+1.85\,n). \quad (6)$$

The maximum tensile unit stress by the Winkler formula is approximately:—

$$T' = \frac{W}{A}\left\{1+\frac{y_t \cdot l}{k^2}(0.73 + 1.9\,n)\right\} \quad . \quad . \quad (4a)$$

or the maximum intensity of bending stress is $(0.73 + 1.9\,n)$ times that given by the ordinary rule for straight beams.

If the unit stress T′ by the Winkler formula (2) has been determined, that (T) by the Andrews-Pearson formula is required, we may, with very slight error, write for a hook of any cross-section:—

$$T = T'\,(1 + 0.15\,n) \quad . \quad . \quad . \quad (7)$$

For crane-hooks of ordinary proportions the excess is approximately 6 per cent., or

$$T = 1.06\,T' \quad . \quad . \quad . \quad . \quad (8)$$

For intrados bending stresses only, over a considerable range of curvature, the approximate factor for converting Winkler's values to those of the Andrews-Pearson formula, may be taken as:—

$$1 + 0.15\,n \quad . \quad . \quad . \quad . \quad . \quad (9)$$

as may be seen from the column $\frac{T-1}{T'-1}$ in Table I.

11. *Conclusions.*—(1) There is no experimental evidence to show that calculations by the Andrews-Pearson formula give more reliable values than those obtained by the simpler Winkler formula.

(2) That the use of either of these formulæ is, for most practical sections, attended by great risk of error, particularly that of Andrews and Pearson.

(3) That nearly all published results on the subject are seriously in error.

(4) That for practical purposes the results by either formula may be obtained from the simple

* "An Investigation of Strength of Crane-Hooks," *American Machinist*, No. 40, Vol. 32, October 30, 1909.

* "The Strength of Punch and Riveter Frames made of Cast Iron." Journal of the American Society of Mechanical Engineers, May, 1910.

formula for straight beams by empirical corrections, data for which are given above.

The writer takes this opportunity of thanking his former student, Mr. H. Lawson, B.Sc., for his careful, accurate drawings in connection with the graphical calculations, which extend much beyond the samples given in this article.

APPENDIX.

Determination of γ, γ_1 and γ_3.

Rectangle, breadth b, depth d (in the plane of bending).

$$\gamma = \frac{R}{d}\log_\epsilon \frac{2R+d}{2R-d} \quad . \quad . \quad . \quad . \quad (10)$$

$$\gamma_1 = \frac{m\,R}{d}\left\{\left(\frac{2R}{2R-d}\right)^{\frac{1}{m}} - \left(\frac{2R}{2R+d}\right)^{\frac{1}{m}}\right. \quad . \quad . \quad (11)$$

$$\gamma_3 = \frac{m\,R}{(m-1)R}\left\{\left(\frac{2R+d}{2R}\right)^{\frac{m-1}{m}} - \left(\frac{2R-d}{2R}\right)^{\frac{m-1}{m}}\right\} \quad (12)$$

Triangle, base b (at intrados), depth h (in the plane of bending).

$$\gamma = \frac{2R}{d}\left\{\frac{2h+3R}{3h}\log_\epsilon \frac{3R+2h}{3R-h} - 1\right\} \quad . \quad (13)$$

$$\gamma_1 = \frac{2m}{3}\,\frac{R}{h^2}\left[(2h+3R)\left\{\left(\frac{3R}{3R-h}\right)^{\frac{1}{m}} - \left(\frac{3R}{3R+2h}\right)^{\frac{1}{m}}\right\}\right.$$
$$\left. - R^{\frac{1}{m}}\left\{(R+\tfrac{2}{3}h)^{\frac{m-1}{m}} - (R-\tfrac{1}{3}h)^{\frac{m-1}{m}}\right\}\right] \quad . \quad (14)$$

previous ones, and tabulating the terms by the aid of seven-place logarithms and antilogarithms gives values of γ_1 correct to five places of decimals without the use of many terms of the series. Similarly

$$\gamma_3 - 1 = \frac{m+1}{m^2\,.\,2!}\cdot\frac{1}{4}\left(\frac{r}{R}\right)^2 + \frac{(m+1)(2m+1)}{m^4\,.\,4!}\cdot\frac{3}{6}\cdot\frac{1}{4}\left(\frac{r}{R}\right)^2 +, \text{ \&c.} \quad . \quad (20)$$

or if $m = 4$,

$$\gamma_3 - 1 = \frac{5}{4^2\,.\,2!}\cdot\frac{1}{4}\left(\frac{r}{R}\right)^2 + \frac{5\,.\,9\,.\,13}{4^4\,.\,4!}\cdot\frac{3.1}{6.4}\left(\frac{r}{R}\right)^4 + \frac{5\,.\,9\,.\,13\,.\,17\,.\,21}{4^6\,.\,6!}\cdot\frac{5\,.\,3\,.\,1}{8\,.\,6\,.\,4}\left(\frac{r}{R}\right)^6 +, \text{ \&c.} \quad . \quad (21)$$

the terms of (20) and (21) being those in (18) and (20) respectively divided by $(2m+1)$, $(4m+1)$, $(6m+1)$, &c., which gives the terms easily from those tabulated for γ_1.

Any Plane Figure. Graphically.—

$$\gamma - 1 = \frac{\Sigma(y^2\,\delta A)}{A\,.\,R^2} - \frac{\Sigma(y^3\,\delta A)}{A\,.\,R^3} + \frac{\Sigma(y^4\,.\,\delta A)}{A\,.\,R^4} -, \text{ \&c.}^* \quad (22)$$

The summations being between $y = +y_c$ and $y = -y_t$ (Fig. 1).

$$\gamma_1 - 1 = \frac{(m+1)(2m+1)}{m^2\,.\,2!}\cdot\frac{\Sigma(y^2\,\delta A)}{A\,.\,R^2} - \frac{(m+1)(2m+1)(3m+1)}{m^3\,.\,3!}\cdot\frac{\Sigma(y^3\,.\,\delta A)}{A\,.\,R^3} + \frac{(m+1)(2m+1)(3m+1)(4m+1)}{m^4\,.\,4!}\cdot\frac{\Sigma(y^4\,.\,\delta A)}{A\,.\,R^4} - \text{\&c.} \quad (23)$$

$$\gamma_3 - 1 = \frac{m+1}{m^2\,.\,2!}\left(\frac{y_t}{R}\right)^2\cdot\frac{1}{A}\,\Sigma\left\{\left(\frac{y}{y_t}\right)^2\delta A\right\} - \frac{(m+1)(2m+1)}{m^3\,.\,3!}\left(\frac{y_t}{R}\right)^3\cdot\frac{1}{A}\cdot\Sigma\left\{\left(\frac{y}{y_t}\right)^3\delta A\right\} + \frac{(m+1)(2m+1)(3m+1)}{m^4\,.\,4!}\cdot\left(\frac{y_t}{R}\right)^4\cdot\frac{1}{A}$$
$$\Sigma\left\{\left(\frac{y}{y_t}\right)^4\delta A\right\} - \text{\&c.} \quad . \quad . \quad (24)$$

the terms being as for $\gamma_1 - 1$, but divided respectively by $(2m+1)$, $(3m+1)$, $(4m+1)$, &c., and therefore easily derived from the previous terms tabulated for (23). It may be noted (*e.g.*, from Table I.) as a useful check that, for hooks of moderately small curvature, $\gamma_3 - 1$ must approach closely to $\frac{1}{9}$ of $\gamma_1 - 1$ (if $m = 4$), or γ_2 approaches $\frac{8}{9}$ of $\gamma_1 - 1$.

In the case of the coupling-hook section of Fig. 4 the derived areas for the portion of the section between parallel sides were calculated, and the remainders shown in Fig. 12 were obtained graphically; in this doubly symmetrical section only one-quarter of the outline need be drawn, and only derived areas of even orders are required—viz., the 2nd, 4th, 6th, &c. The contribution of the rectangle $a\,b$, Fig. 12, to the nth derived area is

$$b\int_o^a \left(\frac{y}{y_t}\right)^n dy = \frac{a\,b}{(n+1)\left(\frac{a}{y_t}\right)^n}$$

Fig. 11.

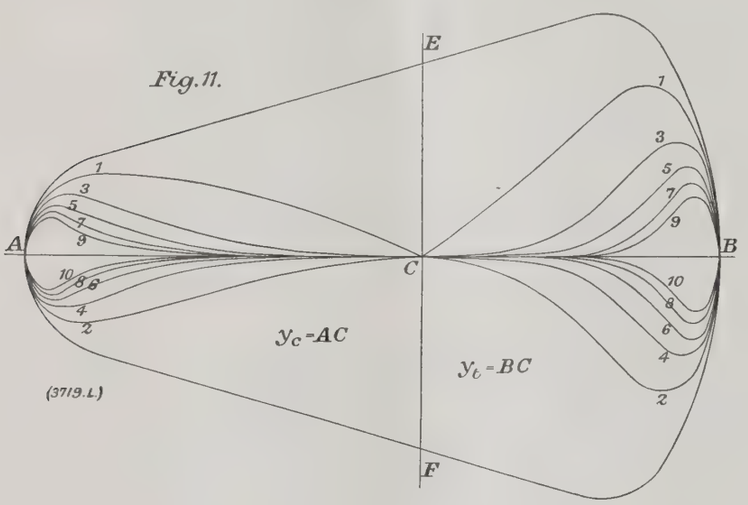
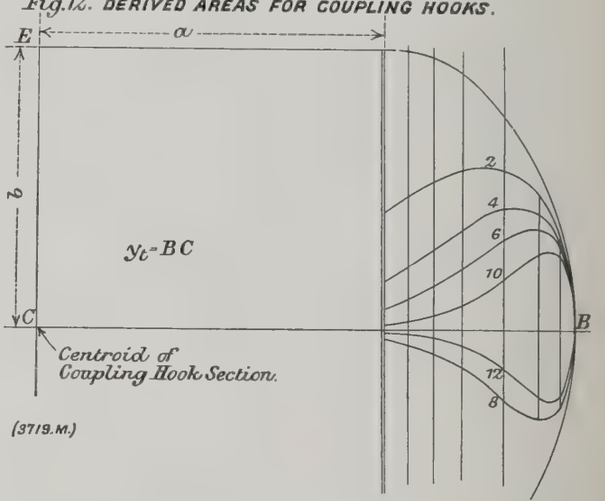


Fig. 12. DERIVED AREAS FOR COUPLING HOOKS.



$$\gamma_3 = \frac{2m}{3}\,\frac{R}{h^2}\left[\frac{3R+2h}{m-1}\left\{\left(\frac{3R+2h}{3R}\right)^{\frac{m-1}{m}} - \left(\frac{3R-h}{3R}\right)^{\frac{m-1}{m}}\right\} - \frac{3}{R^{\frac{m-1}{m}}(2m-1)}\left\{(R+\tfrac{2}{3}h)^{\frac{2m-1}{m}} - (R-\tfrac{1}{3}h)^{\frac{2m-1}{m}}\right\}\right] \quad . \quad . \quad . \quad (15)$$

Circle, radius r.

$$\gamma = 2\left(\frac{R}{r}\right)^2\left\{1 - \sqrt{1-\left(\frac{r}{R}\right)^2}\right\}^* \quad . \quad (16)$$

$$A\,\gamma_1 = \int_{-r}^{r}\left(\frac{R}{R+y}\right)^{\frac{m+1}{m}} dy =$$

$$2r^2\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\left(1+\frac{r}{R}\sin\theta\right)^{-\frac{m+1}{m}}\cos^2\theta\,d\theta\,\theta \quad . \quad (17)$$

Hence

$$\gamma_1 - 1 = \frac{(m+1)(2m+1)}{m^2\times 2!}\times\frac{1}{4}\left(\frac{r}{R}\right)^2 + \frac{(m+1)(2m+1)(3m+1)(4m+1)}{m^4\times 4!}\times\frac{3}{6}\times\frac{1}{4}\left(\frac{r}{R}\right)^4 + \text{\&c.} \quad . \quad . \quad (18)$$

a series which converges quickly if $\frac{r}{R}$ is not a large fraction.

In the text m is taken as 4, so that

$$\gamma_1 - 1 = \frac{5.9}{4^2\,.\,2!}\cdot\frac{1}{4}\left(\frac{r}{R}\right)^2 + \frac{5\,.\,9\,.\,13\,.\,17}{4^4\,.\,4!}\cdot\frac{3\times 1}{6\times 4}\left(\frac{r}{R}\right)^4 + \frac{5\,.\,9\,.\,13\,.\,17\,.\,21\,.\,25}{4^6\,.\,6!}\cdot\frac{5\,.\,3\,.\,1}{8\,.\,6\,.\,4}\left(\frac{r}{R}\right)^6 + \text{\&c.} \quad (19)$$

Successive terms are simply related to the

If there are two axes of symmetry, as in Fig. 4 (or as in the circle above), the terms containing summations of y to odd powers—*i.e.*, alternate terms—vanish. In a crane-hook section such as Fig. 3, on page 321 *ante*, they remain.

For conveniently determining graphically the summations, such, for example, as

$$\frac{1}{R^4}\cdot\frac{\Sigma(y^4\,\delta A)}{A}$$

for several values of R, *i.e.*, several values of $\frac{y_t}{R}$, for any given section we may write it:—

$$\left(\frac{y_t}{R}\right)^4\frac{1}{A}\Sigma\left\{\left(\frac{y}{y_t}\right)^4\delta A\right\}.$$

The numerical values of the ratio:—

$$\Sigma\left\{\left(\frac{y}{y_t}\right)^4\delta A\right\}\text{to A}$$

is easily found by a well-known graphical process of reducing the widths of the area A successively four times in the ratio y to y_t and by measuring the area A and the fourth "derived" area. For a series the successive derived areas may conveniently be mapped out by the use of a pair of proportional dividers. Any errors introduced in the successive modification of the areas need not seriously affect the value of $\gamma - 1$ or $\gamma_1 - 1$, &c., as the fraction $\left(\frac{y_t}{R}\right)$ to successive integral powers gives small coefficients and a quickly convergent series results.

The successive derived areas for the special crane-hook section, Fig. 3, page 321 *ante*, are shown in Fig. 11, above. They were drawn out four times full size, to minimise errors.

The determination of γ_3 easily follows for:—

which, if n is even, is

$$\frac{n-1}{n+1}\left(\frac{y_t}{a}\right)^2$$

times the previous derived area of even order—viz., the $(n-2)$th.

For a curvature, say, $\frac{y_t}{R} = \frac{2}{3}$, the series (22) and (23) are sufficiently convergent for the 11th term to vanish to the fifth decimal place. Actually (as shown in Fig. 12) only six derived areas are required, for after this point in the series the terms have attained a nearly constant ratio, and the last four may be found from this approximate ratio with sufficient accuracy to give the sum reliably to four decimal places.

THE MANHATTAN BRIDGE, NEW YORK.

By FRANK W. SKINNER, Member of the American Society of Civil Engineers.

MANHATTAN ISLAND, on which was built the original city of New York, now Manhattan Borough of Greater New York, is approached by six single-track tunnel tubes under the North River, six under the East River, one double-track tunnel under the Harlem River, by several moderate-span draw-bridges over the Harlem River, and by the Brooklyn, Williamsburg, Queensborough, and Manhattan long-span bridges over the East River. The last four structures have, excepting the Forth Bridge, the longest and heaviest spans in the world, and represent advanced construction and the heaviest work for cantilever and suspension bridges. The Brooklyn Suspension Bridge, completed about thirty years ago, has a 1595½-ft. span, carries two railroad tracks, two roadways, each with one trolley-track, and one 15½-ft. promenade,

* See the writer's "Strength of Materials," Art. 132.

* "Strength of Materials," Art. 131.

and will soon be rebuilt to accommodate more and heavier trains. The Williamsburg Bridge, completed in 1903, has a 1600-ft. span, and carries six tracks, two roadways, and two promenades, and was described in ENGINEERING, vol. lxxx., page 541 *et seq.* The Blackwells Island Bridge has cantilever channel-spans of 1182 ft. and of 984 ft., carries six railroad tracks, two roadways, and two promenades, and was completed in 1909, and described in ENGINEERING, vol. lxxxviii., page 237 *et seq*

The Manhattan Suspension Bridge, between the Brooklyn and Williamsburg Bridges, has a 1470-ft. span, carries eight lines of railroad tracks, two promenades, and one 35-ft. roadway. Plans for the Manhattan Bridge were authorised in 1898, and its total cost will be about 25,000,000 dols. It is 6855 ft. long over all, including 2505 ft. of steel approach - viaducts, and is 2920 ft. long between anchorages. The general arrangement of the main span is well shown in Figs. 1 and 2, annexed. The suspended spans are 725 ft., 1470 ft., and 725 ft. long respectively. They have a maximum clearance of 135 ft. above mean high water, and are 120 ft. wide over all. They have four lines of stiffening trusses, 24 ft. deep, suspended from cables 21¼ in. in diameter and about 3223 ft. long, supported on steel towers at a height of about 315 ft. above mean high water. The suspended superstructure is built of medium open-hearth steel and nickel steel, and is proportioned for regular and congested loads of 8000 lb. and 16,000 lb. per linear foot respectively. The viaducts are built of medium open-hearth steel, and are proportioned for a regular working load of 18,800 lb. per linear foot. As shown in the cross-section of the bridge, Fig. 3, the eight railway tracks are arranged on two different levels.

The construction of the Manhattan Bridge, like that of the Queensborough Bridge, has progressed through several municipal administrations, which have divided responsibilities, delayed the work, and increased the cost. The dimensions and type of structure have been radically modified, and the system, originally designed as a wire cable structure, was changed to one with eye-bar cables and finally restored to the wire cable system. Great pains have been taken to secure harmonious proportions, pleasing outlines and artistic effect, and the structure has been modified by architectural treatment, especially of the sub-structure, to secure a graceful and monumental appearance, which is attained chiefly through massive proportions and graceful lines of the masonry, and by the accentuation of the main elements of the steel-work. A good general view of the bridge in its nearly completed condition is represented in Fig. 4, Plate XXVIII.; while Fig. 5, on the same plate, reproduced from a photograph taken along the central roadway, is also of much interest.

Fig. 1.

Fig. 2.

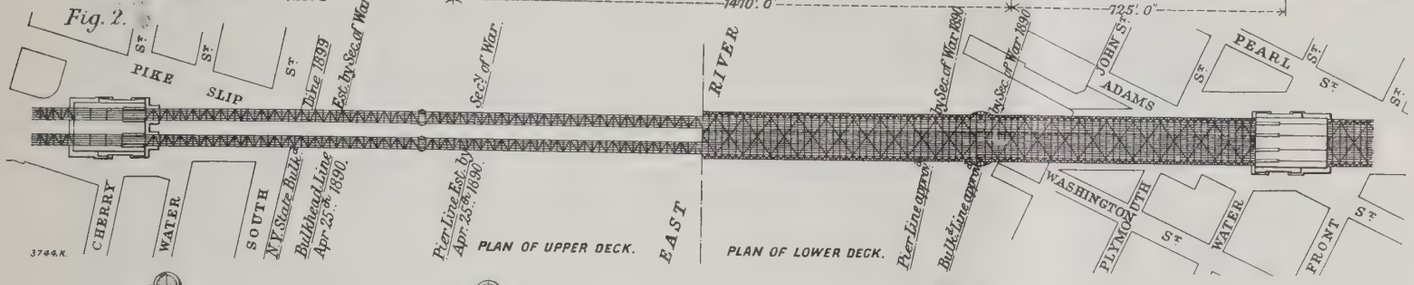
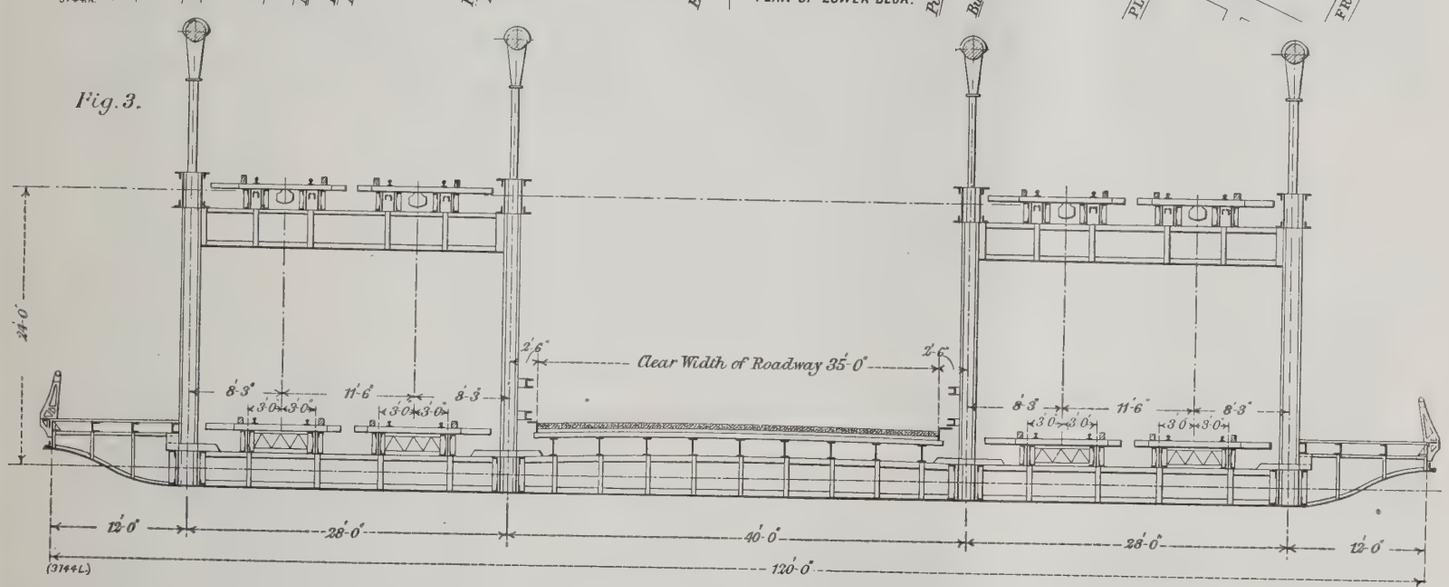


Fig. 3.



MAIN PIERS.

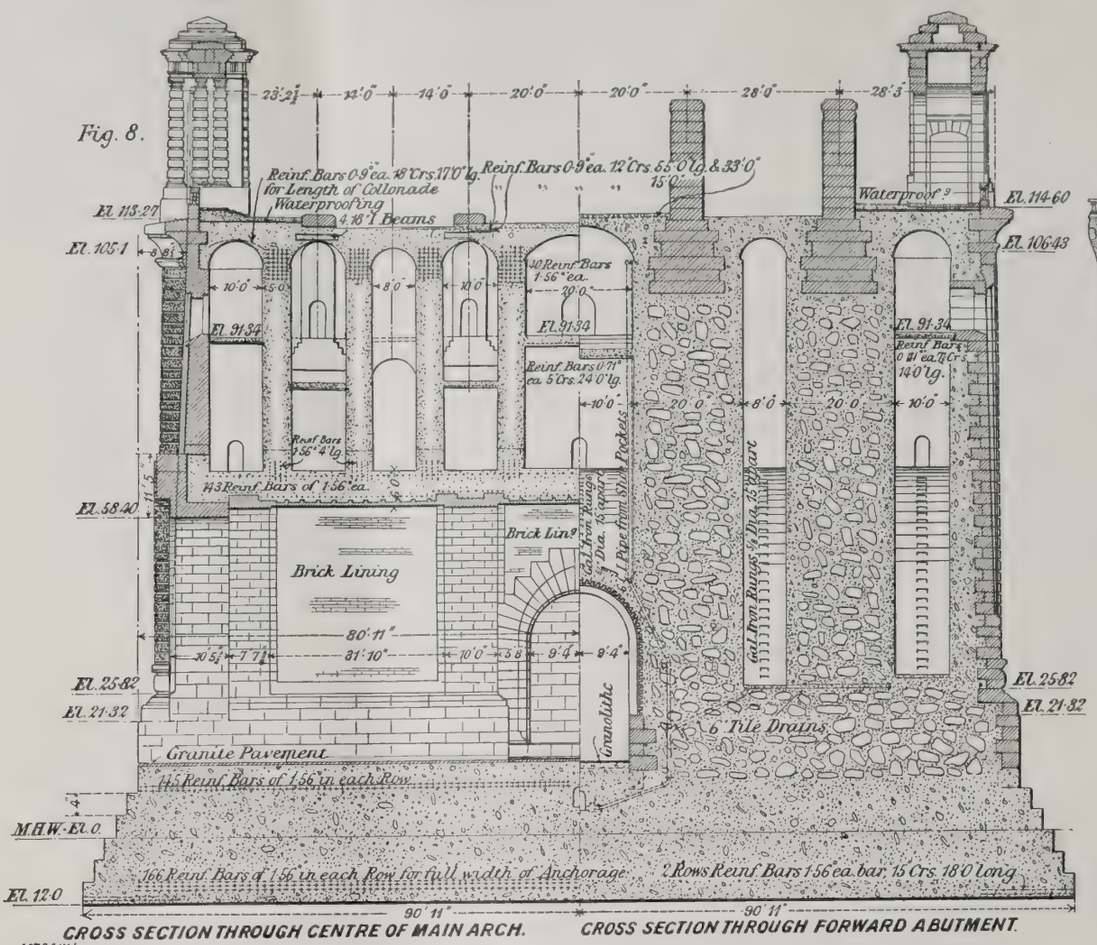
Anchorage Piers.—The anchorage piers serve both as enormous counterweights to secure the ends of the cables, and to carry the tracks and roadway, and are great rectangular masses of cyclopean concrete masonry faced with cut granite. Their construction is shown in detail in Figs. 6 and 7, Plate XXIX., and Figs. 8 to 12, page 380. Figs. 11 and 12 give a good idea of their architectural features. Their imposing bulk is relieved by panels, arches, and heavy top and bottom moulded courses, and each is pierced transverse to the bridge axis by a full centred arch opening of 46 ft. span, through which a city street passes. The arch ring is of concrete, varies from about 5 ft. in radial thickness at the crown to 15 ft. at the skewback, and is reinforced by steel bars near the inner and outer surfaces. The intrados is faced with cut stone toothed into the concrete. Above the arch there are a number of large hollow spaces, which greatly reduce the volume of masonry and afford large rooms and halls available for public purposes, storage, &c. Interior walls bond the different portions of masonry together, and support the steel girders which carry the bridge floors overhead.

The anchorages are about 2890 ft. apart, in the clear, at the top, and are 182 ft. wide and 237 ft. long, parallel to the bridge axis, at the bottom of the footing, which, in Manhattan, is 20 ft. below the surface of the ground, and about 142 ft. below the main top of the pier, at roadway level. Above this there rise four secondary piers for the support of the main cables, nearly 24 ft. higher. The river faces of the piers are battered nearly 1 : 2, and the other faces are nearly vertical. The piers have pile foundations, immediately above which the concrete footings are reinforced, under the archway, where cyclopean stone is omitted, by 145 reinforcing-bars (see Fig. 8) of 1.56 sq. in. section. The total weight of the pier is 463,906,000 lb., which imposes a unit pressure of 6.9 tons per sq. ft. on the earth and piles, and resists a maximum assumed up-lift of 40,000,000 lb. Each cable rests on a cast-steel anchorage shoe, on the shore side of which the strands are separated, and pin-connected to an eye-bar chain (shown in Fig. 7, Plate XXIX.) about 140 ft. long, inclined about 45 deg., and lying in the vertical plane of the cable. In each of these anchor-chains there are 144 "two-strand" chains, as illustrated in Fig. 13, Plate XXX., and eight "one-strand" chains, as represented in Fig. 14, Plate XXX. Each anchor-chain is proportioned for a maximum stress of 15,000,000 lb., and anchors the cable to the plate-girder reaction platform at right angles to it, built into the solid masonry across the lower rear side of the pier. Each cable-strand is anchored by two or three lines of 9-in. by $1\frac{7}{16}$-in. eye-bars (see Figs. 15 to 18), arranged in eight one-strand set and 144 two-strand sets.

The upper ends of the anchor eye-bar chains are shown in Figs. 19 to 22, which show plans and end views of the arrangement. They are connected by 7-in. pins, just long enough to engage the four bars of a set, but the sets are arranged in groups of four and eight, connected by 2-in. bolts passing through the bored axes of the pins, and securing them together at the same time that they are flexible enough to bend and conform without injury to the horizontally curved alignment. The distance-pieces between the links are shown in Figs. 23 and 24. The lower ends of

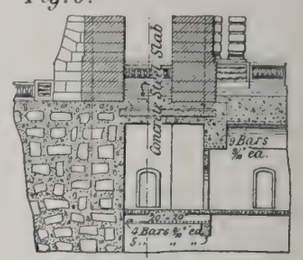
THE MANHATTAN BRIDGE ACROSS THE EAST RIVER, N.Y., U.S.A.

Fig. 8.


Reinf. Bars 0·9" ea. 18 Crs 17'0" lg.
Reinf. Bars 0·9" ea. 12 Crs. 55 0 lg. & 33'0"
for Length of Colonade
Waterproofing
4 16" I Beams
Waterproof
El. 118·27
El. 105·1
El. 114·60
El. 106·43
30 Reinf. Bars 1·56" ea.
Reinf. Bars 0·71" ea. 5 Crs. 24'0" lg.
Reinf. Bars 0·71" ea. 76 Crs. 14'0" lg.
El. 91·34
Reinf. Bars 1·56" 4'lg.
113 Reinf. Bars of 1·56" ea.
El. 58·40
Brick Lining
Cast Iron Rings 4 Dia. 15 apart
1 Pipe from Shaft
Pockets
Granolithic
6 Tile Drains
El. 25·82
El. 21·32
Granite Pavement
113 Reinf. Bars of 1·56" in each Row
M.H.W. El. 0
166 Reinf. Bars of 1·56" in each Row for full width of Anchorage
2 Rows Reinf. Bars 1·56 ea. bar, 15 Crs. 18'0 long
El. 12·0
90'11"
90'11"

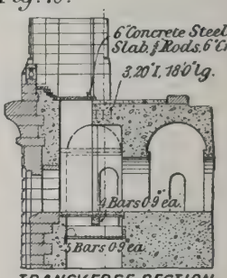
CROSS SECTION THROUGH CENTRE OF MAIN ARCH. CROSS SECTION THROUGH FORWARD ABUTMENT.

Fig. 9.



LONGITUDINAL SECTION THRO' REAR PAVILLION.

Fig. 10.



TRANSVERSE SECTION THRO' REAR PAVILLION.

(3744 W.)

Fig. 11.

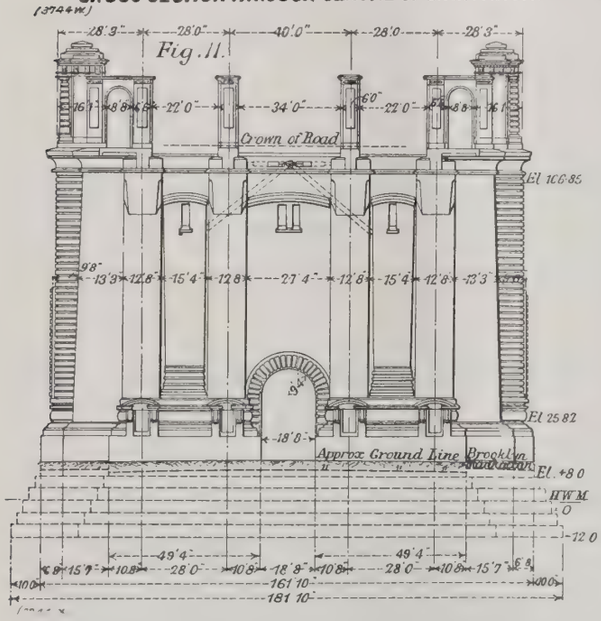
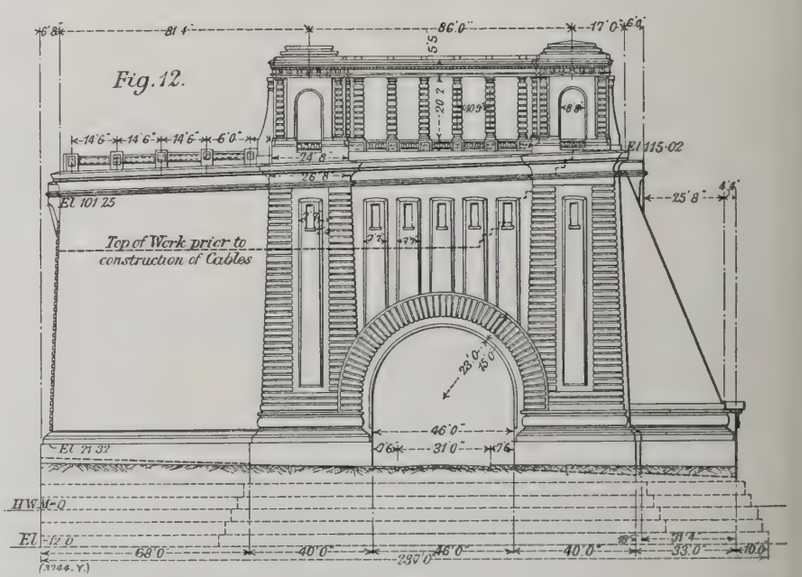


Fig. 12.



(3744. Y.)

the sets have 8-in. pin connections to the webs of pairs of reaction plate-girders, of which there are 72 in all. These are 4 ft. deep and 25 ft. long, and are illustrated in Figs. 15 to 18, Plate XXX.

Just below the main anchor-chains there are, as will be seen on reference to Fig. 6, Plate XXIX., similar, but very much smaller, chains, which, although permanently enclosed in the masonry, were only temporarily used to secure the cables supporting the erection-platform, from which the main cables were constructed. These eye-bars engage short transverse girders bearing on sets of four horizontal reaction I-beams, 13 ft. long, shown in Figs. 33 to 35, Plate XXX.

Near the front of the abutment (see Fig. 7) are the anchorages designed to take the positive and negative reactions from the stiffening trusses. These are illustrated in Figs. 27 to 31, Plate XXX. These anchorages have been made with riveted vertical posts, pin-connected to spread eye-bars, engaging pairs of 3-ft. by 18-ft. horizontal reaction plate-girders, 22 in. apart (see Figs. 30 and 31). Wind anchorages are provided on each anchorage pier by a triangular panel of horizontal web-plate girders (Figs. 32 and 36 to 40), one of them transverse to the bridge axis, and the other two riveted at their intersection to a connection-plate, with a bronze bearing for a large vertical pin receiving the wind stresses (see Figs. 36, 38, and 39). The girders are solidly embedded in the masonry, to which they are additionally bonded by two horizontal, longitudinal, open-web riveted struts, 26 ft. long, at the extremities of the transverse girder, and by two inclined transverse struts (Fig. 32) riveted to the centre of the transverse girder, as indicated in Fig. 40. The principal quantities involved in one anchorage pier are 38,800 yards of excavation, 109,000 linear feet of piles, 57,675 yards of cyclopean concrete, 42,260 yards of other concrete, 14,200 yards of granite, and 2,697,000 pounds of steel. The cost of each anchorage pier was about 1,200,000 dols.

Pier Construction.

The Brooklyn Anchorage Pier.—The site was excavated by pick and shovel and an orange-peel bucket, and the sides retained by wooden sheet piles, which, with the foundation piles, were driven by electrically-operated hammers. All materials were unloaded from boats at the contractor's pier, which was connected to the site by

THE MANHATTAN BRIDGE ACROSS THE EAST RIVER, N.Y., U.S.A.

(*For Description, see Page* 378)

Fig. 4. General View of the Bridge.

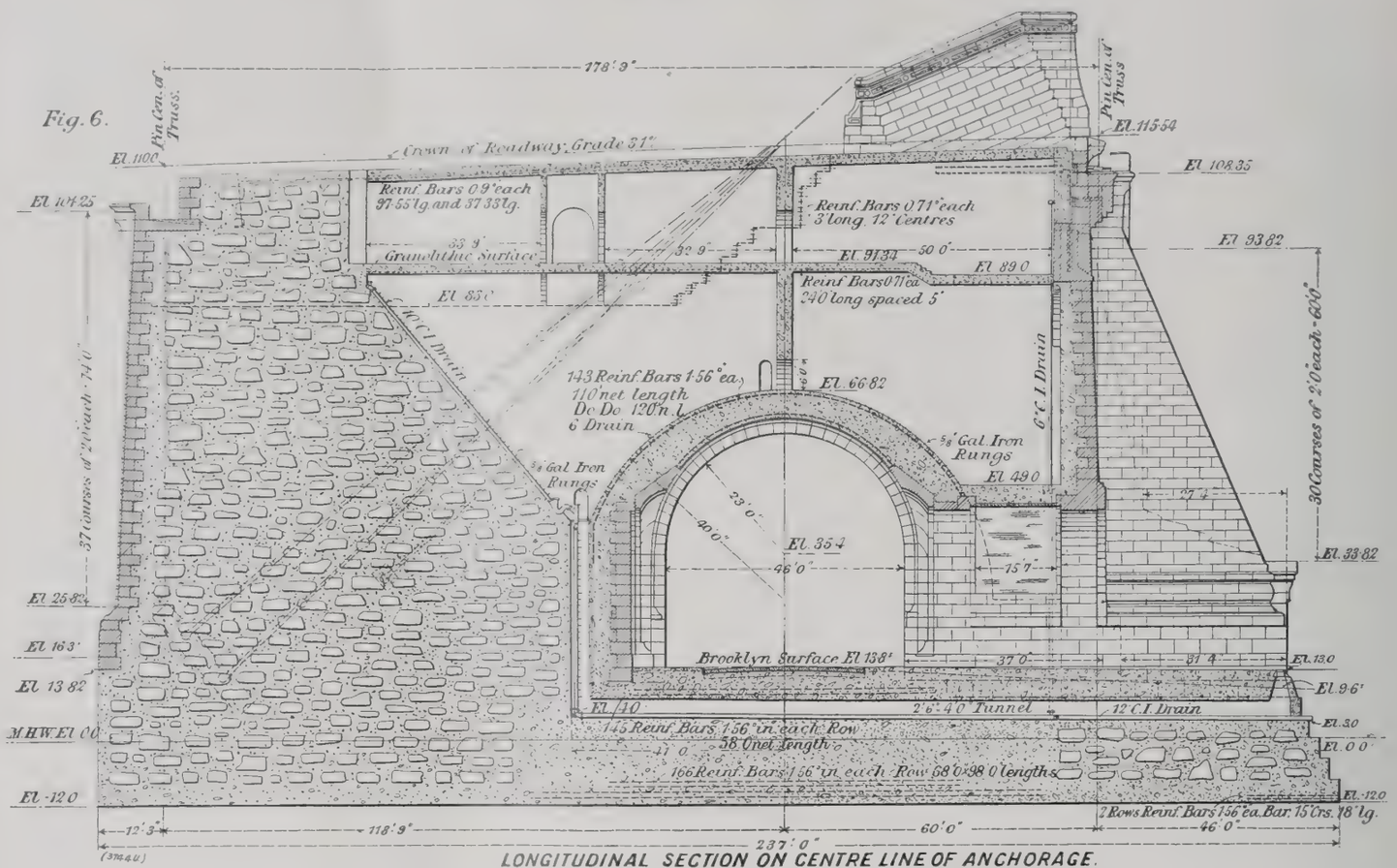
Fig. 5. View Looking along the Central Roadway.

(*To Face Page* 380)

THE MANHATTAN BRIDGE ACROSS THE EAST RIVER, N.Y., U.S.A.

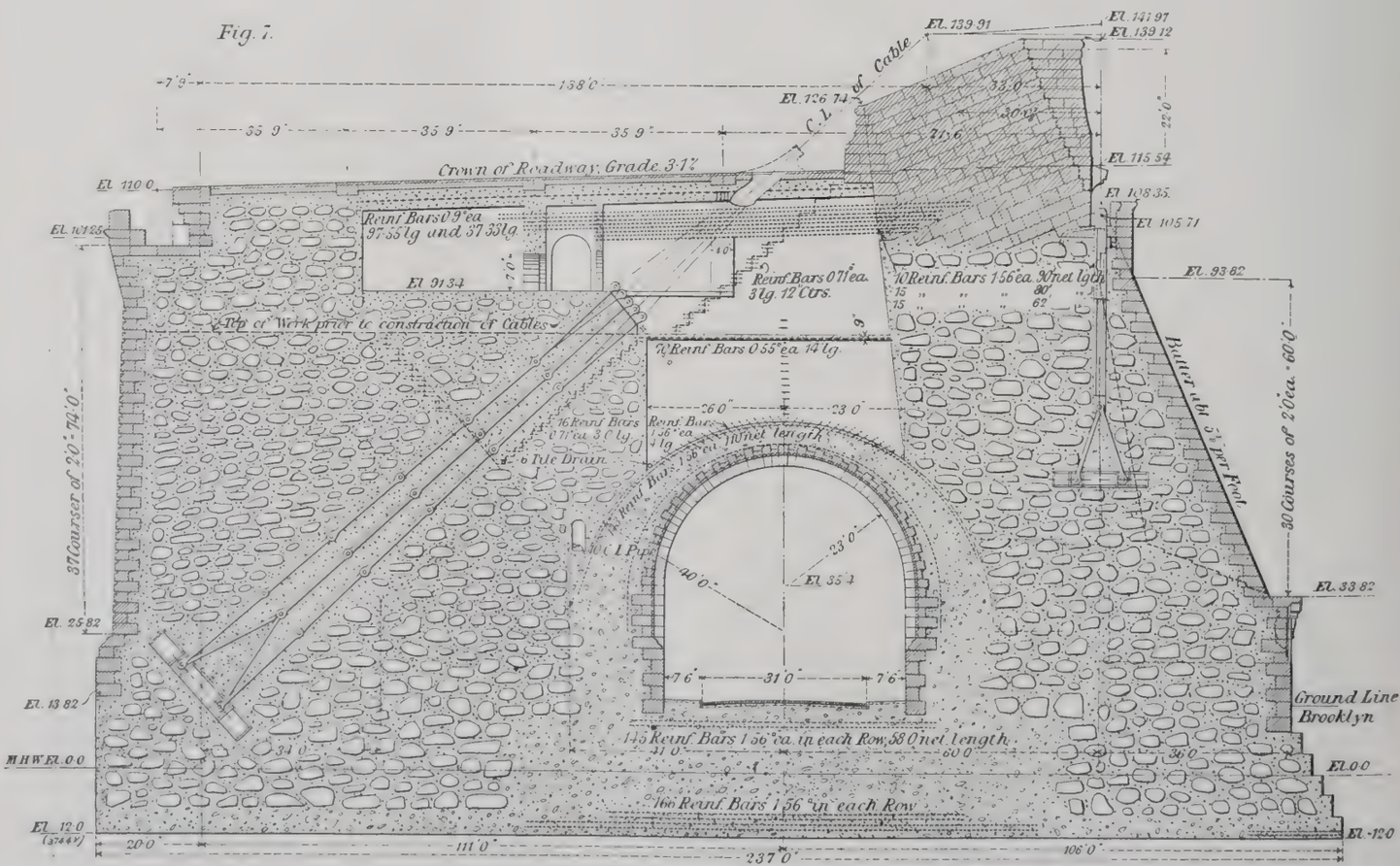
(For Description, see Page 378.)

Fig. 6.



LONGITUDINAL SECTION ON CENTRE LINE OF ANCHORAGE.

Fig. 7.



LONGITUDINAL SECTION THRO' INNER BUTTRESS.

THE MANHATTAN BRIDGE OVE

(For Descript

64 Chains with 2 5/16 Collars 8 " " No "
8" Pin
7" Pin Grip 23 3/16
3" Collar
4 1/2" Collar
4-Bars 9"x1 3/16"x21'0"
4-Bars 9"x1 7/16"x17'0"
7" Pin Grip 19 5/16
7" Pin Grip 16 5/16
1" Collar
1 1/2" Collar
Special Nut Screw 3 1/4" dia. 1 5/8" lg. Nut 1 1/2" High
7" Pin Grip 14 1/2"
64 Chains with Special Nut 8 " " Std. "
7" Pin Grip 12 1/2"
64 Chains 3" Hole in Pin 8 " " Std. Nut
7" Pin Grip 8"
2 Pins for each Chain
For Strand Shoe
64 Chains 4-Bars 9"x1 7/16"x21'0" 8 " 4 " 9"x1 7/16"x21'6"
64 Chains with 2 3/16 Collars 8 " " No "
7" Pin Grip 8 1/4"
4-Bars 7"x1 3/16"x21'10"
2-Bars 9"x1 3/16"x17'0"
2-Bars 9"x1 7/16"x17'0"
1 1/16" Collar
2-Strand Anchor Chain 144 Wanted
7" Pin 8" Grip
1-Strand Anchor Chain 8 Wanted
2-Bars 9"x1 3/16"x21'6"

Fig. 13.

Fig. 14.

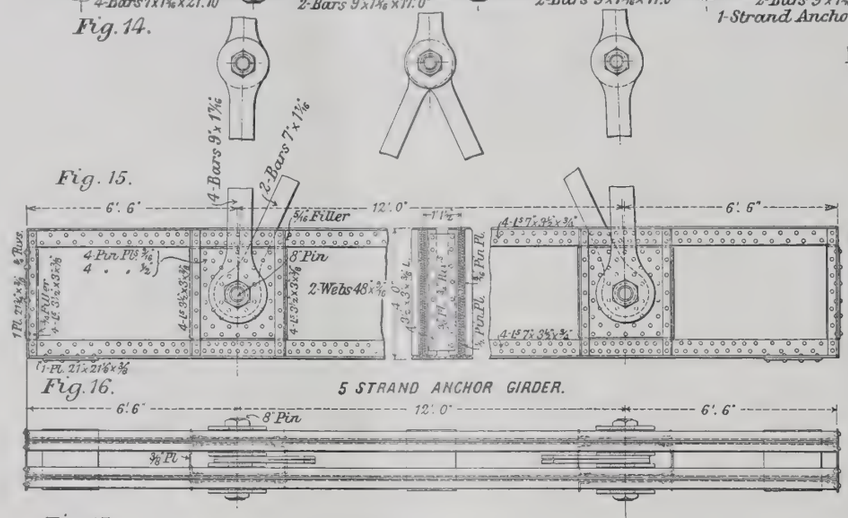


Fig. 15.

Fig. 16. 5 STRAND ANCHOR GIRDER.

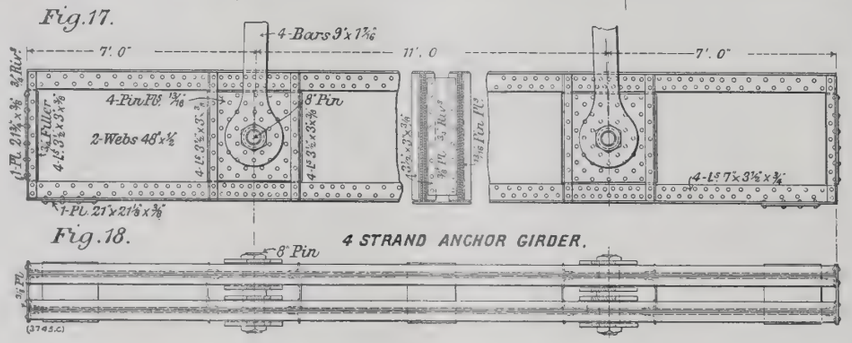


Fig. 17.

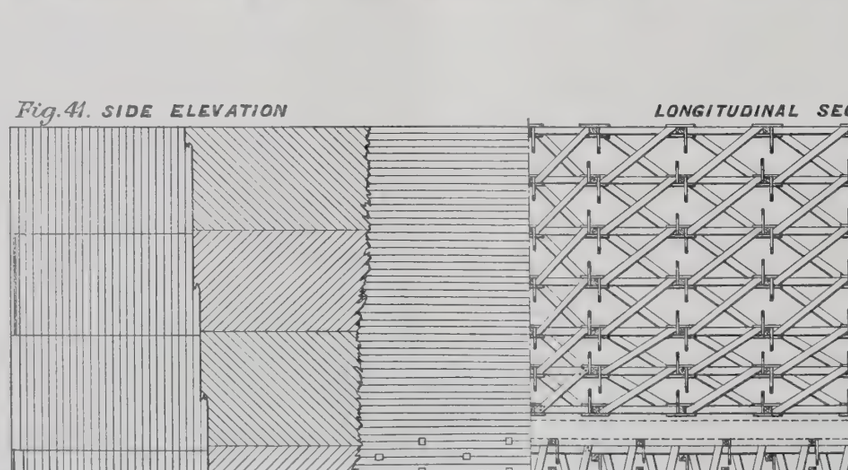


Fig. 18. 4 STRAND ANCHOR GIRDER.

Fig. 19. 4 STRAND GROUP.

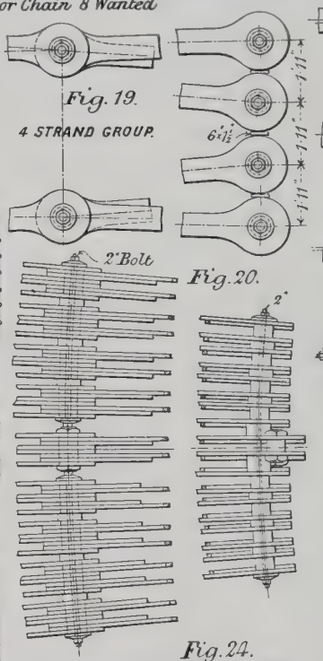
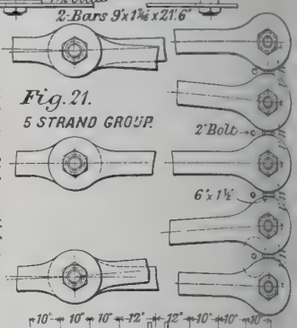


Fig. 20.

Fig. 21. 5 STRAND GROUP.



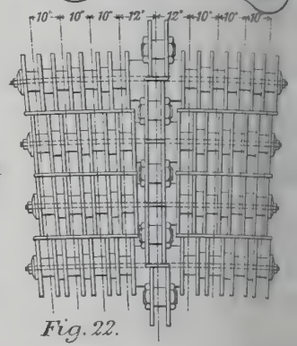


Fig. 22.

Fig. 23.

Fig. 24. SEPARATORS

Fig. 25.

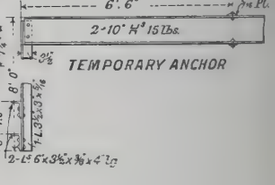
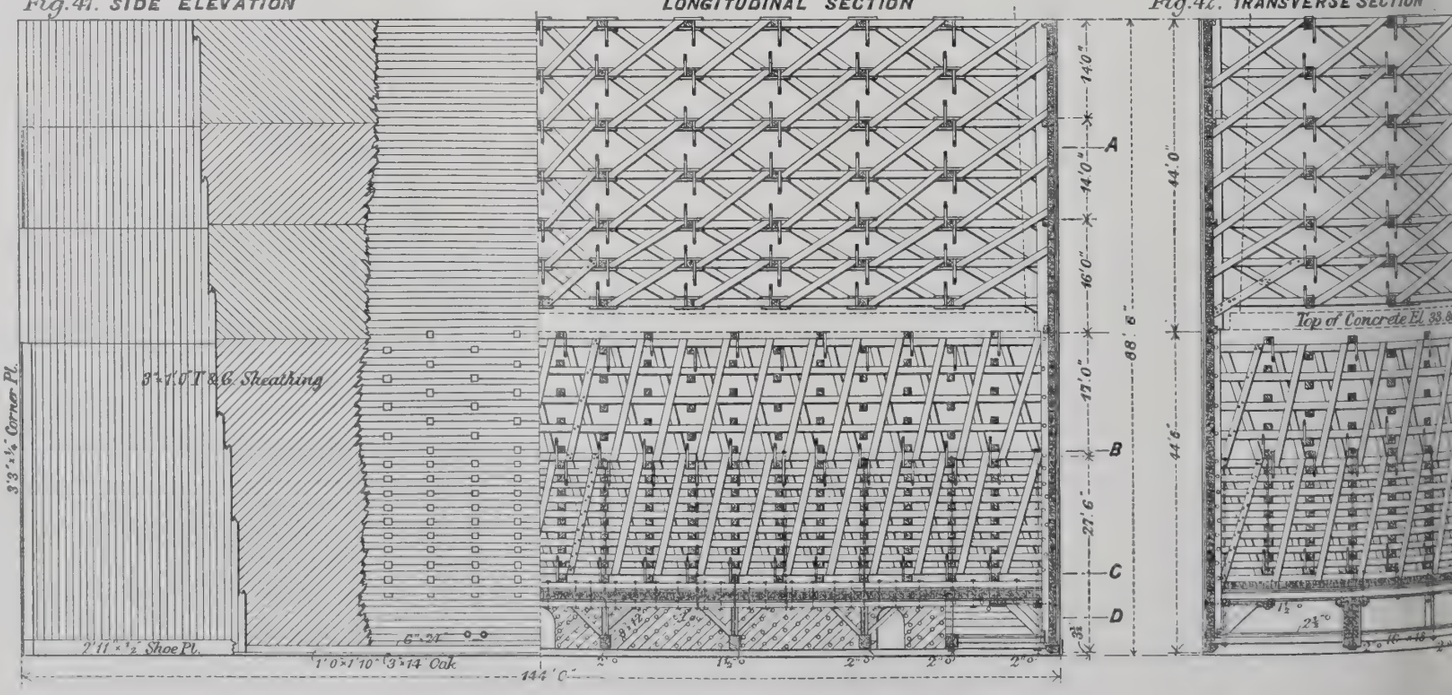


Fig. 26.

Fig. 41. SIDE ELEVATION

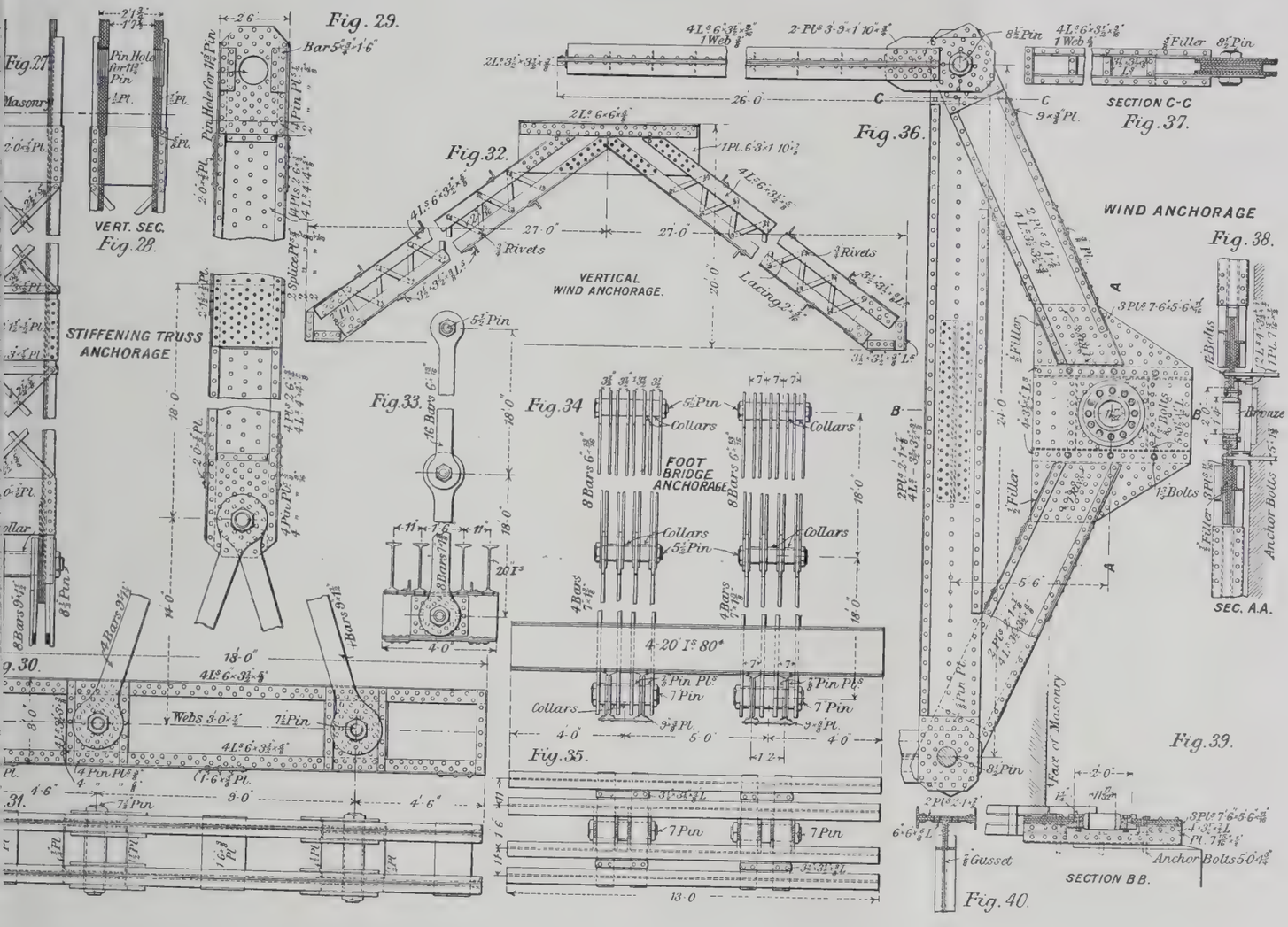
LONGITUDINAL SECTION

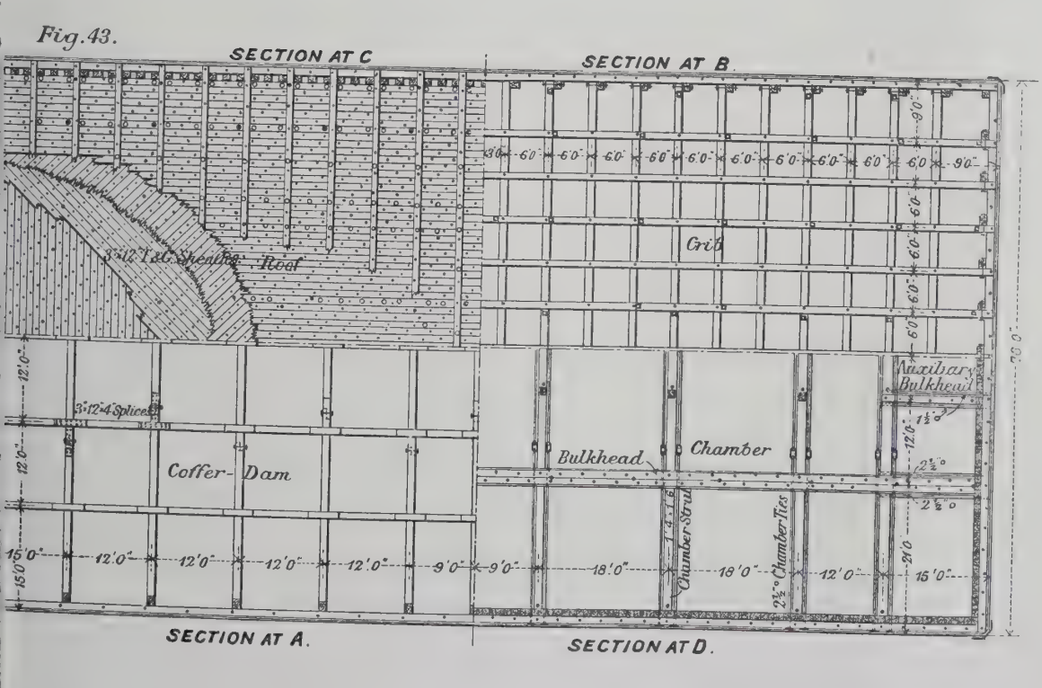
Fig. 42. TRANSVERSE SECTION

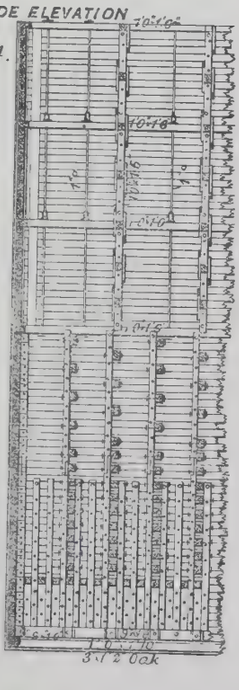


HE EAST RIVER AT NEW YORK.

(378.)







BORING-MILL FOR THE BROOKLYN NAVY YARD, U.S.A.

CONSTRUCTED BY THE NILES-BEMENT-POND COMPANY, AT THEIR NILES WORKS, HAMILTON, OHIO.

(*For Description, see Page* 381.)

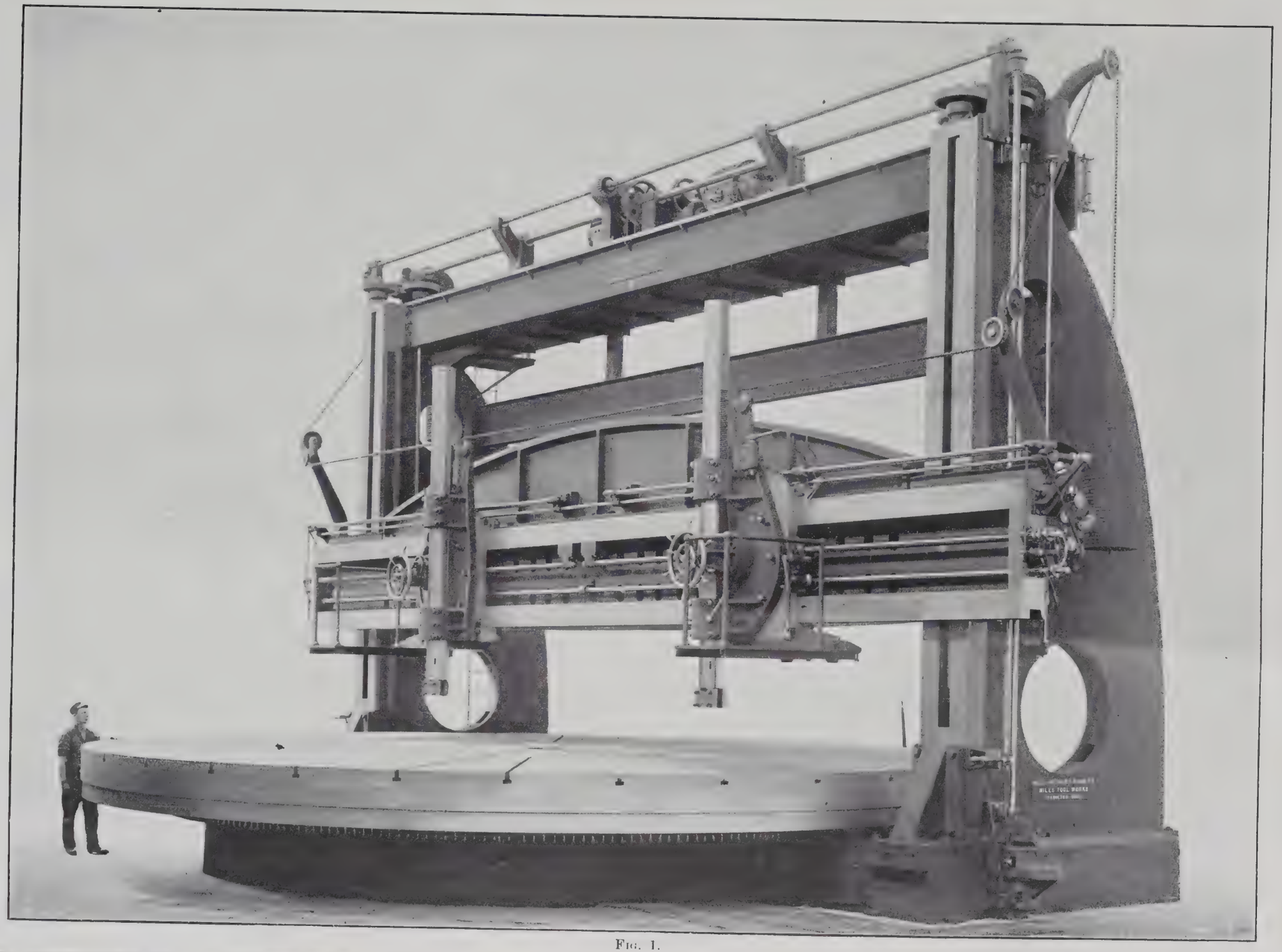


FIG. 1.

BORING-MILL FOR THE BROOKLYN NAVY YARD, U.S.A.

CONSTRUCTED BY THE NILES-BEMENT-POND COMPANY, AT THEIR NILES WORKS, HAMILTON, OHIO.

(*For Description, see Page* 381.)

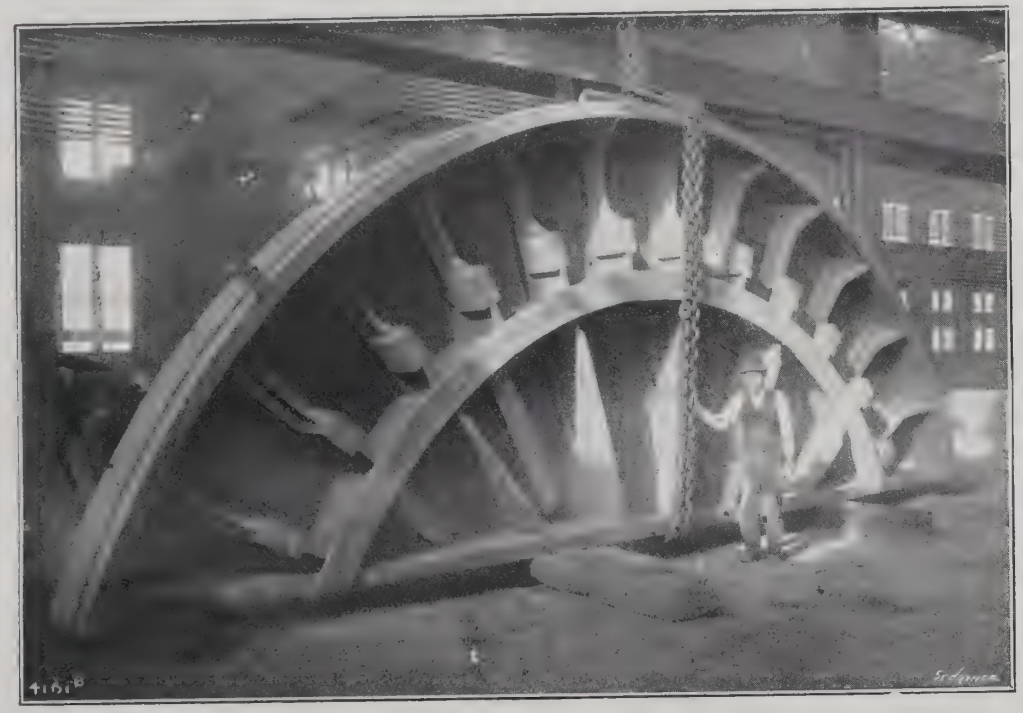


FIG. 2. SIDE SECTION OF TABLE, SHOWING UNDER SIDE; WEIGHT, 70,000 LB.

FIG. 4. HALF OF THE BED; WEIGHT, 69,000 LB.

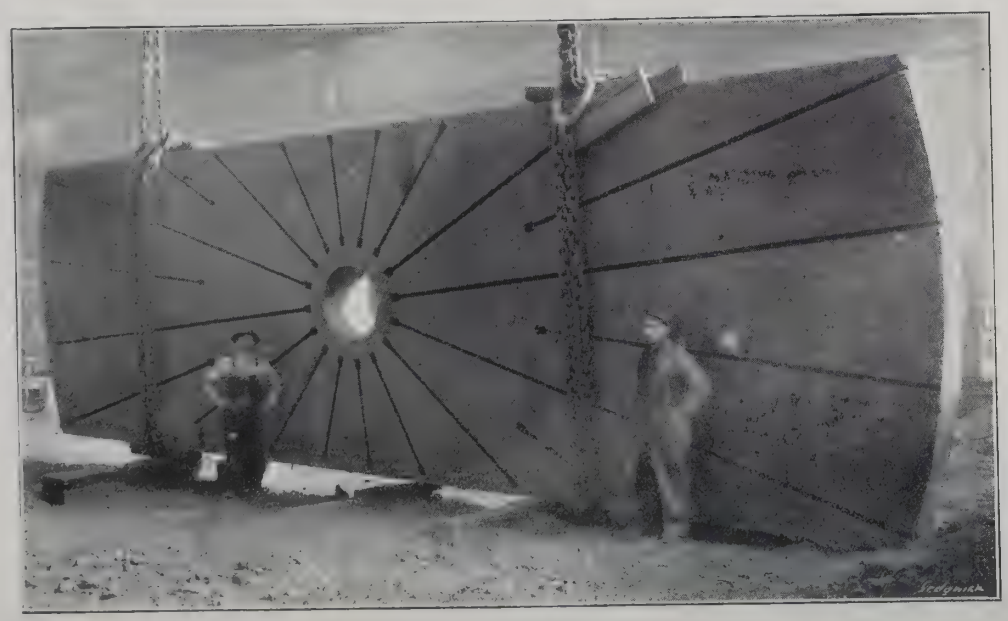


FIG. 3. CENTRAL SECTION OF TABLE SHOWING UPPER SIDE; WEIGHT, 83,000 LB.

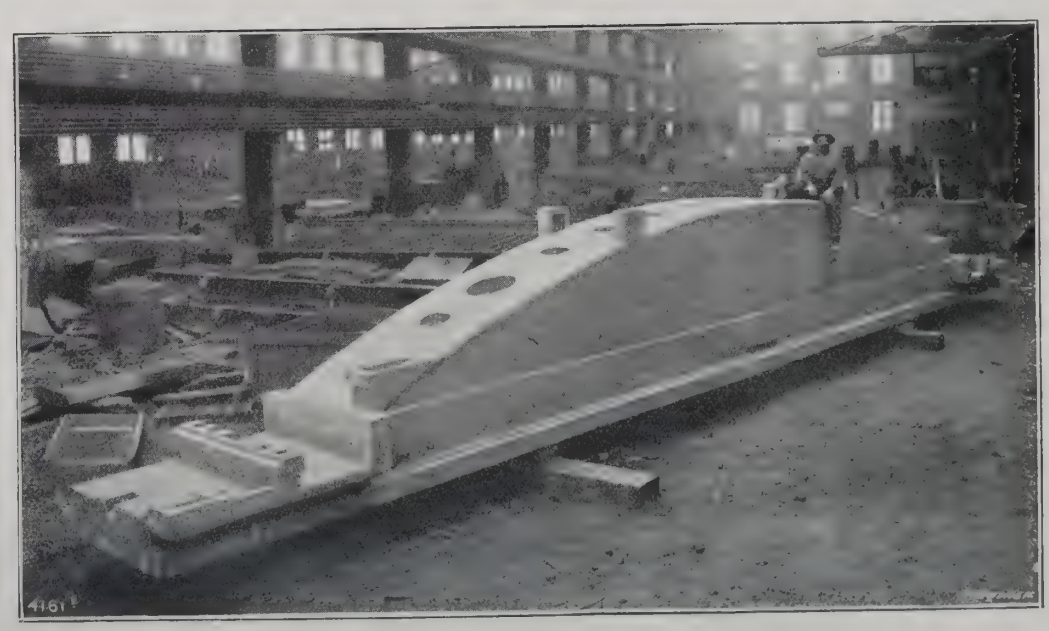


FIG. 5. THE CROSS RAIL; WEIGHT, 85,000 LB.

a 36-in. gauge trestle railroad, carried over the intersecting street and around three sides of the pier, and commanded by derricks.

Broken stone and sand were unloaded from barges by a travelling derrick operating a clam-shell bucket, which emptied into a movable hopper with a shaking device regulating its continuous discharge to a belt conveyor. The belt delivered to a bucket-elevator, by which the materials were raised to two hopper-bottom storage-bins of 180 cubic yards capacity, 80 ft. above water-level. Cement was delivered adjacent to the bins by a derrick, and with the sand and stone was charged to a gravity concrete-mixing machine, with a capacity of 600 cubic yards in ten hours.

The concrete, in 2-yard bottom-dump steel buckets, was taken on small, flat cars on the 36-in. track to the pier, where it was handled by two travellers, each having a 28-ft. by 50-ft. rolling timber platform with a 60-ft. 10-ton derrick boom at each corner. The travellers were at first installed, at grade, on falsework. After the masonry was built up 10 ft. above the traveller track on one-half of the pier, the traveller was jacked up on cribwork to the top and built 10 ft. more, and so on for both travellers. Each traveller and equipment weighed about 800 tons and was out of service three days each time it was raised. The concrete was laid at the rate of from 100 to 400 cubic yards in eight hours by an average force of about 100 men. All the contractors' plant and machinery were operated by motors with a 220-volt electric current. The great arch was built on 5¾-in. by 7-in. lagging on wooden trusses, 45 ft. long, 10 ft. deep, and 5 ft. apart on centres. The timber was assumed to have a modulus of elasticity of 1,200,000 lb. and a maximum tensile strength of 9000 lb. per square inch with the grain. It was proportioned for 1000 lb. extreme fibre stress in transverse strain, and 1200 lb. in compression on end bearing.

Manhattan Anchorage Pier.—The excavation, about 22 ft. deep, was made by pick and shovel and by 1½-yard orange-peel and clam-shell buckets operated by five derricks with 16-ton 90-ft. booms, installed on towers outside the pit and located to command its entire area. The spoil was delivered at a maximum rate of 800 cubic yards in ten hours, to 2½-yard side-dump cars running on a double-track, standard gauge trestle railroad enclosing three sides of the pier and extending about 1000 ft. parallel with the bridge axis to and across the top of the tower pier, where the spoil was delivered to dump-scows. The wooden trestle had a maximum height of 35 ft. and crossed the street on lattice-girder steel spans. Much of the space under it was utilised for storage-bins for coal, broken stone, sand and concrete dumped through the trestle. The tracks were graded 3 per cent. both ways from a summit at the river end of the pier, and the cars were operated in trains of three by a steel cable for each track which pulled them in each direction to the summit, the trips down grade being made by gravity. The pit was enclosed by splined 12-in. sheet piles driven by a steam-hammer and water jet, and the foundation piles were driven by steam-hammers and by 3500-lb. drop-hammers in 45-ft. leads. The excavation, although 12 ft. below water-level, was easily kept dry by an 8-in. centrifugal pump which delivered a maximum amount of 2500 gallons per minute.

Coal, broken stone, and sand were delivered by barges and unloaded by a 1½-yard clam-shell bucket operated by the 60-ft. boom of a derrick installed on the tower pier. The bucket dumped into a hopper delivering to a conveyor belt 24 in. wide and 1000 ft. long on centres, said to be the longest ever installed, which was carried on the trestle under the tracks to the anchorage pier and served the storage-bins. Coal was delivered at the rate of 30 tons per hour, and cement in bags was also sometimes delivered by the belt-conveyor, but more often by cars on the trestle track at the rate of 350 bags per hour to the 18,000-bag storage-house near the mixing plant.

The stone and sand-bins, of 700 and 525 yards capacity respectively, discharged through bottom gates into 60-cub.-ft. steel measuring dump-cars running on surface tracks which delivered their contents to a charging-car of 94 cub. ft. capacity, hauled up an incline by a hoisting-engine and steel cable, and dumping automatically into the hopper of a cubical 3-yard concrete-mixer revolved 10 to 15 times for each batch. The concrete-mixer was operated continuously and supplied about 50 yards per hour to 63-ft. bottom-dump steel buckets which were delivered by narrow-gauge cars running on elevated service tracks to derricks commanding the whole pier, and finally placed by booms erected on steel towers permanently built into the masonry. All machinery was operated by steam provided by the pile-driver boilers and by a central battery of four 100-horse-power boilers, and distributed through about 1600 ft. of asbestos-covered pipe ranging from 2½ in. up to 5 in. in diameter. The work was done by an average force of 100 men, increased to 200 during excavation.

The Tower Piers.—The 68-ft. by 136-ft. Brooklyn Pier is about 67 ft. high to the tops of the pedestals, 31.5 ft. above high water, and is made of limestone masonry faced with granite. Between the two centre pedestals it has a vertical well covered by concrete arches, above which, in the top of the pier, there are two longitudinal and four transverse sets of 15-in. I-beams on the centre lines of the tower columns, embedded in concrete, to reinforce the pier against cracks from load and temperature stresses.

The pier is seated on a wooden pneumatic caisson, very similar to that used for the Manhattan Pier, which is illustrated in Figs. 41 to 44, Plate XXX. This, with its permanent cofferdam, was 78 ft. wide, 144 ft. long, and about 56 ft. high, and was sunk through mud, sand, clay, and gravel to rock at a depth of about 92 ft. below mean high tide. It was built chiefly of 12-in. by 12-in. pine and oak timber and 3-in. by 12-in. planks, with a cutting-edge shod by an 11-in. by 24-in. by ½-in. angle-plate.

The working-chamber, 7¼ ft. high, was braced by horizontal transverse struts and tie-rods, and knee-braces, 18 ft. apart, and by a solid longitudinal centre bulkhead wall, 24 in. thick. The walls and roof were made with two solid courses of 12-in. by 12-in. timber, and three courses of sheathing-planks, caulked. Above the deck the walls were braced by longitudinal and transverse horizontal timbers, 6 ft. apart horizontally, and from 2 ft. to 4 ft. apart vertically. Timbers inclined in opposite directions were bolted to the braces in vertical planes, thus virtually making trusses, which gave great stiffness to the caisson.

The walls of the caisson were extended 44 ft. by a sectional temporary cofferdam of similar but lighter construction, and the upper section was detachably connected to the lower section by overlapping vertical bars with hooks locked together by tapered keys, which were disengaged, permitting the sides to separate and be removed after the pier construction was finished. The caisson was built on pontoons to a height of 27½ ft., and launched, then extended to a height of about 44 ft., floated to the site, completed, and sunk by depositing concrete on its deck. With the pier, it contains about 19,000 yards of concrete, 15,370 yards of stone masonry, 260 tons of iron and steel, and 188,000 cub. ft. of timber. When launched, it weighed about 2534 tons, and drew 13 ft. of water without a false bottom.

The Manhattan Pier.—Its caisson (Figs. 41 to 44) corresponds, as stated, very closely to the Brooklyn caisson, and was built several miles from the bridge site, on a temporary float which amounted to an 84 ft. by 150 ft. false bottom with vertical sides, 8 ft. high, and a full-length longitudinal joint. After the caisson was built up to the limit of height of the derricks, the float joint was unlocked, large quantities of sand were dumped on the floor of the float, tending to disengage it from the caisson, and the halves of the float were pulled out from under the caisson by powerful tugs, aided by long levers. The caisson then sunk low enough to be completed by the shore derricks, and, while being towed to position, was swept past by the tide, and returned without injury when the tide changed.

At the site the caisson was protected by an enclosing wall of temporary piles, moored against the strong tides, and sunk by 5000 yards of concrete to the bottom of the dredged pit, 40 ft. deep. The caisson was sunk 92 ft., and rested, like the Brooklyn one, at about the same depth, on a satisfactory dense stratum of sand and gravel. It required about 22,000 yards of total excavation, most of the material being blown out by the wet process with a water-jet at 100 lb. pressure through seven 4-in. and 5-in. vertical blow-out pipes with U bends above water-level. The cast-iron U's, 2 in. thick, were quickly cut through by the sand. The most rapid sinking was 7 ft. in six 24-hour days; the maximum pneumatic pressure was 44 lb., in which the men worked two 1½-hour shifts. There were several cases of "bends," and four deaths from paralysis. The concrete was mixed in a gravity machine, and was delivered through three special air-locks, each of them a 36-in. steel cylinder 8 ft. long, with horizontal hinged top and bottom doors, both, of course, opening downwards. When the upper door was open the lower door was held closed, and the load of a 1-yard charge of concrete deposited on it was supported by the interior pressure. When the upper door was closed and pressure admitted to the lock, the lower door automatically opened and dumped the concrete, and was immediately pulled up and closed by a hand-tackle operated from outside, and the operation was repeated, and so on, requiring only about one minute for each charge. The New York caisson and pier were completed in one year by a maximum force of 350 men, and cost 485,000 dols. The Brooklyn caisson and pier cost 470,000 dols.

(*To be continued.*)

BORING-MILL FOR THE BROOKLYN NAVY YARD, U.S.A.

AN exceptionally large boring-mill has recently been completed at the Brooklyn Navy Yard, U.S.A. The machine, which is the largest of its class in America, has been built by the Niles-Bement-Pond Company at their Niles Works, Hamilton, Ohio. It is illustrated in Figs. 1 to 5, on Plates XXXI. and XXXII., with this week's issue of ENGINEERING. Fig. 1, Plate XXXI., shows a general view of the complete machine. It has a swing of no less than 36 ft., with a length of 12 ft. under tools. The machine is designed for finishing the tracks of 14-in. and 16-in. gun-turrets for battleships. It is also to be employed for boring cylinders and machining turbine casings.

The machine is of the regular cross-rail type, and is not in any sense an "extension" machine. The actual swing is 36 ft. 2 in., and an idea of its massiveness may be obtained from the fact that it weighs, net, including motors, no less than 665,000 lb. (nearly 297 tons). The table is designed to carry a load of 200,000 lb. (nearly 90 tons). It is 34 ft. in diameter, and had to be cast in three sections. One of the side sections is illustrated in Fig. 2, Plate XXXII., and the central section is shown in Fig. 3. The three sections together weigh over 100 tons. The table is supported on conical rollers running on a 24-ft. circular track sunk in the bed. The rollers are of high carbon steel, and are fitted with guide-frames to secure proper alignment. There is, further, an annular bearing-ring surrounding the central spindle. This is adjustable vertically by means of screws. The spindle is centred by an adjustable conical bush. The table tracks, which are rigidly supported by webs in the bed, and the spindle have forced lubrication, supplied by a pump driven by the main motor. The table is fitted with a spear gear 28 ft. in diameter. This is a casting of semi-steel, with teeth cut from the solid. It is driven by two forged-steel pinions placed on opposite sides of the mill.

The main part of the bed is made of two sections, of which one is illustrated in Fig. 4. There are, further, two extensions attached to the main bed. The bed weighed 69,000 lb., the extensions weighing 48,600 lb. The columns or housings are of box section, each one weighing in the rough 32,000 lb. They are connected at the top by a heavy cross-brace and by a steel girder. The cross-rail, shown in Fig. 5, is a box casting, about 46 ft. long. It weighed 85,000 lb. in the rough. On the upper side of the cross-rail is a heavy camber beam for the purpose of increasing stiffness and taking care of the sag due to the weight of the cross-rail itself and of the heads. The combined depth of the rail and beam is 8 ft.

The cross-rail is raised and lowered by a 30-horse-power motor placed on the cross-brace and driving four large elevating-screws fitted with bronze nuts. The cross-rail carries two heads for boring and turning. Either can be moved to the centre. They have graduated swivels, and can be set by worm-gearing to any angle on either side of the vertical up to 30 deg. The heads and bars have rapid power traverse and also hand movement for fine adjustments. Rapid traverse is effected by a 10-horse-power motor placed on the top brace. The control of the traverse and of engaging or disengaging the feed is effected from a platform attached to each head. The operating levers are interlocked, so that the rapid traverse cannot be thrown into gear for one head unless it is disengaged for the other. The feeds for the bars are eight in number and are operative whether the bars are set vertically or inclined. The feeds for each head are independent. Friction clutches are embodied in the feed mechanism, in order to prevent breaking the gears in the event of the bar or saddle meeting obstruction. The main drive is by a 75-horse-power motor, speeds being provided for boring, turning, and facing.

CUTTING-OFF TOOL FOR LATHES.

CONSTRUCTED BY THE MOTOGEAR ENGINEERING COMPANY, ENGINEERS, ILFORD HILL, ESSEX.

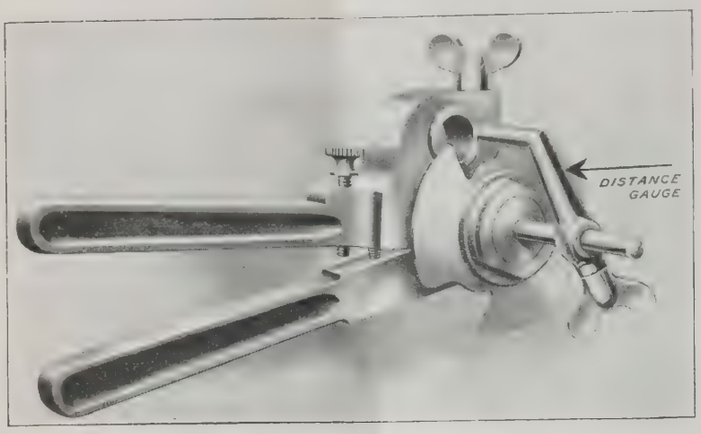


Fig. 1.

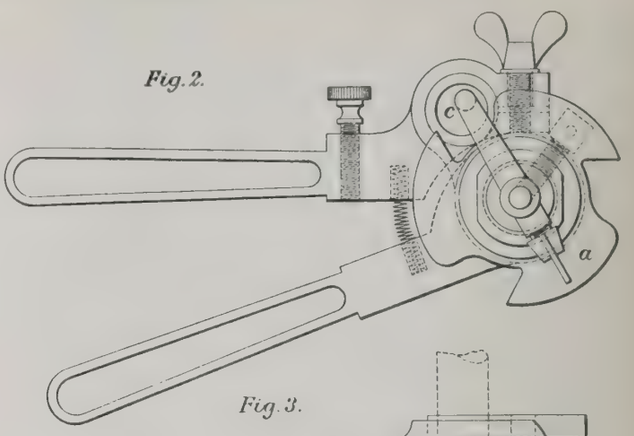


Fig. 2.

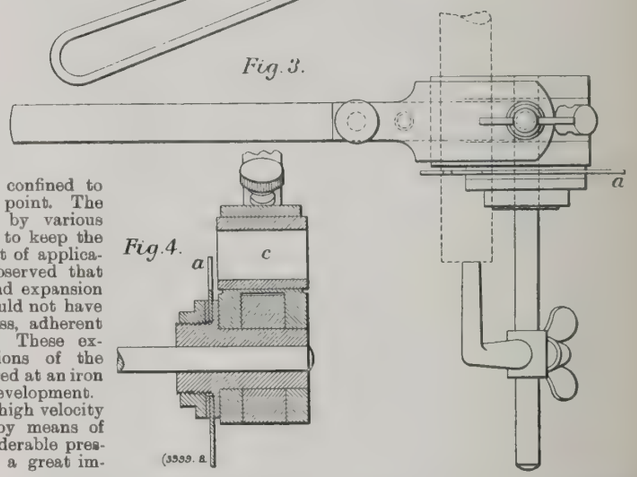


Fig. 3.

Fig. 4.

We illustrate on this page an exceedingly convenient cutting-off tool, devised and manufactured by the Motogear Engineering Company, of Brandon-grove, Ilford Hill, Essex. It is claimed that with this tool stock can be cut in an ordinary lathe as readily and as rapidly as in a regular capstan lathe. One special advantage possessed by the device is that it is unnecessary to change tools in the slide-rest, the tool being entirely self-contained. Its construction and use will be pretty clear on reference to Fig. 1, which shows the tool complete, and Figs. 2 to 4, which illustrate certain details of its design. It consists essentially of a couple of arms hinged together. Of these the lower rests on the lathe-bed, whilst the upper is provided with a hardened-steel bush, which fits over the stock to be cut, and supports it against the pressure of the cutting-tool, thus preventing the "digging in" which so often occurs when the usual cutting-off tool is used in an ordinary lathe. A series of these bushes, ranging in size from $\frac{1}{4}$ in. up to $\frac{3}{4}$ in. in internal diameter, accompany each tool. All have the same external diameter, and are interchangeable, being clamped in place by the wing-nut shown in Figs. 2 and 4, where the bush is indicated by the letter *c*. The cutter *a* is formed out of a disc of steel, and has three cutting edges, any one of which can be used at will. It can be ground, when necessary, as readily as an ordinary cutting-off tool. It is clamped in place by a nut, best seen in Fig. 1, and is concentric with the point about which the two lever-arms pivot. The radius of the disc from which this tool is formed is equal to the distance between the centre of the steady bush *c* and the centre about which the arms hinge, so that when these arms are closed together the cutting edge is fed radially into the stock. As will be seen, a helical spring, the ends of which fit in sockets formed in the lever-arms, tends to press these arms apart. In use the lower arm rests on the lathe-bed, and the upper arm is pressed down by hand against the resistance of the aforementioned spring, thus feeding the cutter into the stock. The depth of cut is controlled by the stop-screw with milled head, shown in Figs. 1 and 2. For repetition work in which it is desired to cut off a number of pieces to the same length a distance gauge is provided. This can be clamped by the wing-nut shown, and makes it easy to produce in succession any number of pieces of identically the same length.

METAL-SPRAYING.*

By R. K. Morcom.

The spraying of metals from the molten state, in order to produce a powder, is an old idea, and the spraying of a liquid to produce a covering of paint, varnish, or enamel is also well known. The subject of this paper is akin to them both, but has for its object the production of uniform metal deposits by means of a spraying process. The exact theory of the process is complex, and at present not completely understood. Practical experience is demonstrating how apparatus of increasing technical convenience for the purpose may be made.

The earliest attempts were carried out by melting the metal in a pot, forcing it through a fine nozzle under high pressure, and then with steam or a gas spraying it on to a surface. The apparatus developed for this purpose was in many ways troublesome and cumbersome, and the use of it was practically confined to metals and alloys of a low melting point. The spraying medium was kept hot by various devices, and an attempt was made to keep the metal molten right to the moment of application.* The fact, however, was observed that under conditions of temperature and expansion of the gases such that the metal could not have been molten throughout the process, adherent coatings were sometimes formed. These experiments, and careful observations of the spreading and adhesion of bullets fired at an iron plate, suggested the next stage of development.

Metallic powders were driven at high velocity against the body to be coated by means of gaseous jets expanded from considerable pressure.† The results achieved were a great improvement on the older method.

To produce the metallic powders the metal had, of course, to be subjected to one of the known pulverising processes, such as distillation, grinding, or spraying. The suggestion that the pulverisation and deposition could be combined in one apparatus was then made by the inventor Schoop; and his researches resulted in the perfecting of the apparatus covered by his colleague Morf in British Patent No. 2801, 1912.

The steady improvement of this apparatus in the laboratories of Schoop and his associates resulted in the machine, Figs. 1 to 6, page 383, the working and theory of which will be described in this paper.

The essential parts of the machine, or "pistol," as it is called, are a combined melting and spraying jet and a feed mechanism. The metal, in the form of rod or wire, is fed to the melting-flame. The flame can be formed by coal-gas, water-gas, acetylene, hydrogen, &c., burning in air or oxygen according to the metal used. The gases are supplied at such pressures as to prevent blowing out and to ensure a highly deoxidising flame. The spraying-jet can be of carbon dioxide, nitrogen, air, steam, &c.; it is fed at such a pressure as to produce a sufficiently high velocity for successful coating. The various pressures must be carefully kept constant by accurate gauges and reducing-valves.

The feeding of the wire is accomplished by a small pneumatic motor, driven by the spraying medium either in series or parallel with the main jet. The dimensions of the wire, nozzle, and feed mechanism vary with the different metals, and the nozzles and feed mechanism are so designed as to be readily interchangeable. For small work hand operation is sufficient; but probably, when large work is undertaken, it will prove convenient to have mechanical traverse and control.

To obtain the best adhesion, the surface on to which the metal is sprayed must be thoroughly clean and of an open nature to give a key for the deposit. Sand-blasting with sharp sand has been found best. Shot gives too polished a surface. Such surfaces as fabrics, wood, unglazed earthenware, and asbestos require only freedom from grease, as their surfaces give a natural key.

The mention of wood and fabrics as suitable substances to coat by means of an apparatus in which an intense flame is used may cause some surprise, which will be increased by the statement that celluloid, and even explosives, can be safely metal-sprayed.

To make this less remarkable, it will be well to enter here upon a brief account of the theory so far developed, to explain the operation, with the aid of Fig. 7.

The melting-jet is focused at A on the tip of the wire. The spraying-jet, cold from expansion, strongly draws forward the products of combustion in the centre of its cone, and by its draught drags off minute particles of metal, either in the plastic or molten state. The central cone, therefore, consists of metal particles, some cooled to solidity, some molten, and some, perhaps, gaseous, surrounded by a protective reducing atmosphere. This cone is hurled forward with great velocity on to the object to be coated, B C, by the outer jet. With a given design of jet there is only a certain volume left by the air-jet which can be filled with flame, and this flame has a limiting temperature which cannot be exceeded. The wire, passing through this cone of flame, receives heat, partly by radiation, but chiefly by conduction, and becomes melted; but there is a definite limit to the amount of heat which can be picked up by the wire passing through the flame, and a definite limit to the rate at which it can be melted. This cannot be increased by forcing more gas into the flame, as the extra gas is merely blown away by the air-jet. It is possible to increase the rate of melting by shaping the nozzles so as to leave room for a larger cone of flame, and experiments are in progress on this point. There is therefore a definite most economical quantity of gas which should be used in the pistol, this quantity being about 1.5 cub. ft. of hydrogen per minute, and 0.5 cub. ft. of oxygen, or about 0.8 cub. ft. of coal-gas to 0.65 cub. ft. of oxygen for the present standard designs.

In refractory metals these quantities may be increased slightly, as a slightly higher temperature can be obtained if the burning gases are under a pressure greater than atmospheric, and this occurs if the gas quantities are increased, the inner surface of the air-jet acting to some extent as an enclosing wall to the flame. On the other hand, for the more easily fusible and oxidisable metals, such as tin, lead, and zinc, it is advisable to keep the gas quantities rather below the figure given, so as to avoid any possibility of overheating and burning any portion of the wire. The outer jet performs a threefold purpose: it keeps the nozzles and wire cool, it cools the object, and it produces the requisite velocity. The velocity of the air leaving the jet will be independent of the volume discharged, and depends only upon the pressure at the jet, so long as there is no disturbance due to the entraining of air from the surrounding atmosphere. This, of course, will actually occur in practice, and the layer of air must have a certain thickness in order to prevent its being broken up and its velocity destroyed by mixing with the surrounding atmosphere.

In addition to this, the air-jet has to atomise the molten metal, and accelerate the particles up to its own velocity, so that to perform this a certain mass of air is required.

As at present constructed, the standard pistol uses about 0.55 to 0.6 cub. ft. per minute for every 1 lb. per sq. in. air pressure, so that with an air supply at 80 lb. per sq. in., which is a very suitable figure for ordinary spraying, the air consumption will be from 45 to 50 cub. ft. per minute. The mass of this will be from 830 to 920 grammes, and the mass of metal sprayed by this air will be from about 8 grammes in the case of iron to about 200 grammes in the case of lead. How effective the cooling is is shown by the fact that the hand can be held to receive a coating of metal without inconvenience.

The action of deposition is probably a complex one. The minute particles of solid metal are driven with such

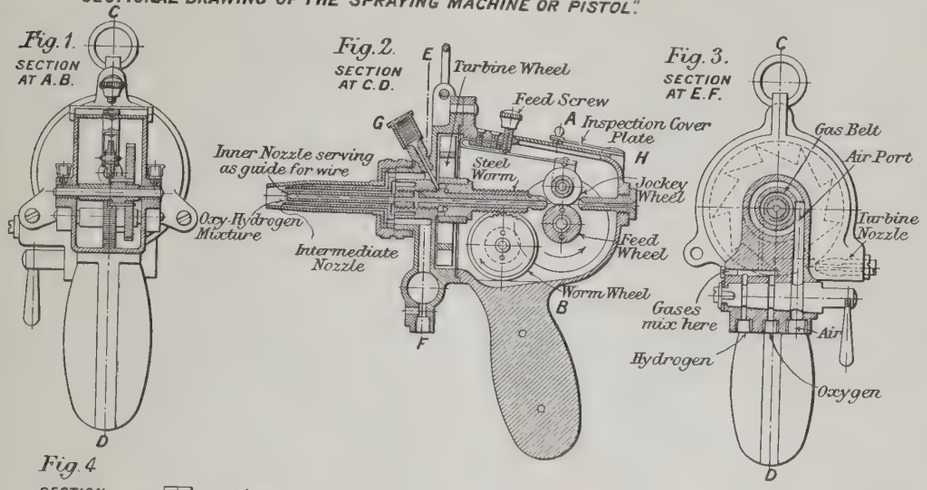
* Paper taken as read at the statutory meeting of the Institute of Metals, held on September 10, 1914, and submitted for discussion by correspondence up to September 30, 1914.

* See British Patent No. 5712, 1910, M. U. Schoop; also Journal of the Institute of Metals, vol. iv., No. 2, 1910. page 307; also No. 1, 1911, vol. v., page 321.

† See Schoop, British Patent No. 21,066, 1911.

METAL-SPRAYING MACHINE.

SECTIONAL DRAWING OF THE SPRAYING MACHINE OR "PISTOL."



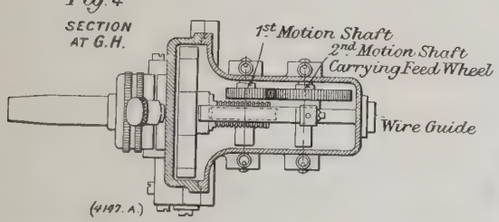
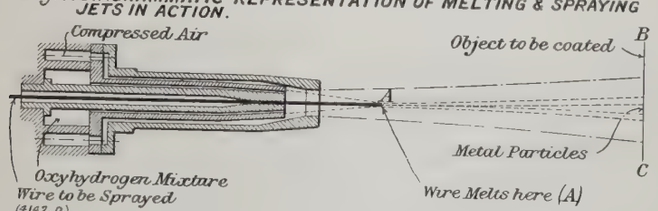


FIG. 5. THE SPRAYING MACHINE OR PISTOL.

FIG. 6. THE SPRAYING MACHINE COUPLED UP FOR HAND WORKING.

Fig. 7. DIAGRAMMATIC REPRESENTATION OF MELTING & SPRAYING JETS IN ACTION.



force against the object that, in some cases, they fuse, but, owing to their small relative size, are promptly chilled by the object to which they adhere. If any of the particles are molten or gaseous, they will adhere. In addition, the suddenly chilled particles are possibly, or even probably, in the state of unstable equilibrium found in "Prince Rupert's Drops," and act like so many minute bombs, bursting on impact into almost molecular dimensions, and penetrating the smallest cracks and fissures of the object.

The process requires some care in manipulation, as, by varying the conditions, it is possible to spray porous or non-porous coatings, and, with some metals, anything from a pure metal to a pure oxide. With care, however, non-porous, oxide-free, adherent coatings can be produced of almost any metal on almost any solid.

In addition to metals it is possible to spray fusible non-metals, or, by stranded wires, alloys of metals or mixture of metals with non-metals. The process is so new that its uses are still partly to be developed. But it is easy to see that it may have far-reaching value for protective coatings against weather or fire, for ornament, for electrical resistance and conductors, for the production of special alloys, for joint-making, and for many other purposes.

Quite in a different category comes that of very fine casting. The surface of a pattern, polished or slightly greasy, is most minutely copied, and it is possible to produce process blocks very rapidly. It may be useful to line moulds before pouring in a metal. The application of the process to the production of very fine or coarse metallic powders is being investigated.

TABLE I.—*Weight of 1 Sq. Ft. of Various Metals Coated to a Thickness of 0.001 In.*

Metal.	Density. C.G.S.	Density. British, Pounds per Cubic Foot.	Weight. Lb.	Weight. Grammes.	Metal only. Price, Pence per Pound.	Metal only. Cost, Pence
Aluminium ..	2.65	177	0.0148	6.62	12.5	0.186
Brass	8.5	537	0.045	20.2	8.0	0.36
Bronze ..	8.8	565	0.047	21.1	9.5	0.45
Copper ..	8.9	560	0.0468	21.0	10.0	0.47
Cupro-nickel	8.9	560	0.0468	21.0	—	—
Iron	7.8	492	0.041	18.4	3.5	0.144
Gold	19.3	1210	0.101	45.5	—	—
Nickel ..	8.9	560	0.0468	21.0	36.0	1.68
Silver ..	10.5	660	0.055	29.7	—	—
Tin	7.3	460	0.0384	17.3	30.0	1.15
Zinc	7.1	450	0.0376	16.9	11.0	0.415
Lead	11.4	720	0.0600	26.9	3.25	0.195

TABLE II.—*Data for Spraying Various Metals.*

Metal.	Diameter of Wire used, Millimetres.	Rate of Feed, Grammes per Minute.	Gas Used per Minute, Cubic Feet. Hydrogen.	Oxygen.	Coal Gas.	Oxygen.
Aluminium ..	1.0	9.5	1.5	0.5	0.7	0.6
Brass	0.8	17.0	1.5	0.5	0.8	0.65
Bronze	0.8	17.0	1.5	0.5	0.8	0.65
Copper	0.8	14.0	1.8	0.6	—	—
Cupro-nickel ..	0.8	12.0	1.8	0.6	—	—
Gold	0.8	45.0	1.5	0.5	—	—
Iron	0.8	8.0	2.0	0.7	—	—
Lead	3.0	300.0	1.0	0.35	0.45	0.4
Nickel	0.8	9.0	2.0	0.7	—	—
Silver	0.8	18.0	1.5	0.5	—	—
Tin	2.0	200.0	0.8	0.3	0.35	0.30
Zinc	1.0	45.0	1.2	0.45	0.55	0.5

Blanks in "Coal Gas" column indicate that experiments with these metals are not yet complete.

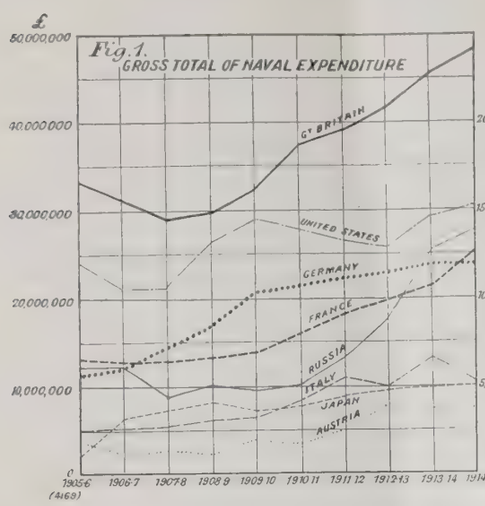
The costs of the process are not prohibitive, and, even where higher than alternative processes, the great range and adaptability of this apparatus, and its independence of muffles, pots, &c., may make it preferable. A table of gas-pressure and feed rates is printed above to give some idea of costs. Experience and extended use on a commercial scale should soon reduce the cost of operation. The bulk of the work has hitherto been carried on in laboratories, but the apparatus is gradually becoming used in the more progressive factories, where extended facilities and the knowledge of specialised requirements will ensure a rapid improvement in technique and results. The research on the lower melting-point metals has been greater than on the others, and undoubtedly the economy with them both can be greatly improved. Preheating of gases and air, supplementary flames acting in front of the main jet, and electrical methods of heating, are all still the subject of experiment. That the experimental stage has been passed for many uses can be seen from the apparatus and samples of work exhibited.

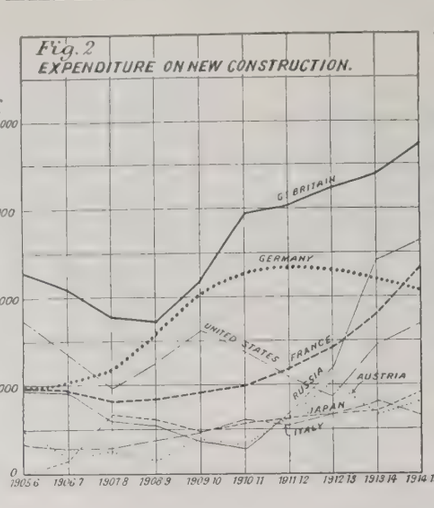
MANCHESTER MUNICIPAL SCHOOL OF TECHNOLOGY.—We have recently received a copy of the calendar of this institution for the ensuing session, which commences on the 6th prox. The calendar gives full particulars of day, part-time day, and evening courses in mechanical, electrical, and sanitary engineering, and also in various branches of applied chemistry, textile industries, architecture, and mining.

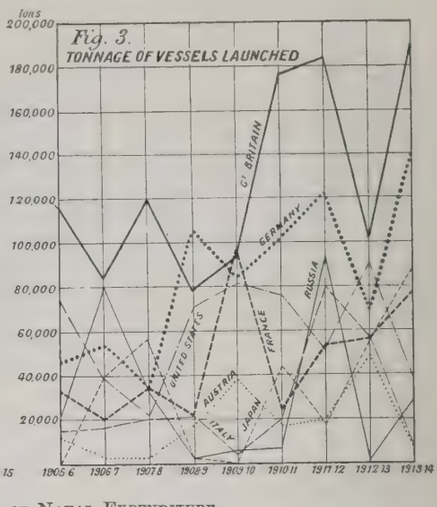
PRIZES FOR ARCHITECTURAL AND MUSEUM STUDIES.—The London County Council offers three prizes, one of 10*l.* and two of 5*l.* each, for drawings of buildings or artistic objects in museums (South Kensington Museum and the British Museum especially). Works submitted for competition must have been executed since Easter, 1914, and must not previously have been utilised for any competition. Drawings must be delivered before noon on Saturday, November 7, 1914, together with the application form (T 2-251), at the London County Council Education Offices, Victoria Embankment, W.C. Further information can be obtained from Mr. R. Blair, education officer, London County Council Education Offices, Victoria Embankment, W.C.

NORWEGIAN INDUSTRIES AND THE WAR.—In Norway the large Eyde Companies, the Norwegian Hydro-Electric Nitrogen Company, and the Rjukan Companies have informed their employees that, as the war may cause difficulties both as regards the obtaining of raw materials and of the necessary ready money for uninterrupted working of the factories through a somewhat lengthy period, no workman will receive, after September 15, more than 25 kr. (27s. 6d.) per working week. The balance of the wages earned is to be credited to his account in the companies' books, and entered in a book which the workman holds as a proof of his claim on the company. On these amounts he is to be credited 5 per cent. per annum, and the money will fall due for payment as soon as possible after the cessation of the war. A similar arrangement has been made with the directors, officials, and all other employees.

THE NAVAL EXPENDITURE OF THE POWERS.







THERE was issued this week the annual Parliamentary return showing the naval expenditure of each of the eight principal naval Powers—Great Britain, France, Russia, Germany, Italy, Austria-Hungary, the United States, and Japan. This return gives in tabular form information regarding the navy estimates and construction of the various Powers between 1905-6 and 1914-15. It is pointed out that in the case of Britain the naval expenditure includes pensions and other items which are not charged to the navy votes of other principal Powers, and that for direct comparison it is necessary to deduct such figures from the British totals. In Table I. we give the British expenditure less such items as pensions, &c.; in the case of other Powers small items have been added when corresponding items are charged to our Navy Vote. The figures given in Table I. are therefore directly comparable. The figures in this table are set out in curves in the diagram, Fig. 1, and this shows the position and the increasing naval expenditure at a glance.

In Table II. there is recorded the expenditure on new construction in the various years, as taken from the statistical abstracts now issued by the Government. These figures are plotted in curves in Fig. 2.

The third table shows the tonnage, when completed, of the vessels launched in each of the financial years by the respective Powers. This necessarily fluctuates, as is shown in the diagram, Fig. 3.

The figures given in these tables, and illustrated by diagrams, are referred to in our leading article on page 389.

TABLE I.—GROSS TOTAL OF NAVAL EXPENDITURE.

Year.	Great Britain*	Germany.	France.	Russia.	Japan.	Austria.	Italy.	United States.
1905-6 ..	33,387,568	11,472,715	13,224,364	12,392,684	2,388,018	3,838,975	5,040,000	24,444,948
1906-7 ..	31,110,688	12,223,089	12,846,771	12,490,444	6,311,420	2,398,223	5,322,154	21,358,199
1907-8 ..	29,119,929	14,511,863	13,099,549	8,850,240	7,371,777	2,713,540	5,661,822	21,260,732
1908-9 ..	29,847,582	16,861,803	13,440,357	10,222,733	8,258,082	2,477,671	6,266,193	26,438,434
1909-10 ..	32,323,255	20,522,959	14,054,063	9,650,167	7,346.879	4,068,333	6,537,118	28,990,592
1910-11 ..	37,296,340	21,388,357	15,761,511	10,227,604	7,729,968	3,545,727	8,341,766	27,848,111
1911-12 ..	39,165,611	22,261,732	18,209,298	13,296,370	8,861,829	5,152,382	10,832,047†	26,569,606
1912-13 ..	41,559,318	22,907,207	19,894,468	17,681,213	9,533,997	7,367,644	10,054,505	25,902,577
1913-14 ..	45,510,836	23,742,687	21,317,634	25,392,784	9,938,433	7,332,703	13,333,762	29,432,991
1914-15 ..	48,113,203	23,740,349	25,412,685	27,769,294	10,023,919	7,408,196	10,313,009	30,331,364

* The figures for Great Britain exclude pensions and other items not charged to the navy expenditure of other Powers.
† Includes 2,320,000*l.* for War Expenses.

TABLE II.—EXPENDITURE ON NEW CONSTRUCTION.

Year.	Great Britain.	Germany.	France.	Russia.	Japan.	Austria.	Italy.	United States.
1905-6 ..	11,368,744	4,720,206	4,705,295	4,576,370	—	2,371,916	1,714,556	8,683,000
1906-7 ..	10,486,397	5,167,319	4,652,010	4,576,583	767,647	1,012,499	1,862,207	6,776,086
1907-8 ..	8,849,589	5,910,959	4,138,967	2,846,268	3,297,964	1,186,667	1,398,111	4,872,888
1908-9 ..	8,521,930	7,795,499	4,193,544	2,703,721	3,027,276	716,662	1,866,358	6,227,874
1909-10 ..	11.076,551	10,177,062	4,517,766	1,758,487	2,392,483	1,908,331	2,190,707	7,976,897
1910-11 ..	14,755,289	11,392,856	4,977,682	1,424,013	2,748,349	1,583,333	2,981,200	6,889,005
1911-12 ..	15,148,171	11,710,859	5,876,659	3,216,396	2,997,493	3,125,000	2,677,302	5,343,7?9
1912-13 ..	16,132,558	11,491,187	7,114,876	6,897,580	3,289,797	5,114,206	3,227,000	4,226,728
1913-14 ..	16,883,875	11,010,883	8,893,064	12,082,516	3,550,721	3,288,937	3,933,000	7,258,953
1914-15 ..	18,676,080	10,316,264	11,772,862	13,098,613	4,623,919	4,051,976	3,237,000	8,443,796

TABLE III.—TONNAGE, WHEN COMPLETED, OF VESSELS LAUNCHED.

Year.	Great Britain.	Germany.	France.	Russia.	Japan.	Austria.	Italy.	United States.
1905-6 ..	116,570	45,729	31,381	20,416	—	11,021	14,555	74,000
1906-7 ..	83,260	53,180	19,338	80,860	39,870	2,233	16,016	37,283
1907-8 ..	119,937	33,985	33,602	31,461	56,450	2,364	19,510	20,633
1908-9 ..	77,202	104,971*	21,205	1,834	1,620	16,034	21,021	69,341
1909-10 ..	92,957	83,184*	96,308	4,371	Nil.	37,122	2,404	80,822
1910-11 ..	176,582	101,830*	21,860	6,130	43,900	16,384	19,642	75,935
1911-12 ..	183,283	123,130*	53,125	93,710	16,800	20,010	80,289	51,542
1912-13 ..	113,058	69,400*	55,776	914	55,081	49,269	57,051	91,477
1913-14 ..	139,740	139,865*	78,313	29,899	85,600	6,543	6,927	36,472

* The tonnage of German ships since 1908 does not include submarine-boats.

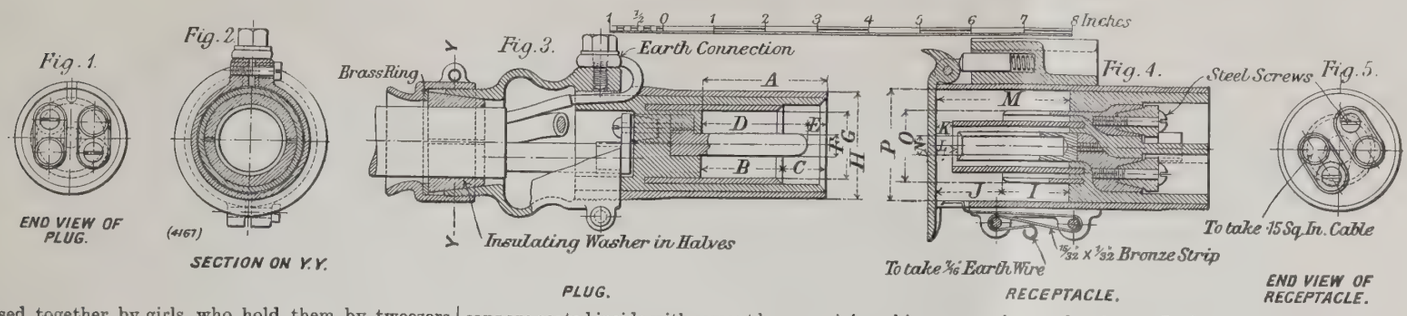
THE OSRAM LAMP WORKS.

IN these latter days, when so much is being said of British manufacture, it should be a matter of interest to our readers to hear something of the Osram lamp works of the General Electric Company, Limited. This company needs no introduction, but the details of its particular activities in connection with the manufacture of tungsten-filament lamps may not be altogether common knowledge. On the 23rd inst. we had an opportunity of inspecting the Osram works at Hammersmith. This factory employs more than 1500 workpeople, and is engaged solely in the manufacture of tungsten lamps. In conjunction with the General Electric Company's glass works at Lemington-upon-Tyne, it constitutes, we are informed, the only works in the British Isles capable of turning out a metal-filament incandescent lamp from start to finish. Other companies, we are told, manufacture the lamps, but purchase the glass bulbs. The position of the General Electric Company, however, enables them to manufacture lamps throughout from the raw material. At the moment there is a slight reservation to this statement. The brass caps which form the tops of the lamps are obtained from Holland, but a department is now being organised at Hammersmith to make these also. Before proceeding to a description of the Hammersmith works, we should say that the Lemington Glass Works, which are the only works devoted to the manufacture of bulbs and glass work for electric lamps in Great Britain, contains six glass-houses, and employs about 250 workpeople. Bulbs are now being supplied to other lamp-makers, who, up to the present, have obtained supplies from the Continent, and arrangements are in hand to extend the works as rapidly as possible.

The Osram Works at Brook Green, Hammersmith, are situated in a large modern six-storey building, equipped throughout with plant of the character necessary for the commodity which is manufactured. The number of special machines is very large, and the works are of great interest from a mechanical point of view. It would, however, not be possible to give an adequate idea of the many ingenious machines and processes without many illustrations and a description of great length, and all we can attempt at present is a brief outline sketch of the construction and assembling of a lamp. We may begin with the filament. This, as is generally known, is of drawn tungsten, and the process of drawing is to some extent a trade secret. We are indebted to the General Electric Company for allowing us to see this process for the first time on the 23rd inst. To review it briefly, we may say that the tungsten, which comes from Australia, reaches the works in the form of a fine powder. This is compressed, under about 4 tons to the square inch, into small bars some 5 in. long by ¼ in. square. The bars are maintained, for a time which we cannot state, under pressure in a hydrogen flame. This removes impurities. The bars are further solidified by passing a heavy current through them. These are then heated in gas-furnaces and swaged a number of times, being gradually drawn out to two or three times their original length. A further heating to a high temperature is next passed through, and the elongated bars are then drawn to the required degree of fineness, more or less on ordinary wire-drawing lines. Diamond dies are used, and the wire is lubricated with "Aquadag," and the dies are heated by Bunsen flames during drawing.

Apart from the preparation of the wire, the first step in the construction of a lamp is the formation of the spider which carries the filament. This is of glass carrying various radiating wire supports. The glass part is formed from tube and rod, which are supplied from the Lemington works in long lengths. The tube forms the ultimate neck of the lamp, while the rod forms the centre support carrying the radiating wires. Both tube and rod are dealt with in semi-automatic machines, consisting essentially of horizontally-rotating frames formed with pockets for a dozen or more lengths of the glass tube or rod; blow-pipe flames below the rotating frame play upon the glass lengths in turn, and as the table rotates by definite steps the heated glass is formed or cut by dies which act on the length of glass which was heated in the immediately previous position of the table. By this means the tube is cut into short lengths flanged out at one end, while the rod is formed in lengths carrying two bosses, into which the wire supports are subsequently fused. The lengths of tube and rod are then fused together, with the leading-in wires in position, in a machine on the lines of those described above. In this machine there are a pair of dies which flatten the tube on to the centre rod and the wires. The leading-in wires are previously prepared of the correct length. Each consists of a short length of platinum wire, with a copper wire at one end for the outer connections, and a nickel wire at the other for the inner. The copper, nickel, and platinum, previously cut to length by an automatic machine, are

A STANDARD CHARGING-PLUG FOR ELECTRIC VEHICLES.



fused together by girls, who hold them by tweezers in blow-pipe flames. No flux is used. We should, perhaps, say here that the greater part of the processes we are describing is carried out by girls.

The tube and rod being assembled, together with the leading-in wires, the next process is the insertion of the radial filament supports. These are of nickel wire, and are cut off to length and looped at one end by an automatic machine. They are inserted into the bosses on the glass rods by hand, the lamp-spiders being carried by a stand on a bench and the bosses being heated by blow-pipe flames. The girls, who handle the wire supports with tweezers, appear very expert at spacing them evenly around the bosses. There are some machines in the works for inserting these filament supports, and so doing away with one of the hand processes. The machines work with reels of wire, so that the initial cutting-off is not required. These machines are perfectly successful, but are of too recent introduction to have yet taken over the majority of the work. The spiders being completed up to this point, they are put in a small pedal-operated press which straightens the radial supports and brings them all to their correct position should any be bent. The next process is the winding-on of the tungsten filament. This is done by hand. Each girl engaged on the work has an ingenious tool, consisting of a special pair of light pliers with a bobbin of the tungsten wire mounted on one side. With this tool she is able to clamp the end of the wire to the first leading-in wire, and then allow the wire to pay out as she loops it over the various supports. With the same tool she then cuts off the wire and connects the free end to the other leading-in wire. We have not previously mentioned, but should state, that the upper and lower filament supports are not of equal weight. One set is very light, and acts as a set of springs to keep a slight tension on the filament. These supports are not strong enough to take the strain of the filament, being looped on them, and during the process a set of dummy supports is interposed by the frame on which the spider is held. When the filament is complete, the dummy supports are withdrawn, and the spring supports take up their work. Before the spiders are removed, after the fixing of the filament, the continuity of the electrical system is tested by passing a current through the filaments, and lighting them up for a moment. This is done in an atmosphere of hydrogen, since flashing in air would destroy the tungsten. It is done by bringing a glass bell down over the spider on its stand, hydrogen entering and displacing the air when it is in its lower position.

The spider at this stage is complete, and ready to place in the bulb. The bulbs are received from the glass works ready blown, with a wide mouth, through which the wound filament can enter. The first process the bulbs undergo is the fixing of a glass tube at their bottom end, through which exhaustion finally takes place. The spiders are then placed in position, and the bulbs pass round a machine of the class we have already dealt with. The bulbs individually rotate in the revolving horizontal frame, and are heated at the neck by blow-pipe burners. The closing-over of the neck of the bulb on to the upper part of the spider is not, however, done with dies, but by the girl attendant, who works with a small forming tool in the manner of a potter. The bulbs and spiders being assembled together, the almost completed lamps are ready for exhausting. This is done in batches of six or eight, each batch in turn being connected to four different sets of pumps as the vacuum becomes more and more complete. A girl superintends a number of batches, and sits on a small trolley, by which she is enabled to move quickly along in front of the various batches she is dealing with. The complete process of exhaustion for a batch takes about ten minutes. The sealing-off is done in the exhausting-frame, and after a momentary current has been passed to see that the filament is unbroken, the lamps are passed to the testing department. All lamps are tested for ten minutes or so at full voltage; and samples are taken and run for 1000 hours or more. The lamps are individually tested for candle-power and consumption. The final process is capping. The brass caps are coated inside with cement by a special machine, and are placed on the lamps under heat in a machine fitted with a series of small electric heaters which fit round the caps. The leading-in wires are then soldered off by hand. After a further final test the lamps are then ready for branding and packing.

There is a department in the works for the manufacture of half-watt lamps, but it has been but recently completed, and, owing to dislocation of labour by the war, is not now running fully. The steady production of the standard tungsten lamp is a matter of greater importance at present than the pushing of new introductions. The process of manufacturing half-watt lamps does not differ materially from that described above, except that in place of exhaustion the lamps are filled with nitrogen by a process of displacement. This is done through a temporary leading-in tube similar to that employed in exhausting ordinary lamps. In this description we have chiefly been concerned with the process of lamp manufacture and have said little of the general equipment of the factory. It has many interesting features, however, of which one is a large hydrogen-generating plant, and another a central compressed-air station. For ordinary blow-pipe purposes for the glass-manipulating machines coal-gas is used taken from the town mains.

A STANDARD CHARGING-PLUG FOR ELECTRIC VEHICLES.

It has always been clear that, for electric-battery vehicles to compete on even terms with petrol and steam-vehicles, facilities for charging must be provided on a very extensive scale throughout the country. For local and special services this may not be necessary, but if such vehicles are to come into use in really large quantities, and are to be in a position fairly to deal with a great part of the work now done by their rivals, their charging points must be available in nearly every town of any size in the country, and on a generous scale in large cities. Encouragement towards the provision of such facilities is naturally one of the main duties of the Electric Vehicle Committee of the Incorporated Municipal Electrical Association, and it has taken a helpful step by issuing drawings of a standard charging-plug and receptacle. Such a standard is clearly very necessary, since the whole usefulness of a system of charging-stations must depend on the employment of a uniform charging connection by the majority of users.

The plug shown in Figs. 1 to 5, with dimensions as in the table above, is designed to carry 150 amperes continuously, and may safely be used for boosting charges up to 300 amperes for an hour or two. It is intended for voltages up to about 120, and may in emergency be used to break circuit; but it is recommended that a proper quick-break switch be provided in the connections. It is proposed by the Electric Vehicle Committee that each battery-car or other vehicle should be furnished with a standard receptacle fixed under the front of the driver's seat, so that he will of necessity have to remove the plug and cable connection before he can take his seat and start the vehicle. The plug and connection would be supplied and owned by the charging garage or station, and should be attached to the charging switchboard by a second standard plug and connection, so that when not in use the connecting-cable could be coiled away in a safe place. It is recommended that the cable should be three-core, provided with the hard rubber protection known as "Cab-Tyre sheathing." Two of the cores of the cable would carry the main current, and the third, which should have an area the equivalent of $\frac{7}{18}$ S.W.G., would form an earth connection. Three sizes of main conductor are proposed—0.15 sq. in., 0.10 sq. in., and 0.075 sq. in. The first would be used in public garages and charging-stations, while the two latter are intended for private garages arranged for cars having lead batteries for which the heavy boosting charges which may be given to Edison batteries are not required. The approximate over-all diameters of the three sizes of cable are 1.75 in., 1.5 in., and 1.31 in.

The construction of the plug and receptacle will be seen from the figures. The outer shell of each piece is to be made of solid-drawn mild-steel tube turned and bored. The bracket and cap for the receptacle are of malleable cast iron, and the spring plunger of hard-rolled brass rod with a tempered-steel spring. The main contact-pieces of both the receptacle and plug are to be of gun-metal moulded into the insulating material, which should be damp and heat-proof. The cable lugs are to have conical seatings, Fig. 3. The cable-gripping device on the plug may be of either gun-metal or malleable cast iron, and the split gripping-sleeve of insulating material. As will be seen from Fig. 3, the earth wire is to be connected to the gripping-sleeve. On the receptacle there is a hard-rolled phosphor-bronze strip, which can be seen at the bottom of Fig. 4. This forms an earthing finger, which makes contact with the outer shell of the plug when it is in position in the receptacle. The plug shell should be turned on the outside to ensure that proper connection is made. The earthing strip of the charging-board receptacle should be connected by a $\frac{7}{18}$ S.W.G., or equivalent bare copper conductor, to a water pipe or other suitable earth, while the strip of the vehicle receptacle should be connected by a similar conductor to the metal framework of the chassis. It is clear that with these connections made, the metal work of the vehicle, together with the outer shells of both the plug and receptacle, will be effectively connected to earth during charging. The centre contact of the plug and receptacle should always be the negative pole, and the terminals should be marked to indicate this. The new plug is to be submitted to the British Section of the International Electro-Technical Commission with a recommendation for standardisation.

In addition to settling the design of the new plug the Electric Vehicle Committee is taking several other steps towards assisting the development in which it is interested. An official quarterly journal is to be issued dealing with the activities of the committee. This will be supplied free to town clerks, heads of electric-supply undertakings, and similar officials, while electric-supply departments will be able to purchase extra copies for distribution at cost price. It is hoped that the first number will be available in October. This journal will no doubt in due course contain particulars of a standard electric sign for use outside charging-stations, the matter at present being under consideration. Finally, we may mention that the committee makes some recommendations in reference to the measuring instruments which it is desirable to fit to battery vehicles. For lead

TABLE OF DIMENSIONS OF PLUG AND RECEPTACLE.

Measure.	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	Machine. N.	Spring. N.	Machine. O.	Spring. O.	P.
English (in.)	$2\frac{3}{8}$	$1\frac{9}{16}$	$\frac{13}{16}$	$2\frac{1}{16}$	$\frac{5}{16}$	0.435	1.406	2.10	$1\frac{13}{32}$	$1\frac{5}{16}$	$\frac{5}{16}$	$\frac{7}{16}$	$2\frac{23}{32}$	0.437	0.422	1.404	1.416	$2\frac{1}{8}$
						0.437	1.408							0.439	0.427	1.406	1.421	
Metric (mm.)	60.33	39.69	20.64	52.39	7.94	11.04	35.71	53.34	35.72	33.34	7.94	11.11	69.06	11.10	10.72	35.66	35.97	53.98
						11.10	35.76							11.15	10.81	35.71	36.09	

batteries, an ammeter and voltmeter for controlling the charge and discharge are suggested. In cases where the battery is not removed from the vehicle for charging and when no constant attendance is provided during this operation, it is recommended that an ampere-hour meter should also be fitted, to give an indication of the condition of the battery charge. Provision should be made for automatically opening the circuit when the battery is fully charged. With batteries of the Edison type an ampere-hour meter is the only instrument which need be provided. The committee also consider that a mileage-recorder is a necessary accessory for judging the condition of the battery in conjunction with the electrical instruments, and for preserving accurate records of working. It is stated that the practice of mounting the instruments directly on the dash-board has not proved altogether satisfactory, and that the latest American practice is to fix them to an independent steel pillar well in view of the driver.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, September 9.

THE main features of the American steel industry may be briefly summarised as follow :—An element of uncertainty prevails as to the future. Specifications against existing contracts are heavy. New contracts are restricted, especially with railroads, on which higher prices have generally prevailed. Foreign inquiry for various steel products are numerous. Some business has been accepted, most of it by the United States Steel Corporation, which is about to place ten of its ships under American registry. Several mills near the Atlantic coast have also booked fair export orders. Several cargoes of Russian manganese intended for Germany have been diverted to this country ; prices, 85 dols. to 100 dols. per ton. Numerous iron and steel projects are held up for want of money. The banks are excessively conservative. Pig-iron is quiet, and on extended deliveries higher, but not beyond the close of the year. The Pennsylvania has closed for 4000 tons of coke and charcoal iron. Cast-iron-pipe makers are again large buyers at firm prices. An inquiry from Russia calls for 4000 tons of Bessemer. Some furnace people contemplate curtailment. Foreign inquiries for various rolled-steel products are increasing. An order for 12,000 tons of plate for a pipe-line in Australia, originally placed in Germany, has been placed here at 7 dols. above the original contract price. Sheets and tin-plates are especially active, mostly in eastern mills for early delivery. August business was very large. Eastern plate-mills are now engaged to 90 per cent. capacity. Structural material is weak and inactive owing to the difficulty of financing loans. Export inquiries for tin-plate are improving. There is a general anticipation of a wide and permanent expansion of trade.

MANGANESE-STEEL RAILS.*

By Sir ROBERT HADFIELD, F.R.S., London, England.

SINCE the writer has been intimately connected with the development of manganese steel for many years, some remarks upon the early work with regard to the rolling and forging of this material might be of interest, and particularly as to the question of rails of special quality and of superior wearing qualities.

In a paper on "Iron Alloys, with Special Reference to Manganese Steel," read before this Institute at the International Engineering Congress in Chicago in 1893,† the writer mentioned that, about twenty years ago, his firm in Sheffield produced railroad material, such as tyres and axles, of forged and rolled manganese steel, thus showing that this product could be manipulated and worked up into the various required forms. The tyres illustrated in the paper referred to above formed a particularly difficult class of work to produce in a special steel ; but no special obstacles were met with. Although there was no difficulty at that time in making and producing manganese steel in various forms—forged, rolled, or pressed—nevertheless, on account of its higher expense, sufficient encouragement was not then obtained from the users to introduce these products on a large scale. There never has been any real difficulty in obtaining forged, rolled, or pressed manganese steel, provided the consumer was willing to pay the necessarily higher cost as compared with ordinary steel.

The matter was further pursued in the present decade. In 1904 a French manufacturer produced rolled manganese-steel rails of the type shown in Fig. 1, page 388. The original tracing prepared by this manufacturer on December 30, 1903, showing the sizes of the billets and rails to be produced, is reproduced in Figs. 2 and 3. These rails were rolled without any incident. One of them was experimented upon by the writer in the following manner. After drilling for 20 minutes, 11 g. of manganese steel were removed, while, in the same time, 750 g. were removed from an ordinary carbon-steel rail. The results of this test are shown in the photographic view, Fig. 1. A piece of this same manganese steel bent double cold is shown in Fig. 4. The material showed a tenacity of 60 tons per sq. in., with an elongation of 40 per cent. This test was so satisfactory that manganese-steel rails of heavy section, 100 lb. per yard, varying from 6 m. to 12 m. in length, were then produced in the same rolling-mill. A section of one of these rails is shown in Fig. 5.

A large number of these rails were rolled in 1907, and were supplied to the Metropolitan Electric Railway of Paris (in the commencing of operations on which, it will be remembered, there was some delay), and put to work, among other places, at the Bastille Station in that city. These rails, after several years of service on severe curve work, have given great satisfaction. After three years' hard service, the actual wear was found to be not more than about 2½ mm. It has been estimated that the rails will remain in service for six to seven years before being worn out, whereas ordinary steel rails wear out and have to be replaced in less than a year.

A plant for producing sound ingots under the system devised by the writer was described in a paper* presented to the Institute at the February (1913) meeting. This system, as adapted to the manufacture of manganese-steel ingots, is illustrated in Figs. 6, 7, and 8. No less than 90 per cent. of sound material is obtained from an alloy steel, which will therefore be seen to offer great advantages. Each 1 per cent. of expensive material saved means that much reduction in the cost of production. The consumer has now to pay for 15, 20, or even 30 per cent. of waste in special steels made in the ordinary way, whereas this waste can, to a large extent, be avoided. Moreover, better and more uniform quality of alloy steel can be obtained.

* Paper read at the New York meeting of the American Institute of Mining Engineers, 1914.

† Transactions of the American Institute of Mining Engineers, vol. xxiii., page 148 (1893).

ENGINEERING INSTITUTIONS' UNIT OF THE NAVAL DIVISION.

WE reproduced on page 360 *ante* a circular issued by the Institutions of Civil, of Mechanical, and of Electrical Engineers, stating that these three Institutions had been invited by the Lords Commissioners of the Admiralty to assist in obtaining picked men for the divisional engineer units and signal company of the Royal Naval Division recently formed by the First Lord of the Admiralty.

We are now informed by the Admiralty that it is proposed that the men should enlist in the Royal Marines, but receive the Royal Engineer rates of working pay and such additions as will make the scale of pay and allowances not less than those drawn by the Royal Engineers.

The rates, as shown by the memorandum issued by the War Office, are as follow :—Sergeant-major, 6s. ; quartermaster-sergeant, 4s. 6d. ; troop, company, or squadron sergeant-major, 3s. 9d. ; troop, company, or squadron quartermaster-sergeant, 3s. 9d. ; sergeant, 3s. 3d. ; corporal, 2s. 6d. ; second corporal, 2s. 2d. ; sapper, pioneer, or driver, 1s. 2d. In addition to these rates of ordinary pay, engineer pay is issuable, dependent upon qualification, at the rates of from 4d. to 2s. a day.

BOARD OF TRADE LIST FOR MANUFACTURERS AND PURCHASERS.—The Commercial Intelligence Branch of the Board of Trade has issued, in the course of the last few days, a new list similar to that to which we recently referred in these columns, but very much more complete. These lists are divided into two sections. In one part is a list of goods which inquirers at the Board of Trade desire to purchase—that is to say, manufacturers and others needing goods of the class listed have applied to the Board for assistance in getting into touch with producers or agents of the class of goods they require. The second list is concerned with goods for which the producers have lost their usual market, and through the assistance of the Board are seeking new openings. The Board of Trade, Commercial Intelligence Branch, 73, Basinghall-street, E.C., is putting suitable firms in touch with each other, and the length of the second list now issued is proof that the first has been of considerable value. We do not doubt that the second will prove equally useful.

CONTRACTS.—Messrs. Joseph Kaye and Sons, Limited, Lock Works, Leeds, state that in addition to 7000 of their patent seamless oil-cans recently delivered to the Navy they have now received orders for immediate delivery for 3000 from the War Department, making 10,000 in all.—The contract list of Messrs. Ed. Bennis and Co., Limited, Little Hulton, Bolton, and 28, Victoria-street, S.W., for the last few weeks comprises a large amount of home business, orders for their machine-stokers from Switzerland, and for their chain-grates with the new patent link for New Zealand and Constantinople. Messrs. Cammell Laird and Co., Limited, Birkenhead, have placed an order for four sprinkler-stokers and self-cleaning compressed-air furnaces for 8-ft. diameter Lancashire boilers, together with an elevator and shoots to serve the machine-stokers. The Municipal Electric Light and Power-Stations of Rotherham, Worksop, and Burton-on-Trent have placed orders for machine-stokers and self-cleaning compressed-air furnaces, and Manchester (Bloom-Street and Stuart-Street Stations) for the re-linking of chain-grates of another make. The woollen-mills of Messrs. Rawdon, Briggs and Co., Limited, Ravensthorpe, Dewsbury, have also contributed a quota of orders. In addition to the above, Messrs. Bennis have recently received orders for twenty-eight of their sprinkler-stokers, besides hand-firing furnaces to burn fuel that is not easily consumed under ordinary conditions, coking-stokers, a bucket-elevator, and a Bennis patent rotary wagon-tipper, most of the orders being repeat orders.

* Transactions of the American Institute of Mining Engineers, vol. xlv., page 473 (1913).

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with a steady tone, and business amounting to 3000 tons of Cleveland warrants was done at 51s. cash and 51s. 4d. one month, with closing sellers at 51s. 1d. cash, 51s. 4½d. one month, and 51s. 11d. three months. There was little change in the afternoon, but no dealings took place, and sellers of Cleveland warrants quoted 51s. 1½d. cash, 51s. 5d. one month, and 51s. 11d. three months. On Friday morning the market was again quite idle, and sellers of Cleveland warrants named 51s. 1½d. cash, 51s. 5d. one month, and 52s. three months. The afternoon session was also idle and quotations were unchanged. On Monday morning the lifeless conditions continued, and the only change in the position was in three months Cleveland warrants, for which sellers were the turn easier at 51s. 11½d. In the afternoon there was still nothing doing, and Cleveland warrants were quoted by sellers at 51s. 1½d. cash, 51s. 5d. one month, and 51s. 11d. three months. On Tuesday morning the market was steady, but business continued at a standstill, and sellers of Cleveland warrants made no change in their quotations. The afternoon session was also quite idle, and Cleveland warrants were quoted by sellers at 51s. 1½d. cash, 51s. 5d. one month, and 51s. 10½d. three months. When the market opened to-day (Wednesday) the position was unaltered, and there was little desire for dealing in Cleveland warrants. At the close of the session sellers named 51s. 1d. cash, 51s. 5d one month, and 51s. 11d. three months. In the afternoon a little improvement took place, and 1000 tons of Cleveland warrants changed hands at 51s. 2d. cash, and closing sellers were firm at 51s. 2d. cash, 51s. 6d. one month, and 52s. three months.

Sulphate of Ammonia.—Business in sulphate of ammonia is still quiet, and the demand for forward supplies does not show much expansion. Prices are almost unchanged.

Scotch Steel Trade.—Very little change has taken place in the Scotch steel trade over the week, and specifications for ship-plates are rather scarce ; but, despite this fact, there is a fair amount of work doing on home account and on behalf of the Government. The demand for angles, &c., is not quite so steady, but that for the heavier gauges of black sheets continues fairly good. Makers complain that the request for the thinner gauges has not been so good of late, but they state that inquiries from abroad point to a better demand, although buyers are grumbling at the high prices being asked. It is said that these will hurt the placing of orders. The general export trade is only fair, but the difficulties and risks attending shipping do not tend to over-much confidence at the moment. Few of our regular markets are sending forward inquiries or orders of any note, and the lots on order for the Colonies, South America, and the Far East do not amount to a heavy tonnage ; but the trade here is optimistic, and makers are confident that a satisfactory expansion will shortly fall to be noted. Prices are inclined to be a shade easier.

Malleable-Iron Trade.—There is a little falling off in activity in the malleable-iron trade of the West of Scotland, although some of the works are still very well employed. The home demand is easier, and shipping departments are not as busy as producers would like.

Scotch Pig-Iron Trade.—There has been no improvement in the Scotch pig-iron trade during the past week, and prices show an easier tendency. The present conditions are rather against any marked increase in business at home, and, although stocks abroad are gradually decreasing, there is a very small demand on export account. The current feeling is that business will be rather quiet for some time, but that a decisive victory for the allied forces on the Continent would give a strengthening influence to general trade. Hematite is in fair demand by the steel-makers, the current price being 75s. per ton. The total number of furnaces in blast is sixty-six. The following are the market quotations for makers' (No. 1) iron :—Clyde, 69s. 6d. ; Calder, Gartsherrie, Summerlee, 70s. ; and Langloan, 72s. (all shipped at Glasgow) ; Glengarnock (at Ardrossan), 71s. ; Shotts (at Leith), 70s. ; and Carron (at Grangemouth), 70s. 6d.

Scotch Imports of Iron and Steel.—During the month of August there was a fair import of iron and steel manufactures from the Continent and the United States into the ports of Glasgow, Greenock, Grangemouth, Leith, Dundee, and Aberdeen. The following are the figures :—

	Ex Continent. Tons.	Ex Continent. Value. £	Ex U.S.A. Tons.	Ex U.S.A. Value £
Iron bars, angles, &c.	3084	19,483	—	—
Steel bars, angles, &c.	980	3,121	26	234
Iron and steel hoops and strips	552	3,798	1783	12,905
Iron and steel plates, not under ⅛ in. thick	297	2,369	—	—
Iron and steel plates, under ⅛ in. thick	5	63	—	—
	4918	28,834	1809	13,139

PERSONAL.—The degree of Doctor of Science (Engineering) has been conferred on Professor Herbert Chatley, of the Tang Shan Engineering College, North China, by the University of London. His thesis embodied an extensive investigation into the subjects of rolling resistance and convex contact, and the contributions presented in support of his candidature included numerous books and papers, referring especially to aeronautical subjects.—Mr. Bertram C. Joy, M.I.A.E., of Craven House, Kingsway, London, W.C., informs us that he has decided not to continue the consulting business carried on by him at the above address for the past seven years.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The pit prop difficulty continues to occupy a prominent place in the minds of South Yorkshire producers. Some considerable length of time must necessarily elapse before any benefit can result from Government consideration of the subject, and in the meantime the price of the small supplies available is rapidly advancing. It is now twice as great as in normal times, and is likely to rise still higher. Speaking at the annual meeting of the Staveley Coal and Iron Co. in Sheffield yesterday, Mr. C. P. Markham, chairman of directors, said he had it on the authority of a pit-prop expert that if the whole of the forests of Scotland were cut down there would not be sufficient timber to supply English pits for a fortnight. He added that all kinds of substitutes were being used, and something suitable would eventually be found; but the outlook in the colliery world was far from satisfactory, and he and his fellow-directors did not see the prospect of making much profit during the ensuing twelve months. Shipping is on a more extended scale. Substantial tonnages are being sent under contract, not only to neutral countries, but to the ports of allied nations. Home consumption is steadily maintained. Armament and engineering firms are big buyers. House coal is a steady market. A brisk business is being done in the better qualities for winter stocking. Owing to the restriction of output, slight weakness in the lower grades has not affected values. Slacks show a small improvement, and are fairly steady, but the colliery position is weak. There is an improved tone in coke. Quotations:—Best branch hand-picked, 15s. 6d. to 16s.; Barnsley best Silkstone, 12s. to 13s.; Derbyshire best brights, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 10s. 3d. to 11s. 3d.; small nuts, 9s. to 10s.; Yorkshire hards, 10s. to 11s.; Derbyshire hards, 10s. to 10s. 3d.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.; smalls, 2s. to 3s.

Iron and Steel.—There has been a marked slackening in inquiries and actual business done in raw material. Inflated values are holding back orders for common brands. A considerable proportion of transactions have been at lower rates than are officially quoted. Reaction is chiefly in foundry pig, owing to the irregular working of foundries in this district and in the Midlands. On the other hand, forge qualities are in brisk demand, and merchants have no difficulty in obtaining full rates both for current and forward delivery. Hematites are a healthy market. A big tonnage of special brands is being bought for armour and gun-making purposes. West Coast sorts are quoted at 79s. 6d., and East Coast sorts at 77s. 3d. The slight upward tendency in the demand for bar iron has ceased, and as regards new business the market is flat. South Yorkshire makers are disappointed in the share of diverted German business which they have secured, but they are still hopeful of an improvement in this class of business and in general trade, where the falling off has been severe. The position in the steel trades is slowly improving, both in the home and export branches. There is an enormous amount of Government work on hand, and further big orders have been received for armour, guns, projectiles, and bayonets. Activity in these departments is of a "boom" character, and that manufacturers have faith in its continuance for a considerable period is indicated by the steps that are being taken to increase capacity for output. Apart from this aspect of trade, the brightest feature is the decisive manner in which manufacturers are drawing together the slackened threads of export business. Outstanding accounts with over-sea buyers of railway and mining material and goods are being discharged and new business is being booked with much greater freedom. Large orders for heavy steel have been placed with South Yorkshire makers by Cape Town and India. Business with South Africa is rapidly expanding, notably in special dies and shoes for gold-mining purposes. In the lighter branches of the steel trade, work is fairly plentiful, orders having been received from South Africa, Russia, India, and Holland. There is a heavy run on picks and shovels for army engineering purposes. Billets are firm at advanced rates, except as regards acid qualities. The rolling-mills are busily engaged in providing material to meet British War Office needs. On the whole the prospects for the future are promising.

MARKETS FOR IRON AND STEEL BARS, SECTIONS, &c.—Two of the important producing countries as regards iron and steel bars, angles and sections, are for the time being unable to contribute their usual quota to the world's trade, and in some countries there must be a turnover, temporary or permanent, in favour of other nations whose trade is not interrupted. Germany is an exporter of rolled bars and sections to the value of 8,299,000*l.* per annum. Belgium is also normally a keen competitor in many markets, as we well know. Our share of the total export trade is of a value of 6,380,800*l.*, but in many markets we have usually a very small proportion of the business going. In India and South Africa, Canada, Australia, and New Zealand, we have the best of the trade, although in all these, except in New Zealand, Germany does an appreciable business. In the Argentine, Japan, the Dutch East Indies, Germany's share is far superior to ours, while in countries near at hand, such as the Netherlands, Switzerland, Italy, Turkey, Norway and Sweden, Denmark, Roumania, &c., the value of Germany's trade runs into six figures, while ours is only up to five and sometimes four. In some markets Belgium has far outstripped Germany, and with these two countries temporarily incapacitated, the demand must come to others still able to produce.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Very little new can be reported concerning the pig-iron trade. A lot of work is still being turned out, but the seventy blast-furnaces still in operation on the North-East Coast are not blowing at their fullest. Though business is on a limited scale, there is an undercurrent of steady confidence, and traders look for very great activity after the war. In the meantime the European trouble is almost the sole topic in commercial circles here. A good deal of pig is being sent to Scotland, and a substantial cargo has this week been shipped to Italy. Values of Cleveland pig are very well maintained. In the early part of the week a few small parcels of No. 3 g.m.b. were purchased at 51s. 3d. f.o.b., but sellers now will not entertain offers under 51s. 4½d., at which figure transactions have occurred. No. 1 Cleveland is 53s. 10½d.; No. 4 foundry, 51s.; No. 4 forge, 50s. 9d.; mottled, 50s. 6d.; and white, 50s. 3d. There is next to nothing passing in East Coast hematite pig, and quotations show a decided downward tendency, despite strenuous efforts of some sellers to maintain values. Nos. 1, 2, and 3 are obtainable from both makers and merchants at 67s., and, in fact, it is understood that some second hands will accept below that figure. Hematite prices are high as compared with Cleveland pig quotations. The difference between No. 3 Cleveland and mixed numbers of hematite used to be 8s. to 10s., whereas to-day it is between 15s. and 16s. Business in foreign ore is still stagnant. Buyers and sellers have wide ideas as to values. Sellers, as a rule, will not quote below the basis of 18s. 6d. ex-ship Tees for Rubio of 50 per cent. quality, but consumers consider the rate should be round about 17s. 3d. Imports of foreign ore to the Tees to date this month amount to only 101,124 tons. Foreign ore has this week been declared contraband of war. Freights Bilbao-Middlesbrough are 4s. 4½d. to 4s. 6d. Coke is easier. There is more offering, and local demand has slackened, but sellers still ask up to 18s. for Durham beehive blast-furnace coke of average quality delivered at Tees-side works.

Stocks and Shipments.—The stock of Cleveland pig-iron in the public warrant stores now stands at 100,353 tons. Since the beginning of the month the stock has been increased by 5649 tons. Not since April 27 has the stock of Cleveland pig-iron been above 100,000 tons. Although shipments of pig-iron from the Tees show an improvement on last month's clearances, they fall considerably below the loadings in September a year ago. To date this month they average 1957 tons per working day, the total despatches being returned at 39,159 tons, 35,859 tons of which have gone from Middlesbrough and 3300 tons from Skinningrove. To the same date last month the loadings were given at 13,824 tons, or a daily average of 691 tons, and for the corresponding part of September a year ago the clearances reached 77,320 tons, or an average of 3866 tons per working day.

Manufactured Iron and Steel.—There is little new to report concerning the various branches of the manufactured iron and steel trades. Works are fully employed, and producers have orders to keep them going until the end of the year. Prices are maintained. Principal market quotations stand:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 10s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 8*l.*; iron ship-rivets, 9*l.*; iron girder-plates, 7*l.* 5s.; steel bars (basic), 6*l.* 15s.; steel bars (Siemens), 6*l.* 15s.; steel ship-plates, 7*l.* 5s.; steel ship-angles, 7*l.*; steel boiler-plates, 8*l.* 5s.; steel joists, 7*l.* 2s. 6d. to 7*l.* 5s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 15s.—all less the customary 2½ per cent. discount; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 15s.; steel railway sleepers, 7*l.* 15s.—all net at works.

THE LATE MR. THOMAS BELL.—We regret to have to place on record the death of Mr. Thomas Bell, who was closely identified with the marine industries of the Tyne district. A Yorkshireman, born seventy-two years ago, he became many years ago associated with a shipping firm in West Hartlepool, the founder being his cousin, and for them he went to Newcastle, at a comparatively early period of his career, to open a branch of the business. From this point onward he achieved not only a great success in business, but proved a most valuable accessory to the municipal government of the City of Newcastle and of the County of Northumberland, passing through all the offices, including the mayoralty of the city and the sheriffdom of the county. He was connected with the Chamber of Commerce, and after thirty-six years of work on the Council he was presented with a service of silver, while the University of Durham conferred upon him the honorary degree of D.C.L. He was connected with many of the industrial establishments, and was chairman of the Wallsend Slipway and Engineering Company, Limited, a large part of the success of which in recent years was due to his wise administration. He gave freely of his great experience and tactful judgment to the settlement of industrial disputes, and several large strikes were settled mainly through his instrumentality. He continued a very active worker, not only in business, but in municipal matters and on several Royal Commissions. In the spring time of this year, however, he met with a serious motor accident when his chauffeur was trying to avoid collision with a motor cyclist, and from this shock he does not seem to have completely recovered. This was one of the causes of his death at his residence at Hesleyside, Bellingham. He is survived by his widow, seven sons, and four daughters, his eldest son being a county alderman.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has been generally quiet; inquiries have been rather more numerous, but they have failed to keep pace with stocks of secondary and cheaper coal. Sellers of best Admiralty qualities have shown a reluctance to reduce their terms, as although Admiralty requirements have been scarcely so large, order-books are sufficiently well filled to keep pits employed for some time. The war has, at the same time, had some effect, of course, upon the coal markets; a number of orders, especially for Italy, having been diverted. The best Admiralty large has made 21s. to 22s.; best secondary qualities have brought 19s. to 20s.; other secondary descriptions, 18s. to 19s.; best bunker smalls, 7s. to 7s. 6d.; and cargo smalls, 5s. to 6s. 6d. per ton. The best household coal has brought 19s. to 20s.; good households have made 17s. to 18s. 6d.; No. 2 Rhondda large has brought 13s. to 13s. 9d.; and No. 2 smalls have realised 7s. 6d. to 8s. 6d. per ton. Patent fuel has been quoted at 17s. to 18s. per ton. Special foundry coke has made 27s. 6d. to 30s.; good foundry coke, 21s. to 25s.; and furnace coke, 18s. to 20s. per ton. As regards iron ore, Rubio has realised 18s. 3d. to 18s. 6d. per ton upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Welsh Steam Coal.—Some interesting observations on Welsh coal were made by Mr. J. H. Davies, Glamorgan county mining lecturer, in his inaugural address to the Ystalyfera Mining School on Friday. Mr. Davies pointed out that the last few years had witnessed an enormous expansion in Germany's production of coal; and to-day, if the output of brown coal were included, her total output was only a little less than that of Great Britain. During the past few years large quantities of Welsh steam coal had been imported into Austria and Hungary to replenish the bunkers of the Austrian navy. France was our best customer. It was not until the Welsh coal strike in 1898 that Germany began to make headway on the west coast of France, and in this she was assisted by the tax on exported coal, which drove many railway companies into the arms of our Teuton enemies. The general strike of 1912 also gave a good fillip to German trade.

Coal and the War.—The shipments of coal from Bristol Channel ports in August amounted to only 1,109,167 tons, as compared with 2,142,151 tons in August, 1913. There was also a loss in August of about 150,000 tons in bunker shipments. So far as South Wales is concerned, trade had the advantage of Admiralty requirements; but full particulars of these requirements have not transpired. Cargo shipments from Bristol Channel ports in August were:—Cardiff, 637,369 tons; Llanelly, 6167 tons; Newport, 270,762 tons; Port Talbot, 62,094 tons; and Swansea, 130,775 tons.

Newport.—The coal trade has shown little change, but the tone of business is generally easier. The best Newport black-vein large has made 17s. 9d. to 18s.; Western Valleys, 17s. to 17s. 6d.; and Eastern Valleys, 16s. to 16s. 6d. per ton.

Bristol and the East.—The president of the Bristol Chamber of Commerce (Mr. E. Spear) has received a communication from the British Chamber of Commerce of Turkey and the Balkan States intimating that it is their intention to open at their Athens branch a showroom in which specimens of British manufactures can be exhibited, and their advantages and merits pointed out to Greek importers and buying houses.

THE 12-IN. UNITED STATES ARMY GUN.—At the proving-grounds at Sandy Hook, a 700-lb. projectile has attained a range of 20,000 yards (11½ miles) from a 12-in. mortar.

TRADE OPENINGS ABROAD.—The Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, E.C., informs us that H.M. Consuls at Milan, Brest, Rio de Janeiro, and St. Paul de Loanda report that there are now excellent openings in their districts for British goods of a type hitherto supplied by Germany. In each case various engineering products and articles of hardware are cited as being required. This is especially so in the case of the report from Milan, where inquiries have been made for British iron and steel bars, rods, saws, tubes, tin-plate, electrical machinery, &c. From Brest it is pointed out that Germany has hitherto supplied goods at a price suited to the purchaser in that district, who often cannot afford the price asked for first-class-quality British products. There would be a large hardware market for goods of a quality within the means of the buyers. Trade would be facilitated by the use of catalogues using French money, weights, &c. A firm whose name may be obtained from the Commercial Intelligence Branch of the Board of Trade has practically a monopoly in Brest in the sale of metal goods, and is now anxious to get into touch with British producers. Prices should be quoted inclusive. In Rio de Janeiro German trade is at a standstill, and the opportunity presented to British merchants is said to be excellent. The personal element is a great factor in Brazil. Active and competent travellers with a good knowledge of Portuguese are advisable, and, if well backed up, should be able to secure a large amount of business at this juncture. German trade in Brazil has been built up on long credit, and British firms would have to make similar allowances to reputable local firms. From St. Paul de Loanda it is reported that cutlery, agricultural machines, railway material, hardware, &c., have hitherto come from Germany, while there are also openings for British products in the form of galvanised sheets, printing machines, lubricating oil, &c.

MANGANESE-STEEL RAILS.

(*For Description, see Page* 386.)

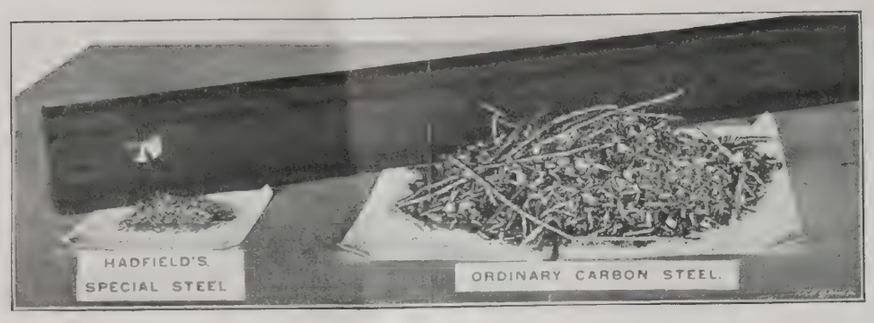
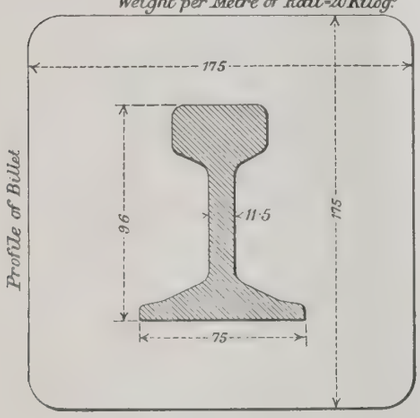
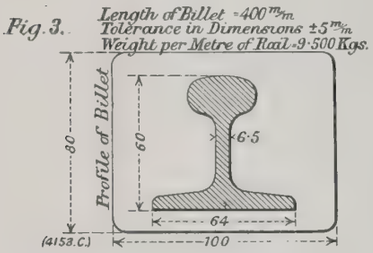


Fig. 1. Manganese-Steel Rails Rolled in France in 1904.

Fig. 4. Specimen of Steel from which Rail shown in Fig. 1 was Rolled. Tenacity, 60 Tons per Sq. In.; Elongation, 40 per Cent.





Figs. 2 and 3. Tracing for the Production of Rail shown in Fig. 1.

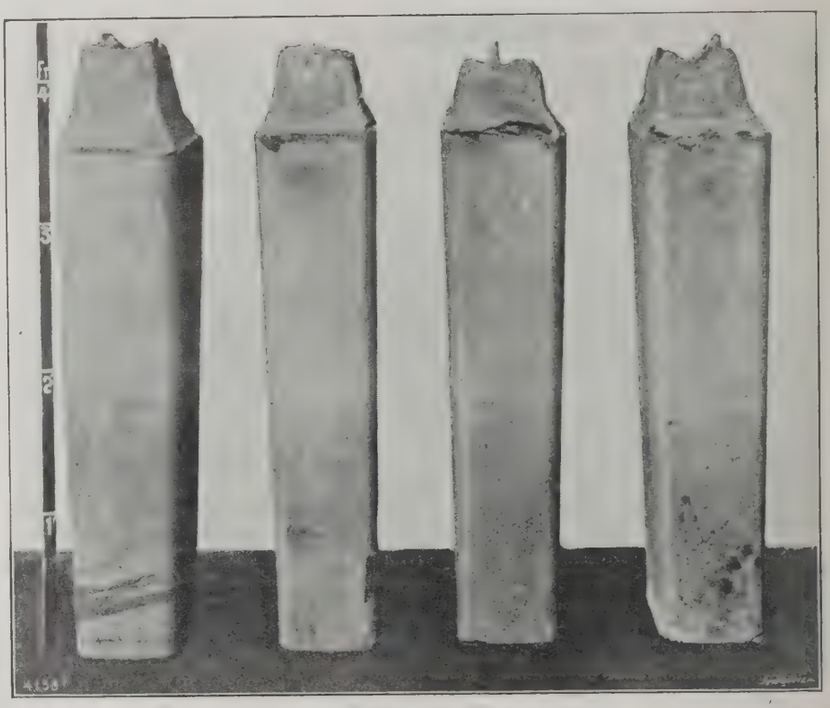


Fig. 6. Manganese-Steel Ingots.

Fig. 5. Manganese-Steel Rail, 100 Lb. Section, Taken from a Lot of 50 Tons, Rolled in 1907; Metropolitan Electric Railway, Paris, France.

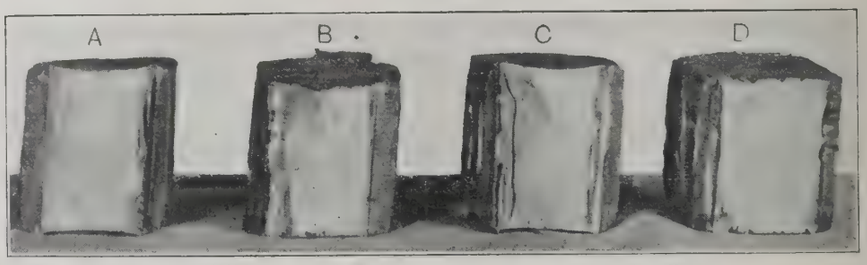


Fig. 7. Heads from above Ingots, Partly Cogged and then Cut-Off.

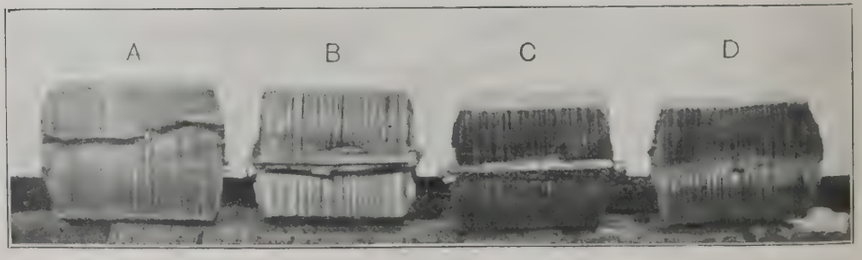


Fig. 8. Fractures from Upper End of Top Billet from Each of the Ingots shown in Fig. 6.

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With One Two-Page Plate and Two One-Page Plates of the MANHATTAN BRIDGE OVER THE EAST RIVER, N.Y., U.S.A., and Two One-Page Plates of a BORING-MILL FOR THE BROOKLYN NAVY YARD, U.S.A.

NOTICE OF MEETING.

THE MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.—Tuesday, September 29, at 3.30 p.m., at the University, Leeds (Education Lecture Theatre). A paper by Mr. E. A. Hailwood, on "Electric Miners' Lamps Compared with the Combustion-Tube Oil-Lamp." The following paper will be open for discussion:—"Self-Contained Rescue-Apparatus and Smoke-Helmets for Use in Irrespirable Atmospheres," by Mr. J. S. Haldane, M.D., F.R.S., Director of the Doncaster Coal-Owners' Research Laboratory.

NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to some Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, SEPTEMBER 25, 1914.

THE "SILENT PRESSURE" OF THE NAVY.

THE Government return of the naval expenditure of the Powers is issued most opportunely, serving, as it does, to throw the illumination of a searchlight upon the diplomatic records of the past few months, and at the same time to assist towards a full realisation on the part of the taxpayer of the debit and credit side of the balance-sheet of the Navy. The events of the past seven weeks bring home to the nation the need for the great expenditure of recent years, while a general review of the situation tends to allay greatly the disturbing effect of the regrettable yet inevitable events of the week—notably, the sinking of H.M.SS. Aboukir, Hogue, and Cressy, armoured cruisers of 12,000 tons, completed in 1901. It is important, as a preliminary to any consideration of the balance-sheet of profit and loss, to reflect upon the capital account, and particularly the value and distribution of our assets. Great Britain is an insular kingdom with vast possessions throughout the world, and the defence of these involves primarily an immense navy. On the other hand, Germany is a great Continental Power, and, as Lord Lansdowne said at Liverpool on Monday last, "we never grudged her the possession of a great army. Why should Germany have begrudged us—an insular and maritime Power—the possession of an adequate fleet to protect our own shores and secure our own commerce? We knew that she had begrudged us that fleet, and her naval preparations had been made with the deliberate intention of destroying that naval preponderance which every Englishman regarded as indispensable for this country."

The sums spent on the various navies of the world, now published, clearly indicate the immense increase in recent years in the German naval expenditure. Taking only the ten years embraced by the Government return, we find that Germany began increasing her total naval expenditure at a very rapid rate from 1907-8, while the British expenditure was actually being decreased. It was only in 1909, when the menace of Germany began to be fully realised in this country, that we accepted, vigorously and readily, the burden of heavier naval armaments. On page 384 of this issue we have set out the figures of total naval expenditure, and plotted them in curves which show at a glance the state of the case. From the British figures we have deducted such items as naval pensions, &c., which are not borne on the Navy Estimates of the principal Continental Powers, in order that the comparison may be on an accurate basis. The German menace is more pronouncedly established by the figures allotted to new construction, and it will be seen that in 1908-9 and 1909-10 the German expenditure approached within a million sterling of the British expenditure. No one can for a moment question the policy of our Government in effecting the rapid increase in our naval expenditure indicated in the diagram, our expenditure in the following year (1910-11) increasing by 3¾ millions sterling, as compared with 1¼ millions by the German Navy authorities. From this time forward it became necessary for us to look the matter squarely in the face, and to establish our superiority in *matériel* as well as *personnel*. No one, even if he be of another nation, looking to our immense interests involved, can for a single moment question the propriety of our naval expenditure to-day on new construction being about 80 per cent. in advance of that of the Germans.

The third set of tables and diagrams published on page 384 of this issue give the tonnage of new vessels launched by the various Powers; and here again the advance of Germany is clearly marked. For the two years 1908-9 and 1909-10 Germany actually launched a greater warship tonnage than Great Britain, so that here again there is found proof for the necessity of our augmented activity since then. During the past five years Britain has launched 755,620 tons, as against 517,409 tons by Germany; but it should be noted that the latter figure does not include submarines, there being no official data available as to these. Approximately our total naval expenditure is double that of Germany, the basis of comparison being the same; the number of men borne is 90 per cent. greater. Last year the expenditure on new construction was 57 per cent. greater. The tonnage of British warships launched was 36 per cent. greater than that of German ships. This disparity between the percentages of cost and tonnage launched of new construction of the two nations is due partly to the greater size and superiority of the British units, and in part to the fluctuations owing to the state of progress of the various vessels in the builders' yards, and the exclusion of German submarines, this type of craft being much more costly per ton displacement. In view of the relative extent of our coast-line, and of the interests involved over-seas, the excess of expenditure by Britain is certainly none too large.

Our Imperial conditions require that in action our Fleet must take the offensive, and it needs no expert knowledge to know that this involves a considerable excess in force. Events during the war have proved beyond any doubt the need for this superiority. An inferior fleet, as a rule, remains in its port until greater equality is achieved in the comparative strength of ships of the line by some of the enemy's big ships being destroyed. That is consistent with the dictates of naval commonsense. It is, on the other hand, a first principle that the "watching" fleet should give the enemy the opportunity to escape, and therefore blockade or investment is not resorted to. Thus the watching fleet, since it has to cover an enormous line of observation, must be of great numerical superiority. The possibility of units or small fleets escaping unobserved, owing to mist or other climatic conditions, is another contingency which can only be met by numerical superiority, since it becomes essential to have sufficient ships, apart from the Grand Fleet, to convoy such expeditionary forces as must be sent from an insular kingdom to engage in land warfare on the Continent, and to combat stray marauding units of the enemy's fleet. From these general principles there follows explanation, too, of the occasional losses which have been, and must continue to be, experienced, even by a fleet which holds command of the sea, as is the case with our Grand Fleet in the North Sea. Notwithstanding isolated cases of losses, the credit side of the British naval balance-sheet is fully satisfactory, in respect that we have exercised a "silent pressure" which is as effective almost as the annihilation of the enemy's fleet, so far as current mercantile shipping is concerned. This general result, too, has been attained without having a greater superiority in numbers than the geographical and strategical conditions demand.

While avoiding any detailed record of the progress of events until there are available definite lessons bearing on the utilisation of applied science, and notably on the type and design of ship most suited to modern warfare, it is permissible to refer to the enormous influence which wireless telegraphy has had on the tactics of commerce destruction. Some of the more regrettable episodes in the sea engagements hitherto are due to the presence on the ocean of commerce-destroying cruisers, and the comparative immunity with which these vessels have continued at sea. They have so far done comparatively little destructive work, but the consciousness of their presence—the continued possibility of their raiding some of the highways of commerce—is disturbing. This presence has been possible only by the existence of the enemy's wireless stations. The best example of this is the work of the German cruiser Emden, of whose whereabouts, from the commencement of the war, there had been no public knowledge. At the outbreak of war she was in the vicinity of Kiao Chau, and since then seems to have scoured practically the whole of the

eastern seas. The German wireless stations, which have very considerable range, were undoubtedly the medium whereby the situation of ships was ascertained and communicated to her, and from which also she got information of the whereabouts of her colliers. Messages, too, could easily be intercepted from merchantmen, but naval codes may have defeated the correct understanding of naval operations. There is no doubt that the commerce destruction work of the German cruisers has thus been facilitated. One after another of the German wireless stations have been destroyed, so that, with the destruction of the last of these, there will be withdrawn from the naval operations the greater part of the influence of this new engineering development. It is important, however, to reflect that of a British merchant fleet consisting of 4000 vessels engaged in oversea trade only 12 have been captured and sunk at sea by these commerce-destroying ships, while 70 more were detained in German ports at the outbreak of the war. In the case of the German merchant fleet, which is enormously smaller, 95 ships were detained in British ports at the outbreak of the war, and 92 have since been captured, making a total of 187 vessels. The loss of the armoured merchant cruisers, Kaiser Wilhelm der Grosse and the Cap Trafalgar—both important ships in the German passenger service—is further proof of our sea supremacy. The sinking of the latter by the Carmania, a British merchant cruiser, is an event which goes some way to prove the effectiveness of merchant ships for commerce protection.

The "silent pressure" of the Fleet must in the end have a great economic influence on the war. The shipping of the Allies and of non-combatant Powers proceeds practically as if there were no war in progress. The consequence is that our supplies of food and raw materials, so far as these come from the Allies or non-belligerent countries, have not been at all seriously affected. Our imports of food total over five millions sterling per week. Were the supply interfered with prices would enormously advance. By the maintenance of prices of all food-stuffs of home or foreign supply at a normal level a sum has been saved since the war began which goes far to meet expenditure on the Navy. Again, our importation of raw materials for manufactures represents something like four millions sterling per week. Here again there has been a saving, not only in the cost of raw materials, but in the constancy of the amount of labour employed as a result of the maintenance of supplies. Indeed, it may be assumed that the effect of the "silent pressure" of the Navy on our enemy, and the consequent maintenance of oversea commerce, has in seven weeks saved Britain in the price of food, raw material, and wages, a sum equivalent to a year's expenditure on the Navy. Unfortunately, there is demanded, as is shown by the loss of the three armoured cruisers this week, and other operations on sea and also on land, a great deal of human life. But even when blood is the "price of Admiralty" we must, and will readily continue to, pay it in.

BRITISH PATENTS AND FOREIGN PATENTEES.

In our issues of August 28 and September 4 we explained the purport and provisions of the Patents, Designs, and Trade-Marks (Temporary Rules) Acts, 1914, under which the Board of Trade has been granted temporary powers to order, on the application of a person interested, and after due inquiry, the avoidance or suspension of patents, designs, and trade-marks, the proprietors whereof are subjects of a State at war with His Majesty. We also explained the machinery that had been devised to carry out the provisions of the Acts, and the procedure that was to be adopted. Since our last article the Board of Trade has issued further rules under the Acts, and it has now been made quite clear that in any case in which an order is made for avoiding or suspending in whole or in part, a patent or avoiding or suspending the registration, and all or any rights conferred by the registration of a design, the Board may, in its discretion, grant licences to make, use, exercise, or vend the patented invention or registered design, upon such terms and conditions, and either for the whole term of the patent or registration of the design or for such less period as the Board may think fit.

In dealing with the objects of the Acts we ventured to give a forecast of the manner in which they would be interpreted by the officials charged with that duty. Before the Acts were passed demands were made, very insistently in some quarters, that an attack should be made on all industrial property in the form of patents, designs, or trade-marks in this country owned or controlled by enemies, and that all patents, designs, or trade-marks so owned or controlled should be forthwith revoked, so that the manufactures and products thereby protected should become public property for the free use of our own producers and users.

This point of view was very one-sided, and open to serious objection. It did not take account of the valuable industrial property owned or controlled by our own countrymen in the territories of the enemy, and the risk to which such property would be exposed by retaliatory proceedings of a like nature. The new Acts were not, in our opinion, passed in any vindictive spirit, and the powers granted to the Board of Trade were not intended to be exercised in an arbitrary manner, and without due and careful consideration. The object of the Acts was merely to place our Government in a position to meet certain conditions should they arise, to take retaliatory measures against the property of enemies should property of our countrymen in their territories be confiscated or unjustly dealt with, and to enable manufactures and products usually obtained from abroad to be made or produced in this country while it was impossible to obtain external supplies. So long as a patent or design owned or controlled by an enemy was in force, a manufacturer who took upon himself to manufacture thereunder without the consent of the proprietor would, at the conclusion of hostilities, have been placed in a very awkward position. To meet, therefore, these conditions, the Acts were passed and are now part of the law of our land. They must not be regarded necessarily as means for confiscation, but rather as suspensory measures.

A large number of applications for the avoidance or suspension of patents and trade-marks has been filed in the Patent Office, and the manufactures thereby protected relate, as is only to be expected, to numerous trades. The applications received are advertised week by week in the *Illustrated Official Journal (Patents)* and the *Trade-Marks Journal*, and notice is also given of the date fixed for hearing the applicant in support of his petition and any person interested who desires to be heard in opposition. The number of applications filed in connection with patents amounted on Saturday last to 51, and in about 15 cases hearings have taken place before the Comptroller-General of Patents (Mr. W. Temple Franks) and his immediate predecessor, Sir C. N. Dalton, in that office. These gentlemen have been appointed by the Board of Trade to act conjointly and hold the necessary inquiry in connection with each application. At the conclusion of an inquiry they are required to report to the Board of Trade the information obtained and their recommendations, after which the Board will decide what is to be done.

So far as we know, the Board of Trade has not yet given a decision in any of the applications. From remarks made by the Comptroller-General during the hearings which have taken place it is possible to gather some idea of the spirit in which the officials regard the applications, and the recommendations the two gentlemen mentioned will make to the Board of Trade. Of course, it is to be remembered that the Comptroller-General and Sir C. N. Dalton are not the final arbiters, and that the recommendations which they may make may not be acceptable to the officials in Whitehall. We do not think, however, that the officials will deal with the cases otherwise than as the two gentlemen they have appointed recommend.

We are pleased to see that the Comptroller-General and Sir C. N. Dalton hold views in regard to the object of the Acts and the manner in which they are to be interpreted very similar to our own. The remarks which the Comptroller-General has made in the course of the hearings as to his view of the object of the Acts will not, we are sure, commend themselves to those persons who were calling for the confiscation of all British patents, designs, and trade-marks owned or controlled by enemies, and who were willing for a temporary advantage to take an action which would not redound to British credit and integrity, and perhaps would place the property of many of their own countrymen in jeopardy in the future.

Let us now deal with some of the cases that have been heard. In the first case, Mr. H. S. Wellcome, of Burroughes, Wellcome and Co., had made application in connection with the patent covering the manufacture of the drug known as "salvarsan." It appeared that the applicant was quite willing to take a licence under the patent—as we have pointed out above, the Board of Trade will probably order the grant of a licence under an enemy-held patent or design—and asked that the licence, if granted, should be for the unexpired term of the patent. The patentees also appeared, and the manager of their English works stated that they were in a position to manufacture in this country all the salvarsan required. The Comptroller-General, in the course of the hearings, has explained his view as to the position of an applicant in regard to the payment of royalty. In his opinion, it would not be fair to deprive the enemy of his property, and the applicants have been asked whether they would be prepared to pay royalty, the money being paid over and held by the State until the war is over. From other remarks of the Comptroller-General it would appear that, generally speaking, the recommendation which he and his colleague would make would probably be that some kind of licence be given, and that the licence, if it continued after the war, be subject to a royalty to the patentee, such as might be arranged with the patentee hereafter or by arbitration. We must confess that we are not enamoured with the suggestion that the royalty payable is to be determined hereafter. We think that the licence should state in terms the amount payable, and, further, should contain a proviso that the enemy is not hereafter to undersell the licensee. From remarks which have been made in other cases, it would appear that the Comptroller-General has seen the importance of these points, and his recommendations to the Board of Trade would deal with them.

In some other cases the transfer of trade-marks has been involved, and, speaking generally, the Comptroller-General has intimated that, unless it were proved to be in the public interest, he and his colleague could not recommend the Board of Trade to transfer to other businesses trade-marks which were known to be associated with foreign firms. If a firm were given, in certain circumstances, the right to use a trade-mark, it must be used in such a way that the public would not be deceived.

THE FOREIGN TRADE IN MACHINE-TOOLS.

One branch of engineering in which the British manufacturer might well expand at the expense of German and Austrian trade is in the construction of machine-tools. It is not the purpose of this article to show whether we in this country, or Germany, or the United States of America are pre-eminent in supplying machine-tools to the world, but rather to draw the attention of engineers to the moderate trade with Germany which we shall certainly lose owing to the war, and the large trade with other parts of the world which we might gain if we set ourselves earnestly and persistently to the task. There are some businesses to which the Board of Trade and the Press have been drawing our attention which are almost new to this country in many of their details, and which consequently involve the expenditure of considerable sums on new factories or new plant. At a time when money is so scarce, and the international atmosphere so uncertain, manufacturers are naturally chary of launching out in these directions, and it is therefore a relief to find a trade in which expansion is possible without any great additional outlay on plant or any difficulties of re-training labour.

The first aspect of the question which should be taken into consideration is the probable attitude of former German customers to the English machine-tool trade. Every one with any knowledge of current political matters knows that the German buyer will go to any country in future for his tools rather than to England, which, by its intervention in the greatest war of all time, has frustrated the Teutonic designs. Now it must not be thought that by retaliating in a similar way—that is, by buying from our own manufacturers all the machine-tools we have previously bought in Germany—we can maintain the balance of trade. We cannot, for

last year (1913) our export trade in lathes and similar tools to Germany was two-and-a-quarter times as much in value as our import of the same class of goods from that country. It is therefore clear that the war will damage our tool trade in, at any rate, one direction, and that it is therefore imperative that we should expand in other directions, not only because of the hope of obtaining new spheres of influence, but on account of the absolute necessity of counterbalancing our losses in the first-mentioned case. An analysis of the problem confronting manufacturers who wish to avail themselves of the present opportunity to secure some of Germany's machine-tool trade would split it up into two main divisions.

The first question to be answered is: What type and quality of machines are the Germans successfully selling in competition with us? and the second question is: In what countries have the Germans been most successful, and what are the possibilities of our securing this trade now that she is for the time being practically prohibited from competing with us.

The range of tools which Germany exports is a wide one, including lathes, planing, shaping, and milling-machines, drilling, boring, and slotting-machines, grinding and polishing-machines, and mechanical saws. The larger and more specialised machines for steel-working have also been exported to a considerable extent, chief amongst which may be mentioned rolling-presses and pressing-mills, hydraulic presses and steam-hammers, punching-machines and shearing-machines, riveting-machines, tack and nail making and file-cutting machines. There is also a large export of wood-working machinery from Germany, such as sawing, planing, chopping, and splitting-machines, and mortising and hole-cutting machines; and stone-working machines are also exported to some extent.

From the export statistics which are available, and after taking into careful consideration the methods and aims of German manufacturers, some indication can be given of the directions in which British machine-tool makers might extend their operations with every probability of considerable present and future success. The Germans, while not forgetting all the general demands of the trade, seem to have made very special efforts in two directions. They have endeavoured to produce a very cheap machine when it was of a type for which a very large demand could be confidently expected, such as that for simple and screw-cutting lathes and power drills. They have also shown considerable enterprise in the construction of very large tools, or tools for very exceptional and specialised purposes, for which the demand is so small that the English engineer has, perhaps, thought that it did not warrant the expense of the first outlay.

Another important feature of the German machines is the way in which they are beautifully finished off with burnt enamel and polished steel and brasswork. Although these finishing touches, of which the Germans often make so much, have no mechanical significance, they have nevertheless considerable value commercially, as they may favourably impress an ignorant buyer.

British manufacturers who make up their minds to plunge energetically into this trade warfare at the present excellent opportunity must also not forget that they will have to face an admirable selling organisation, the completeness of which in every branch of industry has been one of the secrets of German success. When the Germans have finished their machines they leave nothing to chance as far as the selling of them goes. They print their catalogues in the language of the country to which they hope the machines will go. They send a representative or agent who can speak that language to interview personally all their prospective customers, and they arrange with a local financial house to look carefully after their pecuniary interests. They study the local conditions and local requirements of the country with the greatest care, and never object to losing a little on an initial order if there is a fair prospect of repeat orders bringing future gain. If pushed with equal energy and equal tact, however, we need never be afraid that British machines will not sell as well as those which are made in Germany, and it will be as well therefore to glance rapidly at the details of Germany's machine-tool export trade.

As already mentioned, the import of German tools to this country is less than half of the corresponding exports from Great Britain to Germany. Leaving the United Kingdom, then, out of the question, let us see where the remainder of Germany's tools go. France, in 1912, took 500,000*l.* worth of metal-working machines alone, and another 50,000*l.* worth of hydraulic presses and steam-hammers and wood and stone-working machinery. Russia took nearly 600,000*l.* worth, and Italy over 400,000*l.* worth. Germany's machine-tool export then, in 1912, to these three countries was of the value of about 1,550,000*l.*, as compared with less than 300,000*l.* worth from the United Kingdom. Norway, Sweden, and Denmark together took tools to the value of about 190,000*l.* from Germany, and to the value of about 21,000*l.* from the United Kingdom. To Brazil the value of the German export of machine-tools was three times that from the United Kingdom, and to Argentina four times as much. And yet British machine-tools are unquestionably as good as, if not considerably better than, the corresponding German-made article. But Germany's total export of tools to twenty-four of the principal nations was to the value of over 3,000,000*l.*, whereas our own was less than a quarter of that amount. Germany's total export of tools is also about four times the value of ours—viz., 4,200,600*l.* worth from Germany to 1,012,800*l.* worth from the United Kingdom. In Australia and in Japan sales of British machinery are vastly ahead of those of Germany, but in almost every other direction Germany seems to hold the field alone. Taking the more important countries in turn, therefore, it is possible to estimate the value of the chances in each case. Why should Russia's enemy, Germany, send to her seven times as many machine-tools as Russia's ally, Great Britain? Chiefly because they are produced in such enormous quantities in Germany, and with so perfect a system that they can be offered much more cheaply than the English machines. And it must not be thought that they are necessarily bad because they are so cheap; they are doubtless very good value for the price paid. It is obvious that it is no use offering a man who has only 100*l.* in hand a machine that costs 200*l.* A simpler machine will please him well enough, and provide a profit for the maker. There is a sale in Russia for simple lathes, drills, punching and cutting machines; also for horizontal boring-machines, backing-off and facing lathes, engine-lathes, milling-machines, slotters, planers, and shapers of all kinds, and multiple drills; but they must be cheap. There is a big demand for planing, cutting, mortising, and other types of wood-working machinery. Small hand machine-tools of all kinds, for both wood and metal-working, have also a very large sale.

France is the second largest importer of German machine-tools, but in this case Germany sends little more than three times as much as the amount imported from the United Kingdom. Why? The difference in freight charges may partly account for it, but the difference in language is most likely the more important factor. In spite of our insular peculiarities, we in this country have generally some knowledge of French, and can consequently carry on French business; but what percentage of the English business population know anything of Russian? The numbers would be found to be as surprisingly small here as they are large in Germany. There is still ample room for extension of our machine-tool trade in France, however, and what has been said about the Russian market might be repeated of the French.

The Italian market would also well repay systematic working at the present time, for her imports of machine-tools are very large, and nearly six times as much comes from Germany as from the United Kingdom. Italy has so far maintained a neutral attitude in the war, but it is thought she would look very much more favourably on English commercial men at the present time than she would on those coming from Germany or Austria. Special note should be taken of the fact that her import of steam and hydraulic presses, riveting-machines, and mechanical hammers is larger than that of any other country, and also that she imports very large quantities of wood-working machinery—more than twice as much as any other European country, except Russia.

It is not surprising, for geographical and racial reasons, that Switzerland buys 95 per cent. of her machine-tools from Germany, but these reasons certainly do not explain why the Netherlands import nine times as much from Germany as from the United Kingdom. When this war is over we can hardly believe that any Belgian will, if he can help it, buy a German machine, and it is our duty to see that he is offered what he wants at a price that he can pay, and we shall then soon see increased business for us in this market.

Norway, Sweden, and Denmark are all countries where rich manufacturers are conspicuous by their absence, and where cheapness in price is an essential qualification of the machines that are bought. The German machine-tools are the cheapest, hence the Germans have practically a monopoly of the market in these three countries.

The German machine-tool exports to Spain, Roumania, Turkey, the Dutch East Indies, and the United States of America are all vastly in excess of our own, and it is not pleasant reading for an Englishman to see that Canada imports rather more than twice the value of machine-tools from Germany that she does from the Mother-Country.

Two other countries worth very special consideration are Argentina and Brazil. These two great South American Republics import vast quantities of machine-tools from Germany and a certain amount also from the United Kingdom. As the United States are said to export even more machine-tools to Brazil than Germany does, and these are on the whole high in price, it is evident that the Brazilian market is not controlled so much by cheap prices as some of the other countries mentioned, and it may be assumed, therefore, that German success in this direction is probably largely due to commercial efficiency and linguistic capabilities. A recent American Consular report mentioned, "weights should always be given in kilos.," and "copies of all invoices should be in Spanish." How many English exporters carry out these two simple but very important instructions? In trading with Argentina a curious local prejudice has to be taken into consideration—namely, that buyers almost invariably prefer to see what they buy rather than to select from catalogues under guarantee. Hence the local agent with showrooms and a good stock of machines plays an important part there, and it is said that Germany is better supplied in this particular than are the British exporters.

The market in China for machine-tools, except of the simplest and cheapest type, is not yet of great importance, but the probabilities are that this will greatly increase in the very near future, and enormous possibilities for enterprising manufacturers will then occur.

The part played by Austria in the machine-tool export trade has up to the present time been very small, her total exports last year of this class of machinery being only of the value of 40,000*l.* Her technical colleges are, however, wonderfully fitted up for instructing the rising generation in every branch of mechanical science and machine-tool practice, and as a consequence a considerable forward movement in the future may well be expected.

A general review of the whole situation, therefore, clearly indicates that that part of the nation which is engaged in the machine-tool trade has a present opportunity such as will never occur again. One most important competitor has for the moment been put in shackles by our Navy, and thus practically obliterated from the markets of the world. Our other great competitor, the United States of America, has recognised the possibilities of the present, and already an army of commercial travellers are on the way to the South American Continent.

It is time, then, that British manufacturers also entered the arena with the determination that they will never again allow another nation to supplant them in the field of machine-tool enterprise, and that they will carry this to its accomplishment by systematising their work, offering a new range of simpler and cheaper models, and, above all, by demanding from their salesmen and clerical staffs a knowledge of commerce and languages which can do justice to the machinery they supply.

THE SUSPENSION OF LEGAL REMEDIES.

THERE has been so much said and written about the moratorium that people may possibly lose sight of another Act of Parliament which seriously affects the rights of creditors. We refer to the Courts (Emergency Powers) Act, 1914, which received the Royal Assent on August 31, 1914. Although it is only an enabling measure, in that it merely confers certain new powers on the judges

who have to administer the law, it might, if enforced in one way, practically deprive all plaintiffs of the fruits of litigation for a considerable period.

Everyone will admit that a judgment is of little avail unless it can be enforced; it may be enforced, in the ordinary way, by execution—that is to say, a man's property may be sold, and the proceeds of sale may be applied to the payment of judgment debt and costs. Again, the landlord generally has power to distrain or to recover possession of premises for default in the payment of rent. Finally, in the case of a policy of insurance, the company generally has a formidable remedy for the non-payment of a premium due: it may forfeit the policy.

The new Act provides, by Section 1 (1) (*a*), that no person shall proceed to execution on, or otherwise to the enforcement of, any judgment or order of any Court for the payment or recovery of a sum of money except after an application to the Court. The "sum of money" here referred to means any sum of money due under a contract made before August 4, and rent (whether payable pursuant to a lease made before or since August 4), unless it amounts to 50*l.* a year or more. The following are examples of "sums of money" payment of which cannot be enforced without application to the Court:—

(i.) The price of goods sold prior to August 4.

(ii.) Salary due under a contract made prior to August 4.

(iii.) Payments due under the certificate of an engineer on the carrying out of works under a contract.

Before considering the powers of the Court, let us refer to the second half of Section 1, which further limits the rights of a judgment creditor. He may not (1 (1) (*b*)) levy any distress, take, resume, or enter into possession of any property, exercise any right of re-entry, foreclose, realise any security (except by way of sale by a mortgagee in possession), forfeit any deposit, or enforce the lapse of any policy of insurance to which this sub-section applies, or in default of the payment or recovery of any such sum of money, except after an application. The policy of insurance here mentioned only includes a policy for life or an endowment for an amount not exceeding 25*l.* The man who has a policy for 1000*l.* may forfeit it by non-payment of premium.

We now pass on to consider the powers of the Court on the making of an application. Section 1 (2) provides that if on an application the Court thinks that time should be given, on the ground that the defendant is unable immediately to make the payment by reason of circumstances attributable, directly or indirectly, to the present war, the Court may, in its absolute discretion, after considering all the circumstances of the case and the position of all the parties, by order, stay execution or defer the operation of any such remedies as aforesaid for such time and subject to such conditions as the Court thinks fit.

It will be interesting to see how the Court will exercise the very wide powers thus conferred upon it. The fact that there are two sides to everything will doubtless be borne in mind. A stay of execution may be a serious hardship to a judgment creditor. For instance, suppose a tenant in possession of a shop or mill under a lease dated before August 4 is unable to pay his rent. Is the landlord to be permanently kept out of possession because, owing to the war, the tenant cannot make the business pay, although another tenant could do so? We feel sure that before exercising the wide powers conferred upon them our judges will require strict proof of the fact that the defendant is unable to pay owing to circumstances arising out of the war, and that, failing a complete recognition of the plaintiff's rights, the defendant will be compelled to do all he can to make reparation.

Another very important power is given to the Court. Everyone knows that the most powerful means of enforcing the discharge of pecuniary liabilities are under the control of the Bankruptcy Court. A man will resist all other forms of execution, but he will pay up rather than run the risk of being made bankrupt. The Act under consideration provides (by Section 1 (3)) that where a bankruptcy petition has been presented against any debtor, and the debtor proves to the satisfaction of the Court having jurisdiction in bankruptcy that his inability to pay his debts is due to circumstances attributable, directly or indirectly, to the present war, the Court may, in its absolute discretion, after considering all the circumstances of the case, and the position of all the parties, at any time stay the proceedings under the petition for such time and subject to such conditions as the Court thinks fit.

We trust that, in exercising the discretion conferred by this provision, the Court will spare no effort to guard against the unscrupulous debtor who will make the war an excuse for the non-payment of his just debts.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. IV.

By FREDERICK WILLIAM LANCHESTER, M. Inst. C.E.

LOW-ALTITUDE FLYING.

OUR interest in the subject of low-altitude flying from the military point of view is entirely prospective; there are certain advantages to be derived from low-altitude flying that are not at once apparent; the disadvantages are too obvious to need mention.

It has often been noticed by the writer, and it is probably a matter of common observation, that an aeroplane, however visible it may be with the sky as background, is readily lost to sight and becomes exceedingly difficult to pick out when backed by a hill or a mountainside. This is the case with a machine finished "bright;"* when machines are given protective colouring, as is now customary, the difficulty of detecting their presence when below the sky-line will be far greater. Thus, so long as an aeroplane approaches any position at medium or high altitude, it may be clearly seen at some few miles distance, and measures will be taken to give it an appropriate reception; whereas a machine making its approach at quite low altitude would frequently be able to take the enemy quite by surprise. Beyond this it has been found that, except for reconnaissance, high altitude is not altogether advantageous. A certain amount of harm may be done by bomb-dropping, machine-gun fire, the raining of steel darts, &c.; but an aeroplane at a height cannot take an intimate and decisive part in a fray, as, for an example, cavalry charging or infantry with the bayonet. It might prove of enormous and overwhelming value if at any critical moment, or at any critical point, it were possible to let loose a few squadrons of aeroplanes each mounting one or more Lewis guns,† to bring short-range concentrated fire to bear, or alternatively to make an attack by the aid of bombs or hand-grenades. The scene that would ensue, for example, on a congested line of retreat would be indescribable: horses thrown into hopeless confusion or stampeded, mechanical transport lorries holed in a dozen or more vital points, water-jackets or radiators damaged, cylinders pierced, &c., gun teams wiped out, infantry decimated; in brief, chaos over endless miles of high road.

The question arises whether it is possible for the aeroplane to fly at a sufficiently low altitude to act effectively in the manner indicated without exposing itself to immediate destruction. The matter is entirely a question of armour; the unarmoured portions of the machine, which derive their immunity from their *transparency* to rifle-fire, are no worse off at point-blank range than at 2000 ft. or 3000 ft. altitude. Taking the altitude as 500 ft. (a reasonable maximum for the effective execution of the duties contemplated), the thickness of armour necessary is approximately $\frac{5}{32}$ in. (4 mm.) for the British service Mark VI. ammunition, or slightly over $\frac{1}{4}$ in. in the case of the pointed Mauser bullet, the latter thickness representing a weight of 10 lb. per sq. ft. It is evident that the problem of giving complete protection to the motor, pilot, and gunner will become a problem of some difficulty; probably in the present state of the constructor's art the protection would need to be somewhat "scamped," and a certain amount of risk admitted. Whatever economies are effected in armour, the main principle must not be lost sight of—*i.e.*, the thickness must not be tampered with; armour too thin for its duty is worse than canvas or brown paper.

Once the altitude has been brought down to 500 ft.—that is to say, if and when it is recognised as advantageous and found possible to utilise such low altitudes in aeroplane tactics—it becomes a question whether it will not be found to pay to "go the whole hog" and fly at the very lowest altitude possible. It may be at once admitted that all the dangers of flying, *qua* flying, will be thereby increased, but danger of the degree in question is a matter of little or no consideration in actual warfare. Briefly, the immediate suggestion is that if low-altitude flying is systematically to be undertaken, it should be conducted *quite* low—dangerously low, according to ordinary standards. At an altitude of 500 ft. an aeroplane still makes a very clear mark against the sky, visible from a considerable distance. By following the contour of the ground, never rising more than 100 ft. or 150 ft., unless to clear an obstacle not otherwise to be avoided, an attack will be made with comparative suddenness, and the machine will be gone out of sight almost before there has been time to bring a gun to bear. Even when under fire it will have a certain tactical advantage in the fact that it will be attacking a *line** parallel to which it is flying—it need never miss its target—whereas it itself offers the worst kind of mark to the enemy, combining small size, high speed, disconcertingly short range, in addition to which it is, in effect, a disappearing target. If one is tempted to be over-influenced by the obvious danger of such tactics, it is well to recall the exploits carried out as a matter of ordinary experience by cavalry under fire, without the advantage of armoured protection, while presenting a target (man and horse) something like 20 sq. ft. in area, and with a speed contemptibly small in comparison with that of flight. It is only necessary clearly to admit that in this form of fighting we may have to reckon with serious losses of men and machines, not occasional losses, as at present, but rather such as can be expressed as a percentage of the force engaged.

The further reduction of altitude now under discussion means that rifle-fire must be faced literally at muzzle velocity, and corresponding provision made in the thickness of the armour. For the pointed Mauser bullet, representing the maximum requirement of to-day, the thickness of plate needed is scarcely less than $\frac{3}{8}$ in., and the weight 13 lb. or 14 lb. per sq. ft. Evidently the question of weight of armour will become a difficulty of a most serious character, and no pretence can be made to give complete protection; the area must be cut down to an absolute minimum.

THE MACHINE-GUN IN THE SERVICE OF THE AERONAUTICAL ARM.

Rapidity of fire to the aeronautical gunner is a matter of first importance; the time during which he has the enemy under fire is necessarily brief, and in that time he must do the maximum injury possible; consequently we must regard the automatic or machine-gun (or pistol) as without rival as his weapon of offence.

The degree of accuracy attainable in firing with a machine-gun from an aeroplane depends primarily upon the weapon and the man, as in every other kind of shooting, but in addition the steadiness of the aeroplane is an important factor, this being mainly dependent upon the wind and weather. Under favourable conditions an expert shot using the Lewis gun has delivered the whole contents of a magazine (of 47 cartridges capacity) into an area 10 ft. by 60 ft. from an altitude of 600 ft. at a range of 1000 yards. Making allowance for this expert handling of the weapon, as being superior to the average ability available under service conditions, there can be no doubt as to the deadly efficiency of a gun of the Lewis type as an aeroplane armament. The writer has himself witnessed a performance very little inferior to the above in weather that could by no means be considered ideal. Apart from many detail points of merit, the Lewis gun is, for aeroplane service, superior to any other machine-gun at present available: firstly, on account of its self-contained magazine, which, by the abolition of the cartridge-belt, &c., permits of the gun being trained freely in any direction from vertically upwards to vertically downwards, and which also allows of its use as a shoulder-arm; and, secondly, by reason of the adoption of direct air cooling in place of the usual water-jacket.

Assuming the proved accuracy of the Lewis gun as the criterion of machine-gun fire, it is evident that an estimate of the effectiveness of low-altitude

* A term used by boat-builders to denote a varnished boat—not painted.

† This gun was illustrated and described in ENGINEERING of November 8, 1912, page 636.

* In nearly all cases the objective of attack will be a *line* of some kind; thus it may be a convoy or column in retreat; alternatively, if the attack be on an entrenched position or on the attacking force, the line formation is again in evidence; the pilot's instructions in every case would be to fly directly over or parallel to the line attacked.

aeroplane attack becomes little more than a matter of simple arithmetic. We may take, for example, the problem to be that of executing a counter-attack upon infantry, themselves attacking a position in open order, the counter-attack to be delivered against the foremost line, lying prone at two or three paces interval. We are justified in assuming that the magazines will be emptied over an area defined as a belt of 10 ft. or 12 ft. width, in which, therefore, there is one man to approximately 100 sq. ft. of ground under fire. Now the area of target offered by a man prone is approximately 5 sq. ft., so that, as an average, one bullet in twenty will find its mark. This represents a man knocked out for every 10 oz. of lead expended, which must be regarded as extremely economical, in view of the fact that it is usually supposed to take a hundredweight of lead to kill one man, say 30 lb. or 40 lb. for every man put out of action.

In any such work as the foregoing, the question of lowness of altitude is of vital importance. Since no attempt to aim at an individual mark is contemplated, there is no disadvantage from the point of view of the gunner in flying quite low. His target may appear as blurred as the side of a railway cutting viewed from the window of an express train, but so long as he "delivers the goods" within the belt of ground intended, his average hits will not be detrimentally affected. If he is shot at by the infantry line he is attacking, or by a supporting line (usually 300 yards, more or less, in the rear), every man attacking him breaks his cover and becomes a prominent mark for the defending infantry force. Beyond this, the aeroplane carries armour and presents a comparatively small vulnerable target. The advantage of low-altitude flying in the present connection lies in the fact that it is, in effect, a perfect defence against attack by long-range fire. No matter what developments may be made in air-defence artillery—even if means should be found to render an 18-pounder as handy as a sportman's shot-gun—if the attacking aeroplane fly low enough, the enemy cannot bring long-range fire to bear without bringing his own infantry lines under fire at the same time.

The Future of the Fighting Type of Aeroplane.

A reservation has already been made to the effect that low-altitude flying—*i.e.*, under 2000 ft.—as affecting the service use of the aeroplane, lies mainly with the future; the design of the machine for this class of work will require the most careful study on the lines already indicated, the essential point being immunity to attack by small-arm fire. In obtaining such immunity sacrifice of some kind will have to be made. Whether it be in the armour-plating of vitals or in the provision of redundant members or material, a great deal of otherwise unnecessary weight must needs be carried which ultimately reduces the carrying power in other directions. This means eventually either a reduction in the speed or a positive all-round increase in the size and weight of the machine. Granted that all initial difficulties be overcome, the advent of the armed and armoured low-altitude machine will initiate a new phase of aeroplane tactics, and one that cannot fail to have a far-reaching effect on the other Arms of the Service. The difficulties of cavalry operations will be increased incalculably; a body of cavalry, unless protected by a covering force of aeroplanes, will find itself continually open to attack, both by short-range machine-gun fire and by bombs or hand-grenades; in addition to which the demoralising effect of numbers of high-powered aeroplanes flying overhead, within 200 ft. or so, will be by no means a negligible factor. Up to the present the cavalry have been the Arm of greatest mobility, and nearly all cavalry operations on a large scale are fundamentally based upon, and rendered possible by, that fact. Once the aeroplane has taken its place in the actual fighting arena, this condition is definitely a thing of the past, and, so long as daylight lasts at least, any cavalry force not itself accompanied, or supported, by its own aeroplane auxiliary will find its every movement dogged by the hostile aeroplane, and its every operation baulked by counter-attack from above. Caught in the open, its only defence will be in dispersion over the widest possible front or area, otherwise it must take to the woods or whatever other cover is available. Further, it will be impossible for it to undertake a dismounted action, for the led horses (the bugbear of dismounted cavalry) will be either stampeded or destroyed, and its existence as an effective unit will be at an end.

It must not be supposed, however fully the present anticipations of the development of the aeroplane as a fighting machine may be realised, that the value of cavalry is at an end; this is not the writer's view in any sense. It is probable that in the early stages of a battle, or of a campaign, the cavalry Arm will cease to play the important *rôle* that at present is, and has hitherto been, assigned to it, and that the pushing out of advance posts and reconnaissance will devolve more and more on the armed and armoured motor-car and aeroplane. However this may be, there will still remain country in which cavalry can be advantageously employed, country in which cover (woods, forests, &c.) is plentiful, where mounted men are secure from aerial observation and attack, and where a mounted force is virtually the only means by aid of which the terrain can be effectively reconnoitred.

Thus, also, in wooded country, in the reconnaissance that accompanies or precedes an army on the march, it would seem probable that the aeroplane and cavalry will be used in conjunction, the more distant work being accomplished by the aeroplanes, whose presence would also ensure the protection of the cavalry from hostile aircraft. The detail work, including the holding of bridges and advance positions of importance, also the location of and dealing with any patrols or other bodies of the enemy that may be encountered will be accomplished by the cavalry. The obvious disadvantage of the use of the aeroplane for reconnoitring is that it informs the enemy of the advance or presence of a hostile force. Where this fact is of weight, the protecting flight or squadron of aeroplanes would be best handled as a supporting force, with perhaps one machine at high altitude to maintain contact, the duties of this latter machine being to keep in touch and transmit information to the divisional or army corps command, and to call for the supporting aeroplane force should occasion require. Exactly how the combination of the two Arms (aircraft and cavalry) will be controlled and handled it is impossible, without actual experience, to lay down. The main point is that in the new Arm we have a force altogether transcending the cavalry as to mobility and range of observation, and which before long will become an actual fighting force of no mean importance, and these facts cannot fail to be revolutionary in their ultimate influence on the *rôle* and employment of the cavalry Arm.

Ironmasters' Quarterly Meeting.—The date of the Ironmasters' quarterly meeting has been restored to the original fixture—viz., October 8, in Birmingham.

Engineer Units, Royal Naval Division.—A Joint Committee of the Institutions of Civil, Electrical, and Mechanical Engineers is engaged in the selection of men for the Engineer Units of the Royal Naval Division, a notice of which appeared on page 360 of our last issue. There are still some vacancies to be filled, and applications are invited from engineers and architects who are members of professional societies. Application to be made in person at the special recruiting-office at No. 2, Savoy Hill, W.C., between 10 a.m. and 1 p.m., or between 2 p.m. and 4 p.m.

The Superheater Element.—In a recent leading article (page 17 *ante*) we discussed the proportions of the superheater element of the type now commonly employed in locomotive work. We referred at the time to certain experiments carried out on the Pennsylvania Railroad testing plant at Altoona on the effect of changes in length and form of these elements on superheat. The early data which were available when our comments were written seemed to show slight inconsistencies, a fact to which we incidentally referred on page 18 *ante*. Our readers will be interested to learn that we have lately been informed by Mr. C. D. Young, who is in charge of the experimental work at Altoona, that the seemingly inconsistent series of tests have been repeated, and that now all are concordant. In these experiments the length of the elements and of the return bends were altered in a methodical manner. The final results seem to show that an element extending down towards the fire-box, but only half-way back for the return bend, giving only 75 per cent. of the standard element surface, showed results equal to the standard element in which the return bend is brought back to the smoke-box. The point which had attracted our attention was that the results shown for an element having a return-bend length between these two, and therefore of about 87½ per cent. the standard surface, fell far below the others. There appeared to us to be no reason for this. It seemed more logical to expect the 87½ per cent. surface element to group with the 100 per cent. and the 75 per cent. elements. Later tests have proved this to be the case. The results from an element of this description fall about where they should do to be consistent with the other results obtained.

INDUSTRIAL NOTES.

At a meeting of the Coventry Trades and Labour Council, which was held on Thursday, the 17th inst., consideration was given to the way in which, it was alleged, men working in factories full of war orders had preferred working overtime to allowing a distribution of labour among a larger number of their fellows.

Mr. J. Chater, the secretary, stated that the Trades Council had endeavoured to deal with excessive overtime at the ordnance works. The matter came before a central conference of the engineering trade at York, and was referred to local associations in various places. At Sheffield, he added, the employers were prepared for three shifts a day of eight hours each, but some workmen called for a two-shift day, which meant abnormal overtime. At Birmingham much the same thing had happened, and men were working seventy hours a week.

Other speakers dealt with the old ideal of trade unionism against overtime working, an ideal which had been overthrown by workmen's "grabbing." The men's action had rendered it difficult to deal with the ordnance works, but further attempts would, however, be made to regularise hours in the interest of men now unemployed or only partially employed.

The only commentary is that the ordnance firms cannot get the men.

We are informed that a deputation of house-painters in Birkenhead waited upon the Mayor, requesting him to take action in asking people to proceed with their house-painting schemes. The deputation pointed out that unemployment in their trade was continuing, and that whereas in normal times only about 20 men would be out of work, there were at present 180 out of a total of 400. Many private individuals, the deputation said, had abandoned proposed contracts owing to the war. The deputation also urged the importance of the Corporation doing all in its power to put in hand painting work. The Mayor expressed great sympathy with the men, and promised to do all he could to further their object.

The Lancashire cotton trade is also in a difficult situation owing to the war.

At a meeting of the Salford Education Committee held on Monday last, the 21st inst., evidence of the extent of unemployment due to the war was given in two letters addressed to the chairman. The first letter, from the Building Trades' Federation, stated that there was an enormous amount of distress caused by the stagnation of industry, and the Federation were asking all public bodies to press forward work in hand, and, where practicable, to carry on now work which had been reserved for the future. It was only with such assistance, the Federation added, that they could hope to cope with unemployment.

The second letter, from the National Amalgamated Society of Operative House and Ship Painters and Decorators, drew attention to the deplorable state of the painting trade in Salford. It stated that since war was declared large numbers of painters had been dismissed every week, at a time when painters were generally in full employment. A great amount of distress existed, and the Society urged that as much painting and decorating work as possible should be put forward at the earliest possible moment.

The letters were referred to the Elementary Education Sub-Committee.

The consequences of the war are, indeed, most far-reaching. As a further instance, among others, which we could name, we may state that the first report issued by the United States in regard to the traffic through the Panama Canal shows that as a direct result of the European conflagration the receipts are ridiculously low. The tolls received from the first week's traffic amounted to only 3000*l*. This sum is insufficient to pay the operating expenses, to say nothing of the interest on the capital involved. The canal could not have been opened at a worse time.

But the war will not last for ever. A very large proportion of the trade which formerly went to Germany and Austria will be recovered by this country even before the cessation of hostilities, to the benefit of the whole British working class, a class which, as we stated on a former occasion in these columns, is a much more numerous class than the hand-labourers wish to acknowledge. The Panama Canal also, when the time comes, will become a paying undertaking.

Publicity is given by Reuter's Agency to an article contained in the Berlin journal *Vorwaerts*, which states that in Nuremberg there are 55,723 workers, of whom 41,812 are men. About 30 per cent. of these latter have been called to the Colours, and of the remaining 43,549 male and female, 11,756 are out of work. These figures are compiled from official statistics, but the true numbers of unemployed are probably still higher, as some of the trade federations have not sent in their

reports, and the *Vorwaerts* estimates that at least one-third of the working population is without work in consequence of the war. At the outbreak of war there were only 1934 unemployed. This number increased to 9822 in the first month of hostilities. The *Vorwaerts* declares that these figures can be applied to all large towns and trades in Germany, and that it is undoubtedly the fact that unemployment is increasing week by week. Clearly, the journal adds, this question of unemployment is a very serious one for the Government.

In our last issue (on page 369 *ante*) we gave a few particulars of the schemes set on foot in this country to deal with a part of our unemployed population by the reclamation of waste lands. We also referred to the pit-prop difficulty. In Canada, suggestions have also been put forward to provide against unemployment by afforestation. In Norfolk County, Ontario, a farm has been established, under the control of Professor Zavitz, for the purpose of propagating trees, which will eventually help towards the afforestation of Ontario. No fewer than 410,000 trees were distributed in the course of last spring from the stations throughout the province to be planted as a start in afforestation. Forty years hence these small trees will have become a valuable asset. This is only a beginning. Thousands of trees will be sent every year from the farm. These trees will be supplied free. One hundred and twenty acres are now permanently planted for forests. The people of the country have been quick to realise the need which exists for more forest area, and the demands made for trees have been so great that last spring not a tree was added to the permanent plantation. The nut trees were cleared out entirely, and most of the other common varieties shared a similar fate. Chief amongst the varieties sent out were Scotch, white, red, and jack pine, black locust, white ash, hard maple, and nut trees.

The *London and China Telegraph* gives publicity to the following bulletin issued by the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington :—

"In the upbuilding of the Japanese cotton industry the mills have been greatly hampered by lack of money and experience, as well as by lack of skilled operatives, and the difficulty, under their system of transient girl operatives, of creating and maintaining a trained force. The first cost of the mills is so great that, with high interest charges and high taxes, which have greatly increased since the Russian war, the manufacturers have resisted all attempts by the authorities to enact regulations that would interfere with night-work. The mills have been greatly favoured by a supply of extremely cheap labour, and by freedom from laws prohibiting long working hours. They have also been enabled to keep down the cost of raw material by varying the mixings, and thus setting off one cotton against another in a way that is not permissible in countries making the higher classes of goods that require a single grade of cotton. Most of the yarns and cloths produced by Japanese mills are made from a mixture of Indian, American, and Chinese cotton, and the low cost of raw material thus obtained seems to aid the manufacturers in their struggle for the Chinese market as much as does their cheaper labour, especially as the labour is very inefficient. Japan ships cotton yarns and cotton goods to many countries, but its one large market is China, where it finds competition in yarn from India and cloth from the United States. The Japanese fear the future competition of Chinese mills more than they do the American and Indian. The Chinese cotton industry is small, but developing, and if the tariff is raised, as now proposed, the Chinese may quickly become a strong factor in the situation."

In reply to an application sent by the Mercantile Marine Service Association to the Admiralty regarding the pay of masters and officers of the mercantile marine engaged on transport service, Rear-Admiral Herbert Savory, Director of Transports, has written stating that the Admiralty have no objection to the authorised flat rise of 1*l.* monthly being extended to the masters, officers, and engineers of steamers chartered or requisitioned during the present emergency. The Admiralty are informing the owners of such vessels to that effect.

As bearing on the same subject, we may add that an intimation was received at South Shields on Tuesday last, the 22nd inst., from the head-quarters of the Marine Engineers' Association to the effect that all engineers employed on steamers chartered by the Admiralty had been granted an advance of 1*l.* per month on account of war risks.

The *Manchester Guardian* reports that the Home Trade Association of Manchester again had under consideration on Tuesday last, the 22nd inst., the question of whether a reduction of the salaries of their employees is necessary. The subject was last discussed at a meeting held on August 25. The Association then passed a resolution, which in substance was a warning that the economies which war made it necessary for firms to practise might have to be extended to a reduction of salaries. The resolution recommended, however, that no salaries should be reduced until the Association had reconsidered the matter in the light of later experience.

The position was reviewed on Tuesday, when the members of the Association were again advised not to take any action until the end of the year. With one or two exceptions, the firms represented in the Association have acted in accordance with the recommendation made in August, and it is unlikely that the warehouse staffs generally will suffer a reduction of salaries or wages this year.

The committee of the Home Trade Association passed the following resolution, on the motion of Mr. R. H. Brooks (of Messrs. I. J. and G. Cooper, Limited), seconded by Mr. J. G. Nidd (of Messrs. Sparrow, Hardwick and Co.):—"That following the previous recommendation of the Association on the subject of wages and salaries—Resolved: That it be a recommendation to the general body of members that no reductions be made in salaries and wages prior to December 31." At the meeting of the general body of members immediately following, the resolution was unanimously adopted, on the motion of Mr. R. H. Brooks, seconded by Mr. J. Watson (of Messrs. Peel, Watson and Co.).

A letter signed by twelve trade-unionists in the employment of Messrs. Siemens Brothers Dynamo Works, Limited, at Stafford, has been sent to the Press calling attention to the fact that 2000 men are engaged at the works, of whom only 4 per cent. are foreigners, and not all these are Germans. If, as has been suggested, there should be a boycott of the firm, these 2000 men would suffer an immediate loss of work, and it would be a considerable time before they could transport themselves and their families to other towns when vacancies could be found. The town of Stafford would feel the withdrawal of some 100,000*l.* a year now paid in wages, and for this there could be no compensation to be found in migration. The firm of Siemens Brothers, of which the Stafford firm is an off-shoot, was founded in 1847 by Mr. William Siemens.

A NEW PROCESS FOR HEATING BLAST-FURNACE STOVES.*

By A. SPANNAGEL, Dipl.-Ing. (Neunkirchen-Saar).

IN November, 1913, the first description of the new method known as the Pfoser-Strack-Stumm system for the acceleration of the heating of Cowper stoves was published† by Mr. H. Schmalenbach, works manager at Neunkirchen; but as the principle may perhaps not yet be generally known, some account of its further development may be of interest.

The firm of Messrs. Stumm Brothers had for a long time been studying, as many others were doing, the problem of finding a more rational method for heating the blast-furnace stoves. In November, 1912, the firm engaged Mr. A. Pfoser, consulting engineer, of Achern (Baden), to carry out a four weeks' night-and-day test on a stove 25 m. (82 ft.) high and 6.5 m. (21 ft.) in diameter, and on the basis of the exact data obtained to establish a heat balance. In general, the results showed that, of the total heat put into the stove, about 26 per cent. was carried off in the waste gases and 18 per cent. was lost by radiation. The efficiency of the stove therefore amounted to about 56 per cent. Certain observations made while the test was in progress led both Mr. Pfoser and Mr. O. Strack, chief engineer at the Neunkirchen Works, to conceive a method by which the heating of the stoves would be improved. Hitherto the almost universal practice has been to heat up the stove for 3 to 5 hours, and then to remove heat by sending the blast through for 1 to 1½ hours.

The operation of heating up and the removal of heat are both, however, as a matter of fact, a function of the heat conductivity of the firebricks, since both the products of combustion, passing through during heating, and the air passing through while the stove is under blast, are gases possessing the same physical properties. Why, then, should the chequer-work give up its heat to the blast in so much shorter a time than is required to collect the heat from the waste gases?

In searching for the explanation of this phenomenon, it occurred to both the above-mentioned gentlemen that the difference in the velocity of the gases during the periods of heating and of removal of heat had something to do with it, and it is this fact that gave the solution to the question, and forms the principle on which the subsequent invention is based.

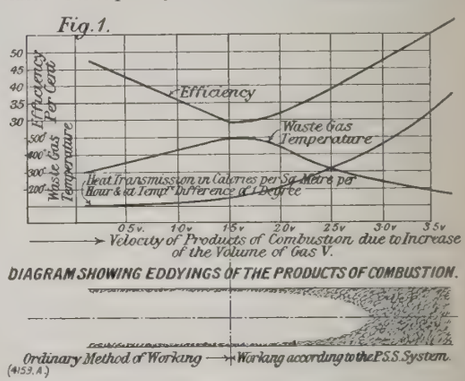
It is generally known that under present conditions, when it is required to raise the temperature of the stoves, which is done by sending through a larger quantity of gas in a given time, the temperature of the waste gases rises, and the waste gas losses are increased—that is, the efficiency is reduced. By practical experiments it has been determined that this rule only holds good up to a certain point. If the supply of products of combustion is increased beyond a certain amount, the waste-gas temperature not only ceases to rise, but begins to fall. The process is represented diagrammatically in Fig. 1. This apparent contradiction may be explained by a consideration of the conditions under which the transmission of heat takes place in the channels of the chequer-work. Through each channel there flows a current of gas, which may be imagined as consisting of innumerable gas molecules. With a low velocity, it may be assumed that the molecules flow almost parallel to each other through the channels, the friction with the bricks being inconsiderable. Therefore, only those molecules flowing close along the channel walls transmit their heat direct by contact, while the inner ones in the centre of the current can only impart their heat slowly by radiation. Thus, if the quantity and velocity of the products of combustion are low, the heating period will be very long, with low waste-gas temperatures. If, now, the velocity of the heating mixture be increased to about the maximum usual velocity, the friction of the gas particles against the bricks causes eddying in the outer layer of gas, and the inner particles are also thereby partly brought into motion. The heat transmission becomes more rapid, but since the quantity of gas is considerably greater, in consequence of the increased velocity, a larger proportion of the heat is carried off unused; that is to say, the heating period is shortened, but the temperature of the waste gases is raised.

By increasing the velocity still more, the gas molecules finally come to be driven with force through the channels, and the friction against the bricks becomes so great that the particles rebound and impart their whirling motion to those in the very centre of the current. The violent eddying brings all the molecules within a very short time in contact with the bricks, and they give up their heat more rapidly. The result is that the waste-gas temperature falls. The amount of heating gas and quantity of heat introduced in a given time is, however, greater, so that the heating period is shortened.

The new system, to which the name Pfoser-Strack-Stumm (P.S.S.) has been given, offers the following advantages :—

1. The ability to shorten the heating period down to or below the period during which the stove is under blast. Consequently two stoves are sufficient to serve one

Fig. 1.


Efficiency Per Cent
Waste Gas Temperature
Efficiency
Waste Gas Temperature
Heat Transmission in Calories per Sq. Metre per Hour & at Temp. Difference of 1 Degree
0.5 v.
1.0 v.
1.5 v.
2.0 v.
2.5 v.
3.0 v.
3.5 v.
Velocity of Products of Combustion due to Increase of the Volume of Gas V.
DIAGRAM SHOWING EDDYINGS OF THE PRODUCTS OF COMBUSTION.
Ordinary Method of Working
Working according to the P.S.S. System.
(4152.A)

blast-furnace, or, in practice, five stoves will serve two blast-furnaces, one being kept in reserve. In a new plant this means a saving both in capital cost and space. With fewer stoves in operation there will also be a reduction in the great losses due to radiation with a corresponding saving in gas.

2. By keeping to the same heating period the stoves can be brought up to a much higher temperature, owing to the greater quantity of air and gas consumed, and by increasing the temperature of the blast an economy in coke will result.

3. An almost uniform blast temperature can be maintained by running two stoves in series. This is quite practicable where four stoves are attached to one blast-furnace. The hot gases can be driven through two stoves in succession, and the blast afterwards sent through in the reverse direction. Such an arrangement is equivalent to having two stoves of double the ordinary height. The blast can be kept at a high and nearly even temperature; the waste-gas temperature is very low, and the heat of combustion is well utilised.

The first tests with the system were made at Neunkirchen, in February, 1913, on an old stove, 25 m. (82 ft.) high and 6.5 m. (21 ft.) in diameter. It was built up inside with hollow hexagonal bricks, the internal diameter being 150 mm. (6 in.), and the heating surface of the chequer-work was 3800 sq. m. (40,888 sq. ft.). The stove was heated by rough-cleaned gas containing about 0.5 gramme of dust per cubic metre.

After long consideration, the plan was tried of forcing a larger volume of waste gas through the stove by blowing in compressed air through a nozzle. For the sake of convenience the supply of compressed air was drawn from the cold-air main, which was throttled up to about 30 cm. (12-in.) water-gauge pressure. By this means it was possible to conduct the experiments without incurring much cost.

The arrangement for the first trials, which can easily be applied to any stove, is shown in Figs. 2 to 4. A nozzle of firebrick is built into the combustion-flue. The gas, at about 10 cm. (4 in.) water-gauge pressure, is admitted through its original inlet, above which the firebrick nozzle is built, and the compressed air is blown in through a cast-iron elbow-pipe, inserted into the flue through an existing man-hole, and directly connected with the cold-air main. The quantity of air was regu-

* Paper contributed to the Iron and Steel Institute, and now open for discussion by correspondence.

† *Stahl und Eisen*, 1914, No. 8, pages 305 to 310.

lated according to the analysis of the hot gases, so as to allow no excess of oxygen or of carbon monoxide.

The heating period of the stove under test was immediately reduced at the first trial to about 1½ hours, the temperatures of the waste gases and of the blast being 350 deg. Cent. maximum, and 800 deg. Cent. respectively, as compared with the former heating period of 4½ hours to 5 hours, and a waste-gas temperature of about 700 deg. maximum, the blast temperature being the same. Since the results were so unexpectedly favourable, a special arrangement was devised for three blast-furnaces.

A fan of about 90 horse-power was installed, which supplied air at a pressure of about 40 cm. (16 in.) water-gauge pressure, through an iron pipe to the six stoves serving the three blast-furnaces. Unfortunately, owing to lack of space, the pipe had to be laid in the ground, a circumstance which caused several inconveniences, particularly as the elbow-pipe projecting into the nozzle was also, for the sake of simplicity, introduced through the bottom of the stove. The arrangement was subsequently altered, the elbow-pipe being introduced at the side above ground. The latest plan, as shown in Figs. 5 and 6, was to lay the compressed-air pipe at a little distance above ground. The form of the nozzle was not altered in any important respect.

The three blast-furnaces in question have now been a year in operation under the new system without any interruption worth mentioning. The lining of the stove has been regularly inspected without revealing a sign of any injurious influence. On the contrary, it was found that the stove required to be cleaned less frequently, as the greater part of the dust in the gases was carried off on account of the higher velocity, instead of depositing in the flues.

The diagram (Fig. 7, page 396) gives the temperatures, measured at the hot-air ring main, of the blast from two of the stoves, Nos. 18 and 19, which supply blast to furnace No. 3. The waste-gas temperatures, which were measured with the thermometer at the end of every heating period, are entered upon the diagram at the commencement of each change over to blast. It will be seen from the diagram that with a heating period of about 1½ hours, and with the same length of time under blast, the blast temperature falls by only about 100 deg. Cent., and the waste-gas temperature fluctuates from 300 deg. to 520 deg. as a maximum.

Fig. 8 shows the blast temperatures measured immediately behind stove No. 7 of the Burbach Works of the United Iron Works Company, Burbach-Eich-Düdelingen, working on the P.S.S. system. The stove is 22 m. (72 ft.) high, 6.5 m. (21 ft.) in diameter, and has 3600 sq. m. (38,736 sq. ft.) heating surface of the chequers. It is heated with pre-cleaned gas containing 0.3 gramme of dust per cubic metre. Fig. 9 shows the corresponding waste-gas temperatures of the same stove.

Comparative tests with the same stove showed that with the new system, and with a heating period of 1 hour, the same temperatures for blast and waste gases were maintained as when heating for 3 hours under the old system. The results of the tests are given in the accompanying table, and they refer to working with uncleaned gas or rough-cleaned gas.

Mode of Heating.	Heating Period, Hours.	Blast Period, Hours.	Mean Blast Temperature in Deg. Cent.	Fall of Temperature in Deg. Cent.	Mean Waste-Gas Temperature in Deg. Cent.	Volume of Blast, Cubic Metres per Hour.
Usual method adopted hitherto	3	1	876	150	445	26,700
New method ..	1	1	867	185	431	28,100

Since May, 1914, the stoves at Neunkirchen are partly worked on clean gas from a Beth-Halberg dry-cleaning plant.

The use of highly-cleaned gas enabled a further improvement to be realised—namely, to increase the velocity of the gases by reducing the cross-section of the heating passages, by which an increase in the heating surface of the whole stove can also be achieved. Hitherto the prospect of choking up, and the high frictional resistance, have prevented the adoption of very narrow passages; but one of these objections is removed by the use of high pressure, and the other by the application of clean gas.

Two stoves, Nos. 14 and 17, each 25 metres (82 ft.) high and 6.5 metres (21 ft.) diameter, and of equal dimensions in other respects, were adapted to the P.S.S. heating system for the purpose of comparative tests. No. 14 was built up inside with comparatively new hollow bricks of the hexagonal form usually adopted at Neunkirchen, as shown in Fig. 11, page 396. The other stove, No. 17, was fitted according to Strack's method.

The features of the new brick shown in Fig. 11, page 396, are that it is eight-sided, and has a hole of rather small diameter. As may be seen from the illustration, each group of four bricks abutting on one another form an additional passage of square section, which increases the heating surface considerably. If the useful height of the stove is 17 metres (55.76 ft.), the old apparatus would have a heating surface in the chequers of 3638 square metres (39,144 sq. ft.), with a weight of brick-

Fig. 2.

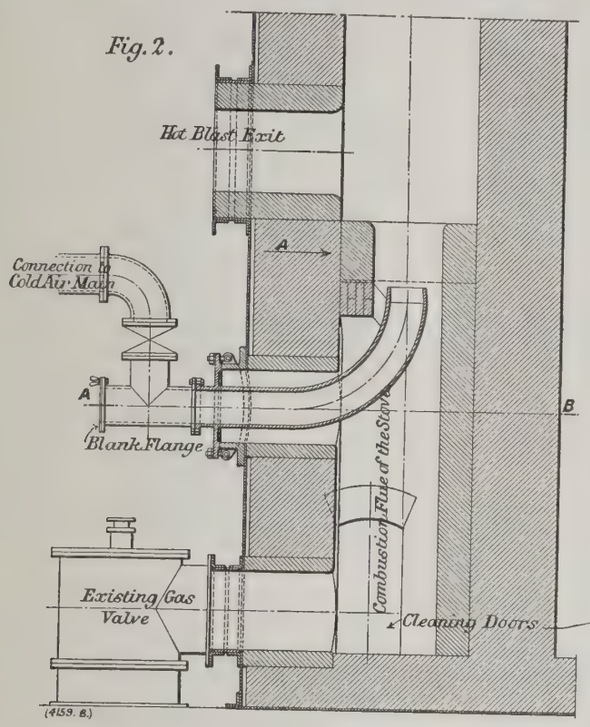


Fig. 3.

BRICKWORK OF BURNER VIEWED IN THE DIRECTION OF ARROW A.

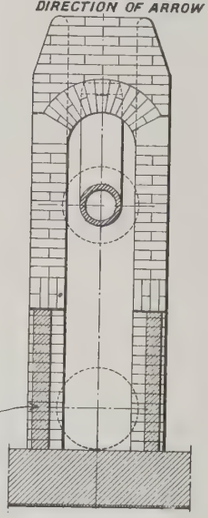


Fig. 4. SECTION A.B.

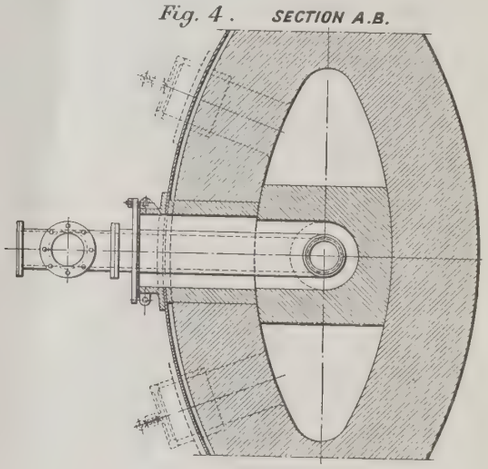


Fig. 5.

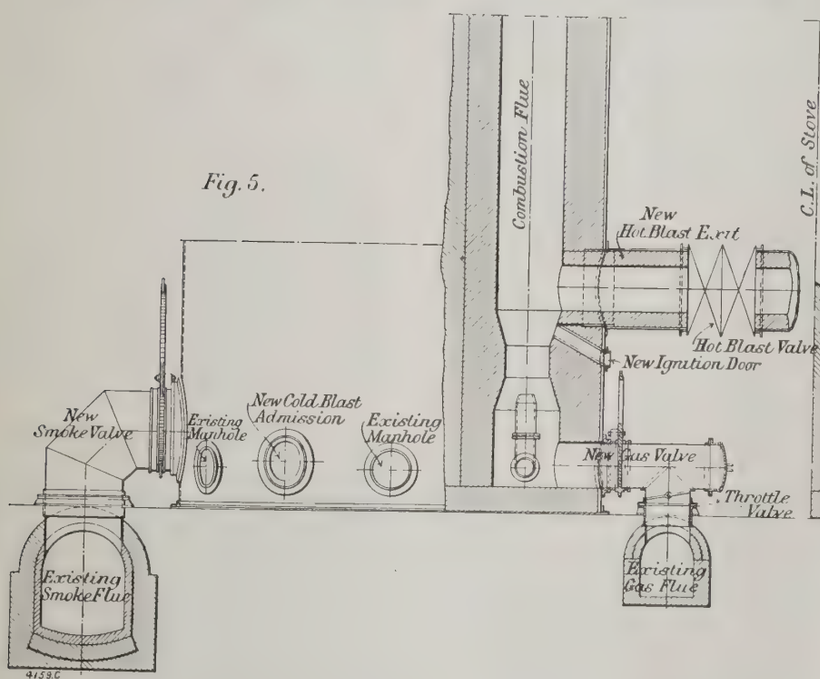
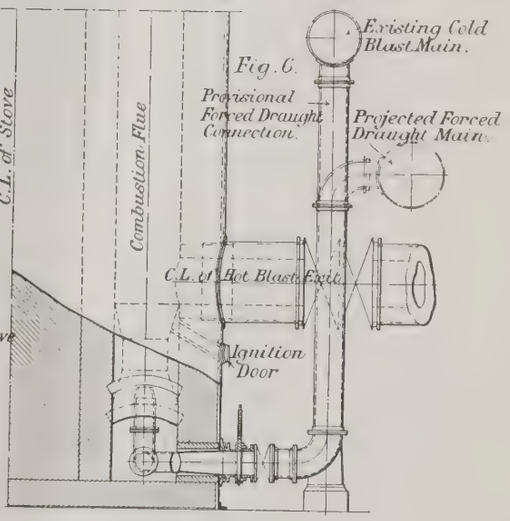


Fig. 6.



work of about 260 tons, whereas the new filling of a stove of the same useful height would give a heating surface of 7782 sq. m. (83,370 sq. ft.), with a weight of 300 tons of brickwork. The new form of brick therefore gives more than double the former area of heating surface, while the brickwork is only about 15 per cent. heavier. The old bricks present 14 sq. m. (150 sq. ft.) heating surface per ton, whereas the new ones give 25 5 sq. m. (274 sq. ft.) for the same weight.

In using bricks with such small holes there exists the danger that, owing to the displacement of the bricks, due to changes of temperature, they may get shifted across one another, and so close the passages. Lateral openings were therefore provided at one end of the bricks, which allow the gases to pass from one passage to the next if the vertical path is blocked. The openings also provide a means for the continuous exchange of gases between the square and round passages. In the square passages the gases give up their heat more rapidly than in the round ones, which have a larger cross-section in proportion to their heating surface. A difference therefore results in the pressure in the respective passages, which the holes provide a means of neutralising continually.

The two experimental stoves were put into operation on May 8, 1914, and have served blast-furnace No. 5 since that time without stopping. During May and June the furnace produced 169 tons of basic pig daily.

The stoves are usually 1½ hours under gas and 1½ hours under blast alternately. In the diagram, Fig. 10, of the temperatures taken at the hot-blast ring main, stove No. 17, filled with the new bricks, after heating for 1½ hours, was purposely left under blast for 2 to 3 hours, in order to show the great quantity of heat stored up. The diagram shows that even after 3 hours the temperature of the blast had only fallen by 180 deg. The waste-gas temperature at the end of the heating period in the new stove was 90 deg. to 116 deg., while in the stove on the old system it was 410 deg. to 440 deg. at the end of 1½ hours. These surprising results prove that it is possible with the Pfoser-Strack-Stumm system, and with the new form of brick, to maintain the same blast temperature when the heating period is reduced to a ratio of less than 1 : 1, and, at the same time, to obtain a lower waste-gas temperature than has ever before been found practicable.

As an illustration of the very remarkable economic importance of the new system, the following example may be referred to :—

The blast-furnace installation at Neunkirchen consisted of five blast-furnaces, each of 170 tons daily capacity, with nineteen stoves. A sixth blast-furnace is in course of construction, for which it is not required to erect a new stove. On the contrary, four of the old stoves are being pulled down to make room for the new furnace. In future, therefore, there will be six blast-furnaces working with fifteen stoves, of which latter not more than twelve will be running continually.

It is scarcely necessary to emphasise the saving in capital cost in this case. The regular economies in gas and coke which can be obtained by the adoption of the new system are even more important.

The gas consumption could not be very accurately determined as long as uncleaned gas was being used, and though highly-cleaned gas has been used since May, 1914, at Neunkirchen, it has, unfortunately, not been possible to do much in the way of measuring the gases, owing to the delay in the delivery of the meters. Some measurements have been made, however, using recording gas-meters by R. Fuess, of Steglitz, near Berlin, which have the advantages that the gas consumption is recorded, and that it can be read off on a counter at any time. Such measurements as have been made confirm Pfoser's experimental determinations, in which the gas was measured indirectly by ascertaining the air consumption. Pfoser had calculated a saving of 10 to 20 per cent. of gas. The comparative tests on the old and new systems using clean gas showed a considerably higher economy, but as tests extending over long periods are necessary to obtain absolute accuracy, the results, as far as known, are not sufficiently exact to justify publication at present.

In a works consisting of blast-furnaces only, where economy in the use of gas is not of such importance, the new system of heating the stoves permits of working with higher blast temperatures, using the same gas consumption. An experimental plant has been fitted up under these conditions, which, after a long test, showed a saving in coke of 40 kg. per ton.

The system is applicable to other purposes besides the efficient heating of stoves. Experiments which have already been made in boiler-firing have given particularly favourable results. Without making costly alterations, the evaporative capacity of Cornish boilers has been more than doubled, though the waste-gas temperatures were lower than under the old system of working.

Fig. 7. HOT BLAST TEMPERATURES OF STOVES 18 & 19 MEASURED AT THE HOT BLAST RING MAIN. NEUNKIRCHEN IRONWORKS.

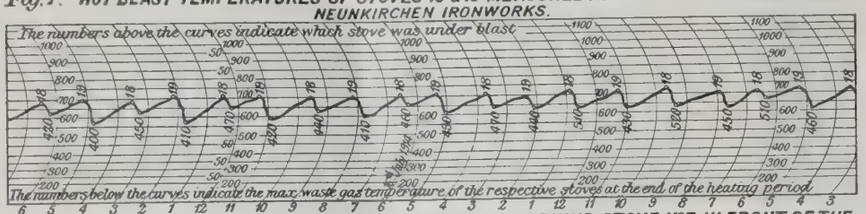
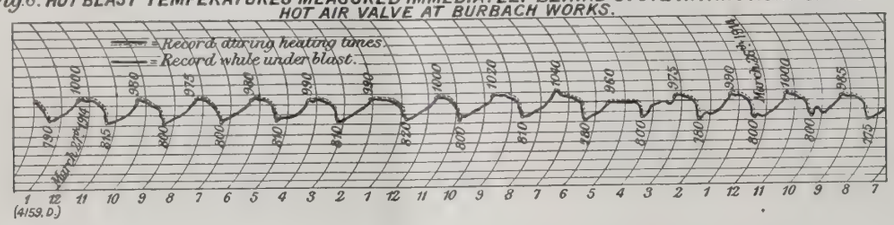

The numbers above the curves indicate which stove was under blast.
The numbers below the curves indicate the max. waste gas temperature of the respective stoves at the end of the heating period.

Fig. 8. HOT BLAST TEMPERATURES MEASURED IMMEDIATELY BEHIND STOVE No. 7. IN FRONT OF THE HOT AIR VALVE AT BURBACH WORKS.



(4159. D.)

Fig. 9. TEMPERATURES OF WASTE GASES FROM STOVE No. 7. FURNACE No. VIII. BURBACH WORKS.

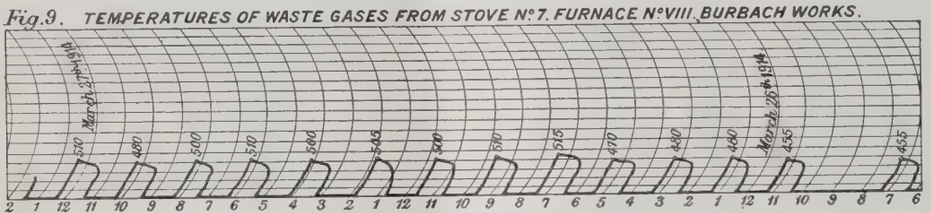
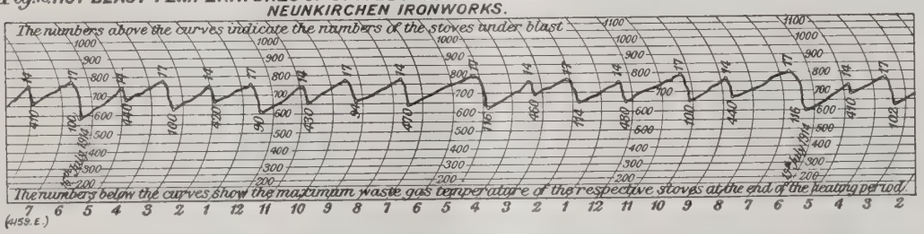


Fig. 10. HOT BLAST TEMPERATURES OF STOVES 14 & 17 MEASURED AT THE HOT BLAST RING MAIN. NEUNKIRCHEN IRONWORKS.


The numbers above the curves indicate the numbers of the stoves under blast.
The numbers below the curves show the maximum waste gas temperature of the respective stoves at the end of the heating period.

(4159. E.)

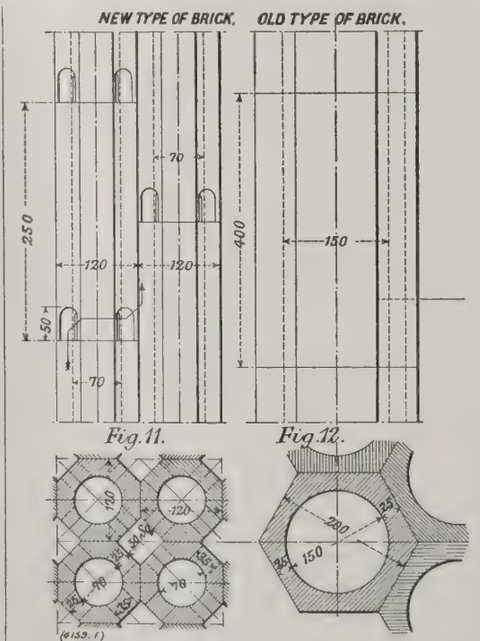


Fig. 11. *Fig. 12.*

(4159. I.)

COPPER AND THE WAR.—We are informed that copper has been declared conditional contraband of war, a decision which will prevent the metal being imported indirectly into Germany by neutral ships. This should also make it more difficult for that country to keep up her supply of cartridge-cases and other war stores.

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.—A pamphlet giving full particulars of courses of study in architecture has reached us from the University College, Gower-street, W.C. The new building for the School of Architecture provides accommodation for upwards of 100 students, and is the largest and most complete of its kind in the United Kingdom. Its completion has enabled the Schools of Architecture of King's College and University College to be combined, and they will in future be carried on in the new building at Gower-street. A department of town planning has been established in connection with the School of Architecture to provide a systematic course of training for architects, engineers, and surveyors who are desirous of acquiring expert knowledge in this subject. The course extends over not less than one session, and includes studio work, lectures, examinations, and other tests. Mr. S. D. Adshead has been appointed first professor of this department. The session commences on the 5th prox.

THE NEW ARMY.—Within a few weeks of war being declared over 20 per cent. of the total male office and works staff of Messrs. Willans and Robinson, Limited, irrespective of age, joined the Services. Lord Kitchener has conveyed in a letter to the firm his special thanks. Places are being kept open and half-pay rates paid for those who joined in that period. The company have always maintained a close connection with the Army, and contributed largely to the formation and support of a Howitzer battery formed some years ago, and whose headquarters adjoin the works. The company have acquired a special interest in aeroplane engine work, having secured, prior to the war period, the sole British manufacturing rights for the well-known Salmson engine (Canton-Unné system).—More than 10 per cent. of the employees of Sir W. H. Bailey and Co., Limited, Albion Works, Salford, Manchester, have enlisted in the Army and the Territorials for active service. The firm is paying 10s. a week to the dependants of each married man, and is also subscribing to a fund which has been created for the benefit of the dependants of the unmarried men by the remaining employees, who are subscribing a percentage of their weekly wages.—Authority has been given by the War Office to raise two companies of specially-selected Automobile Association patrols for service with the 8th (Cyclists) Battalion, Essex Regiment. This is in addition to over 150 of the men who have already joined or rejoined various regiments. They proceeded to Colchester on Wednesday last, to be trained for foreign service. Gifts of field glasses, shirts, socks, &c., should be addressed to the Automobile Association and Motor Union, Fanum House, Whitcomb-street, W.C.

BRITISH-MADE MAGNETO.—Our readers will doubtless be interested to learn that the British Thomson-Houston Company, Limited, of Rugby, will shortly place upon the market a new magneto, made entirely at their Coventry works, for use on motor-cars and on stationary gas and petrol-engines. In general design this magneto follows standard practice, so that its adoption in place of foreign-made magnetos will involve no changes. Like most other modern magnetos, it has base and end-plates of aluminium, and is totally enclosed and weather-proof. The magnets, which are made of a special grade of tungsten steel having great retentivity, are longer than usual, a feature which increases their permanency, and also gives a hotter spark at slow speeds. The armature is neat and compact, and very carefully impregnated, to render it quite impervious. It is mounted on ball-bearings, and has a mica-insulated condenser, contained in a brass cap at one end of the core. Special attention has been given to the design of the contact-maker, in order to render this important detail durable and reliable. British Thomson-Houston magnetos are, at present, available in three sizes only, one small size, suitable for single-cylinder motor-cycles, and two larger, for four-cylinder cars; other sizes are, however, in course of development. We understand that the firm have been experimenting with these magnetos, both in the laboratory and on the road, for upwards of a year, and have found them to be satisfactory under the most severe service conditions. The firm's long experience in the manufacture of electrical instruments, apparatus, and machinery should stand them in good stead in the production of a reliable magneto, and its introduction at the present time is extremely opportune.

RECENT DEVELOPMENT OF THE HYDRAULIC TRANSFORMER.*

By Dr. H. FÖTTINGER, Member.

IN 1909 the author read a paper before the German Schiffbautechnische Gesellschaft on "The Hydraulic Transformer for Marine Propulsion." Since that time considerable progress has been made, both as regards efficiency, size of units, and number of installations, upwards of 225,000 shaft horse-power being now in service or under construction, for all types of ships, including two transformers, each of 25,000 shaft horse-power per shaft. It is only on this account that the author has ventured to accept the invitation of the Council of this great Institution to read a paper on the subject.

As some installations and results have in the meantime been described in reports by Professor Sir John Biles, and published in ENGINEERING,† I shall restrict myself to some points which are less known and only partially understood by scientific as well as by practical men.

Origin of the Hydraulic Transformer, 1903-04.—After the first successes of the Parsons and Curtis marine steam-turbines, electric transmission of power was repeatedly recommended in order radically to improve the reversing and total efficiency of the propeller and steam-turbine.

The author recognised that a simple combination of

Fig. 1. DIFFERENTIAL DYNAMO

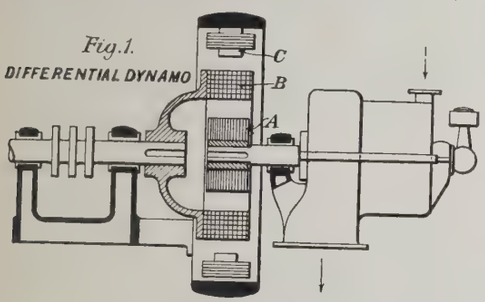


Fig. 2. TWO-STAGE SECONDARY MOTOR

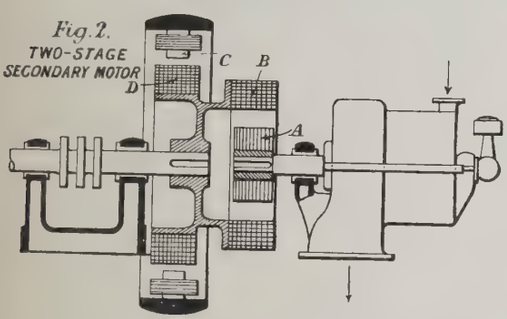
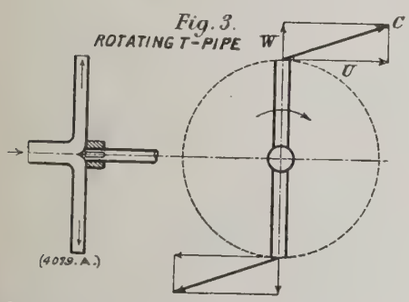


Fig. 3. ROTATING T-PIPE



turbo-dynamos with motors could not be a final solution. In 1903 he proposed a differential dynamo (Fig. 1), consisting of a primary dynamo-rotor A, which transmitted part of the work direct, without intermediate conversion, to the secondary rotor B, whilst the differential power corresponding to the slip was transmitted in the ordinary way by means of a stator C to the same (Fig. 1), or to another secondary rotor D (Fig. 2). Although this differential arrangement greatly increases the efficiency and reduces weight and cost, it does not appear to be suitable for marine service. The author therefore proposed an hydraulic differential turbine in principle similar to that shown in Figs. 1 and 2, the dynamo-rotors being replaced by impellers, and the stators by stationary guide-wheels. Thus originated in 1903 the first design of this hydraulic transformer. The principal type is described in Appendix I., page 401, and special types in Appendix II., page 401.

In 1904 the multi-stage and the reversing transformers were designed; in 1905-06 the theory and calculation were worked out. In 1907 the Vulcan Works, Stettin, undertook to build a 100-horse-power model to reduce from 1000 revolutions per minute to 225 revolutions per minute. This transformer was exhaustively tested in 1908. An efficiency of 83 per cent. was predicted, and obtained, no alterations having to be made. As this experimental engine worked very satisfactorily, a vessel of 77 tons displacement and of 12 to 13 knots speed was built for it, and a steam-turbine of 500 horse-power—*i.e.*, with five times the original power—was employed to drive it.* The revolutions had therefore to be increased from 1000 to 1750 per minute. This first experimental engine has been in practical use since 1909 on the steam-tug, ice-breaker, and passenger steamer Föttinger Transformator, no repairs or alterations having been found necessary. This proves that the first transformer was not merely an "invention," but a practical construction.

The first order came from England in 1910 for the suction-gas cargo-boat Holzapfel I. The engine was designed for 150 horse-power; the transformer was tested up to 900 horse-power, and at 600 horse-power an efficiency of 88.5 per cent. was obtained, the astern capacity being more than 90 per cent. of the ahead. The transformer itself proved entirely successful during the service of the boat in 1911-12. The gas-power plant has been described in a paper by Mr. A. C. Holzapfel,† who, by his enterprise, has led the way to a considerable advance in transformer design. The success of the first two ships, and the wide possibilities of transformers for marine work, caused the directors of the Hamburg-Amerika Line in 1912 to order two vessels from the Vulcan Company—the Admiral von Tirpitz, an Atlantic liner of 25,000 tons, with two turbo-transformers of 10,000 shaft horse-power each, for the Panama Canal service, which will be ready for trial in the autumn of 1914, and the Channel steamer Konigin Luise, with two sets of 3000 shaft horse-power each, for the Heligoland and Mediterranean routes. The practical results thus obtained, and hereinafter referred to, have resulted in orders for twenty-one warship installations, of an aggregate power of 200,000 shaft horse-power.

Explanation of the High Efficiency of the Transformer.—Including all losses, thrust-block friction, and ventilation, the latest transformers for larger powers work with an over-all efficiency of about 92 per cent. This statement has sometimes been doubted by builders of ordinary water-turbines and pumps, who overlook the fact that very different efficiencies can be obtained with differential gears from those with simple combinations, and that our differential turbine is built for other tasks than that of discharging into a pipe-line or duct. The best modern turbines attain 88 to 90 per cent., and centrifugal pumps 86 per cent. efficiency, when discharging the water into pipes or ducts with considerable "outlet loss" (3 to 7 per cent.). With no outlet loss they could attain 92 to 94 per cent. under favourable conditions. Now the decisive factor is that the power of a primary impeller—viz., the hydraulic pinion in a differential turbine—can be transmitted to water with 97 to 99 per cent. efficiency, or with only from 1 to 3 per cent. loss.

Appendix III. explains this very simply, and the fact is established which is fundamental for understanding the transformer principle that the hydraulic pinion works with an average efficiency of more than 98 per cent. By the circuit flow all "outlet losses" are eliminated, the loss of the primary impeller (only half as great) taking their place. These and other characteristics

Fig. 4. DIAGRAM OF HYDRAULIC GOVERNOR FOR THE STEAM TURBINE

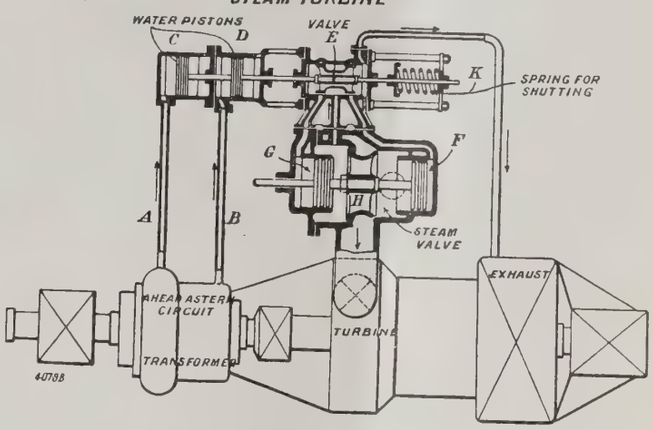
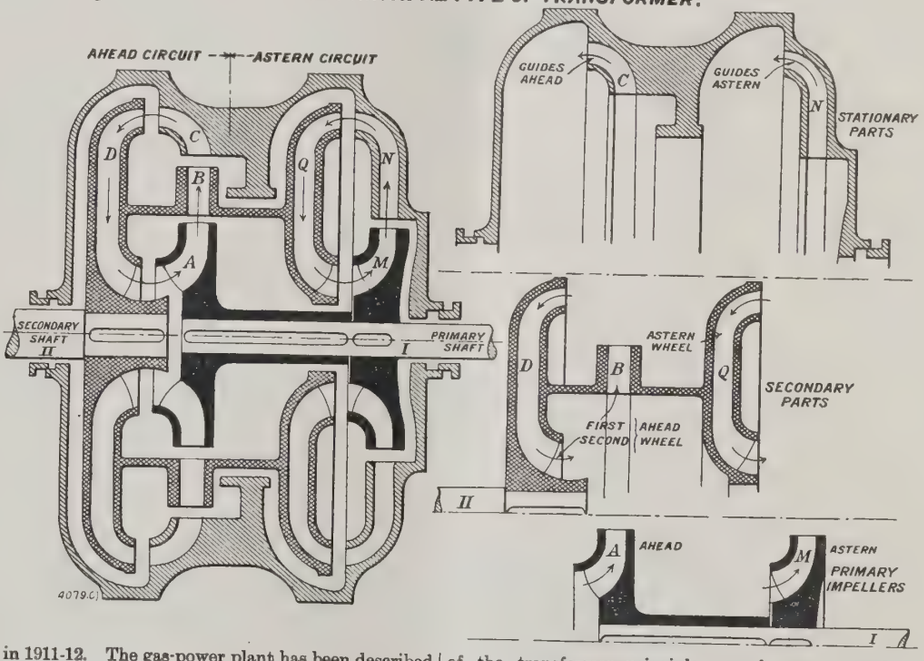


Fig. 5. DIAGRAM OF THE PRINCIPAL TYPE OF TRANSFORMER.



of the transformer principle may be enumerated as follows:—

1. The primary turbine shows a loss of only 1 to 3 per cent., its efficiency being higher than 98 per cent. for large engines.

2. The "outlet losses" (which with ordinary turbines and pumps are at least 3 to 7 per cent.) are eliminated by the closed circuit flow.

3. The very wasteful conversion of kinetic energy into pressure energy (of the centrifugal pumps and discharge pipes in turbines) is avoided.

4. All the vanes work with accelerated motion—*i.e.*, contracting channels, causing considerably less friction.

5. Pipings, ducts, suction-pipes, &c., and their friction are eliminated.

6. The first secondary turbine stage having no guide-wheel, works with 96 to 98 per cent. efficiency.

7. The friction of the side discs of the primary wheel (which is very considerable with ordinary high-lift centrifugals) is reduced from 30 to 50 per cent. by the differential arrangement, the primary wheel being enclosed between the two discs of the secondary rotor, turning in the same direction. This likewise reduces leakage losses considerably.

8. Water volume and head can be freely chosen to obtain the best conditions—*i.e.*, very large volume and small head, leakage loss and disc friction being then only slight. The primary wheels are always of the low-lift type.

9. Cavitation, often arising in propellers, turbines, and

* Paper read before the Institution of Naval Architects, July 7, 1914.

† See ENGINEERING, vol. xcvi., page 792.

* See ENGINEERING, vol. lxxxviii., page 601.

† Transactions of the Institution of Naval Architects, vol. liv., page 88.

pumps on the points of high vacuum, is entirely avoided by placing the transformer casing under additional static pressure, no vacuum existing anywhere.

10. Warm feed water (120 deg. to 170 deg. Fahr.), free from air, is used, having much less viscosity than cold water.

11. The vanes being comparatively small, all surfaces are finished as smooth as glass by a new and cheap method, friction being thus considerably reduced.

12. Mechanical friction is eliminated by utilising the bearings of the steam-turbine and of the thrust-block for the primary and secondary rotor. So at even $\frac{1}{10}$th of the full power the efficiency of the hydraulic gear diminishes but very slightly.

13. The total losses are regenerated by heating the boiler feed from 15 deg. to 30 deg. Cent. (25 deg. to 50 deg. Fahr.). This causes an additional increase in the over-all efficiency varying from 1.5 to 3 per cent.

14. The entrance velocity into the eye of the impeller is unlimited, and its direction can be suitably chosen.

These characteristics of the differential turbine and careful scientific standardisation have shown results and possibilities never obtained before with turbines and pumps or crude combinations thereof.

Limits of Transformer Efficiency (Fig. 7, page 399).—Certain types of transformers for 1 : 1 ratio—viz., for the purpose of coupling and uncoupling two shafts without shock—can be built with almost 100 per cent. efficiency. The larger the diameter the higher the efficiency; 98 to 99 per cent. would be possible. Practically 95 to 96 per cent. would suffice, having regard to practical limitations of size and cost. No stationary guide-wheel being necessary, the frictional loss only originates from the small relative velocity of the water in the primary and secondary wheels. The leakage losses and ventilation are extremely slight. The normal two-stage transformer (Figs. 5 and 6) can probably be built with still higher over-all efficiencies than 90 to 92 per cent., for larger dimensions (as for battleships and liners). By a new and cheap method of finishing, the vane surfaces are made as smooth as glass, whereby in a transformer just delivered the efficiency has been improved by 3 to 4 per cent. Judging from this the limit for the best reduction transformers would lie at about 92 to 94 per cent. over-all efficiency, or about 2 per cent. higher than hitherto obtained. With regard to further possibilities, these figures naturally are not final. The reversing or astern circuits are built much smaller than the ahead ones. From the insertion of a reversing guide wheel between the primary and secondary wheel in the astern circuit a considerable frictional loss arises which lowers the efficiency by 5 per cent. 90 per cent. of the ahead horse-power is easily available for driving astern, if desired. Special types, in which the ahead and astern circuits coincide and the direction of rotation is changed by displaceable guide vanes, represent a compromise between both kinds of rotation.

Reduction Ratio.—The ratios hitherto applied range from 1.2 : 1 to 6 : 1 (the larger number of transformers at present being from 5 : 1 to 6 : 1), the efficiencies having been proved practically equal within these limits. The sizes are larger for larger ratios. From the results attained for two-stage circuits the limit of ratio will be about 7.5 : 1. Higher reductions are obtained by three-stage secondary parts; one for 10 : 1 reduction is now under construction. Judging from all practical results the efficiency will be only very slightly lower than with the present limit of 6 : 1.

Limits of Horse-Power per Hydraulic Pinion.—For fixed revolutions the dimensions of the transformer vary as the fifth root of the horse-power. Consequently an increase of 100 per cent. in power corresponds to a diameter increase of 15 per cent. only. The water velocity is only increased by 15 per cent., the water pressure 32 per cent. The two largest transformers now under construction will transmit 25,000 horse power per hydraulic pinion, and there is no difficulty in constructing them of 50,000 horse-power per hydraulic pinion. Thus the largest capacities practically conceivable can be worked from one steam-turbine without multiple subdivision.

Manœuvring.—The principal type of transformer is manœuvred by filling either the ahead or the astern circuit with water by means of a small centrifugal or "make-up pump" and a change-valve with a lever. In the stop position both circuits are empty, the steam-turbine then running with no load, the revolutions being kept constant or lower by a governor.

Fig. 9, page 399, shows the latest combination of transformer, manœuvring or change-valve, tank, and make-up pump. The valve lies below the transformer, the tank is hung on to the transformer casing. The make-up pump draws from its lowest point, which delivers the water into the middle chamber of the valve. In the ahead position the latter conducts the water into the inlet chamber of the ahead circuit (K, Fig. 6). Simultaneously the lowest point of the astern circuit is drained through the change-valve into the tank. The opposite is the case when driving astern. Filling is effected into the places of least pressure—*i.e.*, to the eye of the primary impeller—while emptying is effected from the highest pressure points in the casing, each circuit having two connections to the valve, which can be made very small. For Channel steamers and destroyers they are moved direct by a hand-lever; for very big transformers the pressure of the make-up pump is made use of—*i.e.*, is conducted to either of the end surfaces of the piston-shaped valve. On the engineer's platform there is generally another smaller lever for regulating the speed of the make-up pump by the number of steam-nozzles.

Practical experience has shown that manœuvring by the change-valve only is quicker than with any other engine of equal size. With smaller transformers 3 to 4 seconds elapse from the telegraph signal until the propeller-shaft begins to reverse, for large transformers 5 to 7 seconds. Compared with the best plants with astern steam-turbines, direct or geared, the stopping distance is reduced by 30 to 40 per cent. An astern capacity of 75 to 80 per cent. of the ahead capacity can always be attained by one-stage reversing circuits, and 90 per cent. by two-stage. This is the case for all speeds, even at reduced boiler pressure, and without having recourse to the heat contents of the boiler water for manœuvring—*i.e.*, without excessive steam influx. A very important practical feature is that the steam-turbine is warmed up uniformly while the transformer is empty, the turbine rotor thus running quickly up to speed.

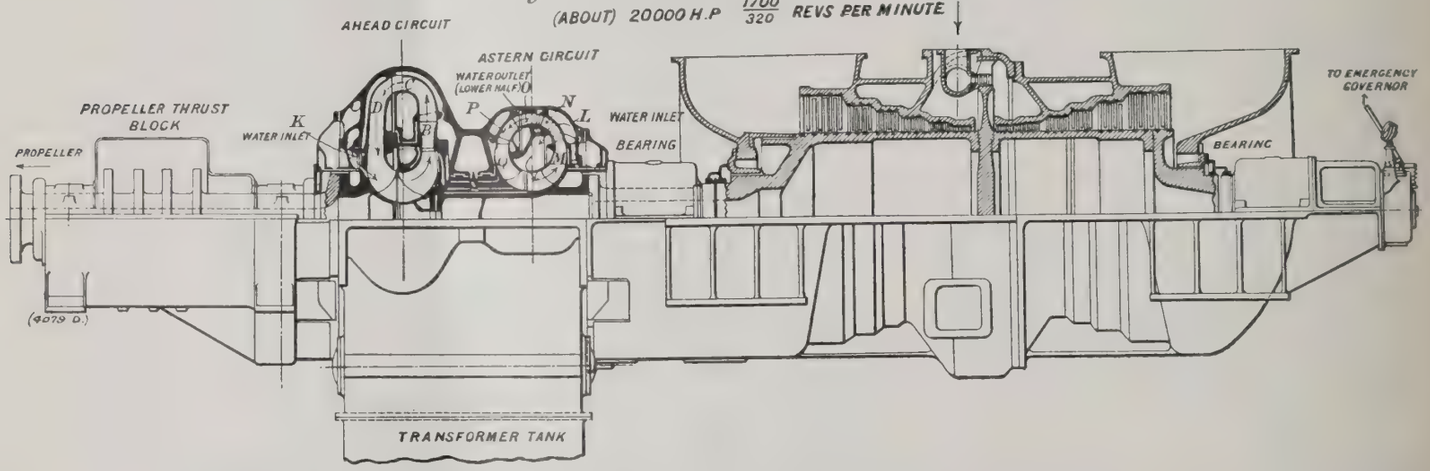
Hydraulic Governors for the Steam-Turbine.—Instead of centrifugal governors (as for a dynamo service), very simple hydraulic governors are provided for the steam-turbine on all new vessels, to maintain the revolutions constant when manœuvring. The plan is as follows (Fig. 4, page 397):—

The steam flow must be reduced as long as neither of the two circuits is quite full—*i.e.*, as long as the water pressure in the casing remains below a certain limit. Whenever this minimum pressure is reached in either circuit the throttling-valve may be opened by a governor. For small engines this can be effected direct by the pressure of the transformer water, which is led through pipes A or B into pistons C or D. For large engines servo-motor action is used. For example, by means of the water-pistons C or D a small piston-valve E is moved, which directs live steam either into the space of the throttling-valve, which is opened or shut by pistons F or G. In actual construction the spring K is replaced by steam pressure. Whenever a circuit is emptied the pressure in A or B sinks, the spring K pushes valve E to the left, and the steam is shut off by piston G and valve H. To keep the turbine running with reduced speed some steam is let into the turbine through a small by-pass. When more power is desired, the engineer opens a small auxiliary valve, in the same way as for a piston engine. If sufficient water pressure is obtained, the steam-piston C or D pushes the valve E to the right, and the throttle H opens. The new governor has been in use for some months on the tug Transformator (500 shaft-horse-power), and has proved entirely successful.

Reduced Speed.—The transmission ratio remains constant at all propeller speeds, therefore reduced speed is adjusted exactly in the same way as for direct drive—either the steam in the manœuvring-valve is throttled or the steam-nozzles are shut off. The power of the make-up pump is proportionately diminished. Experience has shown that the efficiency of the transformer falls off but very little with reduced power, because the mechanical friction (particularly the bearing friction) of the latest transformer absorbs less than 0.3 per cent. of the power. Special primary bearings are dispensed with; those of the propeller thrust-block serve as secondary bearings. Thrust is balanced by water pressure. The percentage of the main loss—*i.e.*, water friction—remains almost exactly constant within very wide limits. At one-tenth of full power on three different transformers a reduction of efficiency of respectively only 3.5 per cent., 3.5 per cent., and 3 per cent. were ascertained, including, however, the total thrust-block friction. Besides throttling the steam-turbine, there is still another possibility of slowing down to very low speed by partially filling the circuits. This is brought about by intermediate positions of the change-valve lever. Of course, this is not economical, but it is very convenient for dead slowing on smaller boats. At cruising speed some of the make-up pumps may be cut out.

Economy in Going Astern.—Although some astern steam-turbines are designed capable of delivering about 50 per cent. of the ahead horse-power from an equal volume of steam, in most of the astern turbines the expansion is kept so low (in order to reduce windage for going ahead) that an astern capacity of over 35 to 40 per cent. is only attained by admitting a steam-flow larger than for the corresponding ahead power—*i.e.*, by temporarily exhausting part of the heat capacity of the boiler water. This is particularly the case at the lower speeds, no provision being made in the astern turbine for good economy at reduced speed. Thus, for a given power of astern turbines, the steam consumption when going astern is from two to three times higher than that for the same speed ahead. This difficulty is entirely overcome with the transformer by applying one steam-turbine only, of high economy and constant sense of rotation, and delivering 80 or 90 per cent. of the corresponding ahead horse-power, or at least twice as much as an astern turbine would do. Thus the economy of the transformer plant for going astern is more than 100 per cent. higher than that of astern turbine plants, direct or geared. Furthermore, when manœuvring, it is unnecessary to accelerate or retard the very high momentum of the high-speed steam-turbine, thereby preserving its large kinetic energy from being wasted at each change of rotation. For all ships performing frequent manœuvres this is an important feature, and the surprising service economy of Konigin Luise was partly due to this fact.

Fig. 6. TURBINE TRANSFORMER (ABOUT) 20000 H.P $\frac{1700}{320}$ REVS PER MINUTE



Transformers for Marine Diesel Engines (Fig. 8, page 399).—The manœuvring of Diesel engines by compressed air is neither desirable for the cylinder walls nor for reliable ignition. Furthermore, additional reservoirs and compressors are required. The Vulcan Company has been repeatedly asked for transformers in connection with Diesel engines. This combination is specially advantageous when a certain reduction of propeller revolutions, either permanent or intermittent, is required through the medium of a disconnecting clutch. The revolutions may then be fixed independently, the Diesel engine continuing to run with slightly varying speed. Compressed air serves for the first start only while the ship is still lying in harbour. All manœuvring is done silently and without shocks by the hydraulic transformer. A special feature is that the transformer (Fig. 8) embodies a smooth-acting disconnecting clutch, worked by emptying or by displacing the guides.

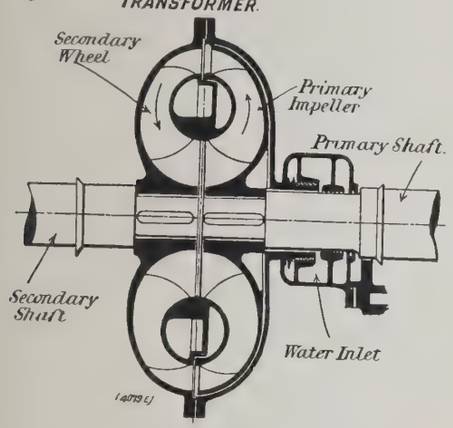
The reversing gear, manœuvring reservoirs and their compressors, and special couplings of the Diesel engine, are entirely dispensed with. When a solid—*e.g.*, ice—fouls the screw, the motor continues to run. The danger of sudden standstill when pitching is removed. Torsional vibrations—a special danger in oil-engines—are considerably reduced or eliminated by the elastic hydraulic coupling drive.

Fig. 8, page 399, shows a transformer for a Diesel engine of 500 to 600 horse-power, at 260 primary and 220 secondary revolutions of the single-circuit type with movable guides (see Appendix II.). Two transformers of similar size have been built of late by the Vulcan Company for use on destroyers at cruising speed. They serve at the same time for uncoupling the motors at full speed, when the turbine is driving. The first engine attained an efficiency of 85 to 86 per cent., the later ones are designed to have higher efficiency. Whoever has seen the engines in operation will have been surprised at

their exceptionally noiseless and reliable manœuvring. Third and fourth engines of same design have subsequently been ordered.

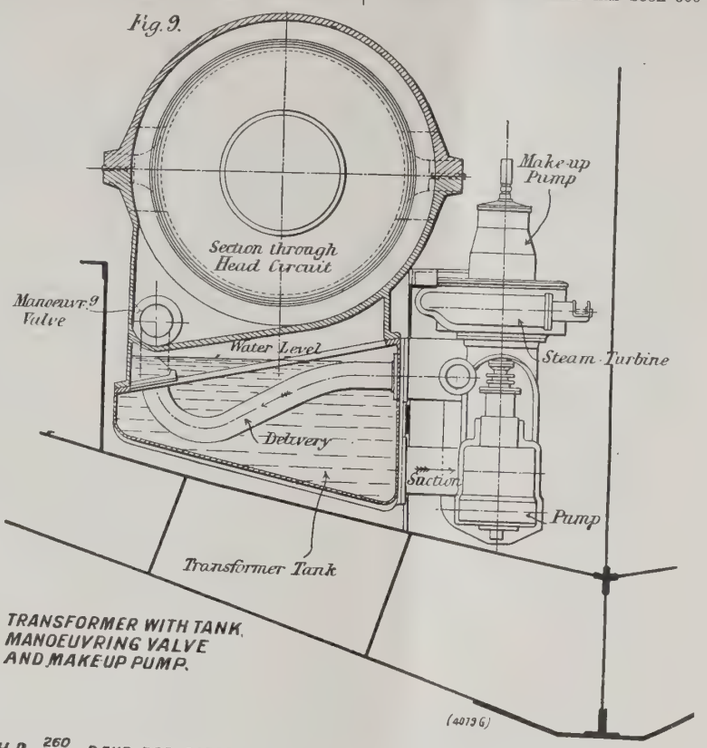
Hamburg-Amerika Liner "Admiral von Tirpitz."—The directors of the Hamburg-Amerika Line some time ago recognised that saturated steam and direct turbine drive could in no respect be final for modern ships. Their managing director, Herr Ballin, and their former engineer-in-chief, Dr. Eggers, had followed the first successes of the transformer with keen interest, and appreciated the possibilities of this new reversing and reduction gear. In 1912 they ordered the 25,000-ton steamer Admiral von Tirpitz for the Hamburg-San Francisco service, with the reservation that the Vulcan Company should prove the absolute reliability and economy of the first 10,000 horse-power transformer by a continuous fortnight's shop trial under full load. This long-duration test was carried out before a number of marine authorities of various nationalities. The contract capacity of each of the two engines was 10,000 shaft horse-power at 160 propeller revolutions. This figure was estimated to be the most favourable for 19 knots speed, considering all

Fig. 7. CLUTCH TYPE OF TRANSFORMER.



successfully. Immediately after the fortnight's trial an uninterrupted twenty-four hours' astern test with 80 per cent. of the ahead power was prescribed, to imitate a ship having run on shore and trying to get off by continually working astern. Such a test would never have been possible with astern steam-turbines, because the

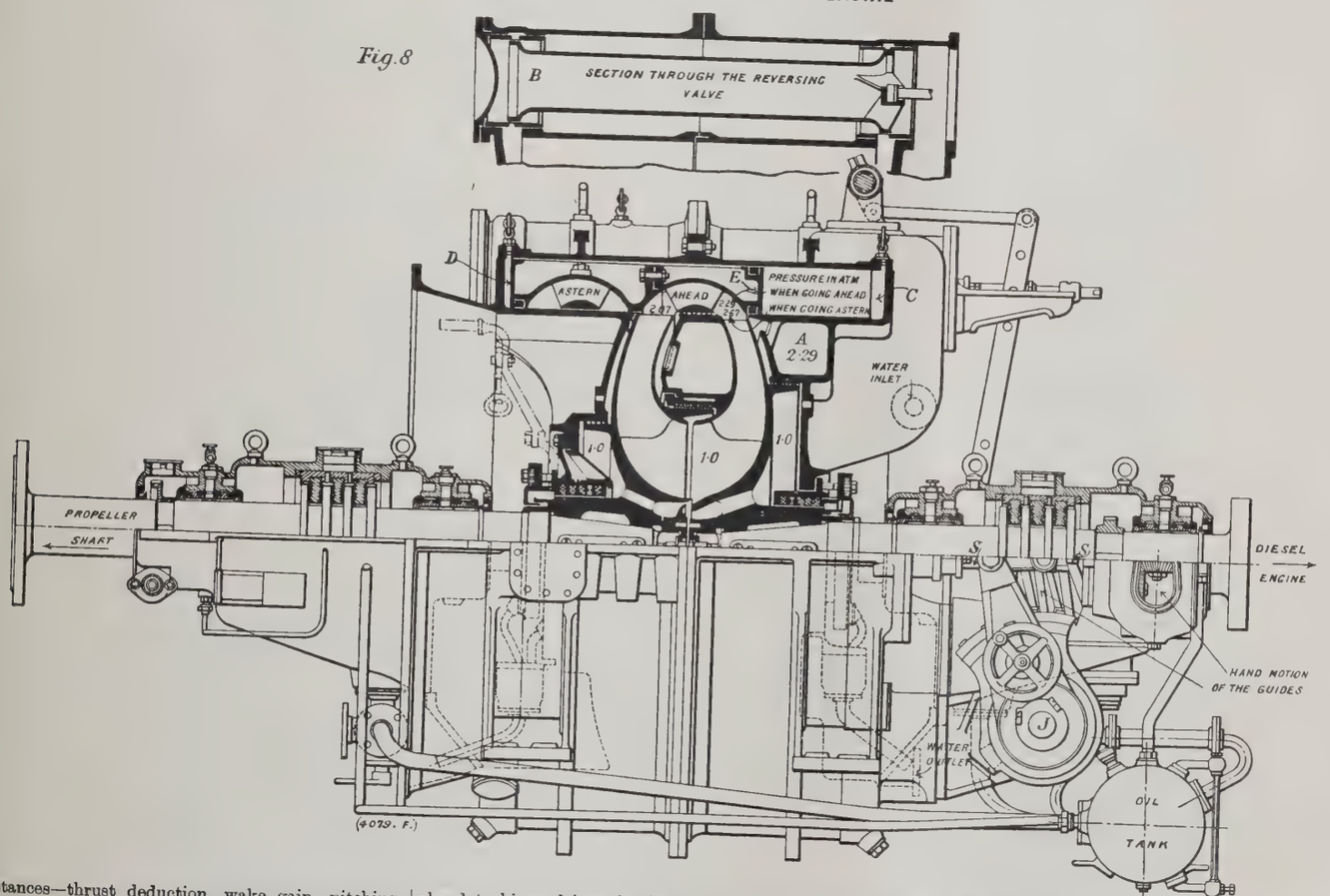
Fig. 9.



TRANSFORMER WITH TANK, MANOEUVRING VALVE AND MAKE-UP PUMP.

TRANSFORMER OF 500 TO 600 H.P. $\frac{260}{220}$ REVS FOR DIESEL-ENGINE

Fig. 8



circumstances—thrust deduction, wake gain, pitching, sea-way, tip-immersion, and weight of shafting and propellers.

The turbine speed was limited by the owners to 800 revolutions. The largest diameter of the transformers is 3060 mm. (10 ft.). Various primary wheels were tested, and the efficiency of the transformer, including six large bearings and two thrust-blocks, was found to be 90 per cent. This corresponds to an over-all efficiency of 92 per cent. on service. The exceptionally severe tests, especially the most rapid reversals, were performed entirely ahead turbines, driven in the opposite direction at full speed, would be enormously heated by the movement of the long ahead blades; with transformers it was easily carried out, as astern turbines and the difficulties of warming up, starting, and restarting the turbines were removed. The water-tube boilers were equipped for superheated steam.

Service Performance of the Channel Steamer "Konigin Luise," of the Hamburg-Amerika Line.—This 1720-ton vessel was a sister-ship to the direct-driven turbine steamer Kaiser, which has been in service for seven years with A.E.G. twin-screw turbines, using saturated steam, generated in four water-tube boilers of 86 sq. ft. grate surface each. The speed (20 knots) and horse-power (2 × 2800 to 3000 for the Kaiser, 2 × 2700 to 3000 for the Konigin Luise) are nearly exactly the same. The designed revolutions of the Kaiser has been 600 per minute, but after trying various propellers, it was shown that the principal gain in the screw was caused by the first 10 per cent. of reduction, further lowering causing little effective gain. So the final screws have 550 revolutions. In the transformer ship, after careful consideration, 450 revolutions have been adopted for the propeller of the Tirpitz.

In a report for the British Föttinger Transformer Syndicate, Professor Sir John Biles has given a comparison of the speed and power results of the Konigin Luise as compared with the Normannia, which latter has practically the same displacement, but reduced propeller

DESIGNS FOR HYDRAULIC TRANSFORMER PLANT FOR WARSHIPS.

Fig. 10. TRANSFORMER PLANT FOR A SCOUT 2 × 20000–25000 S.H.P. WITH MECH. CRUISING GEAR.

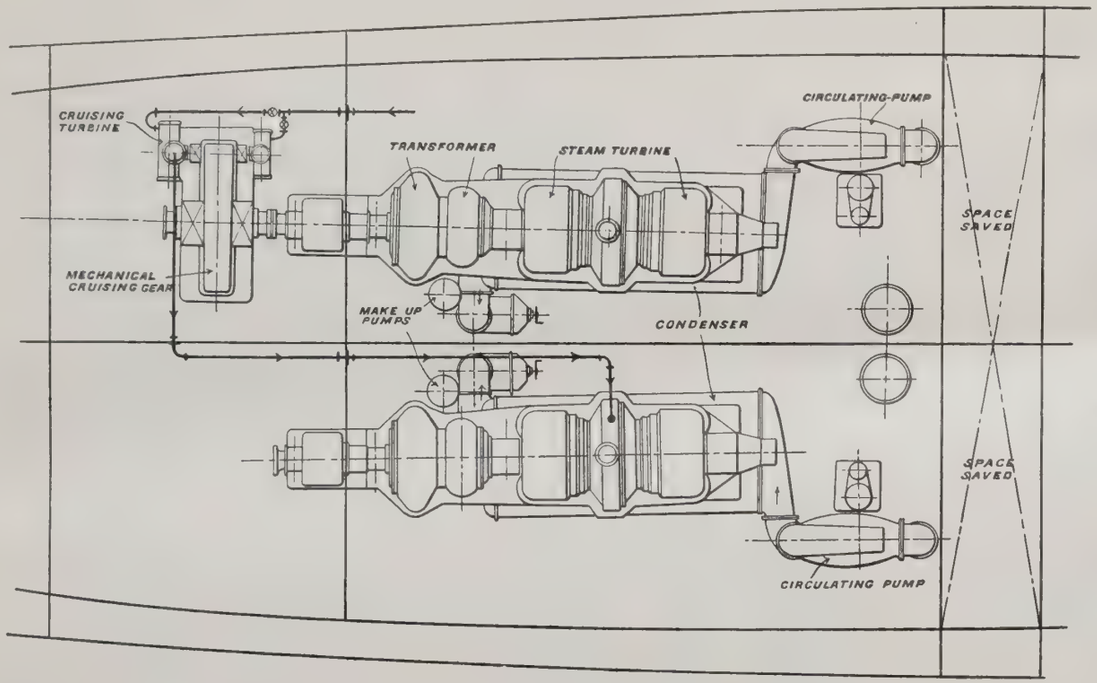
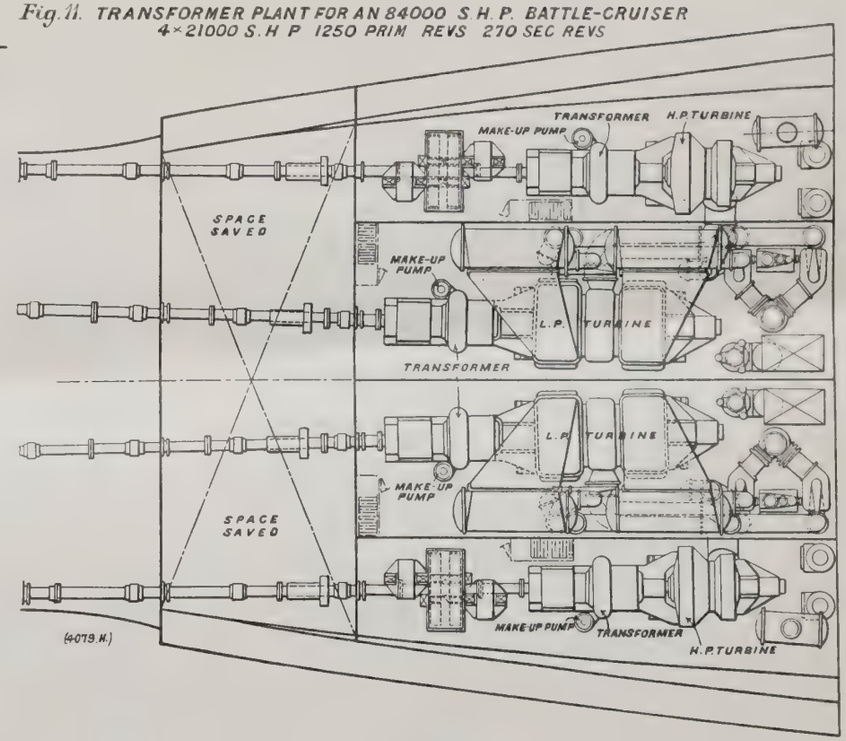


Fig. 11. TRANSFORMER PLANT FOR AN 84000 S.H.P. BATTLE-CRUISER
4 × 21000 S.H.P. 1250 PRIM. REVS. 270 SEC. REVS.

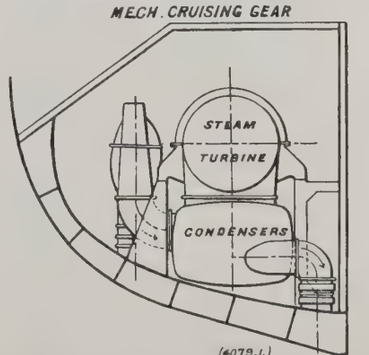


speed—viz., 300 revolutions. The comparison confirms the wisdom of the choice of the Konigin Luise, her propellers being probably a little superior in total propulsive efficiency. It is interesting to note in this connection that the German Navy constructors, from their wide experience, have arrived at the conclusion that direct-driven turbine propellers of present day practice have the same total propulsive efficiency as those of piston engines.

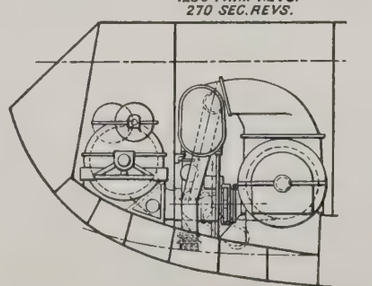
Owing to the use of improved water-tube boilers, with uptake superheaters for slight superheat (about 40 deg. Cent. or 70 deg. Fahr.), and owing to the considerably better economy of the transformer drive and the propeller, the boiler power was reduced by one-fourth—*i.e.*, three boilers of 86 sq. ft. grate, instead of four, being sufficient. This, and a considerable saving of engine-room length, enabled the Vulcan Company to shorten the length of the ship from 92 m. to 83.82 m., or by 8·2 m. (27 ft.). The Konigin Luise proved highly successful on her trials, as well as on her winter service from Genoa to Nice. The performance of the former was carefully tested and described by Professor Sir John Biles; for the data of the latter the author is obliged to the Hamburg-Amerika Line, confirming the results of the trials.

Absence of Corrosion.—It is interesting to note that the transformers of the Konigin Luise were opened out at Hamburg at the end of May, 1914, by the Hamburg-Amerika Line, after the conclusion of 20,000 mile running, in the presence of the representatives of the Germanischer Lloyd and the port officials. No trace of corrosion or erosion was visible, the serrated labyrinthine collars preserved their original knife-edges, and the blade polish of the vanes was unimpaired, the original file-marks being as visible as when in the shops. The same remark applies to the tug Föttinger Transformator

TRANSFORMER PLANT FOR SCOUT WITH MECH. CRUISING GEAR



TRANSFORMER PLANT FOR AN 84000 S.H.P. BATTLE-CRUISER
4 × 21000 S.H.P.
1250 PRIM REVS.
270 SEC. REVS.



(500 horse-power) after five years' continuous work. This is only what was anticipated, owing to the entire absence of air in the transformer water, which is always filled under pressure.

The manœuvring qualities of the Konigin Luise were considerably better than those of the Kaiser, the average distance for stopping from full speed (20 knots) being 1½ times her length; the average time for changing the direction of travel, 1 minute 2 seconds. On her Riviera service, at each trip she had to enter five harbours, most of which are so narrow that she had to back out, thus going astern for about 10 minutes. With the Kaiser, in bad weather, this was impossible, whilst the transformer boat omitted no single port. The same captain commanded both boats. Between 1.1 and 0.7 of the full power the coal consumption varied between 0.595 kg. and 0.65 kg. (1.31 lb. and 1.425 lb.) per secondary shaft horse-power, including all auxiliaries, steering-engine, turbo-dynamo, sanitary pump, and steam for cooking and heating. A still better proof of the actual economy on service conditions is the comparison in the appended table of the Kaiser and the Konigin Luise, which the Hamburg-Amerika Line has kindly authorised the author to publish.

This shows a saving of 43 per cent. coal for the transformer boat against the direct-driven one. The economy is due partly to the reduced size of the boat, partly to slightly lessened speed, partly to the considerable improvement of the machinery—boilers, propellers, turbine drive—not only for going ahead, but also for manœuvring and going astern, and superheated steam.

Coal Comparison of the "Kaiser" and the "Konigin Luise" on their Riviera Service, Genoa-Nice.

—	Number of Trips.	Speed. Mean, Including Harbour Time.	Speed. From Genoa to San Remo.	Total Coal Consumption.* For the Whole Trip.	Total Coal Consumption.* Per Hour.
		knots.	knots.	tons.	tons.
Kaiser	13	13.45	16 75	81.6	4.33
Konigin Luise ..	21	12.95	16.0	46.4	2.48

* Coal: Ferndale.

Combined Plants for Warships.—Considering the question of what arrangement of machinery would perhaps be the most advantageous for new warships, embodying all possibilities of the present development, the author has proposed, for one of the latest cruisers under construction, a combined plant (Fig. 10, above)—viz., a two-shaft transformer plant for all higher speeds, each of the two turbines of 20,000 to 25,000 horse-power with a single Curtis wheel and a Parsons drum, and a cruising turbine of 2500 shaft horse-power on the port shaft only, consisting of a single-wheel cruising turbine and mechanical gearing. From about one-eighth of full power the port main engine, with all its auxiliaries, is entirely cut out, by putting the manœuvring lever into the stop position (*i.e.*, emptying the transformer) and admitting live steam to the cruising turbine only, which exhausts into

the main starboard turbine and its condenser. The shaft horse-power is practically the same on both propellers. After careful consideration this type of machinery was definitely adopted. The cruising turbine is placed in a special compartment, thus removing the direct noise from the engineers' platforms. The turbines under construction are still of the single-flow type with condensers in the wings. By the turbine arrangement of Figs. 6 and 10 considerable weight and space will, however, be saved.

The superiority of this machinery, considering all service conditions, is obvious. It combines a considerably improved economy at higher speed with a 40 per cent. better steam consumption at cruising speed as compared with direct drive. It shows more than 100 per cent. better power and economy for going astern and manœuvring against any plants with astern turbines. The main engines are practically noiseless, and are easily uncoupled by the hydraulic gear.* There is a very notable saving in weight and space, and there is no limit to the horse-power of each steam-turbine. Fig. 11, page 400, shows a similar arrangement for a four-shaft armoured cruiser of 84,000 shaft horse-power, with two high-pressure and two low-pressure turbines, and two geared cruising sets on the wing shafts. The left side shows the space saved as compared with direct drive. The largest plant of this type, now offered by the Vulcan Company under guarantee, is for 120,000 shaft horse-power, or 30,000 horse-power per hydraulic pinion.

Conclusion.—So far the problem of a silent and elastic reduction and reversing gear, for unlimited power and speed, and fit for the most severe conditions of marine service, seems now to have been practically established by the transformer. Its economy has been brought up higher than that of electric transmission, and only 4 to 5 per cent. lower than that of mechanical gearing for ahead motion for the same steam conditions. For reversing and manœuvring its power and economy are over 100 per cent. better.

Furthermore, by eliminating the astern steam-turbines a decisive step in economy is obtained by utilising high superheat on board ship. In so far as the turbine is concerned, temperatures of 650 deg. Fahr. can be safely used, a temperature which is now common practice in large stationary power plants.

The chief features of the Föttinger transformer-driven ship, as compared with the direct turbine drive, are as follow :—

1. Increased speed and economy for all service conditions.
2. Smaller number of units for a given horse-power.
3. Increased comfort and luxury for passengers and crew, due to entire absence of noise and vibration.
4. Increased safety against danger, due to rapid manœuvring.
5. Increased life of turbine-blading, due to constant sense of rotation and absence of water-hammer and boiler priming.

APPENDIX I.

DESCRIPTION OF THE PRINCIPAL TYPE OF TRANSFORMER (FIGS. 5 AND 6, PAGES 397 AND 398.)

The principal type of transformer has two distinct water circuits, one for each of the two directions of rotation. The whole machine is mounted in one single casing.

Ahead Compartment.—The primary ahead running wheel A is keyed to the primary shaft I, which is driven by the steam-turbine. The secondary rotor for running ahead, which consists of two wheels B and D, is bolted to the secondary or propeller-shaft II. Between the secondary wheels B and D stationary guide-blades C are introduced.

Astern Compartment.—The primary wheel M, for astern running, is also keyed to the primary shaft I. The secondary astern running rotor, in this case consisting of one set of blades Q, is coupled up to the first ahead running secondary wheel B, and through this to the propeller-shaft. Unlike the ahead compartment, in this circuit, between the primary and secondary wheel, guide-blades N are introduced, the object of which is to reverse the direction of motion of the water which flows out of the primary wheel, and to reverse thereby the direction of rotation of the secondary rotor as compared with the primary wheel.

The action of the machine is as follows:—If the circuit for running ahead be considered as filled with water throughout, then, owing to the rotation of the primary shaft I, pressure differences are established between the inlet and outlet of the primary wheel A. These result in setting up a current which immediately leads to a circulation inside the wheels, whereby the water finds its way back from the outlet of the primary wheel A, through the sets of blades of the secondary wheels B and D and the sets of guide-blades C, to the entrance in the primary wheel. The reaction set up by the water in its passage upon the secondary wheels soon sets these in rotation. The first secondary wheel B particularly serves for extracting the kinetic energy of the jets coming out of the impeller A, whilst the second (D) serves for utilising their pressure energy.

Fig. 7 (page 399) shows the latest arrangement of steam-turbine and transformer for the special case of a 20,000-horse-power machine of 1700 revolutions primary and 320 secondary. The steam-turbine is of the double-flow system, with one impulse wheel in the middle, and radial nozzle-chests. This type, so far as the author is aware, was first brought out by the Westinghouse Company.

The steam-turbine rotor rests in two bearings and, on a prolongation, carries the two primary impellers A and M. The primary and secondary rotor of the transformer, as well as the stationary guides, correspond to those in the diagram (Fig. 5), with the exception that there are two astern guides N and P, and two astern secondary wheels. The secondary rotor rests on the two bearings of the thrust-block, thus avoiding any additional bearings for the transformer.

The water inlet for filling and making up the leakage of the ahead circuit is concentric with the gland at K through hollows of the secondary wheel D, and the water outlet is from the lowest part of C. The water inlet of the astern circuit is through the annular space L and openings in the guide-wheel N.

The type described has been used for all new transformer plants, the steam-turbine being, however, of the single-flow type, even in the case of the two 25,000-horse-power engines under construction. For six destroyer engines pure impulse steam-turbines of 14,000 horse-power are used in order to increase the revolutions.

* Gearing of those powers per pinion has been proved to be entirely reliable on a long service.

APPENDIX II.

SPECIAL TYPES.

The simplest type, Fig. 7, consists of a primary wheel and a secondary wheel exactly equal, without stationary guides F. Thus the turning moment must be equal, while the secondary revolutions are some per cent. lower than the primary owing to a trifling slip. The efficiency can easily be brought up to 95 to 96 per cent. This type serves as a detachable clutch, coupling being effected by filling, uncoupling by emptying. The two shafts can displace slightly sideways or axially, because there is no mechanical contact of the wheels. Very interesting types are obtained by uniting the ahead and astern circuits—*i.e.*, by adapting the same primary and secondary wheel for ahead and astern service (Fig. 8). Owing to the compromise in the blading the limit of efficiency is somewhat lower than with the main type, but manœuvring can be done by axially displaceable guides (by pushing an ahead or astern guide-wheel concentrically over the primary and secondary wheels, no emptying or filling being necessary). In the stopping position the circumference of the impeller is closed by the middle bow of one of the guides, so that the impeller continues to run with constant or reduced speed and very low power consumption. This type can also be fitted with a multi-stage secondary part. Experience has shown that, with this type, manœuvring is performed as quickly as with rolling-mill engines. The guide-wheels are displaced by the water pressure of the primary wheel escaping out of the ring chamber A through reversing valve B either into space C or into space D, the side surfaces of the guide-vanes serving as an annular piston. To ensure exactly parallel motion, special spindles S are provided, which are connected by the strong crank-shaft T, and allow of hand manipulation by worm-gear. Special types have been built to increase the speed of a turbo-compressor driven by electro-motor, and for a rolling-mill drive by a steam-turbine, with rolling revolutions adjustable from 200 to 400 per minute, by pivoted blades.

APPENDIX III.

EFFICIENCY OF A PRIMARY IMPELLER (97 TO 99 PER CENT.).

A T-shaped pipe mechanically driven (Fig. 3) rotates round the axis a, a, whilst water is flowing through it with a small relative velocity w from the inside to the outside. If the circumference speed u is high, the resultant absolute velocity c, due to u and w, according to the parallelogram of forces, may be very high; accordingly the kinetic energy $\frac{c^2}{2g}$ (and the pressure energy of the same amount) of each pound of water is very high at the outlet, both being transmitted by the rotation to the water. The loss, however, depends on the square of the relative velocity w^2 (ranging about from $0.05\ \frac{w^2}{2g}$ to $0.15\ \frac{w^2}{2g}$) which may be kept very low against $\frac{c^2}{2g}$.

There would be no difficulty with such an impeller in reaching 99 per cent. efficiency, or 1 per cent. loss.

The difficulty only begins behind the impeller. If the water with the full absolute velocity c could flow against stationary vanes, as in a centrifugal pump, there would arise losses ten or twenty times as high, especially when the speed c ought to be reduced and converted into pressure energy.

In the transformer this difficulty is overcome by the differential arrangement, one impeller rotating inside another. Thus the sliding velocity against vanes is considerably diminished (compared with c), and the transformation of kinetic into pressure energy, which causes the bulk of the loss in a centrifugal, is entirely abandoned. The water friction of the side discs of the impeller is again considerably reduced (to $\frac{1}{3}$ or $\frac{1}{2}$) by the differential arrangement—*i.e.*, by enclosing the impeller between two side discs of the secondary turbine, running the same way, thus again reducing the relative speed of rotation.

APPENDIX IV.

LAW OF COMPARISON AND SIZE.

All transformers for the same reduction can be built geometrically similar and standardised in all hydraulic dimensions for small and big sizes. The thicknesses of materials, however, must suit the forces, strains and stresses, &c. Like every hydraulic engine (for example, the propeller), the water pressures vary, under similar conditions of flow, as the squares of the circumference velocity or the revolutions. The horse-power transmitted varies as the third power of the revolutions and as the fifth power of the diameter. This shows that the same transformer transmits eightfold the horse-power with double the number of revolutions, whilst, for the same number of revolutions, a transformer similarly built, but of double size, transmits $2^5 = 32$-fold the horse-power.

From this law of comparison it follows that for the horse-power of a transformer and of its propeller the same law of revolutions holds good. Consequently, in a ship the reduction ratio of the transformer remains constant for full and for reduced power, though there is no rigid connection. Furthermore, the size of a transformer, roughly speaking, stands in a certain proportion to the size of its propeller. The law of sizes proves the opinion of the uninitiated, that transformers for large powers must be very large, to be entirely wrong.

APPENDIX V.

THE MAKE-UP PUMP.

The make-up pump serves three purposes :—

1. To fill the ahead or astern circuit when manœuvring.
2. In actual service to make up the leakage losses (about $\frac{1}{3}$ to $\frac{1}{2}$ per cent. of the circuit water volume) of the outside labyrinth packings, at the same time carrying away the frictional heat.
3. To keep an additional positive (static) pressure, for excluding any vacuum or cavitation, even in the eye of the primary wheel.

The make-up pump (Fig. 9, page 399) is generally driven independently, by a small steam-turbine (3000 to 5000 revolutions) with vertical shaft. The pump rotor is arranged near the bottom of the transformer tank, suction being avoided. The horse-power of the make-up pump at full load amounts to about $\frac{1}{4}$ to $\frac{1}{2}$ per cent. At reduced speed the pressures decrease in quadratic proportion, the leakage in linear proportion; so that at cruising the revolutions and the horse-power of the make-up pump are reduced in exact proportion to those of the main engine, unlike turbo-air pumps or turbo-feed pumps, which require constant revolutions and consume little variable horse-power. Independent make-up pumps can easily be used for fire service, &c., in case of danger. On the gas ship Holzapfel I. it served also for washing the deck.

APPENDIX VI.

REGENERATION OF HEAT.

The total power loss is converted into heat, which increases the temperature of the water. To carry off this heat in a useful manner, the condensate of the air-pump is led into the transformer tank, and an equal quantity is conducted, by a float-valve, from the discharge of the make-up pump to the hot-well. The temperature in the transformer can be raised at will by throttling the influx of the condensate—viz., by reduction of the cooling-water volume. The normal temperature in the transformer should be 50 deg. to 75 deg. Cent. (120 deg. to 170 deg. Fahr.). Thus the total losses are regenerated and put back into the boiler in the form of heat, the feed being heated about 15 deg. to 20 deg. Cent. (25 deg. to 35 deg. Fahr.) without cost, corresponding to an increase of the over-all efficiency of the transformer of 1.5 to 2 per cent. For poorer efficiencies even 3 to 4 per cent. more can be gained. This regeneration by feed-heating proved thoroughly successful on the Konigin Luise, and is being used on all new ships.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

New Zealand : The ratepayers of the Tokomaru Harbour rating district have approved a proposal to borrow 4000*l.* for building an extension to the wharf at Tokomaru Bay. The ratepayers of Te Puke have approved the raising of a loan of 11,000*l.* for a water-supply system and street improvements.

Hayti : His Majesty's Chargé d'Affaires at Port-au-Prince reports that tenders were received down to yesterday, the 24th inst., by the Haytian Government for the construction of a water-works system at Port-au-Prince.

Chili : The *Diario Oficial* publishes the text of a decree, dated July 7, authorising the Antofagasta and Bolivia Railway Company, Limited, to duplicate the existing railway track between the stations north of the port of Antofagasta and the station of Portezuelo. Work must be commenced within a period of six months from the date of the decree, and completed within two years. The company also undertakes to construct, within a period of five years, a quay at the port of Mejillones capable of accommodating merchant vessels of the largest size.

CARS WANTED FOR WAR SERVICES.—Although over 19,000 members of the Automobile Association have volunteered their cars and motor-cycles for war services, difficulty is still being experienced in keeping pace with the requirements of the authorities and organisations working in various parts of the country. To facilitate the supply and distribution of cars called for, the secretary will be grateful if members will kindly notify which branch of volunteer work they would prefer to undertake, also the time they have available. Among the services for which members may volunteer are (1) military service at home; (2) recruiting work in London and the provinces; (3) Red Cross work; and (4) refugee work. Communications should be addressed to the Secretary, Automobile Association and Motor Union, Fanum House, Whitcomb-street, Coventry-street, London, W.C.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

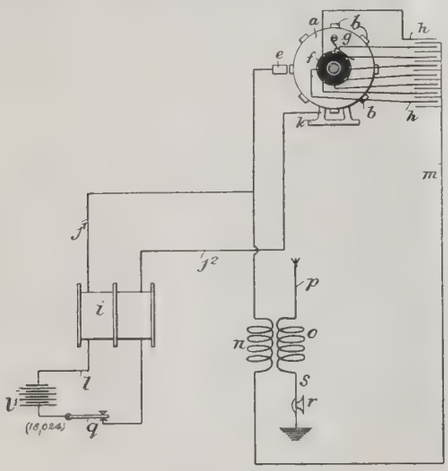
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

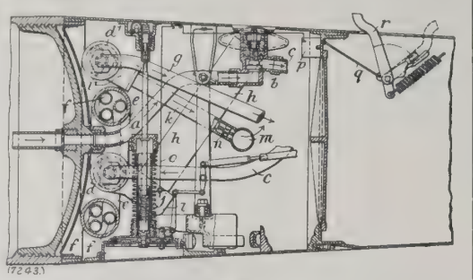
18,024/13. G. E. Heyl and T. T. Baker, London. Wireless Apparatus. [2 *Figs.*] August 7, 1913.—This invention relates to apparatus for the production of a continuous train or series of electromagnetic waves for wireless telegraphy or wireless telephony, of the kind in which a spark-gap energised by an ordinary induction coil or transformer is employed, of which one of the electrodes is continuously substituted by others by consisting, for example, of a series of electrodes mounted around the periphery of a constantly-rotated disc, whereby the peripheral electrodes are successively brought opposite to the other electrode of the spark-gap. According to the present invention, not only is one of the electrodes of the spark-gap continuously changed, but at each substitution a different condenser or capacity is connected in parallel with the spark-gap, so that each time a spark discharge takes place across the spark-gap at each substitution of an electrode, energy is discharged by a different condenser, with the result that, the capacities being alike, similar waves or wave-trains are produced in rapid sequence. *a* is a disc, on the periphery of which a series of spark-gap electrodes *b* are provided at equal angular intervals apart. On rotation of the disc *a*, the electrodes *b* are successively brought opposite a stationary spark-



gap electrode *e*. A stationary commutator *f* is mounted coaxially with the spindle of the disc *a*, and is provided with a plurality of insulated segments equal in number to the number of electrodes *b*. A brush or wiper *g* is carried around by the disc *a*, and makes contact successively with each of the segments of the commutator *f* as each of the electrodes *b* comes opposite the stationary electrode *e*. Each of the segments of the commutator *f* is connected to a different condenser *h*, the other terminals of which condensers are connected in common to the stationary spark-gap electrode *e* through the oscillating circuit *m*. The spark-gap is energised by an ordinary induction coil *i*, the secondary leads j^1, j^2 of which are connected respectively to the stationary spark-gap electrode *e* and to the supporting frame *k* of the rotary disc *a*, with which latter the frame *k* is in electric contact. The primary circuit *l* of the coil *i* is energised by a battery *l*1. The oscillating circuit *m* contains the usual inductance *n*, which is inductively coupled to an inductance *o* of an aerial *p*. For wireless telegraphy a Morse key *q* is included in the primary circuit *l*. For wireless telephony a microphone *r* is included in a suitable position, for instance, in the earth lead *s* of the aerial inductance *o*. *Accepted June* 10, 1914.)

GUNS AND EXPLOSIVES.

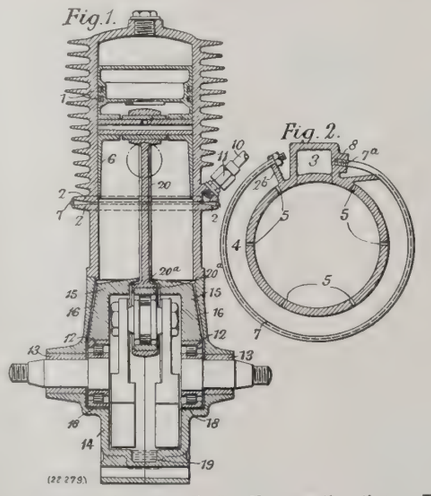
7243/12. R. S. P. Hornby, H.M.S. Inflexible, First Cruiser Squadron; F. Hore, Portsmouth; and F. E. Smith, Southsea. Automobile Torpedoes. [1 *Fig.*] March 25, 1912.—This invention relates to automobile torpedoes driven by compressed air, in which means are provided for preheating the air prior to its delivery to the propelling motor, and after it has passed through the valve provided for reducing the pressure of the air-reservoir to the working pressure of the motor. According to this invention, the air, after leaving the reducing-valve, is arranged to traverse a coil, preferably a flat spiral coil, which is enclosed within a metal drum or other suitable casing, within which the heating of the air is effected. The heating is accomplished by means of a slow-combustion composition contained in a cartridge or cylinder which is screwed into or otherwise suitably attached to the coil-drum, and which is ignited by means of a fuse or other ignition device brought into operation, *e.g.*, by the automatic completion of an electric circuit, either when the air-lever is actuated upon the discharge of a torpedo or after any suitable predetermined interval of time. The heated air is led from the coil to the motor, and the products of combustion of the slow-combustion mixture may be exhausted from the casing into the tail-shaft of the propelling motor, which is made hollow for this purpose in the known manner, or it may be exhausted into the engine-room direct. The high-pressure air is led from the air-reservoir through a pipe *a* to a reducing-valve *b*, and thence by a pipe *c* to a cap *d* closing one end of a spiral drum or casing *e* containing one or more air-tubes *f*, so that the air from the reducing-valve is led to these tubes, passing through them in parallel to a cap d^1 closing the other end of the spiral chamber *e*, this cap having connected with it an outlet-pipe *g* which leads the heated air from the tubes *f* to the engine. The air is heated as it traverses these tubes by hot gases which traverse the casing *e* external to the tubes, and which are generated by the combustion of a slow-burning composition of any known suitable character contained within a generator-tube or casing *h*. One end of this casing is fitted gas-tight into a header *i* attached to and communicating with the interior of the casing *e* at one end external to the air-tubes, and an ignition device *j* of any suitable known character is fitted in this header for the purpose of igniting the slow-burning composition at any desired time. The gases of combustion from the slow-burning composition, after traversing the casing *e*, pass to an outlet header i^1 and



thence through a pipe *k* to an exhaust-pipe *m*, preferably through a non-return valve *n*, from which the combustion products may be discharged into the engine-room or into the hollow tail-shaft of the propelling motor, and thence to the external environment of the torpedo. The ignition device *j* may be brought into operation by any suitable means—as, for example, by the automatic completion of an electric circuit, which is represented by the electric conductor *o*, and which includes a switch *p*, the closing of which switch is effected mechanically by means of a suitable lever *q* actuated by the movement of the air-lever *r* upon the discharge of the torpedo. (*Accepted January* 31, 1913, *but withheld from publication as a Secret Patent.*)

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

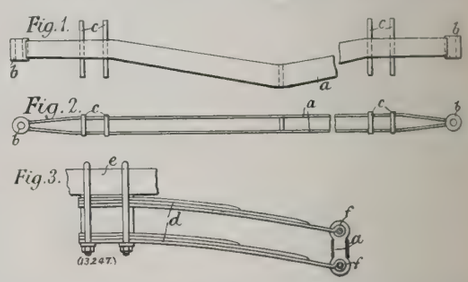
22,279/13. D. A. Pearson, Birmingham. Internal-Combustion Engines. [2 *Figs.*] October 3, 1913.—This invention comprises improvements in or relating to internal-combustion engines, and relates particularly to those employing a lubricating system in which the lubricant is passed to the cylinder through passages in its walls leading from a surrounding chamber formed by cast annular ribs and closed by a ring member. The object of the invention is to render the lubrication more efficient and more economical in use, so as to enable a much greater mileage per gallon of lubricating oil, and thus reduce the running costs of the engine. The invention consists essentially in the combination, with an annular or substantially annular oil-duct surrounding the cylinder and communicating with the interior thereof by perforations, of receptacles or other devices so arranged that unused oil will be conducted therefrom to the crank-shaft bearings, with which said receptacles or other devices are in communication. The cylinder 1 is provided externally with two circumferential and parallel flanges 2 at a convenient distance apart, and advantageously situated a little way beneath the bottom edge of the piston 6 when the same is at the top of its stroke. These two flanges 2 do not extend around the entire periphery of the cylinder 1, owing to the presence of the transfer pass or conduit 3, which, in this particular construction, is formed integral with the cylinder 1. Other than that part, however, that accommodates the transfer conduit 3, the circumference of the cylinder is wholly surrounded by these flanges,



which terminate in end walls 2*a*, 2*b* connecting them. The space between these two flanges constitutes in the finished device the oil-chamber or groove 4, and a suitable number of small holes or perforations 5 are provided in the cylinder wall 1 leading from this chamber 4 to the interior of the cylinder 1, these holes 5 being covered and uncovered by each complete reciprocation of the piston 6. In order to close the oil-chamber 4 against the atmosphere a metal or other wire 7 is provided of a diameter a little in excess of the width of the oil-chamber or groove 4 and adapted to be retained in position by suitable means around and between the outer peripheries of the two flanges 2 of the chamber. For the purpose of retaining this wire 7 in position and enabling same to be tightened around the edges of the flanges 2, to prevent leakage of oil and ingress of air, one end of the wire is provided with a screw-threaded extremity or portion 7*a*, which is screwed into a boss or projection 8 mounted upon the side of the transfer pass or conduit 3. The other end is also screwed and projects through a slot or notch cut in the outer portion of the end wall 2*b*, and the wire 7 is tightened by means of a nut screwed on to its extremity. Any suitable pipe or passage 10, provided with a union 11 whereby it is screwed into the groove 4, may be provided, whereby oil is admitted to the oil-chamber 4 from the oil-tank. For simultaneously lubricating the bearings 12 and 13 of the engine, the top of the crank-case 14 is of domed formation and comprises two halves 15 in the shape of shallow receptacles or troughs, and each has preferably a sloping bottom, from the lowest point of which an oil duct or passage 16 leads through the metal of the crank-case sides to the crank-shaft bearings 12 and 13, so that any oil that falls from the walls of the cylinder 1 into the receptacles or troughs gravitates or capillaritates down the oil-ducts 16 to the said bearings. Two sets of bearings 12 and 13 are provided, the roller bearings 12 taking the mechanical wear of the engine, and the phosphor-bronze or other plain bearings 13 acting as compression retainers. A narrow space is provided between each of the two bearings 12 and 13, and the oil from the ducts 16 feeds into this space, thereby ensuring an efficient supply to both bearings. A further duct 18 is provided below the roller bearings 12, and this allows any excess of oil to run into the sump 19 at the bottom of the crank-case 14. Into this sump 19 the big end 20*a* of the connecting-rod 20 dips at every revolution. In operation, the oil is turned on and flows into the annular oil-chamber 4, whence it percolates through the small holes 5, and is delivered into and around the interior of the cylinder 1 when uncovered by the reciprocating piston. In its motion the piston effectively spreads the oil around the inner surface of the cylinder, which is therefore at all times thoroughly lubricated. The oil that is unused falls into the receptacles 15, and from thence passes down to the duct 16 to the space between the two bearings 12 and 13, which are thereby lubricated, and any excess of oil runs along the duct 18 and into the sump 19, into which dips at each revolution of the engine the big end of the connecting-rod. The small end and the gudgeon-pin are effectively lubricated by the oil as it issues from the oil-chamber 4 as well as the piston and cylinder-wall. (*Accepted June* 4, 1914.)

MOTOR ROAD VEHICLES.

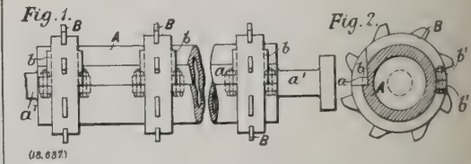
13,247/13. E. Williams, Smethwick. Motor Road Vehicles. [5 *Figs.*] June 7, 1913.—This invention relates to axles for motor road vehicles, and has for its object to provide an improved construction of front axle and spring-mounting for the same. The axle illustrated is constructed from a pair of metal bars *a* spaced at a suitable distance apart. To each end of the pair of bars is secured a bearing-piece *b*, which may conveniently be in the form of a short tube or a jaw-piece, which is welded or otherwise secured to the bars. The bearing-pieces *b* carry the pivot-pins for the forks of the axles on which the front wheels are mounted. The axle is stiffened by distance-pieces *c* fastened by



welding, riveting or otherwise, at suitable distances apart between the bars. These distance-pieces are extended above and below the axle to serve for the attachment of the springs. Each spring-connection comprises a pair of simple or laminated blade-springs *d*, arranged parallel to each other and secured in any convenient manner to the chassis side-members *e*. At the outer end an eye-piece *f* is formed or secured to each spring part for the reception of a pivot-pin, by which the spring is secured to the distance-pieces. Two such spring-connections are employed between the chassis and axle as in ordinary practice. By the above-described construction an effective and inexpensive front axle and spring-connection is provided. (*Sealed August* 20, 1914.)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

18,637/13. E. Bennis, Bolton. Chain-Grate Furnaces. [9 *Figs.*] August 16, 1913.—This invention relates to the construction and use of driving and driven drums which actuate and carry the chain-grates of furnaces of the larger size, for which a demand is arising. Such grates, when of small or moderate size, are usually driven by hexagonal or round drums, with sprockets projecting therefrom strung on a shaft, or by drums the width of the grate; but as there is now a necessity to increase the width of these grates to dimensions far greater than those which have hitherto been constructed, it becomes necessary to devise a means of driving the chain of considerable width, which driving means must preferably be in one piece, because the chain will be continuous across the furnace. For this purpose, according to this invention, it is proposed to cast a driving-drum of a suitable diameter and strength to take a span of from 10 ft. to 20 ft., provided with bearings at both ends, with a groove or slot running longitudinally from end to end, and sprockets with lugs fitting into the groove, that can be clamped in position to engage the chain and drive it forward, causing same to revolve, the drum being in one piece or built up of two or more parts,



mounted on a number of rods or bars or upon a shaft increasing in diameter towards the centre. A similar drum would be cast, but preferably hexagonal for the back of the chain-grate, over which the chain would pass in its return to the drum. The driving-drum A is cast to the desired diameter and length (say, from 8 in. to 20 in. or 24 in. in diameter and from 8 ft. to 20 ft. in length), with sprockets B at intervals on the periphery to engage the links of the chain-grate, and with journals or trunnions a^1 cast into both ends. The drum A is cylindrical with a longitudinal groove or recess *a*, and the sprockets B are provided with key pieces *b* to fit into the groove. The sprockets B are cast to the size of the drum, with lugs b^1 at one side, through which they are cut with a saw, and then fitted with bolts, by which they are clamped in position on the drum A. The sprockets B can be placed in any position along the length of the drum. When the drum is of other shape, the sprockets are cast of corresponding shape to fit thereon and are clamped or secured in a similar manner. The drum A may be cast with internal stiffening-ribs, running either the whole length or at intervals in the interior, or with annular flanges to give stiffness and rigidity thereto. (*Accepted June* 4, 1914.)

CRITICAL LOADS FOR LONG STRUTS OF VARYING SECTION.

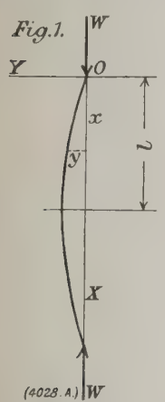
By L. Bairstow and E. W. Stedman.

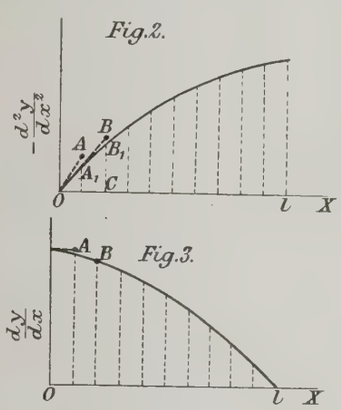
(*Communicated from the National Physical Laboratory.*)

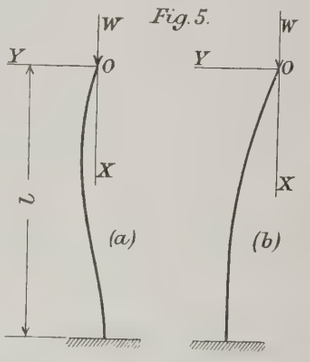
Introduction.—In the issue of Engineering for April 24 last, page 566, Professor Arthur Morley describes a method for determining the critical loads for long columns. The application of the method, however, appears to be somewhat difficult if the variation of the section of the column does not take one or other of certain specified forms.

The method to be described below seems to be much easier to apply, even in simple cases, and has the further advantage that it can be applied with equal ease to the simplest or to the most general case.

It was originally devised for finding the critical loads of wooden struts as used in aeroplane construction, where the ends are generally tapered without any definite calculation, the object being to get the requisite strength for the least weight. The method of calculation here given can be applied to any case where the strut tends to fail by bending, and not by crushing. It can further be made the basis of simple rules which reduce the method to a suitable form for drawing-office use.







Basis of Calculations.—Consider a strut which is hinged at each end and is bending under an applied end load (Fig. 1). Take an origin O at the upper end of the strut, and axes in the directions indicated, so that y is the deflection at any point distant x from the origin. Then, by the well-known formula for beams :—

$$-\mathrm{E}\,.\,\mathrm{I}_x\,.\,\frac{d^2y}{dx^2} = \mathrm{W}\,.\,y\,. \qquad . \qquad . \qquad (1)$$

where E is Young's modulus for the material.

I_x is the least moment of inertia of the section of the strut at x, about a line passing through the centre of area of the section. [It is necessary that, throughout the strut, this line should be always in the same plane, a condition that is usual in practice.]

W is an assumed critical load which may either be guessed or obtained by an approximate method, such as taking the Euler law for a uniform strut of the average section.

Let $2\,l$ = total length of the strut, and for the present assume that the strut is symmetrical about the line $x = l$.

The following conditions hold :—

$\frac{d^2y}{dx^2} = 0$ when $x = 0$.

$\frac{dy}{dx}$ has some initial value, which may be called h.

$\frac{dy}{dx} = 0$ when $x = l$.

$y = 0$ when $x = 0$.

Curves for $-\frac{d^2y}{dx^2}$, $\frac{dy}{dx}$, and y, which comply with the imposed conditions, can now be drawn by a process of trial and error (Figs. 2, 3, 4).

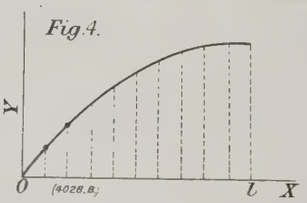
The details of the process are as follow, assuming, for the purpose of description, that the figures have been completed :—

Divide each curve into a number of vertical strips, say each division equals $\frac{1}{10}\,l$ wide. When $x = 0.1\,l$, $\frac{dy}{dx}$ will not have changed from its initial value h by any appreciable amount, and the area of the $\frac{dy}{dx}$ curve up to this point will be approximately $0.1\,l\,h$. This gives the value of y when $x = 0.1\,l$. Substituting this value of y in (1), a value for $\frac{d^2y}{dx^2}$ is obtained, which is then plotted as the point A (Fig. 2).

The points so found may be considered as a first approximation, for they were found by considering $\frac{dy}{dx}$ as constant for a short length of the strut near the point of application of the end load.

Now take the area of the $\frac{d^2y}{dx^2}$ curve up to $x = 0.1\,l$, this gives a corrected value for $\frac{dy}{dx}$, for $\int -\frac{d^2y}{dx^2}\,.\,dx = -\frac{dy}{dx} + c$ and $c = h$.

[The area of the $\frac{dy}{dx}$ curve up to $x = 0.1\,l$ can be again taken, in order to give a corrected value of y, which in turn gives a corrected value of $\frac{d^2y}{dx^2}$.



This is supposed to have been done to obtain the point A_1 of Fig. 2. If necessary, the process can be repeated, but usually the second value of $\frac{d^2y}{dx^2}$ is sufficiently nearly correct.]

In order to extend the curves, the $\frac{d^2y}{dx^2}$ curve is produced in any reasonable manner to some point such as B (Fig. 2), where $x = 0.2\,l$. The area O B C is taken to give a corresponding point B on the $\frac{dy}{dx}$ curve (Fig. 3), which in turn gives a value for y. This value for y is used to give a corrected value for $\frac{d^2y}{dx^2}$ as B_1 (Fig. 2). If necessary, $\frac{dy}{dx}$ and y can also be corrected ; but a general idea can soon be obtained of the form to be expected for the $\frac{d^2y}{dx^2}$ curve, so that very little correction is necessary.

Proceeding in this way, the correct curves are gradually built up by the process of trial and error, and, if the assumed value of W has happened to be the critical load, the ordinate of the $\frac{dy}{dx}$ curve becomes zero when $x = l$. If the value chosen for W had been too large, the curve would have cut the axis at some value of x less than l ; and if W had been too small, the curve would have cut the axis of x at some point for which x was greater than l. After two attempts a very close approximation to the value of W is reached.

The accuracy depends upon the size of the steps taken, and in order to obtain a check on the sufficiency of the number of steps, other than that which can be seen without special investigation as the curves are drawn, a uniform strut may be considered under an end load calculated from one of the well-known Euler formulæ. If the accuracy is sufficiently good, the ordinate of the $\frac{dy}{dx}$ curve will be found to be zero when $x = l$. Ten divisions to the half length are usually ample for the accuracy attainable in engineering calculations of stress and factors of safety.

The method may also be used to give the critical load for a strut held in any way at the ends ; if fixed at one end and free at the other (Fig. 5), the conditions are :—

$\frac{d^2y}{dx^2} = 0$ when $x = 0$.

$\frac{dy}{dx}$ has some value h when $x = 0$.

$\frac{dy}{dx} = 0$ when $x = l$ (l being in this case the total length).

$y = 0$ when $x = 0$.

Also :—

$\frac{dy}{dx}$ may become zero at some point between $x = 0$ and $x = l$;

and

$\frac{d^2y}{dx^2}$ may become zero and change sign.

These latter conditions depend upon whether the strut bends as (*a*) or (*b*) (Fig. 5) ; as in the case of the Euler solutions, the crippling load is the least of any alternatives.

Example.—In order to illustrate the application of the method to a particular case, consider the calculation of the critical load for a spruce interplanar strut of a biplane, hinged at the ends, and loaded axially. Let

$$2\,l = 70 \text{ in.} \quad \mathrm{E} = 1.5 \times 10^6,$$

with the moment of inertia of the mid-section = 0.4 (inch^4), and the distribution of moment of inertia with length as in Fig. 6.

As a first approximation, assume W = 950 lb., a figure suggested in this case by experience.

From (1)

$$-\mathrm{E}\,\mathrm{I}_x\frac{d^2y}{dx^2} = \mathrm{W}\,y.$$

$$-\frac{d^2y}{dx^2} = \frac{950}{1.5 \times 10^6}\,\frac{y}{\mathrm{I}_x} = \frac{y}{1580\,\mathrm{I}_x}.$$

The calculations are most conveniently put into tabular form, the figures being added successively as obtained.

x.	I_x.		$\frac{d^2y}{dx^2}$.	$h - \frac{dy}{dx}$	y.
0	0.060		0	0	0
		0.095			
0.1 l	0.130		− 0.0228 h	0.054 h	3.43 h
		0.160			
0.2 l	0.190		− 0.0261 h	0.142 h	6.60 h
		0.212			
0.3 l	0.235		− 0.0281 h	0.238 h	9.40 h
		0.255			
0.4 l	0.275		− 0.0295 h	0.340 h	11.90 h
		0.292			
0.5 l	0.310		− 0.0304 h	0.445 h	14.05 h
		0.325			
0.6 l	0.340		− 0.0308 h	0.551 h	15.80 h
		0.352			
0.7 l	0.365		− 0.0310 h	0.660 h	17.20 h
		0.375			
0.8 l	0.385		− 0.0307 h	0.769 h	18.15 h
		0.390			
0.9 l	0.395		− 0.0305 h	0.876 h	18.80 h
		0.397			
1.0 l	0.400		− 0.0305 h	0.983 h	19.10 h

When

$$x = 0,\ \frac{dy}{dx} = h,\ \frac{d^2y}{dx^2} = 0,\ y = 0.$$

When

$$x = 0.1\,l,\ \frac{dy}{dx} = h \text{ (approx.)},\ y = 0.1\,h\,l = 3.5\,h$$

$$-\frac{d^2y}{dx^2} = \frac{3.5\,h}{1580 \times 0.095} = 0.0234\,h.$$

The mean moment of inertia has been used. The value of $\frac{d^2y}{dx^2}$ is plotted in Fig. 7. Area of $\frac{d^2y}{dx^2}$ curve up to $x = 0.1\,l$ is found to be $0.016\,h \times 0.1\,l = 0.0016\,h\,l = 0.056\,h$.

This area is best obtained by counting squares on the squared paper.

$$h - \frac{dy}{dx} = 0.056\,h \text{ or } \frac{dy}{dx} = 0.944\,h.$$

This point is plotted in Fig. 8.

Area of $\frac{dy}{dx}$ curve up to $x = 0.1\,l$ is $3.43\,h$

$$\therefore\ y = 3.43\,h.$$

Correcting $\frac{d^2y}{dx^2}$ it becomes $-\frac{d^2y}{dx^2} = 0.0228\,h$.

Proceeding as before,

$$h - \frac{dy}{dx} = 0.054\,h,$$

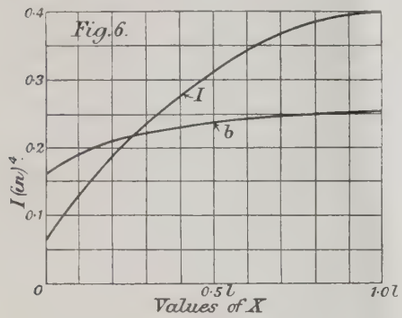
and y remains unchanged to any appreciable extent.

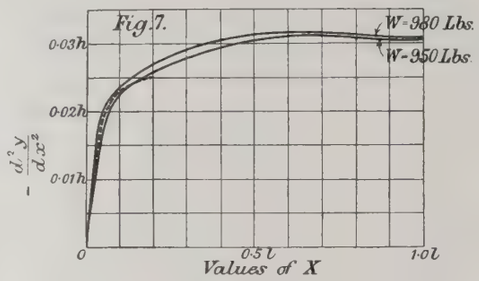
Now produce the $\frac{d^2y}{dx^2}$ curve to $x = 0.2\,l$, where it has an approximate value of $-0.025\,h$, whence $h - \frac{dy}{dx} = 0.139\,h$ and $y = 6.60\,h$.

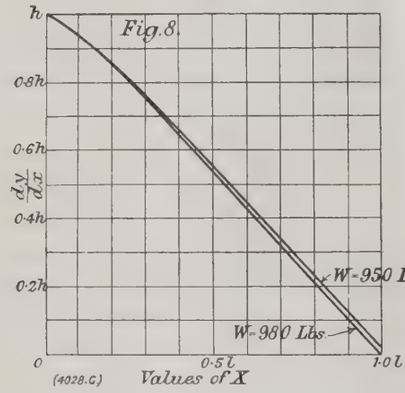
Correcting $\frac{d^2y}{dx^2}$ it becomes

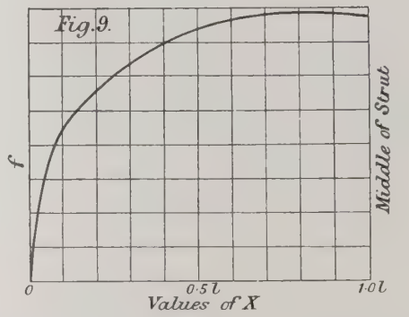
$$-\frac{d^2y}{dx^2} = \frac{6.60}{1580\,I_x} = 0.0261\,h.$$

Making the necessary alteration to Fig. 7, and









taking the area of the curve, find a new value of $0.142\,h$ for $h - \frac{dy}{dx}$. The value of y will not be appreciably changed.

Continuing in this manner, it is found that the $\frac{dy}{dx}$ curve passes to the right of the point $\left(x = l,\ \frac{dy}{dx} = 0\right)$; therefore the value of W chosen was too small.

Choose a slightly larger value for W, say W = 980 lb., and repeat. Now for this value of W

$$-\frac{d^2y}{dx^2} = \frac{y}{1530\,I_x}.$$

The following table gives the figures for the new calculations, and it will be seen that this second value of W is practically the critical load.

x.	I_x.		$\frac{d^2y}{dx^2}$.	$h - \frac{dy}{dx}$	y.
0	0.060		0	0	0
		0.095			
0.1 l	0.130		−0.0236 h	0.055 h	3.42 h
		0.160			
0.2 l	0.190		−0.0269 h	0.146 h	6.59 h
		0.212			
0.3 l	0.235		−0.0290 h	0.245 h	9.40 h
		0.255			
0.4 l	0.275		−0.0304 h	0.349 h	11.85 h
		0.292			
0.5 l	0.310		−0.0312 h	0.458 h	13.95 h
		0.325			
0.6 l	0.340		−0.0315 h	0.568 h	15.70 h
		0.352			
0.7 l	0.365		−0.0316 h	0.678 h	17.00 h
		0.375			
0.8 l	0.385		−0.0313 h	0.789 h	17.95 h
		0.390			
0.9 l	0.395		−0,0310 h	0.900 h	18.50 h
		0.397			
1.0 l	0.400		−0.0308 h	1.005 h	18.70 h

As h is common to the values of y, $\frac{dy}{dx}$ and $\frac{d^2y}{dx^2}$ its real value is of no importance, and it may in all calculations be equal to unity.

Stresses in the Strut when Failure Occurs.—From the usual formulæ for beams

$$\frac{M}{I} = \frac{f}{b},$$

where b is the distance of the outside fibres from the neutral axis and f is the stress. Then

$$f = b\,\frac{M}{I} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

but from (1) :—

$$\frac{M}{I} = -\,E.\frac{d^2y}{dx^2}$$

$$\therefore f = -\,E\,.\,b\,.\,\frac{d^2y}{dx^2} \quad . \quad . \quad . \quad (3)$$

or the stress is proportional to $b\,.\,\frac{d^2y}{dx^2}$.

Suppose the section of the strut is always kept of the same form, but that the dimensions are changed. Then I varies as b^4, and from the curve for I a curve for b (Fig. 6) can be drawn. Values proportional to $\frac{d^2y}{dx^2}$ at any point have been found, and hence values which are everywhere proportional to the stress can be found from (3), giving figures as in the table below :—

x.	$\frac{d^2y}{dx^2}$.	b.	f.
0	0	1.565	0
0.1 l	−0.0236	1.90	449
0.2 l	−0.0269	2.09	562
0.3 l	−0.0290	2.20	638
0.4 l	−0.0304	2.29	697
0.5 l	−0.0312	2.36	736
0.6 l	−0.0315	2.41	760
0.7 l	−0.0316	2.46	777
0.8 l	−0.0313	2.49	780
0.9 l	−0.0310	2.51	779
1.0 l	−0.0308	2.52	776

The actual values of b can be determined when the form of section for the strut has been decided upon.

The values of f, which, it must be remembered, are only proportional to stress, and not actual values, are plotted in Fig. 9, from which it is seen that the stress is fairly uniform over the middle third of the strut.

Strut of Uniform Strength.—Consideration of the distribution of stress, Fig. 9, at once indicates a method of obtaining a strut of uniform resistance to bending. It is evident from the figure that the material between $x = 0$ and $x = 0.5\,l$ might advantageously be more highly stressed, and that the moment of inertia could be reduced in this region.

Eventually by a few trials a distribution of stress can be obtained which is practically uniform over the length of the strut. The ends, of course, must, from practical reasons and to resist crushing, be made of sufficient size, and so the stress must fall to zero at the ends.

Reducing the section of the strut at any section reduces the critical load, but, once a moment of inertia curve for uniform strength has been obtained, the critical load will increase in direct proportion with the increase of moment of inertia, provided the length remains the same.

In aeroplane construction struts are usually tapered towards the ends ; at present this appears to have been done more or less "to eye." In certain cases the tendency has been to produce a form in which the struts do not tend to break at the centre. Such a tendency is, of course, immediately shown by a stress-distribution curve as is given in Fig. 9.

It will be found that in the illustration the crippling load is appreciably less than that of a strut of equal length, but of constant moment of inertia equal to that at the centre. The Euler formula should, if used, be applied to a mean moment of inertia. The relation of this mean to the maximum at the centre is probably roughly constant for one class of strut, and might be determined once and for all by the method described in this paper. The method is, however, so easy to apply that the calculations can be carried out for any new section in less than two hours, or in much less time, after some experience of the detailed calculations.

LITERATURE.

The Diesel or Slow-Combustion Oil-Engine : A Practical Treatise on the Design and Construction of the Diesel Engine, for the Use of Draughtsmen, Students, and Others. By G. James Wells, Wh.Sc., and A. J. Wallace-Taylor, C.E. London : Crosby Lockwood and Son. [Price 7s. 6d. net.]

The books which have previously been published in English on this new type of prime mover have been far from useful from the point of view of the designer and constructor, and the object with which this new book has been written, as given in the brief preface, is to treat specifically and fully with the design and construction of engines working on the slow-combustion system, for the use of draughtsmen, students and others. Undoubtedly, as stated, great difficulty must be experienced at the present stage of development in obtaining the requisite data and drawings in detail of the various important parts of this class of engine ; but even so, a great deal is now available regarding the valves, and manœuvring and control gears of the leading types, which might have been drawn upon by the authors.

No information can be as valuable to the draughtsman and the designer as actual working drawings of engines that have been constructed and have either succeeded or failed. Calculations and formulæ are, no doubt, of great assistance to the engineer in many cases, but the history of the Diesel engine is proof—if proof were needed—of the insufficiency of mathematical processes as a foundation for new machines working under novel conditions. At a later stage, when experiment has demonstrated what are the stresses to be provided for, formulæ become a great assistance. The Diesel engine is now in an intermediate phase. Experience is beginning to accumulate, and should be taken as the groundwork of all that is written upon it.

At the commencement of the book, a brief introduction of some three pages is given. Heat and pressure cycles, as a general subject, are next treated theoretically in Chapters II. to IV. With few exceptions all this matter is to be found in any standard text-book on heat, and only one or two references are made to connect up this general theory with the type of engine under consideration. The same remarks apply to the chapter on fuels and on the balancing of engines.

The testing of oil-engines is a very important point, as each engine, before being delivered from the makers' works, is generally tested and adjusted to give the best results, so that in every establishment building this type of prime mover the testing and running of engines form an important department. Data and log-sheets, &c., for the guidance of such would have been useful, but from the short chapter devoted to this subject—only test results on some comparatively old four-stroke-cycle engines are given—it appears clear that the

authors have no first-hand knowledge of this particular branch.

The application of the compressor to the Diesel oil-engine is one of the problems to be met, and it is one which can only be elucidated by a study of the effects of air compression at variable speeds and conditions of suction. These points are not even mentioned in the book under notice. In the case of compressors, the valves require the greatest amount of attention, and in this chapter the design of compressor-valves, springs, &c., is not elucidated.

When dealing with indicator diagrams, no examples are given of the effect of the various fuels and engine-settings upon the indicator-card, nor are there any reproductions of diagrams other than those which are theoretically perfect.

The possible and practical mean effective pressures in the cylinders of internal-combustion engines is a subject of the greatest importance, but in this connection no mention is made of the two-stroke-cycle engine, it being stated that there is not sufficient information to hand. This clearly is erroneous, as there have been very many particulars recently published of two-stroke-cycle engines, more especially of the marine type.

As an instance of the inadequacy of the book from the designer's point of view, cylinder heads or covers might be quoted. The design of this particular part, as is well known, if not the most, is one of the most important matters in connection with the Diesel engine, and designers would be grateful for data or even a collection of drawings showing various constructions to assist them in what is indeed a complicated problem. In the volume before us, however, cylinder-covers are disposed of in ten lines of text, and many other similar leading features of the Diesel engine are treated in the same inadequate way. Reversing gears, with the exception of that of the Bolinder semi-Diesel gear, are not given in detail, and the book assists in no way towards clearing up many difficulties relating to such gears which the designer may experience.

In the chapter on recent practice, sections are given of some land engines of the leading makers, but no two-stroke-cycle engine of note is illustrated with drawings; photographs, in fact, suffice for the majority of the figures in this chapter. The theory of the fuel-injection pump and of the fuel-control is a most interesting point, but is not touched upon.

In an appendix are given abridgements of some of the most important patents dealing with this prime mover, but as these are constantly changing and being added to day by day, their use is limited to a very short period.

No doubt this book will be read with interest by those who wish to have a general and somewhat superficial idea of the properties of heat, heat diagrams, the general theory of compressors, the fundamentals of balancing, the action and the method of operation of the Diesel engine; but, as already indicated, the object of fulfilling an undoubted want for the designers and constructors of this class of engine is very inadequately fulfilled.

A Hand-Book of Wireless Telegraphy: Its Theory and Practice, for the Use of Electrical Engineers, Students, and Operators. By James Erskine Murray, D.Sc. Fifth Edition, revised and enlarged. London: Crosby Lockwood and Son. [Price 10s. 6d. net.]

The fifth edition of this well-known treatise has fallen in an evil hour. The necessities of military strategy, or the requirements of diplomatic subtlety, have led to the dismantling of the wireless stations in the hands of amateurs, for whose benefit this book is mainly written. Whether the measures of the Government have been successful the authorities know best, but to deprive an amateur of a visible aerial seems a feeble method of preventing what we may call illicit communication. But we are only concerned to point out here that the development of this form of scientific amusement has received a check from which it will take long to recover. We may, however, add that this blow at amateur science has been delivered at a singularly inopportune moment. Information is much needed on the influence exercised by the state of the atmosphere on radiotelegraphic transmission, and the interruption of observations has prevented some experiments that might have proved unusually instructive. A proposal was on foot to make use of the recent total eclipse of the sun, during which the alternating circumstances of day and night are practically reproduced in a short interval, to test certain theories. Such eclipses are comparatively rare, and the Russian eclipse might have proved very instructive. Certainly many amateurs were prepared to follow a carefully-constructed programme, but the stern necessities of war abruptly closed the avenues of information. What is known of the effect of more or less abnormal conditions on transmission will be found very well summarised in Chapter XVI., though the action ascribed to the upper conducting layer of the atmosphere can hardly be regarded as demonstrated.

Each edition of a text-book of this class naturally profits by recent inquiry and embodies the results of researches by the author and others. The noticeable additions in the present volume refer to the uniform alternating current and shock-excitation systems. Recent measurements of transmitted power have also been added. The real value of the book consists, however, in its general survey of the growth and present position of the problem of transmission of signals when the use of an insulated conductor between the sending and receiving station is dispensed with. For those who have not seen the previous editions it may be noted that the work follows the customary lines, and is characterised by a thoroughness of treatment that is quite satisfactory. An historical introduction, full and interesting, is followed by chapters on detectors, much space being devoted to the theory of magnetic detectors, while electrolytic and other forms are rather briefly dismissed. There is much dispute among amateurs as to the most sensitive form of detector. This wrangling could be avoided if it were remembered that "success in wireless telegraphy depends much more on the proper adaptation of the detector, of whatever kind it may be, to the rest of the apparatus, than on the actual species of detector used." Naturally much space is given to the description of the different "systems" of wireless telegraphy, known as the Marconi, the Lodge-Muirhead, Fessenden, Hozier-Brown, &c., though these might be, perhaps, better described as varieties of the spark method. A chapter on "Wireless Telegraphy in Alaska" is here interpolated that seems rather out of place—a faulty arrangement, due, perhaps, to the exigencies of earlier editions. There is no sufficient reason for separating the descriptions of the Poulsen, Goldschmidt, and other systems from those earlier.

The chapter on "Antennæ" is informing, the author following generally the theory of Professor Zenneck in explaining the greater range and improvement effected by the employment of directive and bent antennæ. To the remarks on the theory of transmission we have already referred. A very long quotation is given from M. Tesla's description of his plan for the distribution of electrical energy by utilising the whole world as a conductor, but practical wireless telegraphy has not been advanced by these experiments. We reach more practical matter, and have to recognise the sure guidance of knowledge and experience in the treatment of such matters as electrical measurements, fault-testing, and the efficiency of wireless systems. To those who want accurate information, and full description free from excessive technics, this work can be heartily recommended.

Ambidexterity and Mental Culture. By H. Macnaughton-Jones, M.D. London: William Heinemann. [Price 2s. 6d. net.]

We have no wish, as no intention, to enter into the controversies that centre round this question of the possibilities of ambidexterity. We believe that the advocates of its exercise are somewhat intemperate in claiming benefits that follow its practice, and that the data on which the claims are founded are insufficient. This author asserts, apparently on the authority of medical experts, that the mental and intellectual function of speech is exercised by a machinery that exists only in the left brain of the right-handed, and in the right brain of the left-handed individual. We doubt if this statement is universally accepted, for of late years some doubt has been thrown on the assumed connection of particular localities of the brain with the capacity for exercising muscular and physical movements, and the necessary evidence to establish the facts is under revision. But admitting the correctness of the premises, we doubt if the author makes out his case. He proposes to show that the intellect of the race would be increased by equalising the balance of functional activity on both sides of the brain, by educating from infancy both hands to work with equal power and dexterity. The author fails to convince us. There is apparently no reason why intellectual activity should not need for its display a difference of level. Equality might mean a loss of potential energy, with less capacity for work. The author must forgive us if we draw our similes from physical concepts. Quoting from another authority, it is stated "that a brain-motor centre, cheated of appropriate exercise at its nascent and growth period, does not develop properly." That may be true, but if the development of one portion is at the expense of some other brain-motor centre, we fail to see that there is any advantage gained by the brain mechanism in its entirety. We must decline to follow the author in his attempt to prove that ambidexterity is a factor that contributes to the formation of character and intellectual growth, building up the moral constitution of the individual. Just as little are we prepared to admit that he establishes his thesis by the quotation of instances. So far as the facts are reproduced, coincidence in time is confounded with operating cause. The case of a medical student is given who was left-handed till he was twelve years old. "His parents then made a desperate effort by bandaging the left arm, and such drastic methods, to render him right-handed, and from that time he began to stammer"! The author may be in possession of other facts that connect the stammering with the arm-bandaging, but we can only judge from the statement as it stands.

On one point we are heartily with the author: the necessity for the greater development of manual training. The efforts of educationists have been devoted too exclusively to the literary side. Unskilled in technical processes themselves, they have undervalued the educative effect of well-directed handicraft, and failed to perceive its usefulness as a national asset.

A Text-Book of Physics. By J. H. Poynting, Sc.D., F.R.S., late Mason Professor of Physics in the University of Birmingham, and Sir J. J. Thomson, O.M., M.A., F.R.S., Cavendish Professor of Experimental Physics in the University of Cambridge. Parts I. and II. *Static Electricity and Magnetism.* London: Charles Griffin and Co. [Price 10s. 6d.]

It is impossible to refer to this volume of the "Text-Book of Physics" without expressing a deep regret that the subtle brain and acute intellect that have illuminated so much that is obscure in physical science, and straightened the path for so many inquirers, are no longer with us. Collaborating with Sir J. J. Thomson, Professor Poynting has assisted in the production of a succession of volumes, in which the important fundamental principles of physics have been dealt with thoroughly, but without undue elaboration. They have set up a model of what a text-book should be, and it is not necessary to say that the present volume is an admirable companion to those that have preceded it. While impressed by its conciseness and lucidity, one cannot but feel how severe a loss science has suffered by the death of the distinguished physicist, as renowned for his original researches as for his devotion to the duties of his chair.

The labour of producing such a text-book must be considerable, making a great demand upon the time of a busy teacher and able experimentalist. One is tempted to ask, therefore, what purpose does such an elaborate treatise fulfil? The reading of text-books, it must be admitted, does not give a student an adequate grasp of the subject; laboratory work and experiment are essential parts of the educational curriculum that cannot be omitted without material loss. Are we justified in concluding that the carefully compiled treatise may fairly take the place of lectures, not merely as a supplement, but as a substitute? No doubt the authors intended to render assistance to those to whom access to lectures is difficult, or who find a lecture diet unsatisfying. There is some inducement to go further, and argue that such a well-constructed text-book as the present is an improvement on many lectures, and the perusal better calculated to benefit that particular class of students who are distrustful of the pleasant and easy method of acquiring information by listening to a gifted and accomplished lecturer. An admirable address, punctuated by the deft performance of a carefully-selected experiment or two, may create a very satisfactory impression at the time, and yet, as an educational vehicle, prove disappointing, when the well-rounded periods of the lecturer have ceased to charm. Then it might seem that the text-book has an enduring merit that would appeal to those

who like to force their own way over the rough places, and do not expect to have all their difficulties swept away by the practised aid and thoughtful provision of the teacher.

For such earnest students, we imagine this manual is admirably adapted. It is elementary in the sense that it is based on fundamental principles, and a sincere attempt is made to get to the root of the matter. Apparently there is no difficulty shirked; there are some facts which have to be accepted, for which no explanation can be offered. For instance, it is not possible to explain the phenomenon of magnetism. The hypothesis that each molecule of iron or steel which contributes to the magnetic condition is itself a permanent magnet with definite polarity, and capable of rotation about its centre, may enable us to picture a series of operations, or serve to explain the results of certain experiments, but it in no way explains magnetism. Ampère's hypothesis, or Ewing's model, may suggest an escape from some perplexities, but do not solve the problem of the magnetisation of the molecules. The former provides simply a hypothetical device for securing permanent magnets. Here, as in other places where plausible and recondite theories have been put forward to explain what is obscure, it is easy to point out the valuable aid that the experienced teacher could render by preventing his pupil wandering in the quagmire of doubt and uncertainty. The fascination of the novel and unexpected is not without its dangers. The theory of Langevin, for example, to explain the origin of magnetisation, elaborated as it has been by other scientists, might command assent, not from reasoned conviction, but from admiration of the ingenuity exhibited. We have, however, no intention of discussing the latest theory of the "magneton," more especially as the author, in presenting the hypothesis, neither accepts nor rejects its adequacy.

It were better to explain that this volume, divided into two parts, deals with the chief phenomena of electric and magnetic systems when they are respectively charged or magnetised. It is proposed to deal with the effects due to electric current, or electric magnetism, in a separate volume. The views of Faraday, as mathematically developed by Maxwell, underlie the general method of treatment. "Electric strain" may take the place of "electric displacement" or "electric induction" without disturbing the line of argument. The experiments of Hertz, not less than those of Faraday, show the existence of electric and magnetic energy in the surrounding medium, submitting this medium to conditions that are analogous to "strain," and can be conveniently expressed by the same term. This treatment of the electric action has a rather unfamiliar look, but Professor Poynting gives very good reasons for his nomenclature, maintaining that there are forces accompanying "electric strain" that resemble those in the more familiar elastic strain. The nature of the "electric strain" is not known, and what light might be thrown upon it from the electron theory, being largely a current theory, will find its proper place in the next volume. We have already mentioned that the possible bearing of the electron on the explanation of magnetism finds an appropriate place here. We may add, further, that in the general discussion of magnetism and allied phenomena the effects of intensity and induction are treated in a very illuminating manner, but naturally, where all is instructive and effectively arranged, different sections will appeal with varying force to different readers.

BOOKS RECEIVED.

Report of the Mine Inspector for the Territory of Alaska to the Secretary of the Interior, 1913. Washington: Government Printing Office.

The Development of British Locomotive Design. By E. L. Ahrons, M.I. Mech. E., M. Inst. Loco. Engineers. London: The Locomotive Publishing Company, Limited, 3, Amen-corner; Calcutta: The *Indian Railway Gazette*; New York: The Angus Sinclair Company. [Price 5s.]

The Maintenance of Foreshores. By Ernest Latham, A.M. Inst. C.E. With contributions by Colonel R. E. B. Crompton, C.B., M. Inst. C.E., and A. E. Carey, M. Inst. C.E. London: Crosby Lockwood and Son. [Price 2s. net.]

Fergusson's Percentage Trigonometry or Plane Trigonometry Reduced to Simple Arithmetic, with a Short Description of His Percentage Compass. By John Coleman Fergusson, M. Inst. C.E. London, New York, Bombay, and Calcutta: Longmans, Green and Co. [Price 3s. 6d. net.]

The Powell-Duffryn Steam-Coal Company, Limited, 1864-1914. Cardiff: The Business Statistics Company, Limited, 12, James-street.

The Pocket-Book of Refrigeration and Ice-Making. Edited by A. J. Wallis-Tayler. Sixth Edition, revised and enlarged. London: Crosby Lockwood and Son. [Price 3s. 6d. net.]

Brown's Marine Electrician for Sea-Going Engineers. By Alfred E. Larkman, A.I.E.E., and Alfred H. Larkman. Glasgow: James Brown and Son, 52 to 58, Darnley-street. [Price 5s. net.]

Chemical Engineering. Notes on Grinding, Sifting, Separating, and Transporting Solids. By J. W. Hinchley, A.R.M.S., Wh.Sc. London: J. and A. Churchill. [Price 2s. 6d. net.]

The Science of Works Management. By John Batey. London: Scott, Greenwood and Son. [Price 4s. net.]

CALCIUM CARBIDE AND NITROGEN PRODUCTS.

(*Continued from page* 353.)

The Cyanamide Factory.

The original cyanamide factory, started in 1908, was designed for a yearly output of 12,000 tons. By the installation of a small amount of additional plant the maximum output was raised in 1912 to 24,000 tons, and by the present extensions the annual export will reach about 80,000 tons. For the latter production about 57,000 tons of carbide will be required, and all of this is, of course, provided by the adjoining Alby factory, described in the previous article.

Calcium cyanamide is a compound of nitrogen, carbon, and lime produced from calcium carbide. In the commercial product as manufactured at Odda the relative values of the above-named constituents are approximately as follow:—

	Per Cent.
Nitrogen...	20
Carbon	12
Lime, free and chemically combined ...	60
Inert substances	8
	100

Cyanamide is used either directly as a manure or in association with other fertilising materials, and quite recently success has been attained in devising mechanical means for granulating the cyanamide, or nitrolim, so that it can be used for top-dressing even with a high wind blowing. In addition to its use as a fertiliser it has a wide application as a source of ammonia for chemical manufacture. By means of the catalytic process invented by Professor Ostwald, of which Nitrogen Products and Carbide Company, Limited, owns the world's rights, excluding only Westphalia and Rhineland, ammonia from cyanamide is economically converted into nitric acid, and from this form into a wide range of chemical compounds.

The cyanamide factory site covers an area of approximately seven acres, in addition to which there is a large space occupied by railways, storehouses, and export quays, which is shared in common with the Alby United Carbide Factories, Limited. In full operation the factory employs about 310 workmen, of which the majority work on shifts of about eight hours. The electrical current for motive power and furnaces, amounting to 6000 horse-power, is delivered to the cyanamide factory by two cables directly connected with the generating station at Tysse. The process of manufacture depends upon the fact that when finely-powdered calcium carbide—a compound of calcium and carbon—is heated in an atmosphere of nitrogen to a sufficiently high temperature, the nitrogen combines with the carbide to form calcium cyanamide, and at the same time a portion of the carbon of the calcium carbide is separated out. The nitrogen necessary for the manufacture is produced by the Linde process of fractional distillation of liquid air. The Linde plant of the North-Western Cyanamide Company is the largest in the world. It consists of seven units, having a total capacity of approximately 100,000 cub. ft. of pure nitrogen per hour. The production of this quantity involves the liquefaction of over 100 tons of air per day, and to this plant attention may first be directed.

The Fixation of Nitrogen from Atmospheric Air.

The principle on which the Linde plant for the production of nitrogen operates, it may be well to recall, is the rectification of liquid air under normal pressure and at a temperature at or near the boiling-point of nitrogen. At this temperature the oxygen component still remains in the liquid condition, and as such is removed at the base of the rectifying columns. A diagram indicative of the operations is reproduced in Fig. 46. For the sake of clearness the cycle of operations may be divided into three systems, which will be considered in turn—viz., the low-pressure, the high-pressure, and the ammonia systems.

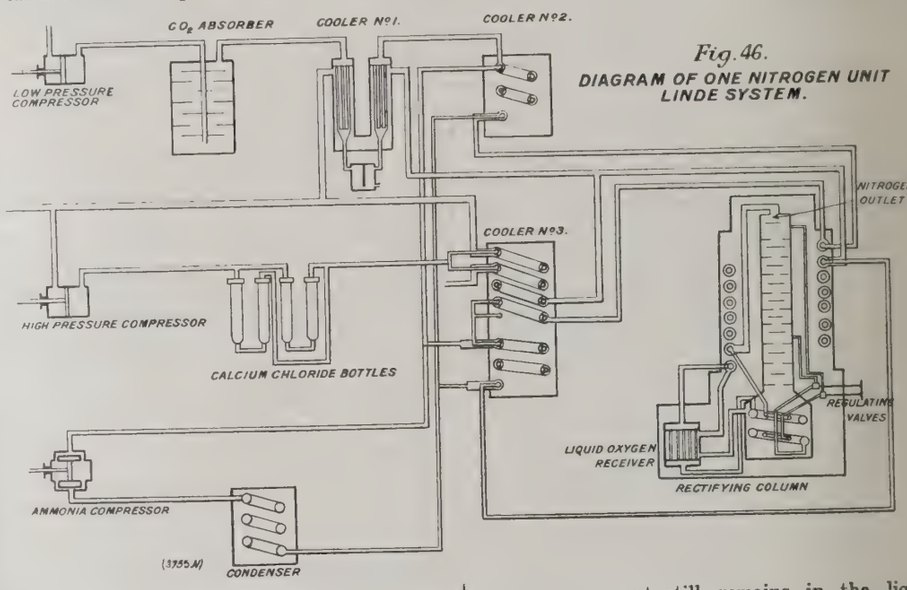


Fig. 46.
DIAGRAM OF ONE NITROGEN UNIT LINDE SYSTEM.

As to the first of these—the low-pressure system—outside air is drawn through a dust-filter by the low-pressure compressor, which delivers it at a pressure of about 5 atmospheres through a vessel containing caustic soda, marked "CO_2 absorber" in the diagram, to the coolers Nos. 1 and 2 on the diagram. The caustic soda removes any carbonic acid the air may contain, as if allowed to go forward it would solidify and obstruct the pipes and the rectifying column. In the cooler No. 1 the low-pressure air receives its preliminary cooling on the counter-current principle by means of pure nitrogen on its way to the furnaces. The cooler consists of a double nest of tubes, through which the air passes, and in so doing is cooled down from about 20 deg. Cent. to below zero. The nitrogen circulating on the outside of the tubes is warmed to between 5 deg. and 10 deg. and is then ready for use. This preliminary cooling of the air removes the greater part of the water vapour it contains, and, being condensed, the water falls into a reservoir below the cooler, from which it is periodically blown out. The air next passes into the cooler No. 2, which consists of a compound spiral, well insulated to prevent the ingress of heat from outside sources. The pipe conveying the air is wound outside another and smaller pipe, through which ammonia liquor is circulated. The evaporation of the ammonia still further reduces the temperature

LINDE PLANT FOR FIXATION OF NITROGEN AT ODDA, NORWAY.

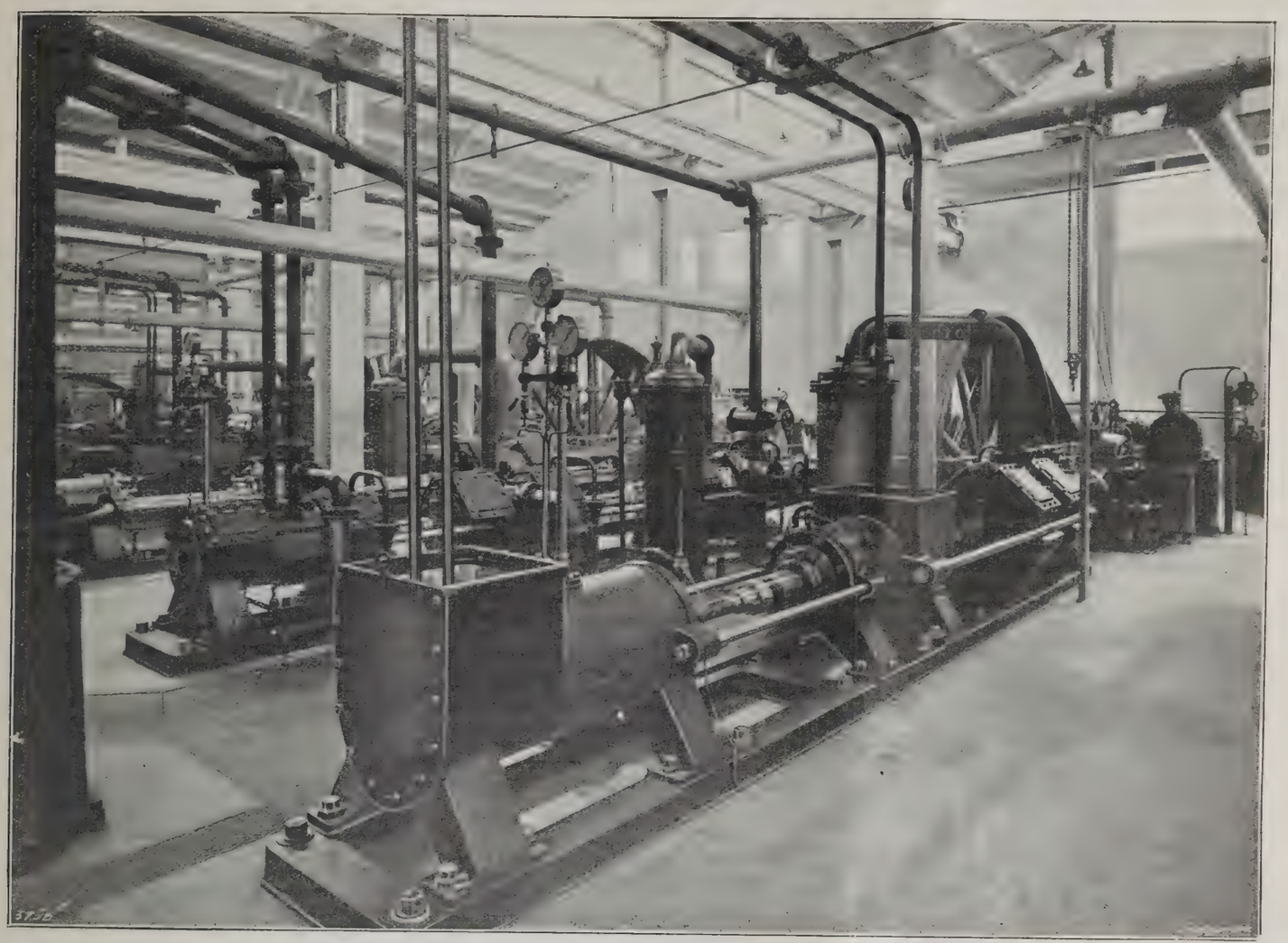


Fig. 47. Six-Stage Compressors, by the Maschinenfabrik Burkhardt, Basle.

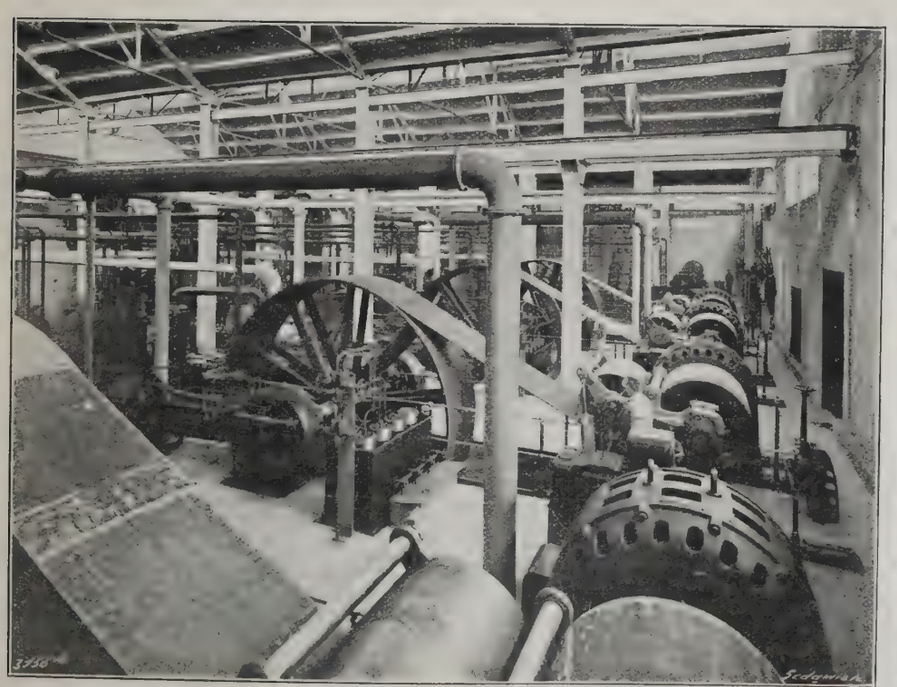


Fig. 48. Jockey Pulleys (Lenix Type), by the Berlin Anhaltische Maschinenbau A.-G.

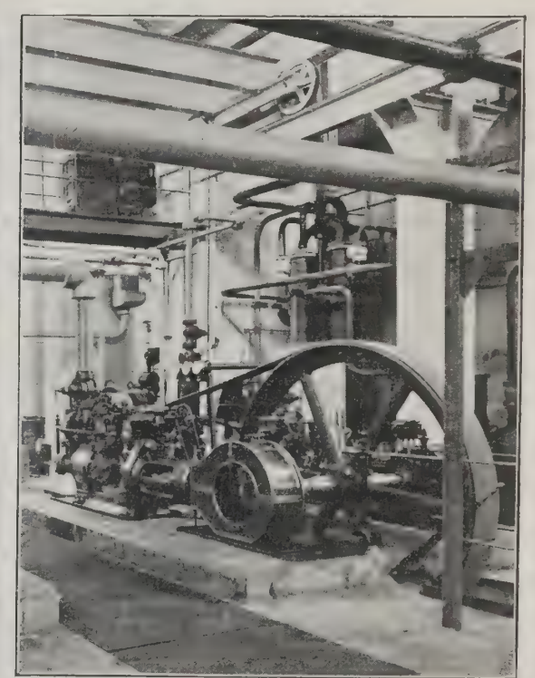


Fig. 49. Ammonia Compressor.

to −30 deg. Cent., at which temperature the air enters the rectifying column. The rectifying column consists of two principal parts: (1) the inner still, or column proper; and (2) the outer sheathing, consisting of a spiral-pipe system, which assists in maintaining the column at a low temperature. For the moment the outer sheathing only will be considered. It consists of two spiral tubes of large section, through one of which the pure nitrogen, taken from the top of the inner column, passes. Through the second coil is passed the oxygen which is distilled from the liquid-oxygen receiver. Through the inside of these tubes are wound smaller pipes, carrying both the low-pressure air and the high-pressure nitrogen delivered from the system to be now described.

The high-pressure system consists of a high-pressure compressor, which takes pure nitrogen from the furnace main and compresses it to about 100 atmospheres. The compressed nitrogen is first passed through calcium-chloride bottles, to remove any water vapour, and then into the cooler marked No. 3 on the diagram. In this cooler are placed three sets of double-wound spiral pipes, through one of which the high-pressure nitrogen passes in contact with the cold nitrogen delivered from the rectifying column. In the lower part of the cooler is placed the third coil, through which the high-pressure nitrogen next passes, and is further cooled by contact with liquid ammonia. In this way the temperature of the high-pressure nitrogen is reduced to about −30 deg. Cent., at which temperature it is delivered to the outer sheath of the rectifying column.

The ammonia system may be dismissed in a few words. Its object is to reduce the temperature of the whole system to as low a point as is possible with ammonia. It consists of the usual arrangement of ammonia compressor with its condenser, but is combined with a special arrangement to prevent priming of the liquid ammonia over into the cylinders of the compressor. The liquid ammonia is fed from the ammonia condenser to the ammonia coils of the coolers Nos. 2 and 3, and thus cools down both the low-pressure air and the high-pressure nitrogen as previously described.

We may now consider the action inside the inner still or rectifying column proper. The high-pressure nitrogen, which has been cooled down to a low temperature by its passage through the spiral coils of the outer sheathing, is still further cooled by passing it through another coil placed in the base of the column. This base forms a receiver for liquid air, the apparatus being worked in such a manner as to maintain the level of the liquid constant. The temperature of this liquid is in the neighbourhood of −194 deg. Cent., the temperature at which nitrogen boils under the condition of pressure which exists. The high-pressure nitrogen thus cooled to about −194 deg. Cent. is then allowed to expand through a regulating valve, the lower of the two valves shown on the diagram, where the pressure is reduced from 100 atmospheres to the normal pressure existing inside the column. Passing through the valve, the nitrogen, now in a liquid condition, is led to the top of the column, down which it is allowed to fall in the form of a spray, being broken up by finely-perforated plates and trays. The low-pressure air, which has been cooled in its passage through the coils of the outer sheathing of the column, is next passed through the tubes of the liquid-oxygen receiver and next through a spiral coil placed also in the liquid air, both at the base of the column. The liquid-oxygen receiver is kept supplied with liquid by the continual overflow of the liquid from the base of the column. The low-pressure air is also thus cooled to a very low temperature, and is then led through a regulating valve, the upper of the two valves shown on the diagram, from which it passes to a point about half way up the column into which it is introduced. The low-pressure air, which has become liquefied on passing through the coil in the base of the column, on entering the column meets the descending stream of liquid nitrogen delivered from the high-pressure system, which condenses out the oxygen constituent of the air introduced and allows the nitrogen drawn off at the top of the column to become almost pure.

In order to explain the condensation of the oxygen, it is only necessary to note that the temperature of the liquid introduced at the top of the column is lower by 13 deg. Cent. than the temperature of the oxygen vapour rising from the lower part of the column, the boiling-point of liquid nitrogen being −195 deg. Cent., and that of liquid oxygen −182 deg. Cent. The result is that the liquid which collects at the base of the column contains practically all the oxygen, and it is found that in practice the nitrogen obtained from the top of the column is of approximately 99.8 per cent. purity. The oxygen leaving the apparatus after evaporation in the oxygen receiver contains about 65 per cent. oxygen, which, for the present, is discharged into the atmosphere.

Turning now to the technical details of the Linde nitrogen plant, it may be premised that the original plant consists of three small units, each of a nominal capacity of 375 cubic metres of nitrogen per hour. Four units of a nominal capacity of 700 cubic metres per hour have recently been installed. The whole of the nitrogen plant, with the exception of the electrical part, has been supplied by Gesellschaft für Lindes Eismaschinen A.-G., Munich. The building containing the nitrogen plant covers a ground space of 146 ft. by 108 ft., divided into five bays, four for the compressors and a separate bay for the rectifying columns. Each bay is served by a hand-crane capable of handling the heaviest pieces, and renders the erection and repair of any part an easy task. The cranes have all been supplied by Herbert Morris, Limited, Loughborough. The carbonic-acid absorbers are contained in a separate room, which keeps the caustic liquor away from the main machinery hall.

The smaller units having been previously described in Engineering, it will perhaps be of some interest to describe at length the new and larger units recently installed. These consist of four six-stage compressors, built by the Maschinenfabrik Burkhardt, of Basle, one of which is illustrated by Fig. 47, on page 407. In normal running two of the six stages supply the low-pressure air at 5 atmospheres pressure to the system, and the other four stages compress the high-pressure nitrogen, which, after condensation in the coil at the base of the column, forms the washing liquid in the column as described above. In normal running the pressure in the high-pressure system is about 100 atmospheres.

During the "running-up" period, however—that is, during the four or five hours occupied in setting any unit to work after a stop—the six stages are worked in series, and during this period the pressure is raised to 200 atmospheres. In practice a column can generally be run continuously for about fourteen days, after which the accumulation of carbonic acid, and, perhaps, some water which may have escaped absorption in the proper vessels, obstruct the passages of the apparatus and make it necessary to shut down for the purpose of thawing it out.

The compressors have pistons of the following diameters:—First stage, 450 mm. (17.72 in.); second stage, 410 mm. (16.14 in.); third stage, 300 mm. (11.81 in.); fourth stage, 210 mm. (8.26 in.); fifth stage, 170 mm. (6.69 in.); and sixth stage, 80 mm. (3.15 in.), with a common stroke of 600 mm. (23.62 in.). The normal speed is 125 revolutions per minute. The suction volumes of the six stages in series are 1150 cub. m. (40,614 cub. ft.) per hour at 200 atmospheres pressure; of the two low-pressure stages, 1100 cub. m. (38,848 cub. ft.) per hour at 5 atmospheres; and of the high-pressure stages, 800 cub. m. (28,253 cub. ft.) at 70 to 200 atmospheres. The machines are mounted on substantial concrete foundations, the space below the floor and between the foundations being used for running the high and low-pressure piping, water-pipes, electric cables, &c.

The motors driving the compressors were supplied by the British Westinghouse Electric and Manufacturing Company, Limited, of Manchester. They are of three-phase induction type, wound for 400 volts and 25 periods. They develop 466 horse-power at full load during the running-up period, and normally 350 horse-power to 400 horse-power during the working period. The motors are controlled by switch-pillars placed alongside them, which consist of automatic oil-break switches—so mounted as to be readily accessible—with ammeters for showing the load. Each switch-pillar is fed direct by two three-phase cables with conductors, each of 240 sq. mm. section, controlled by an automatic switch in the transformer-house. The starting resistances are of the liquid type, placed in the basement below the motors. The speed of the motors is 485 revolutions per minute. The drive is by means of a belt 3 ft. 3 in. wide, constructed of best English orange-tan leather, specially selected for the Viking Rem and Pakningfabrik, Christiania, who manufactured the belts. The space available for the plant being restricted, it was not possible to allow more than 16 ft. 6 in. between the centres of the motor and the compressor-shaft. As it was not convenient to adopt motors built direct on the compressor-shafts, it was decided to employ jockey pulleys of the Lenix type, supplied by the Berlin Anhaltische Maschinenbau A.-G., to increase the arc of contact round the motor driving-pulleys. The method of drive will be clear from Fig. 48, on page 407.

The ammonia system consists of two single-cylinder ammonia compressors, which work on the three smaller nitrogen columns, and two compound ammonia compressors for use on the new columns. One of these ammonia compressors is shown in Fig. 49. Each compressor has an independent condenser. The two compound machines are driven by independent Westinghouse motors of 60 horse-power through belts provided with Lenix jockey-pulleys, which had to be adopted in this case also on account of the shortness of the drive. The speed of the motors can be varied at need by means of Westinghouse controllers, which admit of a 40 per cent. variation. The liquid ammonia is delivered from the condenser to the various coolers as required, the gaseous ammonia evaporated therein being taken to the top of a liquid-separating column, with the object of preventing the return of any priming liquid back to the compressors.

A system of cross-connections has been arranged on the ammonia-pipe connections whereby warm ammonia liquid can be taken before entering the condensers and passed into any cooler which may require to be warmed up for thawing out ice or carbonic acid snow that may have accumulated inside the spirals during the working period. This is an operation which has to be performed every week or so. In the low-pressure coolers No. 2 an auxiliary system of warming-up by means of hot air supplied by a small blower through an electrical heater has been adopted for expediting the thawing-out process. Of the coolers Nos. 2 and 3 there is little to remark, save that they are well-insulated pieces of apparatus. The cooler No. 1, however, is arranged in two parts, provided with change-over valves, by which the direction of flow of the air and nitrogen through them may be reversed, in order that the water condensed and frozen on the outlet side of the combination may be thawed out on changing over by the warmer air entering the apparatus from the compressor at about 20 deg. Cent. This changing over is effected by hand every few hours.

For CO_2 absorption the air supply to the three smaller units is drawn in through two sets of washing-towers. There are two towers working in series, and through them a solution of caustic soda is constantly circulated by means of centrifugal pumps, the towers being placed on the suction side of the compressors. In the case of the new units, however, the carbonic acid is removed under pressure, the low-pressure air after compression being taken through closed vessels filled with the caustic-soda solution, through which the air is caused to bubble by means of a series of perforated plates. The nitrogen produced by the seven columns is taken into one common 12-in. wrought-iron pipe, which conducts it through an underground tunnel running below the three furnace-houses, into which it is distributed by branch piping, which, again, in turn, subdivide it between the different furnaces.

(To be continued.)

STATICAL CALCULATIONS OF RECTANGULAR REINFORCED-CONCRETE TUBES.

By Otto Gottschalk, Buenos Aires.

The formulæ developed in this article were originated by and are mainly intended for monolithic rectangular reinforced-concrete subways. They are applicable, of course, to any other purpose, as, for instance, box culverts, galleries and conduits for any branch of public service. Although reinforced concrete is becoming now more popular among engineers, and even railroads are adopting reinforced-concrete standards for their culvert work, the monolithic rectangular tube has so far not yet obtained the monopoly it deserves for any subterranean work built in open trench, wherever the nature of the soil makes it desirable to spread the loads over a considerable space. The rectangle in itself is the most economical shape as regards space, which is so valuable—for instance, under city streets. Using reinforced concrete allows of joining the sides rigidly to floor and roof;

and in such a rigid frame the bending moments from the superimposed load will counteract those caused by earth pressure; any shock from any side is easily distributed, and accidental caves underneath the floor are easily bridged over, making it possible to put the whole tunnel work on soft soil under conditions where, without this rigidity, foundations would have to be carried down to firm ground. The economy effected by the counter-actions of roof-loads and side pressure, and by giving a share of the carrying capacity to the rigid corners, where space for brackets is always available, is not yet being appreciated sufficiently. Although it may not be advisable in the design of the subterranean work to carry matters to too fine a point, the taking advantage of such statical possibilities will always mean an improvement of the structure.

The city of Buenos Aires offers at present ample opportunities for watching subway structures without regard to economy of design; a considerable waste of materials is to be observed in instances where there were no special requirements of any kind. The waste has arisen solely through not adopting modern methods in place of the old-fashioned brick and I-beam designs. In contrast to this, designs which are more in accord with modern lines will be described and illustrated in this article.

Figs. 1 and 2 are photographs of the reinforced-concrete part of an extended system of private subways intended for the luggage traffic under the new great Retiro Station of Buenos Aires, the capital of Argentina. This station is to be the largest on the South American continent. The views refer to the portions of the subway under the Grand Hall, consisting mainly of one tunnel 16 ft. 5 in. wide by 10 ft. 3 in. high, some 490 ft. long, and one 27 ft. 7 in. wide, of 57 ft. length.

Fig. 1.

The Retiro Station stands on ground reclaimed from the River Plate, with the firm soil between 20 ft. and 30 ft. below the present grade. While the heavy masonry-work goes down to firm soil, it was very desirable to save the expensive excavation work for as many parts of the structure as possible. The fill, well settled in some places, shows in others all varieties possible between entire roads with their street-car rails still in, and decomposing garbage of the immigrants' station which formerly stood on this spot. The railway engineers therefore decided to adopt reinforced concrete both for reasons of stability and economy; the saving over the usual brick design of a cross-section equally strong to withstand the impact from the heavy train movement on top amounts to more than 30 per cent.

The new Retiro Station is being built by the Central Argentine Railway, Mr. R. Reynolds, chief engineer, with Mr. Kirby, engineer in charge of the company's building work. Mr. E. L. Conder is the architect of the station. The reinforced-concrete subway was built in three months' net working time, from April to August, 1913, by the writer, together with Messrs. Scott and Hume, general contractors of the station building. The calculation of the design of the two main sections of the tunnel is dealt with at the end of this article. In spite of the ever-increasing importance of such designs for culverts, flumes, subways, &c., I am not aware of having yet seen formulæ simplified for use in practice, making it feasible to calculate to a fair degree of accuracy the greatest bending moments possible at any point (centre of walls, of top, of bottom, or corners) of a rigid rectangular frame. I therefore wish to go into detail in the present case, in order to derive formulæ and tables usable in a simple way for any design of similar shape.

Basis of Calculation.

We consider a rectangle (Fig. 3, page 410) having the four sides called Nos. 1, 2, 3, 4, with cross-sectional areas of respectively A_1, A_2, A_3, A_4, and moments of inertia of respectively I_1, I_2, I_3, I_4.

Generally we call M the bending moment, N the normal stress at any point of the four sides. The elasticity modulus E is assumed to be constant all over the system, the moments of inertia to be constant within their respective sides. The height of the rectangle to be h, the width l, the length of the tunnel to be considered a unit—for instance, 1 ft. All the calculations are based on the principle of virtual work, which requires, with regard to any statically undetermined stress X, that all over the system:—

$$\int \frac{M}{E\,I} \cdot \frac{\delta M}{\delta X} dx + \int \frac{N}{E\,A} \cdot \frac{\delta N}{\delta X} dx = 0.$$

Moment Caused by Dead Weight of Walls.

The weight of the two walls of a total P causes a uniformly-distributed upward soil pressure p loading side No. 3. The moment caused by this pressure tends to bend outward the two sides No. 2 and No. 4, and this tendency side No. 1 resists (see Fig. 4). The rectangle would be statically determined if we knew the amount of, for instance, the tension X_1 and the bending moment X_2 in the corner 1 – 4.

We now determine the virtual work of the four sides individually.

In beam 1:—

$$M = -X_2;\ \frac{\delta M}{\delta X_2} = -1;\ \frac{1}{E\,I_1}\int_0 X_2\,dx = \frac{l\,X_2}{E\,I_1}$$

$$N = X_1;\ \frac{\delta N}{\delta X_1} = 1;\ \frac{1}{E\,A_1}\int_0^l X_1\,dx = \frac{l\,X_1}{E\,A_1}.$$

In beam 2:—

$$M = X_2 + X_1 x;\ \frac{\delta M}{\delta X_1} = x;\ \frac{1}{E\,I_2}\int_0^h (X_1 x + X_2)\,x\,d\,x$$

$$= \frac{X_1 h^3}{3\,E\,I_2} + \frac{X_2 h^2}{2\,E\,I_3}.$$

$$\frac{\delta M}{\delta X_2} = 1;\ \frac{1}{E\,I_2}\int_0^h (X_2 + X_1 x)\,d\,x$$

$$= \frac{X_1 h^2}{2\,E\,I_2} + \frac{X_2 h}{E\,I_2}.$$

In beam 3:—

$$M = M_0 - X_2 - X_1 h;\ \frac{\delta M}{\delta X_1} = -h;$$

$$\frac{1}{E\,I_3}\int_0^l (-M_0 h + X_2 h + X_1 h^2)\,d\,x$$

$$= \frac{l\,h\,X_2}{E\,I_3} + \frac{h^2\,l}{E\,I_3} X_1 - \frac{h}{E\,I_3}\int_0^l M_0\,d\,x$$

$$\frac{\delta M}{\delta X_2} = -1;\ \frac{1}{E\,I_3}\int_0^l (-M_0 + X_2 + X_1 l)\,d\,x$$

$$= \frac{l}{E\,I_3} X_2 + \frac{h\,l}{E\,I_3} X_1 - \frac{1}{E\,I_3}\int_0^l M_0\,d\,x.$$

$$N = -X_1;\ \frac{\delta N}{\delta X_1} = -1;\ \frac{1}{E\,A_3}\int_0^l X_1\,d\,x = \frac{l\,X_1}{E\,A_3}.$$

In beam 4:—Similar to beam 2.

Eliminating E we combine the virtual works to get the two equations of equilibrium of the total virtual work.

$$\text{I.}\quad X_1\left(\frac{l}{A_1} + \frac{2}{3}\frac{h^3}{I_2} + \frac{h^2 l}{I_3} + \frac{l}{A_3}\right) + X_2\left(\frac{2}{2}\frac{h^2}{I_2} + \frac{l\,h}{I_3}\right) = \frac{h}{I_3}\int_0^l M_0\,d\,x$$

$$\text{II.}\quad X_1\left(\frac{2}{2}\frac{h^2}{I_2} + \frac{h\,l}{I_3}\right) + X_2\left(\frac{l}{I_1} + \frac{2}{I_2}\frac{h}{} + \frac{l}{I_3}\right) = \frac{1}{I_3}\int_0^l M_0\,d\,x$$

The two roots of the two equations are:—

Fig. 2.

$$X_1 = \frac{\frac{h}{I_3}\left(\frac{l}{I_1} + \frac{2h}{I_2} + \frac{l}{I_3}\right) - \frac{h}{I_3}\left(\frac{h}{I_2} + \frac{l}{I_3}\right)}{\left(\frac{l}{A_1} + \frac{2}{3}\frac{h^3}{I_2} + \frac{h^2 l}{I_3} + \frac{l}{A_3}\right)\left(\frac{l}{I_1} + \frac{2h}{I_2} + \frac{l}{I_3}\right) - h^2\left(\frac{h}{I_2} + \frac{l}{I_3}\right)^2} \frac{P l^2}{12}$$

$$X_2 = \frac{\frac{1}{I_3}\left(\frac{l}{A_1} + \frac{2}{3}\frac{h^3}{I_2} + \frac{h^2 l}{I_3} + \frac{l}{A_3}\right) - \frac{h^2}{I_3}\left(\frac{h}{I_2} + \frac{l}{I_3}\right)}{\left(\frac{l}{A_1} + \frac{2}{3}\frac{h^3}{I_2} + \frac{h^2 l}{I_3} + \frac{l}{A_3}\right)\left(\frac{l}{I_1} + \frac{2h}{I_2} + \frac{l}{I_3}\right) - h^2\left(\frac{h}{I_2} + \frac{l}{I_3}\right)^2} \frac{P l^2}{12}$$

The values of the dimensions of the rectangular tunnel have got to be assumed and put into the above formula. If we put:—

$$\alpha = \frac{h}{I_2} + \frac{l}{I_3};\qquad \beta = \frac{l}{I_1} + \frac{2h}{I_2} + \frac{l}{I_3};$$

$$\gamma = \frac{l}{A_1} + \frac{2}{3}\frac{h^3}{I_2} + \frac{h^2 l}{I_3} + \frac{l}{A_3},$$

we have:—

$$X_1 = \frac{\beta - \alpha}{\beta\gamma - h^2\alpha^2} \cdot \frac{h}{I_3} \cdot \frac{P\,l^2}{12}$$

and

$$X_2 = \frac{\gamma - h^2\alpha}{\beta\gamma - h^2\alpha^2} \cdot \frac{1}{I_3} \cdot \frac{P\,l^2}{12}.$$

For practical use, however, simpler approximations may be desired, which we can obtain, assuming A and I constant all over the system, or,

$$A_1 = A_3 = A;\quad I_1 = I_2 = I_3 = I.$$

Hence

$$\alpha = \frac{h+l}{I};\qquad \beta = \frac{2}{I}(h+l) = 2\alpha;$$

$$\gamma = 2\frac{l}{A} + \frac{2}{3}\frac{h^3}{I} + \frac{h^2 l}{I}.$$

We make, further,

$$h = n\,l,\ \text{or}\ n = \frac{h}{l}$$

Thus,

$$X_1 = \frac{n+1}{3n + 4n^2 + n^3 + 12\frac{n+1}{n}\cdot\frac{I}{l^2 A}} \cdot \frac{P}{4};$$

$$X_2 = \frac{-n^3 + 6\frac{I}{l^2 A}}{3n^3 + 4n^3 + n^4 + 12(n+1)\frac{I}{l^2 A}} \cdot \frac{P\,l}{12}.$$

A still further simplification for estimating purposes may be admitted in cases where the depth of the con-

crete does not exceed, say, one-sixth of the height of the tunnel, as in this case the factor $\frac{I}{l^2 A}$ becomes very small, and for purposes of approximation may be neglected, which will give us, finally :—

$$X_1 = \frac{n+1}{3n+4n^2+n^3} \cdot \frac{P}{4},$$

and the moment in the upper corner,

$$X_2 = \frac{-n}{3+4n+n^2} \cdot \frac{P\,l}{12}.$$

The moment in the lower corners is

$$M_c = X_1 h + X_2,$$

or

$$M_c = \frac{3+2n}{3+4n+n^2} \cdot \frac{P\,l}{12}.$$

These values for X_1, X_2, and M_c, as was stated above, are only approximations admissible for a width or depth of concrete not more than one-sixth of the width or height of the tunnel. To state an instance :—For a square tunnel section, $h = l$, or $n = 1$, the approximate values are :—

$$X_1 = \tfrac{1}{16} P; \quad X_2 = -\tfrac{1}{56} P\,l; \quad M_c = \tfrac{5}{56} P\,l.$$

The exact formula for M_c is :—

$$M_c = \frac{\beta h^2 + \gamma - 2h^2\alpha}{\beta\gamma - h^2\alpha^2} \cdot \frac{1}{I_3} \cdot \frac{P\,l^2}{12},$$

with α, β, and γ as denoted above.

Moment Caused by Uniformly-Distributed Load on Roof.

A uniformly-distributed load on top of the roof causes an identical soil pressure upwards on bottom. We can reduce this case to the one treated above by assuming that first the top only is loaded, and afterwards the bottom only, and by then adding up the moments obtained. Expressed in formulæ we have a corner moment of :—

$$M_c{}^1 = M_c + X_2 = \frac{\beta h^2 + 2\gamma - 3h^2\alpha}{\beta\gamma - h^2\alpha^2} \cdot \frac{1}{I_3} \cdot \frac{P\,l^2}{12}$$

Assuming again the moment of inertia to be constant all over the system, and

$$n = \frac{h}{l} : M_c{}^1 = \frac{3n^2 + n^3 + 12\frac{I}{l^2 A}}{3n^2 + 4n^3 + n^4 + 12(n+1)\frac{I}{l^2 A}} \cdot \frac{P\,l}{12}$$

and when $\frac{I}{l^2 A}$ is small

$$M_c{}^1 = \frac{3+n}{3+4n+n^2} \cdot \frac{P\,l}{12}$$

As an instance, this formula becomes for $h = l$ and $n = 1$: $M_c = \frac{P\,l}{24}$, for $h = 0$, and $n = 0$, $M_c = \frac{P\,l}{12}$

Moment from Earth Pressure.

The earth pressure from superimposed loads on either side of the tunnel is generally assumed to be the same from top to bottom. We then have again a rectangle loaded symmetrically according to Fig. 3, with the only modification that the sides Nos. 2 and 4 will be loaded, and the sides Nos. 1 and 3 bent towards the outside. Slight allowance must be made, according to local conditions, for the possibility that part of the pressure from one side is taken up on bottom and roof through friction, and that therefore that part of the pressure will act exactly as indicated in Fig. 4 by X_1.

The pressure from the earth pressing on both sides of the tunnel increases from zero on the top to some value p on the bottom (Fig. 5). In almost any case it is perfectly safe to calculate with the formulæ obtained, taking F_1 (Fig. 5) $= \frac{p\,h}{2}$, and from the moment at the corners $M^1{}_c$ thus obtained to assume that on the upper corners $0.90\ M^1{}_c$ is taken, and on the lower corners $1.10\ M^1{}_c$.

In cases where this earth pressure seems of importance, exact formulæ might be derived in the same way as for the uniformly-distributed load shown before, determinating the reaction X_1 and moment X_2 of one corner. The results obtained are (Fig. 5) :—

Moment in upper corners and in roof :—

$$M_{12} = M_1 = \frac{n^2(2n+7)}{3+4n+n^2} \cdot \frac{F_1 l}{30};$$

Thrust on top, $F_1 - X_1 = \frac{10+13n+3n^2}{3+4n+n^2} \cdot \frac{F_1}{10}$.

Moment in lower corners and in floor :—

$$M_{23} = M_3 = \frac{n^2(3n+8)}{3+4n+n^2} \cdot \frac{F_1 l}{30};$$

Thrust on bottom, $X_1 = \frac{20+27n+7n^2}{3+4n+n^2} \cdot \frac{F_1}{10}$.

Moment approximately in centre of walls :—

$$M_2 = -\frac{n^3+6n^2+9n}{3+4n+n^2} \cdot \frac{F_1 l}{24}.$$

Summary of Formulæ.

For structures of small size, such as ordinary culverts of less than 6 ft. span, it is sufficient to take into account the total load on top, T only :—

Moment in centre of roof and floor, $M_1 = \delta\,l\,T$; in four corners and walls, $M_2 = \epsilon\,l\,T$.

For larger structures of importance (subways, &c.) per lineal foot of tunnel :—

Q = deadweight of roof; P = superimposed load; T = P + Q = total load of roof; W = weight of the two walls; F_1 = earth pressure from back-fill; F_2 = earth pressure from surcharge; $F_1 + F^2 = F$ = total earth pressure.

The greatest possible bending moments then are for width, l :—

Centre of roof, $M_1 = (\delta T + \zeta W)\,l$;

Upper corners, $M_{12} = M_{41} = (\epsilon T - \zeta W + \epsilon^1 (0.9\,F_1 + F_2))\,l$;

Centre of bottom, $M_3 = (\delta T + \iota W)\,l$;

Lower corners, $M_{23} = M_{34} = (\epsilon T + \eta W + \epsilon^1 (1.1\,F_1 + F_2))\,l$;

Walls, bending outside, $M_2 = (\epsilon T + \nu W)\,l$;

Bending inside, $M_2{}^1 = \delta^1 F - \nu W - \epsilon Q$;

Tension in roof = compression in bottom, $X_1 = \kappa W$.

sq. ft. The flooring on top of the roof weighs 50 lb. per sq. ft., and the roof itself 110 lb. per sq. ft. Concrete in roof, mixed 1 : 2 : 4, may be stressed in compression to 750 lb. per sq. in.; concrete in walls and floor, 1 : 3 : 5, up to 500 lb. per sq. in. The moments at the several points have to be investigated, and the live load will be determined which can be allowed alongside the tunnel (owing to traffic) without over-stressing the inside steel of the walls. The theoretical height and span of the system are :—

$$l = 17.7 \text{ ft.}; \quad h = 10.6 \text{ ft.}; \quad n = \frac{h}{l} = 0.6.$$

The loads :—

Q = 16.4 (110 + 50) = 2630 lb.; P = 16·4 × 200 = 3280 lb.; T = Q + P = 5910 lb.

The weight of the two walls is :—

W = 2 × 1.25 ft. × 10.25 ft. × 150 = 3830 lb.

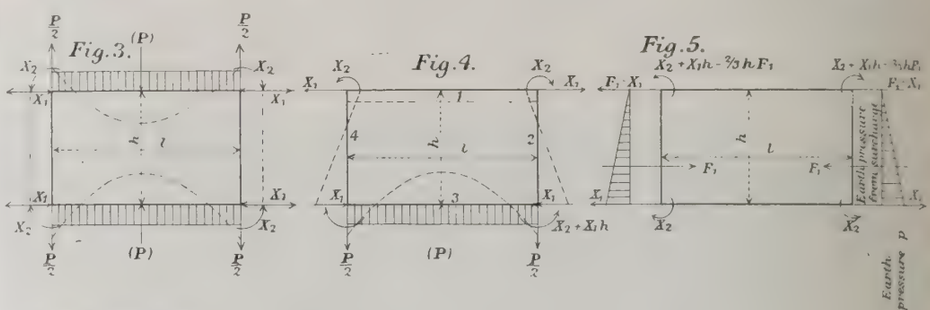
Earth pressure from sides is :—

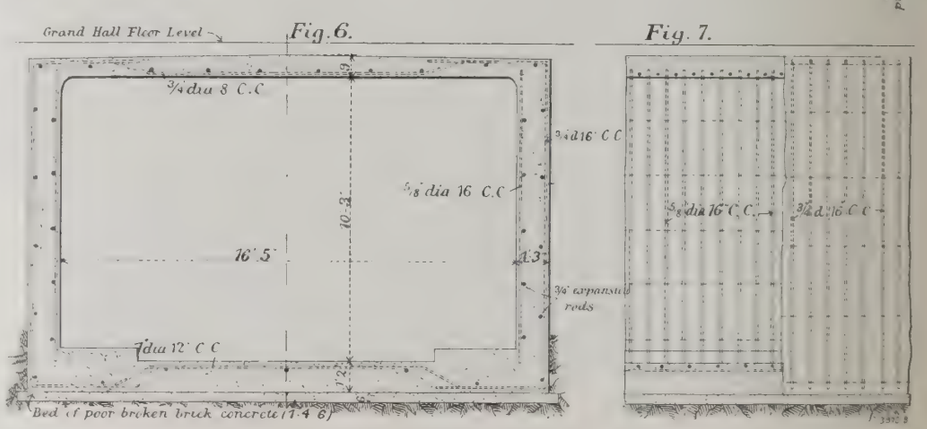
$F_1 = 100 \times 10.25^2 \times \frac{1}{3} = 1320$ lb.

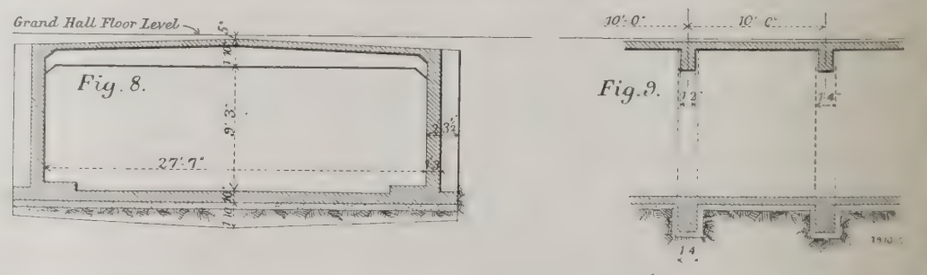
Earth pressure from top is :—

$F_2 = (200 + 50) \times \frac{1}{4} \times 10.25 = 640$ lb.

$F = F_1 + F_2 = 1964$ lb.







The computed values of δ to κ are given in Table I., page 411, for the several proportions $n = \frac{\text{height}}{\text{span}} = \frac{h}{l}$ from 0.35 up to 1.20. The figures given are based on the following formulæ :—

$$\delta = \frac{1}{24} \cdot \frac{3+10n+3n^2}{3+4n+n^2}; \qquad \delta^1 = \frac{1}{24} \cdot \frac{6n^2+9n+n^3}{3+4n+n^2};$$

$$\epsilon = \frac{1}{12} \cdot \frac{3+n}{3+4n+n^2}; \qquad \epsilon^1 = \frac{1}{12} \cdot \frac{3n^2+n^3}{3+4n+n^2};$$

$$\zeta = \frac{1}{12} \cdot \frac{n}{3+4n+n^2}; \qquad \eta = \frac{1}{12} \cdot \frac{3+2n}{3+4n+n^2};$$

$$\iota = \frac{1}{24} \cdot \frac{3+8n+3n^2}{3+4n+n^2}; \qquad \kappa = \frac{1}{4} \cdot \frac{n+1}{n(3+4n+n^2)};$$

$$\nu = \frac{1}{3}(2\eta - \zeta) = \frac{1}{12} \cdot \frac{2+n}{3+4n+n^2}.$$

Examples of Application.

Example No. 1.—The tunnel, shown in Figs. 6 and 7, of 16 ft. 5 in. clear span and 10 ft. 3 in. clear height, to be designed for a live load on top of 200 lb. per

Taking the coefficients from the table, the bending moments are for $n = 0.6$.

Centre of roof M_1 ... = (0.0730 × 5910 + 0.0087 × 3830) 17.7 − 461 × 17.7 = 8160 ft.-lb.

Top of wall M_{12} ... = (0.0520 × 5910 + 0.0187 (640 + 0.9 × 1320) − 0.0087 × 3830) × 17.7 = 311 × 17.7 = 5500 ft.-lb.

Centre of wall M_2 min. = (0.0563 × 1960 − 0.0377 × 3830 − 0.0520 × 2630) × 17.7 = − 174 × 17.7 = − 3080 ft.-lb.

M_2 max. = (0.0520 × 5910 + 0 0377 × 3830) 17.7 = 457 × 17.7 = 8100 ft.-lb.

Bottom of wall M_{23} ... = (0.0525 × 5910 + 0.0187 (640 + 1.2 × 1320) + 0.061 × 3830) 17.7 = 587 × 17.7 = 10,400 ft.-lb.

Centre of floor M_3 max. = (0.0730 × 5910 + 0.0642 × 3830) 17.7 = 675 × 17.7 = 11,950 ft.-lb.

The dimensions of concrete and steel derived from the moments obtained are shown in Figs. 6 and 7;

OIL-BURNER FOR HEAVY OIL.

CONSTRUCTED BY MESSRS. GEORGE BELLON ET CIE., ENGINEERS, VINCENNES, PARIS.

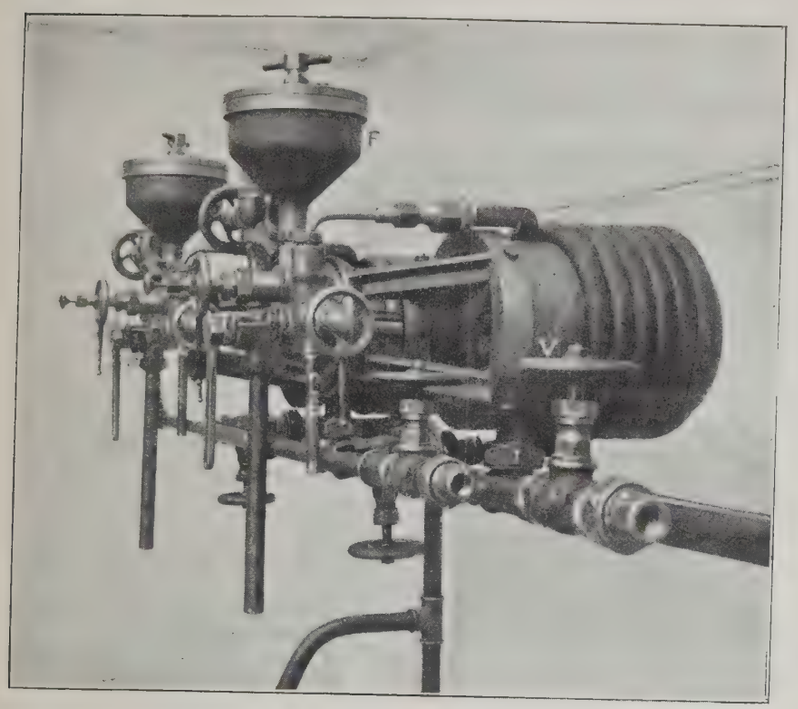


Fig. 1.

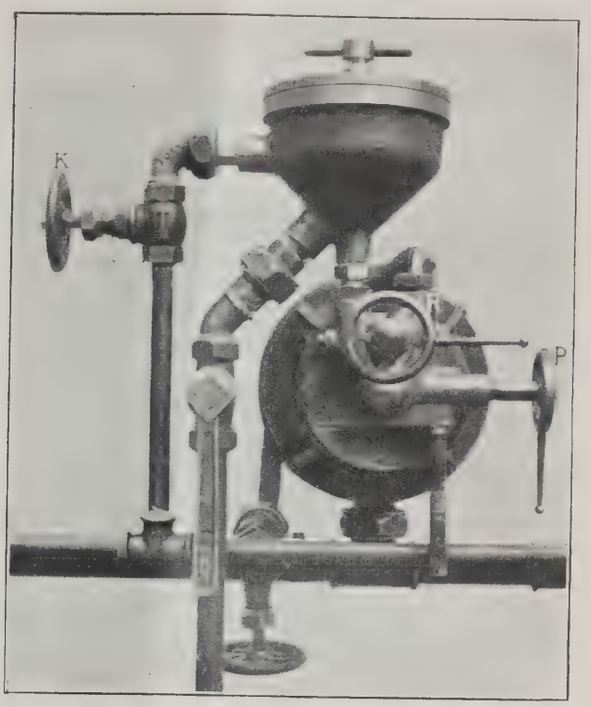


Fig. 2.

maximum permissible tension of steel assumed to be 20,000 lb. per sq. in. It should be noted that under the 200 lb. per sq. ft. live load on the sides of the tunnel, even with no load from tunnel roof, no tension in the steel on the inside of the side walls occurs on account of the M_2 min. being negative. The side wall, therefore, would be sufficient without interior reinforcement for an additional live load alongside the tunnel equal to

$$17.7 \times 0.0560 \times F_2 = 3080 \text{ ft.-lb., and}$$

$$F_2 = \frac{3080}{17.7 \times 0.0560} = 3120 \text{ lb.,}$$

corresponding to a load on the surface of

$$\frac{4 \times 3120}{10.25} = 1200 \text{ lb. per sq. ft.}$$

With the interior reinforcement, however, of $\frac{5}{8}$-in. rods at 16 in. centres = 0.23 sq. in., sustaining an additional moment of about 4600 ft.-lb., another 1800 lb. per sq. ft. may be added to the live load on top. The tunnel as shown therefore can resist a lateral soil pressure equivalent to a live load on top of 200 + 1200 + 1000 = 2400 lb. per sq. ft., which cannot possibly be exceeded by any train-load.

Example No. 2.—A tunnel of 27 ft. 7 in. clear width, according to Figs. 8 and 9, is to be built on soft soil, so that all load is uniformly distributed over the soil. The live load on the roof slab is 200 lb. per sq. ft.; on the roof girder 150 lb. per sq. ft. has to be provided for. All other conditions, similar to example 1, except that earth-pressure moments will be disregarded on account of being insignificant, as compared with moments from vertical loads. The greatest possible bending moment and the reinforcement at every point of the frame have to be determined. Assuming theoretical width and height at 28.9 ft. and 11.6 ft. respectively, we have $n = \frac{h}{l} = 0.4$, while the loading clear width is 27.6 ft.

The loads then are on the girders 10 ft. apart.

TABLE I.—Values of Coefficients for Different Ratios of h/l.

$\frac{h}{l} = n.$	$\delta.$	$\epsilon.$	$\delta'.$	$\epsilon'.$	$\zeta.$	$\eta.$	$\nu.$	$\iota.$	$\kappa.$
0.35	0.0633	0 0617	0.0361	0.0076	0.0065	0.0680	0.0432	0.0568	0.222
0.40	0.0655	0.0595	0.0405	0.0095	0.0070	0.0665	0.0420	0.0585	0.184
0.45	0.0676	0.0574	0.0446	0.0116	0.0075	0.0650	0.0408	0.0600	0.162
0.50	0.0694	0.0556	0.0486	0.0139	0.0079	0.0635	0.0397	0.0615	0.143
0.55	0.0712	0.0538	0.0524	0.0163	0.0083	0.0620	0.0386	0.0623	0.128
0.60	0.0730	0.0520	0.0563	0.0187	0.0087	0.0608	0.0377	0.0642	0.116
0.65	0.0747	0.0503	0.0602	0.0213	0 0090	0.0596	0.0367	0.0656	0.106
0.70	0.0762	0.0488	0.0635	0.0240	0.0093	0.0584	0.0358	0.0667	0.097
0.75	0.0776	0.0474	0.0668	0.0268	0.0095	0.0572	0.0349	0.0678	0.089
0.80	0.0788	0.0462	0.0703	0.0295	0.0098	0.0560	0.0340	0.0689	0.082
0.85	0.0800	0.0450	0.0737	0.0323	0.0100	0.0550	0.0333	0.0700	0.076
0.90	0.0811	0.0439	0.0770	0.0354	0.0101	0.0540	0.0326	0.0709	0.071
0.95	0.0822	0.0428	0.0802	0.0388	0.0102	0.0530	0.0319	0.0718	0.067
1.00	0.0833	0.0417	0.0833	0.0417	0.0103	0.0520	0.0312	0.0727	0.063
1.10	0.0853	0.0397	0.0896	0.0482	0.0106	0.0503	0.0300	0.0746	0.054
1.20	0.0870	0.0380	0.0955	0.0545	0.0108	0.0488	0.0286	0.0763	0.050

		lb.
Dead-weight of flooring and slab (70 + 50) × 10 × 27.6	=	33,100
Beam $\frac{14 \times 22}{12 \times 12} \times 150 \times 27.6$	=	8,900
Total dead-weight	Q =	42,000
Live load, P = 150 × 10 × 27.6 ...	=	41,400
Total load, T = P × Q	=	83,400
		lb.
Load directly on walls: live load and flooring $\frac{15}{12} \times 220 \times 10 \times 2$	=	5,500
12-in. walls proper: $2 \times \frac{12}{12} \times 150 \times 11 \times 10$	=	33,000
Two buttresses: $2 \times 11 \times \frac{15.5 \times 16}{12 \times 12} \times 150$	=	5,700
Weight of the two walls per 10-ft. panel	W =	44,200

We now take from the table the corresponding coefficients, giving the moments as follow :—

		ft.-lb.
Centre of roof:	$M_1 = (0.0655 \times 83,400 + 0.0070 \times 44,200) \times 28.9 = 5760 \times 28.9$	= 166,500
Top of wall:	$M_{12} = (0.0595 \times 83,400 - 0.0070 \times 44\,200) \times 28.9 = 4650 \times 28.9$	= 134,500
Bottom of wall:	$M_{23} = (0.0595 \times 83,400 + 0.0665 \times 44,200) \times 28.9 = 7920 \times 28.9$	= 228,600
Centre of wall:	$M_2 = (0.0595 \times 83,400 + 0.042 \times 44,200) \times 28.9 = 6810 \times 28.9$	= 197,000
Centre of floor:	$M_3 = (0.0655 \times 83,400 + 0.0585 \times 44,200) \times 28.9 = 8020 \times 28.9$	= 231,500

Tension in roof = compression in floor : $X_1 = 0.184 \times 44,200 = 8100$ lb. This tension requires a steel area of $\frac{8100}{20,000} = 0.405$ sq. in., to be added in the roof beam, and deducted from the floor-beam steel. The total steel reinforcement required is in :—

Centre of roof-beam : $\frac{166,500 \times 12}{18.1 \times 20,000} = 5.52$ sq. in. for bending, 5.52 + 0.41 = 5.93 sq. in. total.

Top of wall : $\frac{134,500 \times 12}{17.5 \times 20,000} = 4.60$ sq. in.

Bottom of wall : $\frac{228,600 \times 12}{23.5 \times 20,000} = 5.83$ sq. in.

Centre of wall : $\frac{197,000 \times 12}{22.7 \times 20,000} = 5.20$ sq. in. ; all wall steel on outside.

Centre of floor-beam : $\frac{231,500 \times 12}{26.7 \times 20,000} - 0.41 = 4.79$ sq. in. on top of beam.

The concrete is not being over-stressed in compression, as there is a concrete slab wherever the compression occurs, except in centre of the floor-beam, where the beam has to be deep and wide enough so that the reinforcement will not exceed 1 per cent. of the concrete area. In the case treated here the bottom girder 16 in. by 32 in. is sufficient.

THE BELLON OIL-BURNER.

An interesting oil-burner of novel type is illustrated in the two annexed figures. It uses heavy oil and is intended for furnaces, kilns, ovens, &c. The burner is entirely self-contained and requires no external supply of steam or compressed air. Owing to the construction employed, it is claimed that there is a total absence of choking of the nozzle which occurs with some burners, owing to the formation of a coke-like deposit of partly-burnt oil. The arrangement consists of a cylindrical flame-chamber, open at each end. On the outside of the chamber there is a coiled pipe, through which a stream of water is passed, which is turned to steam by the heat of the burner itself. The steam end of the coil of pipe is led through a valve-casing to a nozzle fixed concentric with and at the front end of the cylindrical chamber. The nozzle is directed into the flame-chamber.

Inside the chamber there is an oil-nozzle, which is fixed at right angles to the steam-nozzle, and projects downwards from the top side of the chamber. The

outlet of the oil-nozzle is on the centre line of the steam-nozzle. When the burner is in operation the jet of steam, which is superheated, impinges on the oil emerging from the oil-nozzle, and breaks it up into minute particles, at the same time carrying it forward through the chamber. When the oil is ignited a long flame is obtained, in which the oil is completely burned. The steam-jet is surrounded by a tuyere containing ports, through which the air for combustion is drawn by the action of the steam-jet, and carried to the flame. The steam-jet flowing across the mouth of the oil-nozzle creates a suction in the oil-supply pipe, so that, if necessary, or if desired to prevent possibility of flooding, the oil-reservoir may be placed at a lower level than the burner.

The general lines of the construction of the burner can be seen in the illustrations. The cylindrical flame chamber, with the outer coiled water-pipe, is best shown in Fig. 1. The inlet end of this pipe is connected through a stop-valve to the water main, which is carried below the burner. This stop-valve is marked V in Fig. 1. It will probably be clear, but should perhaps be pointed out, that this figure illustrates two Bellon burners side by side. The steam end of the water-pipe can be seen in both figures connecting to the top of the valve-casing. The lower valve, marked P in Fig. 2, connects the water-coil to the vertical drain-pipe, which leads from the bottom of the valve-casing. Valve K, shown in Fig. 2, is the oil-supply valve, which admits oil to the filter F. R is the valve admitting oil to the jet. To start up the burner, it is necessary to heat the water-coil with a blow-pipe or in some similar manner. The water supply is turned on with the drain open, and so kept until dry steam issues from it. Valve P is then closed and the steam-jet starts up. The oil-valve R is then opened, and the resulting jet of oil may at once be lighted. The burner is then in work and needs no further attention except such regulation of the steam and oil-valves as the conditions of heat demanded by the furnace may require. The burner is constructed by Messrs. Georges Bellon et Cie., of 2*ter*, Rue du Moulin, Vincennes, France.

INDUSTRIAL NOTES.

On Saturday last, the 26th ult., a meeting of the members of the Wear, Tyne, Tees, and Hartlepools Committee of the Iron and Steel Ship-Workers' Society was held at Sunderland, when a resolution was unanimously adopted pledging the members to use every endeavour to support the demands of the Admiralty for expediting the construction of Government vessels, both in His Majesty's dockyards and in private yards.

We are informed that the miners employed at Norwood Colliery, Dunston, to the number of about 600, men and boys, received their notices a fortnight ago, and the notices expired on Saturday last, the 26th ult. The pit has not worked during the past fortnight, and the ponies and gear have been brought to bank. A number of the men have been given employment at Dunston Colliery.

The council of the Notts Miners' Association at their monthly meeting on Saturday last passed a resolution requesting local officials to bring to the notice of district officials any cases of distress or unemployment arising out of the war.

Mr. W. Carter, secretary, reported on the action of the Linby Colliery management in discharging eighteen men. An interview had taken place with the owners, and at a meeting of the workmen that morning it was decided not to hand in notices after hearing the company's explanation.

An appeal from men working at the new Rufford Colliery, belonging to the Bolsover Colliery Company, for permission to form a lodge to be connected with the association was granted, and officials were instructed to render assistance.

The correspondence between the association and colliery-owners regarding surface workers was read, and it was agreed that the men's officials should continue to press for a conference to deal with this class of labour.

At the monthly meeting of the Employers' Parliamentary Association, recently held in Manchester, the President (Sir Charles W. Macara) said he had always been an advocate of the thorough organisation of the forces of capital and labour. It was well known, he stated, that he always had supported the thorough efficiency of the defensive forces of the nation. In the serious crisis through which the country was passing he strenuously advocated that the co-operation of the industrial, commercial, financial, transport, and labour interests with the Government should be carried out to the fullest extent. Ever since the war began he had been doing his utmost to secure this co-operation, and he felt sure that if it could be carried out efficiently it would be a powerful factor in keeping the industries going and the workers employed in the creation of wealth, which was an essential factor to success. He moved:—"That the various interests—industrial, commercial, financial, transport, and labour—ought to co-operate with the Government in order to keep the industries of the country going as far as it is possible to do." This was carried unanimously. It was also decided to assist members of the Association by the establishment of a temporary inquiry bureau, whereby members buying and selling goods could be placed in connection with each other, to their mutual advantage. Arrangements were to be made whereby the scheme should be worked in co-operation with the one recently instituted by the Board of Trade. As regards our trade relationships with enemy countries, the following resolution was unanimously adopted:—"That this committee strongly supports the opinion of the Association of Chambers of Commerce that the Government be urged to enter into negotiations with the committee of bankers with a view to the assets of manufacturers and merchants in the way of foreign book-debts and stock being guaranteed against loss jointly by the Government and the banks." The questions of the advisability of the adoption of the Continental system of sending acceptances with invoices and of the existing arrangements with respect to war-risks insurance were discussed. It was agreed that alterations under these heads were at present inadvisable.

The Gloucestershire Education Committee held a meeting on Saturday last, when Mr. F. W. B. Cripps moved that the School Attendance and Medical Inspection Sub-Committee be requested to consider and report on the best means of carrying out the suggestion of Mr. Pease with reference to the desirability of allowing certain children in agricultural districts to leave school at an earlier age during the continuance of the war. Remarking that this matter first arose over the harvest question, Mr. Cripps said he thought it would be quite as important within the next two or three months in regard to the planting of next year's crops. He knew the committee's legal difficulty, but they had had a very strong lead from the Board of Education, and he thought that in an exceptional time like the present, if it could be made out in any locality that there was a shortage of labour owing to the number of men at the war there was a fair case for their turning a blind eye—that was, he believed, the only way it could be done—to the Act of Parliament. They had the support of Mr. Pease, who had almost suggested that course. He (Mr. Cripps) did not ask the committee to make it a general rule; each case ought to be taken on its merits. He did not advocate any open breach of the law, but when the state of affairs was really so pressing the committee should do their best to meet the problem of labour shortage in the farming industry.

Mr. John Sawyer, chairman of the school attendance and medical inspection sub-committee, said the course suggested by the sub-committee was this:—In districts where labour was short, and the local education authority were satisfied that certain boys of twelve years of age, or, in some cases, eleven, could do useful agricultural work, and their parents were willing for them to go to work, it was suggested that the committee should not take steps to compel attendance, but allow them to be temporarily absent from school. It was also suggested that before the temporary absence was granted the school-attendance officers should furnish to the secretary of the Education Committee particulars as to the number of farm hands who had enlisted, and the names and ages of the boys who would be employed on the respective farms. As a temporary measure, permission had been given to certain farmers in different parts of Gloucestershire to employ certain boys in harvesting until the end of the month.

One speaker, whilst agreeing with the attitude of the sub-committee, suggested that steps should be taken to ensure that the child labour should not in any case be used for the displacement of, or be brought into competition with, adult labour.

To this the chairman agreed, and said in each case the committee required that information should be supplied to them as to the number of men who had left a farm, in order to see that no one was being displaced.

Another speaker, dealing with the question from the point of view of the Farmers' Union, said that, with so many young men taken away from the country districts by the war, it was very desirable that the farmers should have the assistance of boys. He wished to know whether the period during which those boys were absent from school would be taken into account when they arrived at the age of thirteen, and stand against them in the matter of school attendance.

The chairman replied that that would be for the Board of Education to determine.

The committee endorsed the action of the sub-committee in the matter.

The following note is from *Steel and Iron*, Pittsburg:—"The European war, it is feared, may demoralise the chemistry courses in some 596 American colleges and technical schools. Only one-tenth of the supplies which American colleges import annually from Germany have arrived.

"Eastern colleges will suffer the most, since they have been able in normal times to get laboratory materials from Europe on from eight to ten weeks' notice. On the other hand, Western colleges have always carried a much larger stock in their storerooms. One leading chemical importer in New York city authorises this statement of the situation:—

"We are filling all orders from our stock, and have started to manufacture the articles of German origin which we are most liable to run short of. This increases the expense greatly."

"Filter-paper is one article which all laboratories must have, and the chief producer of it is in Rhenish Prussia. Just what will be done to supply this is not yet known. All the wholesale houses are selling it in small quantities, even to the biggest commercial laboratories, which have been in the habit of ordering 1000 packages of it at a time.

"We shall all teach chemistry this year," said one college authority, "but the youth who has been in the habit of smashing everything breakable will not be over-welcome in any college laboratory."

The same journal also gives publicity to the following information:—

Throughout America, chambers of commerce and other commercial bodies are organising export trade committees. The Government's Bureau of Commerce at Washington has taken up the export problem most whole-heartedly. The recently-organised Foreign Trade Council of the United States, headed by President Farrell, of the Steel Corporation, has started to preach the gospel of Opportunity for the American manufacturer, in view of the world-cataclysm that has swept away the industrial activities of half the manufacturing area of the globe. But what can all this profit American commercial interests when the American maker of steel or metal products sits back in his easy chair and remarks that—"Domestic markets are good enough for me. Foreign trading is too full of kinks!"

That remark was made, at a trade gathering in Pittsburg, by a Pittsburg steel manufacturer whose product is in line for export expansion. A short time ago the Secretary of the Interior, at Washington, asked a company of American manufacturers of coal-tar products if it would not be possible, in the present emergency, to supplant the German coal-tar dyes with American products. The upshot of the meeting was summed up as follows:—

"It was thought by all the representatives of the manufacturers present that it was not profitable to go into the business, for the reason that a demand could not be secured for a sufficient amount of American dyestuffs with open foreign competition."

Evidently that venerable ancient warrior, Alexander, had "something on" the present American commercial spirit, as represented in these two instances!

An instance of the efforts which are being made in this country for dealing with the unemployment problem is afforded by the fact that last week the Improvement Committee of the Manchester Corporation approved a scheme for the making of a new road from Slade-lane, Longsight, to Cheadle. The work will cost approximately 200,000*l.*, and is to be undertaken largely with a view of providing for the unemployed. It will be proceeded with as soon as the expenditure necessary has received the sanction of the Local Government Board.

Provision will be made for a road 80 ft. wide. Seventeen feet of the centre may in the future be made to carry tramlines. Trees will be planted along the sides of the footpaths, and the road will follow practically the line of the new railway. The consent of Lord Egerton of Tatton, who owns about a quarter of the land, has been obtained, and the other landlords will be seen upon the matter shortly. A contribution of 60,000*l.* has been promised towards the cost of the Manchester works by the National Roads Board.

With reference to the cultivation of sugar-beet in this country, we are informed that Mr. E. Russell-Taylor, J.P., chairman of the council of the English Beet-Sugar Pioneer Association, 41, South Castle-street, Liverpool, and chairman of the Beet-Sugar Founders, Limited, recently stated that his Association had for years past been experimenting in all quarters of the British Isles. The Association's experiments pointed to the following facts:—

1. Our climate is suitable for the cultivation of sugar-beet;

2. Our soils are renowned for growing the best of root crops;

3. The yield per acre of sugar-beets grown is equal to any Continental country;

4. The saccharine contents of the beets is equal

to, if not greater than, that of our foreign neighbours;

5. And as sugar-beet is a great fertiliser of the land, other crops, particularly cereals, on land which had produced sugar-beet give considerably larger yields.

It is to be hoped that, following upon these experiments, a large acreage of our agricultural lands will in the near future be set apart for the growing of sugar-beets on an extensive scale.

Satisfactory news reaches us to the effect that, according to the Board of Trade's figures, in the trades compulsorily insured against unemployment—*i.e.*, building, engineering, shipbuilding, vehicle-making, &c.—the percentage of unemployment on September 25 was 5.7, as compared with 5.8 the week before and 6.2 a month ago. These figures relate to the whole of the United Kingdom, and include all unemployed workmen in insured trades. In the matter of uninsured trades the numbers of men and women on the registers of the Labour Exchanges on September 25 showed a slight decrease on the figures of the week before.

To refer to one particular instance, we may state that, according to the local daily Press, the position in Wallasey, so far as unemployment is concerned, is so satisfactory that the Distress Committee, after a careful investigation, have arrived at the decision that the present state of affairs does not warrant any steps being taken to provide employment. The Local Government Board having intimated that where unemployment was excessive local authorities would be assisted in schemes of work for the purpose of affording employment to persons displaced in consequence of the war, a register was opened in the borough on August 31 for the purpose of ascertaining the extent of unemployment. Up to September 15 only 87 persons had made an application for work. Of these 72 were males and 15 females, and 51 had previously registered at the Board of Trade Labour Exchanges.

Foreign Patents and the War.—The Board of Trade have now issued a general licence under paragraph 9 of the Royal Proclamation of September 9 as to "trading with the enemy." The operative part of the licence states that the Board of Trade gives and grants licence to all persons resident, carrying on business, or being in his Majesty's dominions, to pay any fees necessary for obtaining the grant or the renewal of patents, or for obtaining the registration of designs or trade-marks, or the renewal of such registration in an enemy country. The licence also permits the payment on behalf of an "enemy" of fees payable on application for or renewal of the grant of a British patent, design, or trade-mark. British holders of German, Austrian, and Hungarian patents will, under the above licence, be enabled to take such steps as they consider desirable to protect their interests.

Trading with the Enemy.—The British Engineers' Association are dissatisfied with the terms of the law relating to trading with the enemy as governed by the "Trading with the Enemy Proclamation No. 2," issued on September 9, 1914, and the "Trading with the Enemy Act, 1914," which was passed through both Houses of Parliament on September 16, 1914. In a circular just issued they state that the Proclamation permits all people to trade with every German and Austrian (whether naturalised as a British subject or not) residing in Great Britain and elsewhere (except with those actually residing in Germany or Austria), precisely as if Great Britain were not at war with those countries. Though the Proclamation does not allow any money to be sent to any enemy in Germany or Austria, any German or Austrian agent in this country can without difficulty evade this provision by passing his remittances to Germany or Austria through a bank or other business concern in a neutral country. Goods from existing stocks carried in Germany and Austria can actually be procured in Great Britain at the present day through a neutral country. The Council of the Association have addressed a protest to the British Government, urging the revision of the terms of the Proclamation, so that, at all events, certain Germans and Austrians in this country, and more particularly (*a*) those who manufacture in Great Britain, and (*b*) those who act as agents for manufacturers in Germany and Austria, should be classed as "enemies." The Council hold the view that a Controller appointed by the High Court should be placed in charge of every manufacturing concern in this country which is owned or controlled by Germans or Austrians, so that no payments can be made by such concerns to individuals or firms in Germany or Austria. The Council also hold the view that all trading with German and Austrian agents in this country should be prohibited. In a proposed definition of an alien enemy for purposes of trading, the Association include parties who have taken out papers of naturalisation in Great Britain or in any other country, unless such parties can show that their act of naturalisation was prompted by motives which are not detrimental to British interests. The circular adds that it is well to warn members that there are many *bona fide* British firms whose names might make it appear that they were German. Again, members have often been misled as to the *bona fides* of certain British firms owing to the fact that German firms have registered themselves under very similar titles.

NOTES FROM THE UNITED STATES.

Philadelphia, September 16.

Domestic business in steel is almost stagnant; orders are mostly for small lots. Large enterprises are choked off. Financial conditions are at the bottom of the dulness. Capacity is unimpaired, but production is very little more than one-half of capacity, and yet there is very little change or fluctuation in prices, and no effort is made to secure business by concessions. There have been no cancellations to speak of. At present rate of production the pig-iron output estimated for the year will be 20 per cent. below 1913. Prices do not yield. There is no desire on the part of furnace interests to load up with business in the present situation, and consumers are buying only as they are obliged to. The premature high anticipations of a heavy export demand for steel products have not been realised. Ferro-manganese is now more easily had, and 6000 tons are now afloat from England; quotations are 85 dols. to 100 dols. Confidence prevails in an ultimate heavy export demand, though the visible assurances are wanting. There are a few inquiries for rails for export, totalling 40,000 tons, which will no doubt result in orders to be taken naturally by Atlantic coast mills, one lot passing through the Panama Canal. No important business need be expected from the railroads for some time. Strong pressure is being brought by railroad interests on the Government to allow a general advance in freight rates. Several hundred millon dollars worth of railway capital is now unable to yield dividends, and the situation is becoming serious.

ELECTROLYTIC IRON.

*Electrolytic Iron: Its Manufacture, Properties, and Uses.** By L. Guillet, D.Sc., Professor of Metallurgy at the Conservatoire Nationale des Arts et Métiers, Paris.

The industrial manufacture of iron by electrolysis is a problem which has engaged attention for many years, but it is only within the last year that it has entered the practical stage.

At St. Petersburg, in 1860, Klein succeeded in making blocks from electrolytic iron from which it was possible to print bank-notes. The bath used by Klein was a solution containing 5 per cent. of sulphate of iron and 5 per cent. of sulphate of magnesium. It worked with a current of low density, 0.1 to 0.2 ampere per square decimetre, and it was maintained neutral by the addition of carbonate of magnesia.

In 1867 Feuquières exhibited at Paris some galvanic deposits of iron, but his process was never divulged. At Aix-la-Chapelle, in 1881, Classen introduced an electrolytic method for the analysis of iron, in which he used a solution of double oxalate of iron and ammonium, with an insoluble platinum anode. This process found no other application except as an analytic one.

In 1900 the firm of Merck, in Germany, took out a patent (German patent No. 126,839) based on the electrolysis of highly concentrated pure ferrous chloride. The operation was carried on at a temperature of 70 deg. Cent., and with a current density of 3 to 4 amperes per square decimetre.

In America, in 1904, Burgess and Hambuechen succeeded in producing fairly large quantities of electrolytic iron, using a solution of double sulphate of iron and ammonium, the temperature being kept constant at 30 deg. Cent., and the current density being 1 ampere per square decimetre.

In 1905 Maximovitch tried a mixture of sulphate of iron and sulphate of magnesium. The bath was maintained neutral by periodic additions of bicarbonate of soda, and the current density was very low, not exceeding 0.2 to 0.3 ampere per square decimetre. The special object of all the foregoing processes was the production of pure iron, but none of them ever proved capable of industrial application.

About the same time, Professor Foerster, of Dresden, carried out several investigations on electrolytic iron, in collaboration with his pupils. The results are summarised in a publication entitled "Propriétés Electrochimiques du Fer."† Professor Foerster's best deposits were obtained in working at a temperature of 95 deg. Cent., with a solution of sulphate of iron kept slightly acid, the density of current being about 2 amperes per square decimetre.

In 1907 Cowper-Coles took out a patent involving the use of a 20 per cent. solution of sulphocresylate of iron, and endeavoured to manufacture weldless tubes direct, using as the cathode a rotating cylindrical mandrel. This process, which was analogous to the Elmore process for making copper tubes, has not yielded results of much importance.

In 1909 Professor Fischer, of Berlin, and Messrs. Langbein and Pfanhauser, at Leipzig, were granted various patents relating to electrolytic iron. The German patent No. 212,994 specifies the use of highly-concentrated solutions of chloride of iron and chloride of lime, working at a temperature of 110 deg. Cent., and with a current density of 20 amperes per square decimetre. This process has been much talked of, though no information is forthcoming as to whether it is being actually worked on a large scale. In any case, the direct production of thin sheets is not undertaken, and it would appear that the process consists mainly in producing rough plates of irregular shape and thickness, which are afterwards rolled down to thin plates. The method of manufacture is therefore largely a mechanical one.

Since 1910 the Company Le Fer, at Grenoble, has taken out patents for the manufacture of electrolytic iron. In principle, the method consists in the use of a revolving cathode and a neutral solution of iron salts, maintained in the neutral state by the circulation of the liquid over the surface of the iron. The bath also receives periodic additions of a depolarising medium, such as oxide of iron, the object of which is to eliminate, at least in part, the hydrogen deposits on the cathode, which injuriously affect the material if present in too large a quantity. By these means it is possible to work with a current of high density (1000 amperes to the square metre), and an iron of excellent quality is obtained. The process is applicable either to the production of very pure iron, which can compete with best iron and Swedish iron, or to the direct manufacture of tubes and sheets in the finished state. It has emerged from the laboratory stage, and is now being put into operation on an industrial scale.

The works of St. Marie and Gravigny and the Bouchayer and Viallet Company have acquired from "Le Fer" the options on a licence to manufacture sheets and tubes respectively. Messrs. Bouchayer and Viallet displayed commercial tubes at the Lyons Exhibition, and have just completed work on a large department which is about to begin the continuous manufacture of tubes.

Results of the Process.—The practical results obtained may be summarised as follows:—

1. With regard to the character of the metal. Using any pig-iron in solution, an iron can be obtained of the following average composition, after removal of the gases by annealing:—

	Per Cent.
Carbon	0.004
Silicon	0.007
Sulphur	0.006
Phosphorus	0.008

By the aid of certain operations the percentage of phosphorus can be made very low. By means of modifications in the electrolyte the following successive results have been obtained:—In 1911 the phosphorus was reduced (*a*) from 0.200 to 0.140 per cent.; (*b*) from 1.130 to 0.080 per cent.; (*c*) from 0.065 to 0.055 per cent.; (*d*) from 0.030 to 0.018 per cent.; in 1912 it was reduced from 0.012 to 0.008 per cent. At the present time it is possible to guarantee phosphorus lower than 0.010 per cent. The pig-iron used in the production of the electrolytic iron in question had the following composition:—

	Per Cent.
Carbon	2.35
Silicon	1.31
Sulphur	0.07
Phosphorus	1.07

With a density of current of 1000 amperes per square metre, the yield per kilowatt-year is 2 tons of metal, including the cost of current for the accessory services, particularly for the rotation of the cathodes. The mechanical properties will be considered in detail later.

2. As regards industrial products. As will be mentioned later in detail, the manufacture of tubes is being proceeded with on an industrial scale. The metal deposited is extremely brittle and hard, due to the occluded hydrogen, and probably also, as will be seen, to internal strain. Since the deposition of the iron takes place on a metal mandrel, the whole is annealed under the conditions to be described in the next section of the paper, and the finished article is easily withdrawn from the mandrel. The current practice of the Bouchayer and Viallet Company is to manufacture tubes of a length of 4 metres, 100 mm. to 200 mm. in diameter, and with a thickness of 0.1 mm. to 6 mm. (Fig. 1, page 414). Their installation is capable of turning out at least a hundred tubes per day. Apparatus is also in course of construction to enable the diameter of the tubes to be considerably increased. The manufacture of sheets is at present the subject of investigation; but no doubt the researches in the industrial laboratory which are at present in progress will lead to a method by which they can be commercially manufactured. After annealing, the crude iron possesses all the requirements of an excellent metal capable of fusion.

*Properties of Electrolytic Iron.**—At the meeting of the Swedish Technical Association of January 16, 1913, Mr. Palmaer† expressed the following opinion regarding a specimen obtained by the Cowper-Coles process:—

"Compared with an open-hearth steel plate from the Avesta Iron Works, containing 0.1 per cent. of carbon, the electrolytic plate showed approximately the same tensile strength. It was striated in one direction; parallel to the striations the elongation was the same as for the open-hearth plate, but at right angles the elongation was very small. The conductivity was very high.

"The iron corrodes very easily, probably on account of its content of iron chloride (0.02 per cent. Cl).

"Its low hysteresis and its high permeability would enable it to compete with the special sheet-iron used in the manufacture of electric machines. . . . On being taken out of the bath, the material, in the cold state, contained 0.45 per cent. of hydrogen. At 850 deg. Cent. 0.002 per cent. remained, and at 500 deg. Cent. the material contained 0.020 per cent. of hydrogen."

Properties of the Crude Material.—The material in the crude state—that is, in its state on removal from the

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* Paper submitted to the Iron and Steel Institute and now open for discussion by correspondence.

† Published by Messrs. Knapp, Halle a. S.

* Some of the data referred to here are taken from the results of an investigation by A. Portevin, a report of which was included in a note presented by H. Le Chatelier on March 3, 1913, to the Académie des Sciences.

† *Chemiker Zeitung*, April 1, 1913, page 393.

electrolyte bath—is hard and brittle. In fact, two effects are produced in the process of manufacture. The metal is interstrained, and has absorbed gases, particularly hydrogen. Sir Robert Hadfield has been good enough to examine a specimen submitted to him. On heating in vacuum to between 800 deg. and 1100 deg. Cent. for four hours, and then raising it to the neighbourhood of 1400 deg. Cent. for a further two hours, he found that 34 grammes of the iron had a volume of 4.3 cub. cm., and yielded 28.8 cub. cm. of gas of the following composition:

Fig. 1. Tubes of Electrolytic Iron.

	By Volume. Per Cent.	By Weight. Per Cent.
Hydrogen	18.8	65.3
Carbon monoxide	7.4	25.7
Carbon dioxide	0.2	0.7
Nitrogen	2.2	7.6
Oxygen	—	—

The presence of carbon monoxide is somewhat noteworthy.

It will be of interest to examine in detail the question of annealing. It is, moreover, a peculiar one, and the investigations are not yet completed. In fact, the results depend on the thickness of the sheet obtained. Moreover, the time of exposure to the atmosphere, after manufacture, has an influence on the occluded gases. Experiments are in progress for the determination of the influence of these two factors, and it may be possible to report the results shortly. On its removal from the electrolyte the iron is very brittle, and has a Brinell hardness of 193, using a ball of 10 mm. diameter under a load of 3000 kg.

The micrographic examination reveals an entirely characteristic structure, consisting of innumerable fine needles, very much resembling martensite. This structure does not disappear at 300 deg. Cent., but it fades as the temperature rises and disappears entirely about 800 deg. to 900 deg., the temperature required for complete annealing (see photo-micrographs, Figs. 2 to 6, above). Some trials have been made with the object of determining the best temperature and time of annealing, the results being summarised in Tables I. and II., page 416.

These tests show:—

1. That the bending test in general gives better indications than the ball test.

2. That annealing is only complete at 900 deg. after remaining 10 minutes in the salt bath.

3. That the time has very little influence, so long as the temperature does not reach 700 deg.

4. The commencement of the annealing action appears to be a function of the thickness of the plate.

5. With thin plates the sensible annealing effect takes place from 400 deg., and even from 300 deg.

These tests are still in progress, and it is hoped shortly to be able to communicate further results.

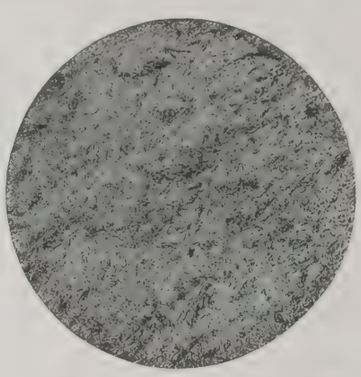


Fig. 2. Crude Electrolytic Iron Unannealed. Etched with Benedicks' Medium. Magnified 250 Diameters.

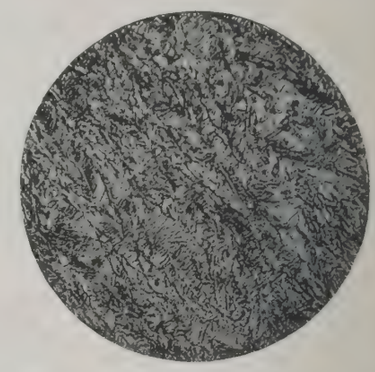


Fig. 3. The same Annealed at 300 deg. for 10 Minutes. Magnified 200 Diameters.

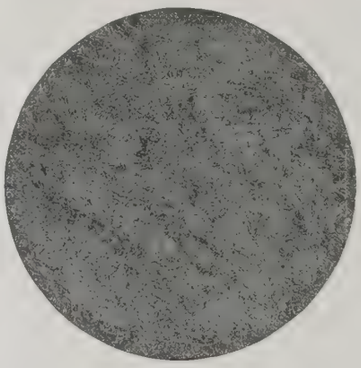


Fig. 4. The same Annealed at 500 deg. for 10 Minutes. Magnified 200 Diameters.

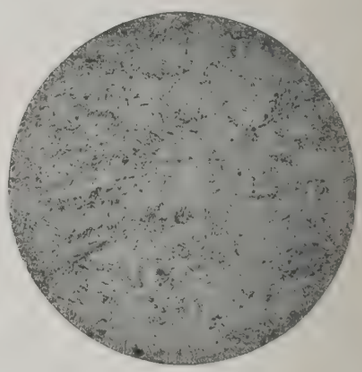


Fig. 5. The same Annealed at 700 deg. for 10 Minutes. Magnified 200 Diameters.

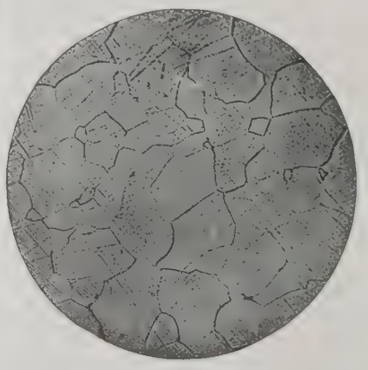


Fig. 6. The same Annealed. Magnified 300 Diameters.

Properties of the Annealed Iron.—After annealing for two hours in magnesia at 900 deg., the iron shows a Brinell hardness of 90. The micrographic structure is perfectly normal. The tensile test gives a breaking strength of 30.9 kg. to 32.8 kg. per sq. mm., and an elongation of 40.2 to 42.1 per cent. in the direction of the axis of the tube. Further, the annealed tubes, when subjected to compression tests, can undergo deformation to an extraordinary degree without a sign of any fracture (see Figs. 7 to 10, on the opposite page).

The critical points were determined with a Saladin-Le Chatelier double galvanometer, as follows:—

	Heating.	Cooling.
Crude iron... ...	981-937	902-778
Annealed iron ...	788-932	902-778

It may therefore be concluded that, in the case under consideration, the gases do not influence the position of the transformation points. Nevertheless, the curves for the crude iron show, at temperatures which vary in different specimens, but notably at 530 deg. to 690 deg., heat absorptions on heating, which do not recur in cooling. After heating once, these points disappear, and are due, therefore, either to the influence of the dissolved gases or to cold working. It may be mentioned that Roberts-Austen* observed some peculiar points in iron (particularly at 475 deg. and 766 deg.), which disappeared after repeated heatings.

In Fig. 11 a curve obtained with the Saladin-Le Chatelier apparatus for the annealed iron is shown. It will be particularly observed that the highest transformation point A 3 is characterised by a rapid thermic variation, whereas the transformation point A 2 corresponds, especially in cooling, to a progressive thermic variation. If one were to accept Benedicks'† theory, this would lead to the admission of a mutual solution, at least to a limited extent, of the two allotropic forms of iron α and β, or even of their mutual solubility in every proportion.

The measurements of electric conductivity yielded interesting results. They were made on an iron of the following composition:—Carbon, indeterminable; manganese, nil; silicon, nil; sulphur, nil; phosphorus, 0.025; arsenic, 0.011. The mean of the determinations carried out with the Thomson bridge on four turned bars of electrolytic iron, 5.70 mm. in diameter and 120 mm. long, after annealing under the conditions already mentioned, was 10.22 microhms per cub. cm. According to Benedicks, the presence of 0.025 per cent. of phosphorus and 0.011 per cent. of arsenic should alter this value by 0.24 microhm per cub. cm., reducing it to 9.98 microhms. According to Lorenz,‡ the value of the specific conductivity is 10.37×10^4 at 0 deg. and 6.63×10^4 at 100 deg., which, by interpolation, gives a value of 9.64×10^4 at 20 deg., or a resistivity of 10.37 per cub. cm. Kohlrausch§ gives as the value of the resistivity 9 microhms, and Preece‖ 9.73 microhms per cub. cm., whereas Benedicks finds by extrapolation 7.6 microhms per cub. cm. at 16 deg. The latter attributes the high results of the other two investigators to the presence of 0.004 to 0.007 per cent. of hydrogen by weight. Assuming Benedicks' value to be correct and his intrepretation to be equally applicable to the case under consideration, that would lead to the supposition that 0.008 per cent. of hydrogen by weight is present in solid solution in the iron of our specimens.

Similar determinations made on small rectangular unannealed bars of 5.1 mm. by 6.1 mm. in cross-section and 120 mm. long have given a value of 12.16 microhms per cub. cm. at 20 deg. Owing to its brittleness the metal could not be turned in the lathe to a very small diameter. Taking account of the phosphorus and arsenic, that value would be reduced to 11.92, which is higher by 1.94 microhms per cub. cm. than the value for the

* Fifth Report of the Alloys Research Committee, Institution of Mechanical Engineers, 1899.

† Eighth Congress of Applied Chemistry, New York, 1912.

‡ Landolt-Bornstein, *Tabelle*, 1905, page 716.

§ Benedicks' Thesis, Upsala, 1904, pages 116 and 106.

‖ *Ibid.*

annealed iron. Supposing, however, that this difference is due to hydrogen in solid solution, it would correspond to 0.006 per cent. of hydrogen by weight. The crude iron would then contain, in solid solution, 0.014 per cent. of hydrogen. It may be mentioned, however, that since making these determinations Portevin has shown, in a research not yet published, but a summary of which he presented to the Société d'Encouragement pour l'Industrie Nationale, that Benedicks' value, obtained by extrapolation of the resistivities of a series of quenched carbon steels, is higher than that of all the direct determinations. On repeating the measurements of resistivity on hypo-eutectic steels quenched from 1000 deg., Portevin maximum point in the curve might correspond to a critical point in the neighbourhood of 800 deg.

Electric Resistance.—The curve of the electric resistance of iron (1 division representing the electric resistance at 0 deg.) shows between 750 deg. and 850 deg. a perfectly continuous change of direction which it would be difficult to assign to a critical point. A discontinuity in the course of the curve is manifested at 950 deg. and 1020 deg., with a change of direction between these two temperatures. The continuity of the first change of direction had previously been noted by Morris in 1897, and by Harrison in 1902. The discontinuity at 950 deg. and at 1020 deg. has not hitherto been recorded.

Tubes.—The nature of the industrial results has already been alluded to, but the principal point of interest may be emphasised. As is well known, all present methods of manufacturing tubes present certain insurmountable difficulties when it is desired to obtain regular thicknesses of less than 6 mm. As a general rule, in the products obtained the thickness of the wall is far from constant. With the electrolytic process it is possible to obtain the most satisfactory regularity whatever the thickness, diameter, and length of tube.

The tubes will withstand considerable pressures. Thus, a tube of 100 mm. in diameter and 0.75 mm. in thickness, subjected to 1200 lb. per sq. in., underwent a permanent deformation of a regular character, as if squeezed in a press. Another specimen of the same tube was exposed for two and a half months to a temperature of 120 deg. in a boiler. It was then tested to 1200 lb. per sq. in., but no trace of fracture was perceptible.

Fig. 7.

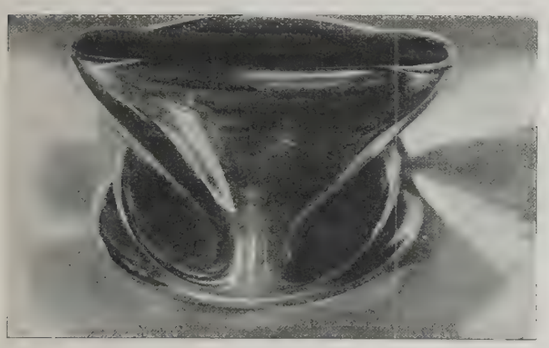


Fig. 8.

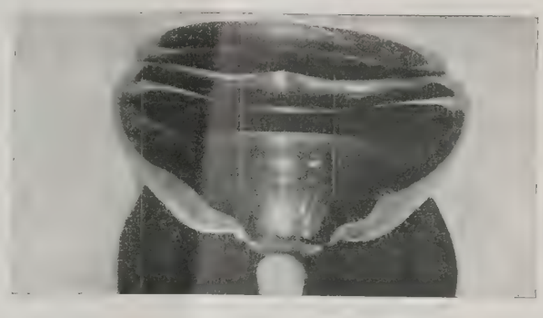


Fig. 9. Crushing Tests on Electrolytic Iron Tubes.

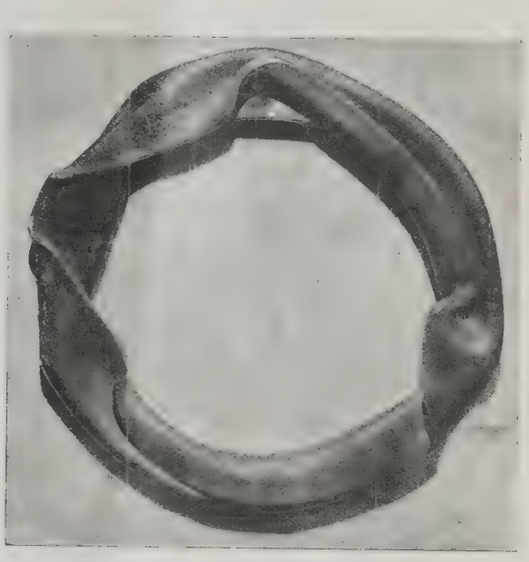
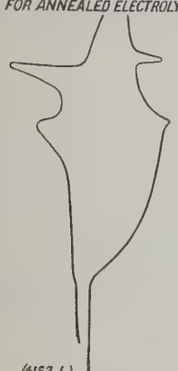


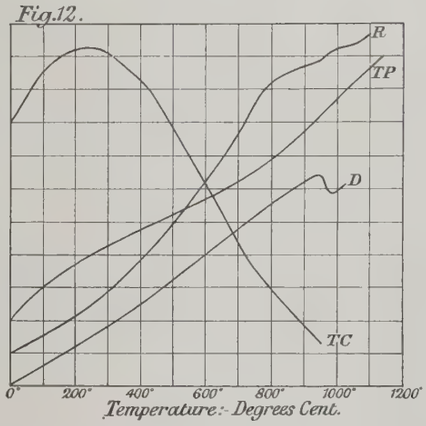
Fig. 10. Flattened Electrolytic Iron Tube.

Fig. 11. HEATING & COOLING CURVES FOR ANNEALED ELECTROLYTIC IRON.



(4163.L.)

Fig. 12.



TC-Heating Curve for Thermo-electric Force, referred to Copper.
TP- " " " " " " " "Platinum.
R-Curve of Electric Resistance.
D-Curve of Expansion of Electrolytic Iron.
(4163.M.)

obtained, by extrapolation, the figure of 9.3 microhms, instead of 7.6, as found by Benedicks. This figure approximates very closely to 9.98 found for the annealed iron.

On the other hand, Broniewski* has obtained results of measurements on an electrolytic iron from the same source as that stated by the present author, which are shown in the accompanying Fig. 12, which gives the heating curve for the thermo-electric force referred to copper (T C) and referred to platinum (T P), the curve of the electric resistance (R) and the curve of expansion (D) of the iron.

Thermo-Electricity.—The curve of the thermo-electric force of the iron referred to copper (1 division representing 0.5 millivolt) shows a critical point at 730 deg. Cent. The curve of thermo-electric force referred to platinum enables higher temperatures to be attained, but on a smaller scale (1 division representing 2 millivolts), and it shows a critical point at 1020 deg. Harrison, in 1902, and Belloc, in 1903, found no discontinuity in the curve of thermo-electric force of iron, but they suggest that a shows an arrest at 890 deg., and a very slight change of direction in the neighbourhood of 700 deg. When it is considered that the critical point occurring at 950 deg. on the heating curve of the electric resistance of iron is lowered on the cooling curve to 890 deg., it may be reasoned by analogy that the absorption of the heat takes place during heating in the neighbourhood of 950 deg. From these determinations Broniewski draws conclusions as to the existence of solid solutions and the different allotropic forms of iron which he considers require further investigation, an opinion shared by the author.

Industrial Applications.—The industrial applications of electrolytic iron fall into three principal categories:—(1) The direct manufacture of tubes; (2) the direct manufacture of sheets; (3) the preparation of pure iron as a raw material intended for fusion. There are various other uses of less importance, such as the preparation of rods of very pure iron for autogenous welding.

Expansion. — The curve of expansion (1 division representing 0.002 of the length of the specimen at 0 deg.) shows in the neighbourhood of 950 deg. a maximum followed by a contraction. The magnitude of this contraction appears to depend in a marked degree on the conditions of heating, as already noted by H. Le Chatelier in 1899. Charpy and Grenet place the point at which the contraction occurs in iron with 0.03 per cent. of carbon between 860 deg. and 890 deg.

Thermal Points. — The cooling curve

Sheets.—The results obtained have already been noted. The importance of being able to obtain sheets direct without rolling will be appreciated. The iron is of first-class quality, capable of undergoing very considerable deformations in the cold. Tests on tubes and plates have been made in the draw-bench, and it is surprising with what facility the metal can be worked. The material is therefore highly suitable for purposes of stamping, both in the form of plain annealed plates (black plates) or of tinned plate. Finally, on account of their purity, these sheets are specially adaptable for use in the construction of electric machinery. Dr. Max Breslauer,* of Berlin, has demonstrated the important aspect of this question, both from the point of view of magnetic properties and of regularity of thickness and compressive strength. The efficiency of alternating motors and transformers, and also of direct-current motors, is increased by using this material in their construction. He concludes that the use of electrolytic iron constitutes a real progress, both as regards hysteresis and permeability. In transformers the saving in weight of material is 33 to to 40 per cent. The capacity of alternating motors can be increased by 50 per cent., running at the same temperature and occupying the same space. In direct-current machines 16 per cent. of the iron can be saved.

Electrolytic Iron as a Raw Material for Fusion.—Without doubt electrolytic iron will be able to compete successfully with Swedish iron. The quality is much more regular, and the crude metal, being very brittle, can easily be broken into pieces of any required size, however small, and, at the same time, it can be supplied in suitable thicknesses. The cementation of such products would be more regular than those ordinarily used. Tests made at various steel works have shown that tools and special steels manufactured from this material give results at least equal to those

* *Comptes Rendus de l'Académie des Sciences*, March 3, 1913.

* *Elektrochemische Zeitschrift*, June 12 and 19, 1913.

Table I.—*Hardness Determinations under a Load of 30 Kg., with a Ball 3 Millimetres in Diameter, and Number of Bendings.*

Treatment.	Diameter of Impression in Millimetres.	No. of Bendings through 180 Deg.
First Series.—Tests on Plate 2 Mm. Thick.		
Before annealing, and after exposure to the air for five months	0.54	0
After annealing at 400 deg.	0.52	6
After annealing at 500 ,, ...	0.52	6
After annealing at 600 ,, ...	0.56	8
After annealing at 700 ,, ...	0.64	10
After annealing at 900 ,, ...	0.80	11
Second Series.—Tests on Plate 4.5 Mm. Thick.		
Before annealing and after exposure to the air for five months	0.40	0
After annealing at 400 deg.	0.40	0
After annealing at 500 ,, ...	0.48	1
After annealing at 600 ,, ...	0.50	1
After annealing at 700 ,, ...	0.56	3
After annealing at 900 ,, ...	0.80	3

Table II.—*Influence of Time of Annealing in the Salt Bath. Hardness Determinations under a Load of 30 Kg., with a Ball 3 Mm. in Diameter, and Number of Bendings. Thickness of Plate, 2 Mm.*

At 200 deg. and 300 deg. the annealing showed no influence on the hardness or number of bendings, which was nil.

At 300 deg. it showed no influence on the hardness, and the number of bendings rises to two, however long the period of annealing.

Treatment.	Diameter of Impression in Millimetres.	No. of Bendings through 180 Deg.
Annealed at 400 deg. For 10 minutes..	0.52	5
Annealed at 400 deg. ,, 20 ,, ..	0.53	5
Annealed at 400 deg. ,, 40 ,, ..	0.53	6
Annealed at 400 deg. ,, 60 ,, ..	0.54	7
Annealed at 400 deg. ,, 120 ,, ..	0.55	6
Annealed at 500 deg. For 10 minutes..	0.56	5
Annealed at 500 deg. ,, 20 ,, ..	0.54	6
Annealed at 500 deg. ,, 40 ,, ..	0.54	7
Annealed at 500 deg. ,, 60 ,, ..	0.54	6
Annealed at 500 deg. ,, 120 ,, ..	0.52	5
Annealed at 600 deg. For 10 minutes..	0.54	9
Annealed at 600 deg. ,, 20 ,, ..	0.55	8
Annealed at 600 deg. ,, 40 ,, ..	0.55	8
Annealed at 600 deg. ,, 60 ,, ..	0.55	9
Annealed at 600 deg. ,, 120 ,, ..	0.58	9
Annealed at 700 deg. For 10 minutes..	0.60	10
Annealed at 700 deg. ,, 20 ,, ..	0.64	11
Annealed at 700 deg. ,, 40 ,, ..	0.64	10
Annealed at 700 deg. ,, 60 ,, ..	0.68	11
Annealed at 700 deg. ,, 120 ,, ..	0.75	10
Annealed at 800 deg. For 10 minutes..	0.74	11
Annealed at 800 deg. ,, 20 ,, ..	0.75	13
Annealed at 800 deg. ,, 40 ,, ..	0.74	12
Annealed at 800 deg. ,, 60 ,, ..	0.78	10
Annealed at 800 deg. ,, 120 ,, ..	0.78	10

obtained with Swedish iron. The cost price is the only remaining consideration.

The principal factors which make up the cost price are the electric energy and the pig iron. It has already been mentioned that 2 tons of extremely pure iron can be produced per kilowatt-year. Using a current of 500 amperes per square metre instead of 1000 amperes, the voltage drops to about one-half, and the production per kilowatt-year is nearly doubled. Working with a still lower density, the yield can be even further increased. In countries where the cost of motive power is high, it would pay to work at 500 amperes or even less. It would then be possible to produce 3 to 4 tons, and even more, per kilowatt-year. If the cost of the unit be taken as 1 centime (0.1d.), an ordinary figure in the Alps, and using a current density of 1000 amperes, the cost of current would not exceed 43 francs per ton of iron produced. Since pig-iron is used as the raw material, it may be reckoned that there is about 10 per cent. of waste in the form of sludge, graphite, &c. The price of the pig-iron would vary according to the locality, and in the mountainous country it would run at about 64s. to 88s. per ton. The price, however, would be higher in those localities where the electric current was cheapest, and *vice versâ*. The average outlay on pig-iron per ton of electrolytic iron would therefore be from about 72s. to 80s. To this would still have to be added the cost of labour, maintenance, cost of electrolyte, depreciation, and interest on the capital cost of the plant. These various amounts have not yet been definitely ascertained, but the total cost price, based on current prices for material and labour, of the electrolytic iron, in the condition in which it leaves the electrolyte bath, would probably not exceed 6*l.* to 7*l.* 12s. per ton, according to the locality.

Engineer Units of the Royal Naval Division.—This is the body which is being raised by the Institutions of Civil Engineers, of Mechanical Engineers, and of Electrical Engineers from their own members, associate members, and students, for use in the New Army. The Board of Selection will continue to interview applicants until the end of this week. Applicants (who must have had actual experience of constructional work) are required to attend in person at 2, Savoy-hill, W.C., between 10 a.m. and 1 p.m. or between 2 p.m. and 4 p.m. (Saturday, 10 a.m. to 1 p.m. only).

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was dead idle, and sellers of Cleveland warrants quoted 51s. 2d. cash, 51s. 6d. one month, and 52s. three months. In the afternoon a firm tone prevailed, but dealing was limited to one lot of Cleveland warrants at 51s. 1½d. cash, and closing sellers named 51s. 2d. cash, 51s. 6d. one month, and 52s. three months. On Friday morning the market was quietly steady, and no business was reported. Sellers of Cleveland warrants made no change in the quotations. In the afternoon Cleveland warrants, amounting to 1500 tons, were put through at from 51s. 4d. to 51s. 4½d. one month, with buyers over at 51s. 4d. and sellers at 51s. 5d. For the other positions sellers quoted 51s. 2d. cash and 52s. three months. The market was closed on Monday, being the local autumn holiday. With the resumption of business on Tuesday morning Cleveland warrants were weaker and 1500 tons were done at 50s. 11½d. cash, and closing sellers quoted 51s. cash, 51s. 3½d. one month, and 51s. 10½d. three months. The afternoon session was another blank as regards business, but sellers' prices for Cleveland warrants were firmer at 51s. 1d. cash, 51s. 4½d. one month, and 51s. 10½d. three months. When the market opened to-day (Wednesday) the tone was slightly easier again, and business was confined to one lot of Cleveland warrants at 51s. 3d. one month, with sellers over at 51s. cash, 51s. 3½d. one month, and 51s. 10½d. three months. In the afternoon, while cash and one-month iron were steady, the three months position was easier. Business amounting to 2500 tons of Cleveland warrants changed hands at 51s. 8d. and 51s. 8½d. three months, and at the close sellers quoted 51s. cash, 51s. 3½d. one month, and 51s. 9d. three months.

Sulphate of Ammonia.—An easier tendency prevails in the sulphate of ammonia market, and the current price for prompt lots is from 10*l.* 8s. 9d. to 10*l.* 10s. per ton, Glasgow or Leith. There is not very much activity in forward dealing, as neither buyers nor sellers seem very much disposed to enter into engagements at present.

Scotch Steel Trade.—Although the steel trade in Scotland is managing to hold on very well indeed, considering the small demand from some sources, yet there is an undoubted scarcity of specifications. This is especially the case in ship-plates, largely owing to the reluctance of shipowners in ordering new tonnage, despite the fact that freights are at present very high. Of course, shipping in general is rather quiet, but, on the other hand, it is really marvellous the amount of business which is being carried on when we consider the nearness and the immensity of the war in which we are engaged. It is certainly affecting the over-sea markets to no little extent, if we can judge by the rather limited inquiries which are coming to hand, and during the past week these were only fair, but signs are not wanting of an early improvement in that direction. In a moderate way the home demand is fairly good, although orders are mainly for small lots for immediate requirements, but in the case of black sheets and sectional material the demand is not very encouraging. Steel-rail makers are dull and are anxiously awaiting the placing of some important lots now under consideration. Prices are nominally steady, but where not controlled by the Association they are slightly inclined in buyers' favour.

Malleable-Iron Trade.—The position of the malleable-iron trade in the West of Scotland has not materially changed, and only a limited number of the works are securing a full week's employment. It is freely considered that a decided victory for the Allied Forces now in the field would be the first thing to give a fillip to business, and it is earnestly hoped that that may be forthcoming shortly. Prices are unchanged.

Scotch Pig-Iron Trade.—The business in Scotch pig-iron during the past week has been of a very meagre description both for home consumption and for export. The holding back of new work is very general, and producers are suffering; but some are of opinion that with the ending of the moratorium—a month hence—there is a prospect of business opening out considerably. Inquiries to hand this week are not heavy, but shipping has been fairly good. The following are the market quotations for makers' (No. 1) iron:—Clyde, 69s. 6d.; Calder, Gartsherrie, and Summerlee, 70s.; and Langloan, 72s. (all shipped at Glasgow); Glengarnock (at Ardrossan), 71s.; Shotts (at Leith), 70s.; and Carron (at Grangemouth), 70s. 6d.

Scotch Shipbuilding.—The Scotch shipbuilding trade is not as busy at present as we should like, and new orders are not being booked in any number, with the result that as the tonnage on hand gets completed there is little left to do. The output for the past month was the third highest for this year, and amounted to twenty-one vessels, of 60,563 tons. That figure was made up as follows:—

	Vessels.	Tons.
The Clyde	17	56,848
The Forth	2	3,280
The Tay	—	—
The Dee	2	435
Total	21	60,563

The Clyde total ranks high for the month of September, and, with the single exception of the total for the corresponding month of last year, it has never been bettered. The figure for the nine months now stands at 356,361 tons, which is over 131,000 tons less than the output for the three quarters of last year.

Wages in the Iron Trade.—Intimation has been made to Mr. James C. Bishop and Mr. James Gavin, joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board, by Mr. John M. MacLeod, C.A., Glasgow, as follows:—"In terms of the remit, I have examined the employers' books for July and August, 1914, and I certify the average net selling brought out is 6*l.* 9s. 3.14d. per ton. This means no change in the wages of the workmen."

Contracts.—The Kitson-Empire Lighting Company, of Stamford, have supplied large quantities of their special 500-candle-power incandescent oil-lamps for field-hospital service to the Russian and French Governments. Over three million of these lamps have been made.

Personal.—Messrs. Schäffer and Budenberg, Limited, state that their entire Manchester business has been transferred to their new works at Broadheath.—Messrs. J. W. Brooke and Co., Limited, Adrian Works, Lowestoft, announce that they have purchased the whole of the drawings, patterns, machining-jigs, and templates for the well-known Hesse reversing gear, recently manufactured by Messrs. Hesse and Savory.—Messrs. Haslam and Schontheil, Limited, of 11, Windsor-place, Cardiff, have sent out a general notice to the trade and their customers, intimating that from September 28 the title of their firm will be Haslam and Stretton, Limited. The change is necessary owing to Mr. Theodore Schontheil, who is a British-born subject, having adopted the surname of Stretton, but the business will be carried on entirely as heretofore.—Messrs. Laing, Wharton, Limited, of 7, Great Newport-street, London, W.C., have removed to Mildmay Park Works, Mildmay-avenue, London, N., and are laying down additional plant and tools with a view to coping with increasing business.

Merchant Shipping and the War.—The Secretary of the Admiralty communicates the following tabular statements with regard to the capture and destruction of British and enemy merchant shipping:—

German Shipping Detained and Captured.

	Number.	Tonnage.
Vessels detained in British ports at outbreak of war	102	200,000
Vessels captured since outbreak of war	88	338,000
,, remaining in Suez Canal zone	14	72,000
,, capable of being armed detained in United States ports	15	247,000
Vessels detained or captured by Allies	168	283,000
Total	387	1,140,000

British Shipping Detained and Captured.

Vessels in German ports	74	170,000
,, captured or sunk by Germans	12	59,000
Total	86	229,000

Since this return was issued the German cruiser Emden has sunk four more British merchant ships and captured a collier, while H.M.S. Cumberland has captured nine German ships.

Trade Openings for Building and Furniture Fittings.—In the year 1912 Germany exported building and furniture fittings, door-handles, ventilators, castors for furniture, locks, and similar material to a total value of 76,250*l.* to the United Kingdom. To our Colonies and to countries which are neutral during the present war she exported similar material to a value of 1,037,300*l.* These two figures, together with a sum of 30,560*l.*, representing similar exports by Austria-Hungary, make up a total of 1,144,110*l.* A considerable part of the demand which this business represents will quite possibly cease to exist during the war, but there should be an important residuum, some part of which our manufacturers should be able to take advantage of. No particulars are available of the exports of material of this class from the United Kingdom, but it is certainly large, and the business is one with which we are well equipped to deal. Particulars of the German and Austro-Hungarian exports to a large number of countries, together with a considerable amount of miscellaneous information in reference to various markets, are given in a White Paper just issued by the Commercial Intelligence Branch of the Board of Trade. Copies of the paper should be obtained by all interested manufacturers.

The New Army.—Up to the present 453 men—equivalent to 20 per cent.—of the employees of the British Aluminium Company have joined the Forces. At the Kinlochleven, Larne, and Milton Works, and at the head office, the response has been both prompt and enthusiastic, some 40 per cent. of the total employees at Kinlochleven alone having volunteered, which includes practically all those who are eligible. In addition to this, about 200 of the men employed at the company's Milton (North Staffs) rolling mills are being drilled nightly on the company's premises by their mates who happen to be old soldiers, and both here and at Larne—where the Ulster Volunteers are busy recruiting—more men are joining daily. The families of all married employees serving with the colours, or others dependent upon them, are being paid 10s. weekly, those residing on the company's premises doing so rent free for the present.—We are informed that approximately 25 per cent. of the employees of the Beldam Packing and Rubber Company, Limited, 1 and 2, Gracechurch-street, E.C., have responded to their country's call to arms, and arrangements have been made to guarantee reinstatement of these men on the expiration of the war, also half-pay to the wives of married men, and suitable provision for the dependants of single men during the war.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—House coal is the most active section of the market. Merchants are fully occupied in dealing with futures to cover the coming winter's requirements. Business that has been held back on account of the general unsettlement is now being placed, in order that the higher autumn rates may be avoided. Thus the pits are busily engaged. According to the practice of previous years, an all-round advance of 1s. per ton was to be expected from October 1, but producers this year have to recoup themselves for the increased cost of timber, tallow and other products which collieries consume in large quantities, and a section of the South Yorkshire coal-owners are inclined to enlarge the advance to 1s. 3d. or 1s. 6d. Time will show whether the situation is such that they can uphold those advances. The hard-coal market is in a very difficult position. There is still a certain amount of shipping being done, but its magnitude is very disappointing to producers. Oversea trade is principally with France, Italy, the Mediterranean, Norway and North Russia. The home trade is quiet. Continental gas companies are anxious to prepare against increased consumption during the coming winter, but freights are so high that little more is being done than order for present requirements. Slacks are somewhat irregular. In the lower grades prices are on the weak side. Coke is a sound, steady market. Quotations:—Best branch hand-picked, 15s. to 16s.; Barnsley best Silkstone, 12s. to 13s.; Derbyshire best brights, 11s. 6d. to 12s. 6d.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 10s. 3d. to 11s. 3d.; small nuts, 9s. to 10s.; Yorkshire hards, 11s. to 12s.; Derbyshire hards, 10s. to 11s.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.; smalls, 2s. to 3s.

Iron and Steel.—The improving tendency is still in evidence, but in the raw-material market is not very pronounced. New business in the foundry-iron section has this week been rather flat, although prices are unchanged. The run on forge iron continues, and makers have no difficulty in disposing of the whole of their output at advanced rates of 59s. 8d. for Lincolnshire sorts and 56s. for Derbyshire sorts. Foundry iron is quoted at from 59s. 3d. for Derbyshire brands to 60s. 8d. for Lincolnshire brands. Hematites are strong, with a steady demand on special qualities for Government work and a fair volume of inquiry for forward delivery of ordinary sorts. Special hematites stand at 82s. In ordinary brands the current selling prices are West Coast, 79s. 6d.; East Coast, 77s. 3d. Bar-iron makers are badly placed for new general business, but are being materially assisted by Government orders and a small amount of diverted German trade. The quotation of 8*l.* 5s. for crown bars is unaltered. The engineering trades comprise the busiest section of industrial activity in the district. There is an enormous rush of work for immediate and future delivery, and the federated employers, who have abolished all overtime restrictions, are gladly engaging experienced hands from other provincial centres to assist in the expediting of output. A decrease is also reported in unemployment in the general steel trades, there being a dearth of skilled labour in certain leading branches. The unprecedented activity at the armament factories is unbroken. The lighter sections have booked more business than for several weeks past. Orders have this week been received from Yokohama, Calcutta, Copenhagen, Madras, and Buenos Aires for files, sheare, and saws. The crusade against German commerce has resulted in the placing of further orders for hand tools and cold-drawn steel with South Yorkshire makers. Steel billet makers announce a weakening in the demand for basic sorts. Home trade is poor. Scrap is becoming a much more valuable commodity, and prices are hardening.

FIRE PRECAUTIONS IN EMERGENCY HOSPITALS.—A precautionary notice relating to fire dangers in hospitals and convalescent homes has been prepared by the British Fire-Prevention Committee, and is now available gratuitously for hospitals and convalescent homes which are doing emergency work in connection with war cases. Copies will be provided free upon application to the British Fire-Prevention Committee, 8, Waterloo-place, London, S.W.

THE ENGINEERING INDUSTRY IN BELGIUM.—A letter has been received at the offices of the Institution of Automobile Engineers from the English manager of the F. N. Company, stating that M. Galopin, who acted as host to the Institution in their summer meeting in Belgium, has written to say that the factory at Liége is perfectly intact, and that the clerical departments are back at work preparing for next year's programme. Another Liége factory—that of the Société John Cockerill—is still at work executing orders. The Derihon factory, also at Liége, has not been destroyed, and the brothers Derihon are in good health and spirits, but no work is being done. No definite news has been received in regard to the works of Messrs. Dyle and Bacalan at Louvain, but it is believed that the factory is undamaged, though the offices have been destroyed and the hands dispersed. The Minerva works at Antwerp have not yet been injured by Zeppelins, though attempts have been made upon them. The factory is at work much as usual, though some of their energies have been diverted from the manufacture of cars. Engineers will be particularly pleased to learn that Messrs. Greiner, *pere et fils*, together with their wives, are all well, and that the factory of Messrs. Mabille and R. Pelgrims, at Mariemont, though it has been in the thick of the fighting, is undamaged, and is actually at work.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The pig-iron market is characterised by quietness. Production is a good deal in excess of requirements, notwithstanding the fact that many of the sixty-nine furnaces in operation on the North-East Coast are not working at full pressure. Makers of Cleveland pig-iron declare that current quotations are unprofitable, and some of them hint at the advisability of blowing out more furnaces unless demand improves or cost of production is lowered by reduction in prices of raw material. A surprising and gratifying feature of the market is the upholding of pig-iron prices since the outbreak of war. No. 3 g.m.b. Cleveland pig is 51s. 3d. f.o.b.; No. 1 is 53s. 9d.; No. 4 foundry, 51s.; No. 4 forge, 50s. 9d.; mottled, 50s. 6d.; and white, 50s. 3d.—all for early delivery. Sheffield consumers of hematite are said to be in the market again, but, so far as can be ascertained, they have not as yet made any purchases. Both makers and merchants are rather keen sellers, and, in fact, the latter are pressing sales of Nos. 1, 2, and 3 East Coast brands at 66s. 6d., and some firms would entertain offers at even less. The foregoing figure, however, may be given as the general market quotation for early delivery. There are rumours of possible business for delivery over periods next year, but on what terms has not transpired. There is little or nothing passing in foreign ore. Values show a downward tendency, sellers apparently realising that it is useless to hold out for the prices they have been asking. Some sellers adhere to quotations on the basis of 18s. 6d. ex-ship Tees for Rubio of 50 per cent. quality, but it is understood that contracts can be made on lower terms. A basis of 18s. 3d. would not be refused, and, indeed, offers at 18s. would receive careful consideration. Buyers consider that the basis should not be above 17s. 6d. Freights Bilbao-Middlesbrough are round about 4s. 6d. Supply of coke is rather more plentiful, and, with local consumption somewhat diminished, values are easier. Many sellers are very reluctant to admit actual fall in price, and endeavour to keep the quotation for Durham beehive blast-furnace coke at 18s. delivered at Tees-side works, but purchases are possible at 17s. 9d., which is a figure considered still too high by users.

Stocks of Pig Iron.—Stocks of pig-iron are steadily accumulating, not only in the warrant stores, but at makers' yards also. What makers' stocks stand at is not known, but the quantity at their yards is believed to be rather heavy. Messrs. Connal and Co., the warrant storekeepers, hold here 103,368 tons of No. 3 Cleveland pig, or 8665 tons more than on September 1.

Manufactured Iron and Steel.—Satisfactory accounts are given of the manufactured iron and steel industries. Producers generally are very well placed, and in practically all branches a lot of work is being turned out. Manufacturers are very busy with orders for light rails for allied governments. Demand for shipbuilding material shows some falling off due to men being drawn from the shipyards to the colours, and to work in the Government dockyards. A lot of small-section work hitherto made by Belgium has been secured by firms in this district. Prices all round are well maintained. The following are the principal market quotations:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 10s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 8*l.*; iron ship-rivets, 9*l.*; steel bars 6*l.* 15s.; steel ship-plates, 7*l.* 5s.; steel ship-angles, 7*l.*; steel boiler-plates, 8*l.* 5s.; steel joists, 7*l.* 2s. 6d.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 15s.; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 15s.; and steel railway sleepers, 7*l.* 15s.—railway material net at works, and all other descriptions quoted less the customary 2½ per cent. discount.

Ironworkers' Wages.—The accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England certify the average net selling price of iron rails, plates, bars, and angles for the two months ended August 31 last to have been 6*l.* 14s. 2.15d., as compared with 6*l.* 13s. 1.91d. for the previous two months, and, in accordance with sliding-scale arrangements, wages for October and November will be the same as prevailed during the preceding two months.

Consett Steel-Workers' Wages Reduced.—The accountants to the Arbitration Board have certified the average net selling price of steel plates at Consett for the three months ending July last at such a figure as reduces wages of steel-mill men by 2½ per cent. for the last quarter of the year, leaving wages at 12½ per cent. above the standard.

Iron and Steel Shipments.—The iron and steel shipments from the Tees during the month of September were up to expectations, although they fell considerably below those of a year ago. Those of pig-iron averaged 2266 tons per working day, the total loadings being returned at 58,923 tons, 51,438 tons of which went from Middlesbrough and 7485 tons from Skinningrove. For August the dispatches amounted to 31,870 tons, or a daily average of 1225 tons, and for the month of September a year ago the clearances were given at 117,914 tons, or an average of 4535 tons. All the iron loaded at Skinningrove went to Scotland. Of the iron shipped from Middlesbrough 29,350 tons went to foreign customers, and 22,088 tons to coastwise buyers. Scotland, as usual, was the largest buyer, receiving 14,155 tons, whilst the United States of America took 7380 tons; Sweden, 7271 tons; Italy, 3100 tons; Japan, 2578 tons; South Australia, 2300 tons; and Norway, 1500 tons. Tees loadings of manufactured iron were given at 17,002 tons, 7827 tons of which went foreign, and 9175 tons coastwise, and those of steel reached 27,693 tons, of which 23,265 tons went abroad, and 4428 tons to home customers. The Argentine was the largest receiver of manufactured iron, taking 5376 tons. The most important buyer of steel was India, with an import of 16,208 tons, whilst South Australia received 2295 tons of steel.

Armstrong College and Engineering Classes.—It is announced that, owing to the Armstrong College buildings at Newcastle having been requisitioned by the War Office, the engineering classes will be held during the coming session at Rutherford College, Newcastle, where students will be enrolled on October 6 onwards. Evening classes are suspended until the 1915-16 session.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has remained without material change. The outlook for October is not considered particularly encouraging, as there is a disposition on the part of industrials only to cover their immediate requirements and to postpone forward purchases, pending further war developments. It is feared that, unless Admiralty requirements increase considerably, supplies will prove in excess of current consumption, and that prices will remain easy in consequence for all descriptions of large coal. The inquiry for smalls has slightly improved, especially for bunker qualities, which have shown a hardening tendency. House coal, patent fuel, and coke have remained unchanged. The best Admiralty large has been quoted 20s. to 22s.; best secondary qualities have made 18s. to 19s.; other secondary descriptions, 17s. 6d. to 18s. 6d.; best bunker smalls, 7s. 9d. to 8s. 3d.; and cargo smalls, 5s. to 6s. 6d. per ton. The best household coal has brought 19s. to 20s.; good households, 17s. to 18s.; No. 2 Rhondda large has made 13s. to 13s. 9d.; and No. 2 smalls have been quoted at 6s. 6d. to 7s. 6d. per ton. Patent fuel has realised 17s. to 18s. per ton. Special foundry coke has brought 27s. 6d. to 30s.; good foundry coke, 21s. to 25s.; and furnace coke, 18s. to 20s. per ton. As regards iron ore, Rubio has realised 18s. 3d. to 18s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Welsh Steel Rails.—Messrs. Guest, Keen and Nettlefolds, Limited, have obtained an order for 3000 tons of steel rails for shipment to India. Wales has to contend just now with American competition; one leading United States firm has tendered, for instance, for a large Australian order. The United States Steel Corporation also recently secured an order for 14,000 tons of steel rails for South America.

Newport.—Monmouthshire steam-coal has shown no improvement, buyers rather holding back than otherwise. There have been good supplies of large, which has remained easy. Smalls have been about stationary. The best Newport black vein large has realised 17s. to 17s. 6d. per ton; Western Valleys have brought 16s. 6d. to 17s. per ton; and Eastern Valleys, 15s. 9d. to 16s. per ton.

Dowlais.—The Dowlais works have been generally well employed. The blast-furnaces have been busy, and the Siemens furnaces have been well occupied. The Goat Mill has been engaged upon steel rails, square merchant steel, and steel sleepers, as well as upon tin bars. The Big Mill has also been well employed, and has turned out steel tram-rails, fish-plates, curves, and props. The collieries have produced a good quantity of coal.

ASSOCIATION OF RAILWAY COMPANIES' SIGNAL SUPERINTENDENTS AND SIGNAL ENGINEERS (ENGLAND).—The forty-ninth conference of the above Association will be held at the Railway Clearing House, London, on Tuesday, October 13.

ARMSTRONG COLLEGE.—A copy of the Calendar of the Armstrong College, Newcastle-on-Tyne, has recently come to hand. This College, it will be remembered, forms one of the units of the University of Durham. The faculties of science and commerce in this University are seated entirely at the Armstrong College, where all classes and examinations for degrees in these faculties are held. In addition to pure science the College gives instruction in mechanical, civil, and electrical engineering, and also in mining, metallurgy, naval architecture, and agricultural science. Full particulars of day and evening classes and courses of study in all the above-mentioned subjects, and many others, will also be found in the Calendar, together with much other information relating to the College and its work. The price of the Calendar is 1s., and it can be obtained from the Secretary, post free, for 1s. 4d.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—The opening meeting of the session of the Institution of Automobile Engineers will take place on Wednesday, the 14th inst., at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W., at 8 p.m., under somewhat unusual circumstances. Owing to the president-elect, Colonel H. C. L. Holden, being fully occupied with his duties as Director of Mechanical Transport at the War Office, his presidential address will be postponed, and a paper will be given by Mr. L. H. Pomeroy, entitled "Automobile Engineering and the War." Very important suggestions in regard to the conduct of business during the war will be outlined, and it is hoped that much valuable information will be forthcoming. In order to render the discussion more valuable to the industry generally, the Council have decided to welcome all those who are interested, whether they are members or not.

THE FRENCH SOUTH AMERICAN QUADRUPLE-SCREW LINER "LUTETIA."

CONSTRUCTED BY THE SOCIÉTÉ ANONYME DES CHANTIER ET ATELIERS DE ST. NAZAIRE, ENGINEERS, ST. NAZAIRE.

(*For Description, see Page* 426.)

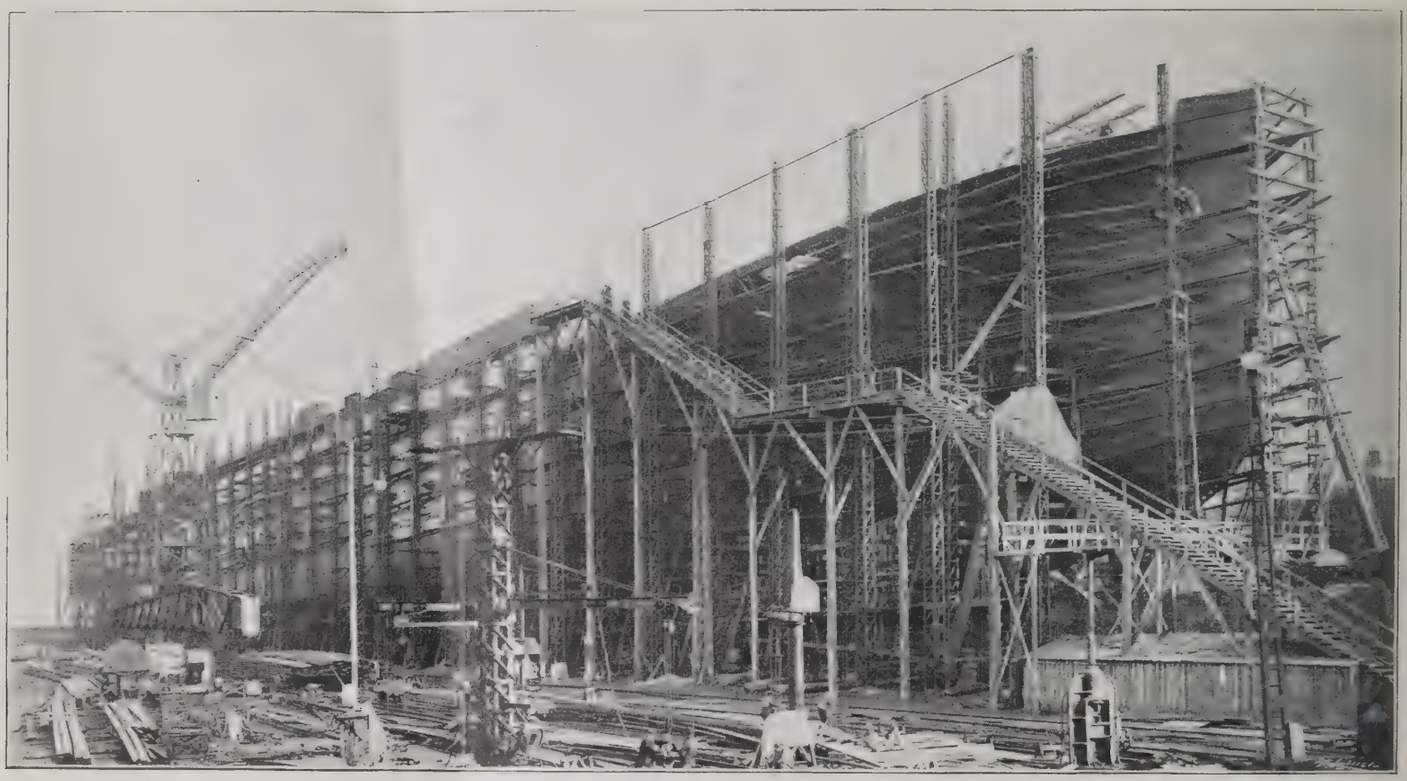


Fig. 9. The "Lutetia" on the Building-Berth.

Fig. 10. The "Lutetia" in St. Nazaire Harbour.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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NOTICES OF MEETINGS.

THE SOCIETY OF ENGINEERS.—Monday, October 5, at 7.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. A paper entitled "Cylinder Bridge Foundations in the East, and the Construction of the Sittang River Bridge, Burma Railways," will be read by Mr. A. Stewart Buckle (Member).

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 9, at 8 p.m. Informal meeting at 39, Victoria-street, Westminster. Mr. Wm. P. Durtnall on "The Barrier of Ignorance," illustrated by lantern.

THE INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.—Monday, October 12, at 8 p.m., the Graduates' annual report for the session 1913-14 will be presented, after which a paper entitled "The Reclamation of Waste Products in Industrial Undertakings," will be read by Mr. George H. Ayres (Graduate), of Huddersfield. Chairman: Captain H. Riall Sankey (Member of Council).

NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to some Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, OCTOBER 2, 1914.

THE FINANCING OF CONTRACTS.

THE abnormal financial conditions now prevailing, and the need of "accommodation" by all manufacturers and traders, but particularly by those of comparatively limited monetary resource, in the present effort greatly to expand our foreign commerce, has given rise to the suggestion that we should adopt some system analogous to the German credit banks. It is therefore appropriate that, following upon our consideration of the general relation of the bank to the manufacturer in a recent article (see page 333 *ante*), we should review the influence of such institutions on industry, and the alternative systems whereby contracts may be financed by the lodgement with our banks of securities possessed by those seeking accommodation, especially as the extent of available securities is not always realised.

Credit banks have undoubtedly provided German traders and manufacturers with the means whereby they have been enabled to compete on very favourable terms with British traders, but it must not be forgotten, on the other hand, that a large measure of their success in foreign markets has been due to the employment of cheap labour, and also to the fact that, although the goods produced were pleasing in appearance, yet the quality was seldom so good as similar British manufactures, although meeting the customer's requirements. Again, while the credit banks did assist production very materially, they fostered over-production, the effects of which are now aggravating, and must continue to aggravate, the distress being caused in Germany by the war. In any case, the present time of financial stress is not the most favourable time to start any entirely new system of banking in this country. It is rather the time strictly to examine our present methods, to see whether full advantage is being taken of all the facilities they offer, and whether the whole system is sufficiently elastic to meet the demands made upon it.

For several years past the trade of this country has been increasing by leaps and bounds, as is proved by the Board of Trade returns. Previous records have been broken with monotonous regularity, so that it is apparent that there is nothing very seriously wrong fundamentally with the financial system on which it rests, although, judging from the complaints now made, the fullest use is not made of the facilities it gives. One of the greatest advantages—yet least appreciated because of its familiarity—is the phenomenal development and use of the cheque. In no other country are cheques so extensively in vogue as with us, and only a superficial examination into the ease, simplicity, and cheapness by which stupendous trade transactions are carried through by means of cheques will compel an admission that the wonderful system is of incalculable advantage to the traders of the country. Again, complaints are made of the difficulty of obtaining advances, when required, to finance contracts; but this is very often due to ignorance of the ways and means of obtaining such advances. It must nevertheless be admitted that there is perhaps a hardship inflicted upon the trader who has no security to offer which is approved by the banks, and to remove this it has been proposed that a scheme should be devised by the Government in conjunction with the banks whereby the making good any loss sustained by the banks in granting advances to *bona fide* traders, in order to allow of the carrying on of their business, should be guaranteed by the Government.

Generally, however, a trader who requires temporary financial help in the course of his business can always obtain such when he can offer adequate banking security, and that, too, at a very cheap rate. As a rule the rate is 1 per cent. above the Bank of England rate for discounting bills, with, of course, a minimum, which is usually fixed at 4½ per cent. This rate allows a margin of profit to be obtained by the trader from the use of the borrowed money. In this connection also it has to be observed that, by a course of evolution, the methods and instruments necessary to enable properties to be properly deposited as security have been developed to the greatest simplicity and least expense, and the range of properties which banks will accept as security cover most investments which a prudent man will ordinarily make. If we take the case of a manufacturer who requires an advance to obtain, say, raw material. Should he have investments in any bonds, stocks or shares, he can deposit them with his banker under a simple form of charge at the cost of a sixpenny stamp, and immediately obtain an advance of, say, two-thirds of their selling value—*i.e.*, of course, supposing they are not of a speculative nature, nor have a large reserve liability attaching to them. If his money is invested in house property, the deeds can be deposited under a form of equitable mortgage. There is a larger stamping cost—2s. 6d. per cent., calculated on the value of the property lodged. This form has the advantage that it need not necessarily show on the title deeds. The extent of the advance to be obtained on this security will roughly be, say, two-thirds of the valuation of the property from the bank's point of view—viz., its possible selling value. Another form of security is a life insurance policy which has a surrender value. The expense attaching to this kind of security is, however, more costly, as the policy has to be legally mortgaged; but when this has been done an advance can be obtained up to about the amount of the surrender value. Other acceptable securities are dock and warehouse warrants which cover raw material and goods deposited therein, and advances are made against these, providing they are lodged with a letter undertaking to devote the proceeds of their sale first to paying off the advance made against them. The discounting of good trade bills is well known to be one of the foundations of financing trade, and supplies a large portion of the means whereby the trader is able to carry on his business. There may be traders who are unable to offer any such securities or sufficient of them, but if they are able to obtain someone of established standing and repute, who is stated by his banker to be good for the amount proposed, his guarantee will generally be taken. There is the trader also whose whole means are employed in his business and who cannot offer any of the securities set out above; but if he can show by his balance-sheet that he is doing a lucrative and flourishing business, and has a good preponderance of easily-realisable assets over liabilities, even he can generally obtain the advance he requires, providing it is for the purposes of his business, is required temporarily, and is in due proportion to the business he is doing.

It will therefore be seen that even with the limitations of the present banking system a wide field is available for financing trade. The methods employed, too, have the advantage that they reduce the evil of overtrading to a minimum. The only case requiring greater elasticity is, perhaps, that of a trader who can obtain profitable business, which he is fully capable of carrying out successfully, if he could be accommodated temporarily with the necessary capital. It is precisely such cases that the credit bank has been established to meet; but it ought to be easy to devise some means whereby this difficulty may be overcome under the present banking system of this country.

The success of all trading banks is due to the intimate knowledge obtained, and the thorough inspection maintained, of the businesses with which they are connected. This knowledge and inspection are greatly assisted by the strictly-enforced legal necessity in foreign countries of keeping proper

books of account, and this practice could, with much advantage, be adopted in this country. Foreign traders also, by reason of the close supervision of the credit banks, are compelled to take strict measures and devise systems whereby the state of the business can be gauged almost from day to day, while full and proper balance-sheets are prepared, sometimes monthly, or, at any rate, much more frequently than in England. All this information is imparted to the banker, and in all matters where finance plays an important part the advice of the banker is sought. The result is that, when assistance is required, either as monetary help or in reply to inquiries respecting the business and its financial standing, this knowledge enables such assistance to be safely given to the full extent the occasion requires, and to the great benefit of trade generally. The English trader's management of the financial side of the business is in sharp contrast to this. Instead of confiding in his banker, and affording him every opportunity of ascertaining the financial standing of the business, the practice would almost seem to be to keep the banker in ignorance. Too often is the view taken that it is a great mistake to allow the banker to have more knowledge of the business than he can glean from the transactions in his books. This is no doubt due in some measure to the curious secretive trait in the English character, and in a larger degree to the impersonal relations at present existing between the management of joint-stock banks and their clients. Whatever the reason, it is undoubtedly a fact that this attitude seriously limits the usefulness of the banker to the trader, and is the cause of a good deal of the rigidity now enforced with regard to the advancing of money without security. Indeed, the impersonal attitude of the banks may have been initiated by reason of the prevalence of this secretive habit.

Thus the establishment of a new form of trading bank seems not only inopportune, but to a great extent unnecessary, as the present system with some amendment might be made sufficient for the financing of contracts. But to obtain the fullest results from our financial system, particularly to enable a resumption of the personal factor in banking relations, it is necessary for both sides to change their attitude if not their practices. The trader should break himself of the habit of reticence, and fully and properly keep his banker informed as to his financial position, so as to obtain the greatest benefit possible from this relation. On the other hand, the banker should endeavour to make his system so flexible that it will be able to meet every change and phase of business as closely as possible, remembering that it is essential that more personal relations should be established with his customer. If these two suggestions could be borne in mind and acted upon, the assistance given to trade would result in a great stimulus to industry, and a sound increase to national prosperity.

REPEATED STRESSES.

We believe it was Fairbairn who first proved by experiment that structural material subjected to alternating loads would fail at stresses very materially below the statical breaking strength. If our memory serves us, the investigation originated in a dispute between this great engineer and the Board of Trade, who held that certain bridgework designed by Fairbairn failed to comply with their requirements, which made no distinction between the effect of live and dead loads. Fairbairn, being an engineer of exceptional acumen, was convinced that a structure was far more severely tried by live than by dead loads; but a Government department ever seeks safety in a rigid adherence to regulations, however antiquated and imperfect they may be. The controversy ended accordingly in Fairbairn agreeing to strengthen the structure in question, whilst the department consented to subscribe towards the cost of breaking a girder by repeated loadings. These experiments established very clearly the accuracy of Fairbairn's view, but little or nothing further appears to have been accomplished in this country for some years. In Germany, however, Wöhler published in 1871 the results of a very exhaustive series of experiments which confirmed and greatly extended Fairbairn's results, and these have formed the starting-point for many subsequent researches directed to the same end.

The great difficulty met with in Wöhler's method of experiment is the length of time required to complete a research. Some of his specimens were submitted to as many as 48,000,000 repetitions of stress. Many investigators have attempted to obviate this great expenditure of time by increasing the range of stress to such a limit that failure occurs with a more reasonable number of repetitions. One proposal made, for example, has been to determine the stress required to fracture the specimen in 1 million repetitions, whilst at the National Physical Laboratory, Berlin, the standard adopted has been the number of repetitions of a stress of 19 tons per sq. in. which will break a specimen. It is, however, by no means certain that the order of merit of specimens as determined by these short-time tests is the same as when the stress is so low that some millions of repetitions are required to effect fracture.

In his memorandum to the Manchester Steam-Users' Association, lately issued, Mr. C. E. Stromeyer claims to have discovered a method of determining from short-period tests the stress limit which a bar will carry indefinitely, thus obtaining from short-period tests the same information as would be afforded by a very prolonged Wöhler test. He finds that the results of repeated stress experiments can be expressed in the form :—

$$N = \frac{10^6\ C^4}{(S_n - F_l)^4},$$

where $\pm S_n$ denotes the stresses to which the bar is subjected, F_l the "fatigue limit" of the material, and N the number of repetitions before fracture. The "fatigue limit" denotes the limit of alternating stress which the material will carry indefinitely. The formula, it will be seen, comprises only two constants—viz., C and F_l, and these can be determined by two experiments, one of which is preferably made with a pretty high range of stress, and the other with a range which produces fracture in, say, one million repetitions. To test the formula Mr. Stromeyer has prepared his test-pieces with a series of six "waists," each of which is broken in turn under the alternating stress by gripping the specimen in a special rotating socket, the other end being loaded. From each bar, therefore, six sets of results are obtained, each successive waist being subjected to a smaller range of stress than its predecessor, and requiring a correspondingly greater number of repetitions to produce fracture. By breaking in this way a single bar in six different places errors due to local variations in the quality of the material are minimised, though no doubt they are not wholly eliminated. Some very interesting data on this head are given in Mr. Stromeyer's report, from which we reproduce the annexed table, showing the very considerable differences in the elastic limit and yield-point of eight specimens sawn from the corner of a large boiler-plate.

Table I.—*Elastic Limits and Yield-Points of Specimens from a Large Boiler-Plate.*

Sample No.	Test Results.				Differences from Mean.			
	Elastic Limit.	Yield-Point.	Tenacity.	Elongation.	Elastic Limit.	Yield-Point.	Tenacity.	Elongation.
	Tons per Sq. In.			p.c.	Per Cent.			
1	—	22.0	28.2	22.5	—	− 0.5	+0.7	−8.1
2	14.1	24.6	28.0	24.0	+18.5	+11.3	0	−2.0
3	12.5	21.7	27.4	26.5	+ 5.0	− 1.8	−2.1	+8.1
4	10.7	22.0	28.0	24.0	−10.0	− 0.5	0	−2.0
5	11.4	22.6	28.2	24.5	− 4.2	+ 2.2	+0.7	0
6	10.6	22.1	28.0	23.0	−10.9	0	0	−6.1
7	12.2	22.5	27.9	24.5	+ 2.5	+ 1.8	−0.4	0
8	11.9	19.4	28.3	25.7	0	−12.2	+1.1	+12.2
Mean	11.9	22.1	28.0	24.7	—	—	—	—

With the notched-bar test, again, successive fractures of the same bar often show very substantial variations in the amount of work required to produce fracture, a circumstance which, to some degree, limits the usefulness of this very convenient and searching test. It is, in fact, too drastic in character to serve as a basis for specifications, since a very large margin between maximum and minimum results would be required to cover the variations found in steel of recognised excellent quality. The Wöhler test appears less exacting, and Mr. Stromeyer's results yield reasonably straight lines when the repetitions required for fracture are plotted against

$$\left[\frac{1}{S_n - F_l}\right]^4.$$

The important factor in the Wöhler tests is the value of F_l. The direct determination of this constant necessitates the execution of experiments extending over a year or 18 months, and is therefore impractical from the commercial standpoint. The short-period tests, as hitherto carried out, do not, however, discriminate good material from bad. This was strikingly shown in some results brought before the Institution of Mechanical Engineers in 1909 by Dr. J. E. Stead, of Middlesbrough, in a discussion of a report by the Alloys Committee. A number of steel bars, of which one-third contained 0.04 per cent. of phosphorus, another third 0.30 per cent., and the remainder 0.5 per cent., were tested in various ways. In the Wöhler test the high-phosphorus steel withstood more than 10½ times the number of repetitions required to fracture the low-phosphorus bars; whilst in impact tests, and in Professor Arnold's alternating-strain test, the low-phosphorus bars showed a very marked superiority. As everyone knows, the high-phosphorus metal is exceedingly unreliable, and the apparently good results obtained in the Wöhler test were wholly, indeed dangerously, misleading. It should, however, be noted that in the case in question the Wöhler test was carried out under such a stress that fracture took place in from 60,000 to 650,000 repetitions. It is conceivable that had the stress been lowered so that millions of repetitions were needed, the low-phosphorous steel might have made a better showing. It would be of very great interest if a set of experiments could be made with a similar range of materials by Mr. Stromeyer's method, so as to discover whether the values of the fatigue limit under an infinite number of stress repetitions really affords a clue as to the structural value of the material.

Although the value of this fatigue limit would appear from Mr. Stromeyer's data to be determinable from short-period tests, the time needed even for 50,000 repetitions of stress constitutes a material drawback to the commercial adoption of the method.

Great interest attaches, accordingly, to another method of determining this limit, described in a later portion of Mr. Stromeyer's memorandum. As Lord Kelvin pointed out years ago, the stretching of a bar within its elastic limit cools it, whilst a compression heats it, and this fact has very ingeniously been made use of by Professor E. G. Coker for the measurement of stresses and the determination of the elastic limit. The latter operation is feasible, because whilst stretching a bar cools it, so long as the elastic limit is not passed, heat is developed so soon as a permanent set begins to be developed. It is, indeed, a commonplace of the laboratory that the broken end of a tensile testing-piece is too hot to hold at the instant of fracture.

Since an elastic stretch of a body cools it, and an equal elastic compression heats it to an equal degree, a bar under alternating stress should maintain its temperature unaltered so long as the range of stress does not exceed the elastic range of the material, and this is the basis of Mr. Stromeyer's new method of determining the fatigue limit of a specimen. To this end the test-piece is surrounded with a loosely-fitting jacket of rubber, through which a current of water is maintained. The specimen is subjected to an alternating stress, the limit of which is increased until a rise of temperature equal to $\frac{1}{100}$ deg. Cent. is observed in the issuing water. This indicates that the range of stress is exceeding the elastic range of the material, and this range as thus determined is, Mr. Stromeyer finds, identical with the fatigue limit as fixed by very prolonged Wöhler tests. The method has, he says, the advantage of yielding the required result very rapidly, an hour being ample for the operation, and the method is therefore suitable for industrial use.

Of course the question still remains as to how far the fatigue limit constitutes a trustworthy guide as to the suitability of the material for various ends. Indeed, Mr. Stromeyer quite properly points out that other considerations besides the capacity of enduring fatigue have to be taken into consideration in deciding on the suitability of a metal for a particular purpose. Thus, for a crank-shaft a material with a high fatigue limit is desirable, whilst for a mechanism exposed to sudden shocks—such, for instance, as a clutch—it is advisable to sacrifice this property in favour of a capacity for taking punishment. In fact, where severe shocks have to be withstood, it is impossible to avoid straining even the strongest metal beyond its elastic limit, and a high limit is of no value,

since it is sure to be exceeded, and is commonly associated with a certain lack of ductility.

The following table gives the values of C and F_l for various materials, as determined by Mr. Stromeyer for use in his formula :—

Table II.—*Summary of Torsion and Bending Fatigue Tests.*

Materials.	Torsion Fatigue.		Bending Fatigue.	
	F_l.	C.	F_l.	C.
	tns. p. sq. in.		tns. p. sq. in.	
Chrome-nickel steel, F 5117	12·60*	0.50	—	—
Nineteen samples of chrome-nickel steel	11.37*	0.70	—	—
Manganese steel, F 5109..	11.10*	2.42	—	—
Cast steel	10.70*	0.68	—	—
,, ...	7.03*	1.91	—	—
Mild-steel plates. High results, Q ..	9.69	1.26	14.08	4.70
,, ,, ,, ,, H ..	9.71	1.55	13.86	5.46
,, ,, ,, ,, R ..	11.04	1.11	13.82	5.71
,, ,, ,, ,, L ..	8.16	1.55	14.39	4.36
Mean for above mild steels ..	9.65	1.37	14.04	5.06
Mild-steels. Exceptional qualities, Y	7.56	2 40	13.30	5.40
,, ,, ,, ,, F	8.64	1.26	Doubtful	
Mild-steel plates. Low results, J ..	7.01	1.36	9.36	5.31
,, ,, ,, ,, ,, A ..	7.09	1.26	8.94	4.79
,, ,, ,, ,, ,, T ..	6 33	2.03	8 95	5.13
,, ,, ,, ,, ,, U ..	6.94	1.69	8.15	5.61
,, ,, ,, ,, ,, Z ..	5.54	1.43	9.69	4.53
,, ,, ,, ,, ,, N ..	5.90	1.58	7.42	5.17
Mean	6.47	1.56	8.75	5.09
Mild-steel rods, L F	6 83*	1.60	—	—
,, ,, L A	5.97*	0.97	—	—
Pure-nickel rods, N I	6.22*	1.83	—	—
Farnley iron rods, F A B†	6.00*	0 61	—	—
Copper rods, as rolled, C U†	5.50*	0 41	—	—
,, annealed, C U†	2 69*	0.97	—	—
Aluminium rods, as rolled, A L ..	2.16*	0.13	—	—
Cast iron (one sample), C I	3.98*	1.61	—	—
Phosphor-bronze rods, as rolled, P B..	7.82*	0.78	—	—
Magnalium rods, as rolled, M A ..	4.21*	0.77	—	—
Duralium rods, as rolled, D A	5.80*	Negative	—	—

* These fatigue limits were determined calorimetrically.
† See also Table V.

It will be seen that Mr. Stromeyer finds a material difference between the results of torsion tests and bending tests. This point is not without its interest in connection with the much-vexed question as to the actual nature of the process by which metals fail. With some metals, certainly, this failure appears to be primarily due to shear ; but there are other metals with which the experimental evidence agrees better with Rankine's hypothesis, that the tensile stress is the measure of the strength of the material. There seems little or no evidence in favour of St. Venant's view that the maximum strain is the true criterion of strength, though this is the view that has commended itself to many mathematicians.

A very interesting matter mentioned in Mr. Stromeyer's memorandum is that there is some evidence that certain varieties of steel can undergo a certain "healing" process with time. Practical experience has led many engineers to believe that this view is correct; but hitherto such experimental evidence as has been available has rather negatived the supposition. It is, of course, well known that the elastic properties of a steel rail improve for a day or two after it leaves the rolls ; but bars subjected to alternating stress, and then given a long period of rest, have hitherto afforded little or no evidence of a recovery of their original elastic properties, breaking with about the same total number of stress repetitions as if these had proceeded without interruption. Nevertheless, there were not a few practical and theoretical considerations which gave support to the view that there should be some elastic recovery of the kind in question. With his thermal method of testing, Mr. Stromeyer has found distinct evidence of this, certain specimens when again tested, after an interruption of 18 hours, showing only a normal development of heat. In other cases, however, there was no sign whatever of any recovery from the effects of the previous straining. Unfortunately, none of the specimens which showed signs of an elastic recovery were of ordinary mild steel, and further experiments on this very interesting point are highly desirable.

IRON-ORE DEPOSITS IN FRANCE.

Among the papers which were to be read at the Paris meeting of the Iron and Steel Institute a few weeks ago was one written by Mr. Paul Nicou, mining engineer, Paris, describing the iron-ore deposits of Eastern and Western France. The paper opens with the following statement :—"Now that France has become—during the last few years and owing chiefly to the development of the calcareous ores of the Briey ore-field—one of the principal ore-exporting countries, it will soon become a matter almost of necessity for the leading ore-importing countries to arrange to secure a share of the output in proportion to their respective requirements." This was written before the war broke out, and the Eastern, or French Lorraine ore-basin dealt with by the author having been since the commencement of hostilities one of the battle centres—it extends from Longwy, in the north, along the Franco-German frontier—most of the headworks, kilns, furnaces, and power-stations have, no doubt, and very unfortunately, suffered heavy damage, and will have to be repaired or totally rebuilt before any further operation can be proceeded with. Some time must now necessarily elapse before the French concessionaire companies can apply the Lorraine iron ores to their own needs or to export any quantity.

The Lorraine ore-basin is divided into three districts—the Longwy district to the north, the Briey district in the centre, and the Nancy district to the south. Over the whole zone 114 concessions have now been granted, covering an area of about 68,356 hectares (169,000 acres). The formation extends beyond the French frontiers, and covers large areas in the Grand Duchy of Luxemburg and in German Lorraine ; it also extends over a comparatively small area in Southern Belgium, as shown by the map attached to the paper. In Luxemburg the area which can usefully be worked covers 3600 hectares (8900 acres) ; in German Lorraine the figure is 43,000 hectares (106,260 acres), and in Belgium 300 hectares only (740 acres). The whole formation in France, Belgium, Luxemburg, and German Lorraine constitutes what is called the "Minette basin." The ore mined in the Belgian, Luxemburg, and German areas is stated to be less rich in iron than that of the Briey basin. This is illustrated by the fact that works in Luxemburg and German Lorraine which had been put down to deal with their own local ores have since acquired participations in a number of French Lorraine deposits. Westphalian works also have repeatedly endeavoured to obtain from the French basin a portion of their supplies.

From a geological point of view, the author states, the "minette" deposits form a portion of the great Paris basin, bounded to the north-east by the primary rock of the Ardennes, and by the Eifel and the Vosges. The beds outcrop at various places, the formation being the more recent the nearer Paris is approached. In French Lorraine the beds belong to three different geological systems, in one of which the ironstone mainly occurs, with a fairly uniform dip towards the west of about 1 to 1.5 in 100. The ore contains from 1.7 to 1.9 per cent. of phosphorus. The percentage of iron seldom exceeds 42 in the ore which has been dried at a temperature of 110 deg. Cent.; it is very generally between 33 and 40 per cent., and falls below 30 per cent. in some iron-bearing limestones used as fluxes, mined in some portions of the Nancy basin, whereas in other portions of the zone and, generally speaking, in Briey, the percentage of iron ordinarily runs between 36 and 40 per cent.

Dealing separately with the regions in French Lorraine, the author states that the ore of the Nancy zone is generally freely silicious, containing from 12 to 16 per cent. of silica and from 6 to 9 per cent. of lime. At certain points it becomes calcareous, as, for instance, below the forest of Haye, where analyses have shown it to contain 14 per cent. of lime and 10 per cent. of silica ; the iron percentage rarely exceeds 37 per cent. in the ore dried at 110 deg. Cent. The Nancy zone appears to contain 200,000,000 tons of ore. The annual output is approximately 2,000,000 tons, the great bulk of which is dealt with in local iron works ; a small proportion is carried, chiefly by water, to the blast-furnaces of the North of France, the Ardennes district, and abroad. In 1913 the quantity exported was 343,000 tons, of which 106,000 tons were sent to Belgium and 237,000 tons to Germany.

In the Briey zone there are three sub-divisions —those of Orne, Landres, and Tucquegnieux. The Orne sub-division is situated to the south of the Avril fault ; the seam has an average thickness of from 3 m. to 5 m. (10 ft. to 16 ft.), the percentage of iron ranging from 34 to 40 per cent. The ore is freely calcareous except towards the west, where the percentage of silicon increases. The Landres sub-division lies to the west of the Bonvillers and Norry faults ; the thickness of the seam varies from 5 m. to 9 m. (16 ft. to 30 ft.), but towards the west it falls to 3 m. or 4 m. (10 ft. to 13 ft.). According to the areas where the ore is mined, the dried ores show about 12 per cent. of lime, 6 per cent. of silica, and 35 to 42 per cent. of iron, or 17 per cent. of lime, 6 per cent. of silica, and 31 to 35 per cent. of iron. In the Tucquegnieux sub-division, the seam has a thickness of from 6 m. to 7 m. (20 ft. to 23 ft.), the gangue being distinctly calcareous generally. One pit, at Erronville, which started working in 1912, yielded ore containing from 36 to 39 per cent. of iron. The Briey zone is estimated to contain 2000 million tons of ore.

In the Longwy zone there are, as in the two preceding ones, several seams of different character, some in which the percentage of iron varies between 20 and 28 per cent., others containing 32 to 40 per cent. of iron with 13 to 20 per cent. of silica, and 3 to 7 per cent. of lime, the thickness of the seams varying from 1 m. to 4 m. (3 ft. to 13 ft.) reaching 7 m. (23 ft.) in some instances. The estimated quantity of ore in the Longwy zone is 275,000,000 tons. In 1913 there was exported from this part of the French Lorraine basin to Germany 271,000 tons ; to Belgium, 175,000 tons ; and to Luxemburg, 58,000 tons.

A fourth zone is styled the Crusnes zone, which lies in the neighbourhood of the Landres district above referred to, and where less work has been carried out so far than in the three other portions of French Lorraine. It is estimated to contain 500 million tons of ore, mostly silicious, and in which the iron content varies from 30 to 38 per cent.

The iron ore available in the French Lorraine basin will therefore be seen to amount to a total of close upon 3000 million tons. Belgium has become practically dependent on the Lorraine ores, and in 1912 she took from the French basin 4,351,000 tons. The French Lorraine basin, says the author, may become in the near future one of the largest contributors of iron ore to the United Kingdom. The Lorraine mines are, no doubt, in a less favourable condition, from the point of view of transport facilities, than other French mines, since Homécourt, the centre of the French Lorraine basin, is about 400 km. (250 miles) by rail from the harbours of Dunkirk or Calais, and no direct waterway is so far available to the sea from the Briey mines, from which alone exports to England would be contemplated. In Belgium the available shipping ports for transit to this country are Antwerp, Ghent, and Bruges, and, as a matter of fact, some ore shipments have already been made to Great Britain from these ports.

The other iron-ore basins dealt with by the author are those in Normandy, Anjou, and Brittany, on the Atlantic Coast of France. A large portion of the iron ore mined in Normandy is dealt with in the blast-furnaces which form part of iron works located in the North of France ; other blast-furnaces for treating it are in course of construction in the vicinity of Caen. Some of the Normandy iron ore was shipped until recently to the Thyssen works in Westphalia, and an increasing proportion has been shipped to Great Britain. The Normandy hematites of St. Remy contain from 52 to 55 per cent. of iron, 10 to 12 per cent. of silica, 3 per cent. of alumina, 2.5 per cent. of lime and magnesia, 0.6 to 0.7 per cent. of phosphorus, and 3 per cent. of water. Those of other mines have a percentage of iron of from 46 to 51 per cent., whilst still other mines yield other classes of ores. The iron-ore resources of Normandy are difficult to estimate ; according to one calculation, they amount to 220,000,000 tons.

Those of Anjou and Brittany are more difficult to estimate still. The ores from these districts are partly dealt with at the Trignac Iron Works, located in close proximity to the Chantier et Ateliers de St. Nazaire, and are partly exported to Great Britain and to Germany. They consist of oolitic iron ore, hematite and magnetite, either intermixed or separate, the colour varying from dark grey to yellowish red, the percentage of iron attaining at times 61 per cent., but usually amounting to 52 and 55 per cent. They are highly silicious, containing frequently from 13 to 20 per cent. of silica. They are slightly calcareous, containing 1 per cent. of lime ; slightly clayey, containing

from 2 to 4 per cent. of alumina. The phosphorus content varies from 0.6 to 0.7 per cent.

The Normandy, Anjou, and Brittany basins yield annually over one million tons of ore; of this quantity, about two-thirds is utilised in other French districts or exported.

Besides the above main French iron-ore deposits, there are others, very much less important from the point of view of available quantities, in the South of France, in the Pyrenees, and in the Var Department on the Mediterranean. The Pyrenees iron ore is remarkably free from phosphorus, and practically the whole of it, with that of the Var Department, is dealt with in French iron works.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. V

By Frederick William Lanchester, M. Inst. C.E.

The Principle of Concentration.

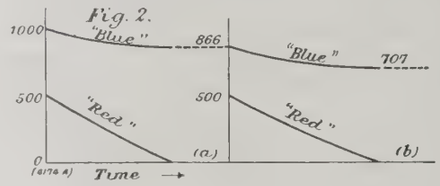
It is necessary at the present juncture to make a digression and to treat of certain fundamental considerations that underlie the whole science and practice of warfare in all its branches. One of the great questions at the root of all strategy is that of *concentration*; the concentration of the whole resources of a belligerent on a single purpose or object, and concurrently the concentration of the main strength of his forces, whether naval or military, at one point in the field of operations. But the principle of concentraion is not in itself a strategic principle; it applies with equal effect to purely tactical operations; it is on its material side based upon facts of a purely scientific character. The subject is somewhat befogged by many writers of repute, inasmuch as the two distinct sides—the moral concentration (the narrowing and fixity of purpose) and the material concentration—are both included under one general heading, and one is invited to believe that there is some peculiar virtue in the word *concentration* (like the blessed word "Mesopotamia"), whereas the truth is that the word in its two applications refers to two entirely independent conceptions, whose underlying prineiples have nothing really in common.

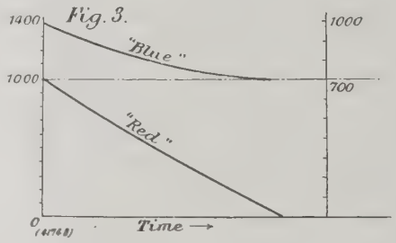
The importance of concentration in the material sense is based on certain elementary principles connected with the means of attack and defence, and if we are properly to appreciate the value and importance of concentration in this sense, we must not fix our attention too closely upon the bare fact of concentration, but rather upon the underlying principles, and seek a more solid foundation in the study of the controlling factors.

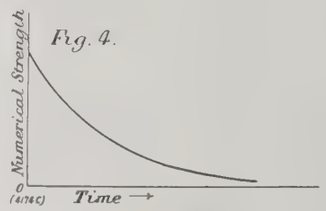
There is an important difference between the methods of defence of primitive times and those of the present day which may be used to illustrate the point at issue. In olden times, when weapon directly answered weapon, the act of defence was positive and direct, the blow of sword or battleaxe was parried by sword and shield; under modern conditions gun answers gun, the defence from rifle-fire is rifle-fire, and the defence from artillery, artillery. But the defence of modern arms is indirect: tersely, the enemy is prevented from killing you by your killing him first, and the fighting is essentially collective. As a consequence of this difference, the importance of concentration in history has been by no means a constant quantity. Under the old conditions it was not possible by any strategic plan or tactical manœuvre to bring other than approximately equal numbers of men into the actual fighting line; one man would ordinarily find himself opposed to one man. Even were a General to concentrate twice the number of men on any given portion of the field to that of the enemy, the number of men actually wielding their weapons at any given instant (so long as the fighting line was unbroken), was, roughly speaking, the same on both sides. Under present-day conditions all this is changed. With modern long-range weapons—fire-arms, in brief—the concentration of superior numbers gives an immediate superiority in the active combatant ranks, and the numerically inferior force finds itself under a far heavier fire, man for man, than it is able to return. The importance of this difference is greater than might casually be supposed, and, since it contains the kernel of the whole question, it will be examined in detail.

In thus contrasting the ancient conditions with the modern, it is not intended to suggest that the advantages of concentration did not, to some extent, exist under the old order of things. For example, when an army broke and fled, undoubtedly any numerical superiority of the victor could be used with telling effect, and, before this, pressure, as distinct from blows, would exercise great influence. Also the bow and arrow and the cross-bow were weapons that possessed in a lesser degree the properties of fire-arms, inasmuch as they enabled numbers (within limits) to concentrate their attack on the few. As here discussed, the conditions are contrasted in their most accentuated form as extremes for the purpose of illustration.

Taking, first, the ancient conditions where man is opposed to man, then, assuming the combatants to be of equal fighting value, and other conditions equal, clearly, on an average, as many of the "duels" that go to make up the whole fight will go one way as the other, and there will be about equal numbers killed of the forces engaged; so that if 1000 men meet 1000 men, it is of little or no importance whether a "Blue" force of 1000 men meet a "Red" force of 1000 men in a single pitched battle, or whether the whole "Blue" force concentrates on 500 of the "Red" force, and, having beaten them, turns its attention to the







other half; there will, presuming the "Reds" stand their ground to the last, be half the "Blue" force wiped out in the annihilation of the "Red" force* in the first battle, and the second battle will start on terms of equality—*i.e.*, 500 "Blue" against 500 "Red."

Now let us take the modern conditions. If, again, we assume equal individual fighting value, and the combatants otherwise (as to "cover," &c.) on terms of equality, each man will in a given time score, on an average, a certain number of hits that are effective; consequently, the number of men knocked out per unit time will be directly proportional to the numerical strength of the opposing force. Putting this in mathematical language, and employing symbol b to represent the numerical strength of the "Blue" force, and r for the "Red," we have:—

$$\frac{db}{dt} = -r \times c \quad . \quad . \quad . \quad . \quad (1)$$

and

$$\frac{dr}{dt} = -b \times k \quad . \quad . \quad . \quad . \quad (2)$$

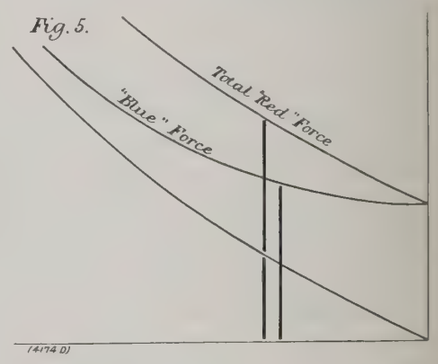
in which t is time and c and k are constants ($c = k$ if the fighting values of the individual units of the force are equal).

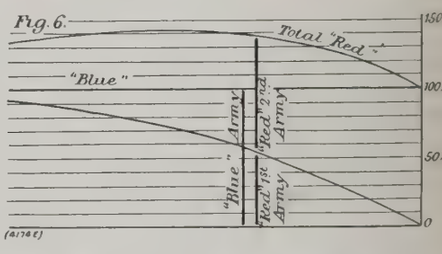
The reduction of strength of the two forces may be represented by two conjugate curves following the above equations. In Fig. 2 (a) graphs are given representing the case of the "Blue" force 1000 strong encountering a section of the "Red" force 500 strong, and it will be seen that the "Red" force is wiped out of existence with a loss of only about 134 men of the "Blue" force, leaving 866 to meet the remaining 500 of the "Red" force with an easy and decisive victory; this is shown in Fig. 2 (b), the victorious "Blues" having annihilated the whole "Red" force of equal total strength with a loss of only 293 men.

In Fig. 3 a case is given in which the "Red' force is inferior to the "Blue" in the relation $1 : \sqrt{2}$ say, a "Red" force 1000 strong meeting a "Blue" force 1400 strong. Assuming them to meet in a single pitched battle fought to a conclusion, the upper line will represent the "Blue" force (numbers being read on the left-hand scale), and it is seen that the "Reds" will be annihilated, the "Blues" losing only 400 men. If, on the other hand, the "Reds" be numerically greater, but the "Blues" by superior strategy compel the "Reds" to give battle divided—say into two equal armies—then in the first battle the 700 "Reds" will be annihilated with a loss of only 300 to the "Blues" (numbers being read from the right-hand scale), and in the second battle the two armies will meet on an equal numerical footing, and so we may presume the final battle of the campaign as drawn. In this second case, the result of the second battle is presumed from the initial equality of the forces; the curves are not given.

In the case of equal forces the two conjugate curves become coincident; there is a single curve of logarithmic form, Fig. 4; the battle is prolonged indefinitely. Since the forces actually consist of a finite number of finite units (instead of an infinite number of infinitesimal units), the end of the curve must show discontinuity, and break off abruptly when the last man is reached; the law based on averages evidently does not hold rigidly when the numbers become small. Beyond this the condition of two equal curves is unstable, and any advantage secured by either side will tend to augment.

In Fig. 5 a pair of conjugate curves have been





plotted backwards from the vertical datum representing the finish, and an upper graph has been added representing the total of the "Red" force, which is equal in strength to the "Blue" force for any ordinate, on the basis that the "Red" force is divided into two portions as given by the intersection of the lower graph. In Fig. 6 this diagram has been reduced to give the same information in terms *per cent.* for a "Blue" force of constant value. Thus in its application Fig. 6 gives the correct percentage increase necessary in the *paper* fighting value of, for example, an army or fleet to give equality, on the assumption that political or strategic necessities impose the condition of dividing the said army or fleet into two in the proportions given by the lower graph, the enemy being able to attack either portion with his full strength. Alternatively, if the constant (= 100) be taken to represent a numerical strength that would be deemed sufficient to ensure victory against the enemy, given that both fleets engage in their full strength, then the upper graph gives the numerical superiority needed to be equally

* This is not strictly true, since towards the close of the fight the last few men will be attacked by more than their own number. The main principle is, however, untouched.

sure of victory, in case, from political or other strategic necessity, the fleet has to be divided in the proportions given. In Fig. 6 abscissæ have no quantitative meaning.

There are many who will be inclined to cavil at any mathematical or semi-mathematical treatment of the present subject, on the ground that with so many unknown factors, such as the morale or leadership of the men, the unaccounted merits or demerits of the weapons, and the still more unknown "chances of war," it is ridiculous to pretend to calculate anything. The answer to this is simple: the direct numerical comparison of the forces engaging in conflict or available in the event of war is almost universal. It is a factor always carefully reckoned with by the various military authorities; it is discussed *ad nauseam* in the Press. Yet such direct counting of forces is in itself a tacit acceptance of the applicability of mathematical principles, but confined to a special case. To accept without reserve the mere "counting of the pieces" as of value, and to deny the more extended application of mathematical theory, is as illogical and unintelligent as to accept broadly and indiscriminately the balance and the weighing-machine as instruments of precision, but to decline to permit in the latter case any allowance for its known inequality of leverage.

In the equations (1) and (2), two constants were given, c and k, which in the plotting of the figures 2 to 6 were taken as equal; the meaning of this is that the fighting strength of the individual units has been assumed equal. This condition is not necessarily fulfilled if the combatants be unequally trained, or of different morale. Neither is it fulfilled if their weapons are of unequal efficiency. The first two of these, together with a host of other factors too numerous to mention, cannot be accounted for in an equation any more than can the quality of wine or steel be estimated from its weight. The question of weapons is, however, eminently suited to theoretical discussion. It is also a matter that (as will be subsequently shown) requires consideration in relation to the main subject of the present articles.

Any difference in the efficiency of the weapons—for example, the accuracy or rapidity of rifle-fire—may be represented by a disparity in the constants c and k in equations (1) and (2). The case of the rifle or machine-gun is a simple example to take, inasmuch as comparative figures are easily obtained which may be said fairly to represent the fighting efficiency of the weapon. Now numerically equal forces will no longer be forces of equal strength; they will only be of equal strength if, when in combat, their losses result in no change in their numerical proportion. Thus, if a "Blue" force initially 500 strong, using a magazine rifle, attack a "Red" force of 1000, armed with a single breech-loader, and after a certain time the "Blue" are found to have lost 100 against 200 loss by the "Red," the proportions of the forces will have suffered no change, and they may be regarded (due to the superiority of the "Blue" arms) as being of equal strength.

If the condition of equality is given by writing M as representing the efficiency or value of an individual unit of the "Blue" force," and N the same for the "Red," we have :—

Rate of reduction of "Blue" force :—

$$\frac{db}{dt} = -\,\mathrm{N}\,r \times \text{constant} \quad . \quad . \quad (3)$$

and "Red,"

$$\frac{dr}{dt} = -\,\mathrm{M}\,b \times \text{constant} \quad . \quad . \quad (4)$$

And for the condition of equality,

$$\frac{db}{b\,dt} = \frac{dr}{r\,dt},$$

or

$$\frac{-\,\mathrm{N}\,r}{b} = \frac{-\,\mathrm{M}\,b}{r},$$

or

$$\mathrm{N}\,r^2 = \mathrm{M}\,b^2 \quad . \quad . \quad . \quad (5)$$

In other words, the fighting strengths of the two forces are equal when the *square of the numerical strength multiplied by the fighting value of the individual units are equal.*

It is easy to show that this expression may be interpreted more generally; the *fighting strength* of a force may be defined as being proportional to the *square of its numerical strength × the fighting value of its individual units.*

Thus, referring to Fig. 6, the sum of the squares of the two portions of the "Red" force are for all values equal to the square of the "Blue" force (the latter plotted as constant); the curve might equally well have been plotted directly to this law as by the process given.

As an example of the above, let us take the case of an army of 50,000 giving battle in turn to two armies of 40,000 and 30,000 respectively, equally well armed; then the strengths are equal, since $(50{,}000)^2 = (40{,}000)^2 + (30{,}000)^2$. If, on the other hand, the two smaller armies are given time to effect a junction, then the army of 50,000 will be overwhelmed, for the fighting strength of the opposing force, 70,000, is no longer equal, but is in fact nearly twice as great—namely, in the relation of 49 to 25. Superior morale or better tactics or a hundred and one other extraneous causes may intervene in practice to modify the issue, but this does not invalidate the mathematical statement. The position may be summarised by saying that if two equally armed forces meet in battle, their relative *paper* fighting strength is a function of their numbers alone, and is equal when the numbers are equal; likewise, and more generally, *the paper fighting strength of any force is the product of the square of its numerical strength and the fighting value of its individual units.*

Let us now take an example in which the fighting value of the unit is a factor. We will assume that, as a matter of experiment, one man using a Lewis machine-gun as a shoulder arm can do as much mischief in a given time as sixteen riflemen. What is, *on paper*, the number of men armed with the Lewis gun necessary to replace a battalion a thousand strong in the field? Taking the fighting value of a rifleman as unity, let n = the number required. The paper fighting strength of the battalion is $(1000)^2$ or, $n = \sqrt{\frac{1{,}000{,}000}{16}} = \frac{1000}{4} = 250$, or one quarter the number of the opposing force.

This example is instructive; it exhibits at once the utility and weakness of the method. The basic assumption is that the fire of each force is definitely *concentrated* on the opposing force. Thus the enemy will concentrate on the one machine-gun operator the fire that would otherwise be distributed over four riflemen, and so on an average he will only last for one quarter the time, and at sixteen times the efficiency during his short life he will only be able to do the work of four riflemen in lieu of sixteen, as one might easily have supposed. This is in agreement with the equation. The conditions correspond to those prevalent in the Boer War, when individual-aimed firing or sniping was the order of the day.

When, on the other hand, the circumstances are such as to preclude the possibility of such concentration, as when searching an area or ridge at long range, or volley firing at a position, or "into the brown," the basic conditions are violated, and the value of the individual machine-gun operator becomes more nearly that of the sixteen riflemen that the power of his weapon represents. The same applies when he is opposed by shrapnel fire or any other weapon which is directed at a position rather than the individual. It is well thus to call attention to the variations in the conditions and the nature of the resulting departure from the conclusions of theory; such variations are far less common in naval than in military warfare; the individual unit—the ship—is always the gunner's mark. When we come to deal with aircraft, we shall find the conditions in this respect more closely resemble those that obtain in the Navy than in the Army; the enemy's aircraft individually rather than collectively is the air-gunner's mark, and the law herein laid down will be applicable.

Apart from its connection with the main subject, the present line of treatment has a certain fascination, and leads to results which, though probably correct, are in some degree unexpected. If we modify the initial hypothesis to harmonise with the conditions of long-range fire, and assume the fire concentrated on a certain area known to be held by the enemy, and take this area to be independent of the numerical value of the forces, then, with notation as before, we shall have—

$$\frac{db}{dt} = b \times \mathrm{N}\,r,$$

$$\frac{dr}{dt} = r \times \mathrm{M}\,b,$$

or

$$\frac{\mathrm{M}\,db}{dt} = \frac{\mathrm{N}\,dr}{dt},$$

or the rate of loss is independent of the numbers engaged, and is directly as the efficiency of the weapons. Under these conditions the *paper strength* of the forces is directly proportional to their numerical strength; there is no direct value in concentration, *qua* concentration, and the advantage of rapid fire is relatively great. The conditions in effect approximate more closely to those of ancient warfare.

Evidently it is the business of a numerically superior force to come to close quarters, or, at least, to get within decisive range as rapidly as possible, in order that the concentration may tell to advantage. As an extreme case, let us imagine a "Blue" force of 100 men armed with the Lewis gun as a shoulder arm, opposed by a "Red" 1200 men armed with the ordinary service rifle. Our first assumption will be that both forces are spread over a front of given length and at long range. Then the "Red" force will lose 16 men to the "Blue" force loss of one, and, if the combat is continued under these conditions, the "Reds" must lose. If, however, the "Reds" advance, and get within short range, where each man is an individual mark, the tables are turned, the previous equation and conditions apply, and, even if "Reds" lose half their effective in gaining the new position, with 600 men remaining they are masters of the situation; their strength is $600^2 \times 1$ against the "Blue" $100^2 \times 16$. It is certainly a not altogether expected result that, in the case of fire so deadly as the modern machine-gun, circumstances may arise that render it imperative to come to close range.

It is at least agreed by all authorities that on the field of battle concentration is a matter of the most vital importance; in fact, it is admitted to be one of the controlling factors both in the strategy and tactics of modern warfare. It is aptly illustrated by the important results that have been obtained in some of the great battles of history by the attacking of opposing forces before concentration has been effected. A classic example is that of the defeat by Napoleon, in his Italian campaign, of the Austrians near Verona, where he dealt with the two Austrian armies in detail before they had been able to effect a junction, or even to act in conjunction. Again, the same principle is exemplified in the oft-quoted case of the defeat of Jourdan and Moreau on the Danube by the Archduke Charles in 1796. It is evident that the conditions in the broad field of military operations correspond in kind, if not in degree, to the earlier hypothesis, and that the law deduced therefrom, that the fighting strength of a force can be represented by the square of its numerical strength, does, in its essence, represent an important truth.

FOREIGN MARKETS FOR MOTOR-CARS AND CYCLES.

A good deal of attention has been given at one time and another to the production in this country of motor-cars suitable for use abroad. It appears from statistics and reports, however, that still more might yet be done in order to secure a fair share of the trade which is rapidly developing in many quarters. There are many countries which, owing to the state of their roads, or their great distances and the consequent slowness with which new habits spread, are only just beginning to take an interest in the new form of locomotion. In these cases the design must be specially suited to the needs of the country, and cannot merely be an English model with a new name. We have throughout the Empire, and elsewhere, easily within the reach of our manufacturers, a variety of fields from which to derive experience, and if we keep our eyes open we can learn in some cases lessons from our competitors.

The variety of conditions to be met makes it difficult for one pattern to suit various countries. For instance, in one the roads in the country districts are bad, but in the towns are worse, necessitating the employment of a substantially-built car. In another, most of the work will be found to be on hills on good roads with hairpin bends, in which circumstances high speeds and long wheel bases are disadvantages. Elsewhere the country may generally be flat, but be intersected by irrigation canals, crossed by numerous small arched bridges, when ample clearance underneath the car is essential. For success in another market it is necessary to keep in view the fact that garage charges for cleaning are almost prohibitive, while climatic conditions in other lands require special radiator provision, effective side protection against rain-squalls,

or unusually liberal tank accommodation must be given in view of the distance from source of fuel supplies, and so on. It is thus impossible to lay down certain lines and say that such a car will suit the foreign market. There is undoubtedly a demand in certain lands for a cheap light car. This is being met with much enterprise by American firms. There is little doubt that we could do more in this way than we do at present, for in certain countries, such as India, there would seem to be a good future for machines of this type. In other countries, however, experience with the light car seems to end in a demand for something more substantial. There are said to be indications in South Africa that the light car has had the important effect of educating people up to the value of the motor, but that with experience the public comes to prefer a better class of vehicle. Except in certain European countries, it has to be remembered that the roads are usually very trying, and though a car may be taken for a demonstration run over all kinds of surfaces, the ordinary purchaser requires a machine which will prove serviceable with a minimum of repairs and attention over a long period. On the other hand, many people will buy a particular make if it has shown up well in reliability trials, and it is therefore well to demonstrate in this way, if opportunity offers, the degree of excellence attained by our products.

It is stated that advantage of the opportunities is seldom taken in connection with the Russian market, in many parts of which British cars are practically unknown. Although we exported cars to Russia last year to a value of 118,600*l.*, Germany exported three times as many, their aggregate value amounting to 650,500*l.* Russia is one of those countries where the road question is particularly paramount. Most of the roads appear to be of an execrable character, usually badly cut up by country carts, or deep in mud, and there is bad cobble paving in the towns. A strong car, selling at about 450*l.*, seems to have a good market in Russia; but a cheaper car, if one could be made to withstand the wear and tear, would undoubtedly sell well. If, however, it proved a failure, not only would its own market be lost, but probably also that of other patterns of the same nationality. Germany's success in the Russian motor market is due to the activity which her merchants evince in other directions. They let slip no opportunity of parading their goods before the public, endeavour to keep actual machines at the larger centres, instead of catalogues only, and, in addition, effect quick delivery on favourable terms to their agents. Increasing sales of German cars are a feature in numerous markets. In Spain these cars have been actively pushed. In Italy cars were imported from Germany in 1910 to the number of 65. In 1911 the number rose to 85, while in 1912 it was 170. In the same three years our own exports to Italy merely increased from 15 to 41.

Our exports of motor-cars, chassis and parts total about 3,650,000*l.* Those of Germany are valued at 4,113,350*l.* Germany's principal buyer is Russia, but next to her comes the United Kingdom. It is extraordinary that with the excellent makes of cars produced in this country people should think it necessary to buy German products of this description. At one time there may have been an excuse for so doing, as we were behindhand at the start. There can be no doubt, however, that at the present time it is possible to suit all tastes and all classes of purchaser in this country. In 1912 Germany sent us passenger-cars to the value of 364,900*l.*, and commercial cars worth 12,450*l.* Her exports of passenger cars to Brazil, a country not in a position to satisfy their own needs in this direction, amount to about 333,200*l.*, and to the Argentine to 310,950*l.* In addition, she exports to four other countries to an annual value of between 100,000*l.* and 200,000*l.* Her exports of commercial cars are not so impressive, totalling about 319,000*l.*, the bulk going to Russia and Brazil, which together took in 1912 some 290 out of 574 such cars exported. While we export in fair quantities to some foreign countries, our largest markets are parts of the Empire. Our exports to Australia were valued last year at 523,200*l.*, to India at 419,000*l.*, and to South Africa at 307,100*l.* France comes next in our list, taking from us cars, &c., to the value of 186,100*l.* France takes more expensive cars aggregating the same value from Germany. In the Argentine our trade is about one-third the value of that of Germany, while in Brazil it is, in comparison with our rival's, quite insignificant. From the above figures it will be seen that our Australian market is good, but it is worthy of note that Germany has sent a steadily increasing number of cars to that country, while our share of the total business has dropped from 49.9 per cent. in 1910 to 36 7 per cent. in 1912. With so good a field, everything possible in the way of improving marketing should be done to retain the hold we have and regain some part of the trade secured by others.

Of motor-car engines and parts Germany exports to the value of 471,900*l.* Our exports of parts are valued at 788,200*l.*, our largest customer being France, who, though so much to the fore in the development and production of motor-cars, buys from us parts to the value of 221,600*l.* Germany has no such good customer, her best being ourselves, with purchases amounting to 89,800*l.* However, she sends goods to the value of over 10,000*l.* per annum to no less than twelve countries, while our exports are only sent on a like scale to nine. The fact that we export parts to producing countries, such as France, Italy, and the United States, suggests that quality is of assistance to us in this matter. We send to Italy parts valued at 56,000*l.* per annum, and to the United States to the value of 43,500*l.* Germany likewise sends to the United States parts valued at 49,300*l.*

It is with some satisfaction that we can record that our exports of motor-cycles greatly exceed those of Germany. We send cycles abroad to the value of 733,300*l.* Germany exports to the value of only 124,600*l.* Our best markets are again Australia and South Africa. Doubtless very shortly India will also become an important one; she even now takes cycles to the value of 55,200*l.* per annum. In Germany's two best markets we have a fairly good footing. To Denmark Germany sends motor-cycles to the value of 21,350*l.*, while our share in that market is valued at 13,400*l.* In Russia—Germany's only other market of value—her footing is more secure compared with our own. Her trade there is worth 22,850*l.* per annum, and ours only 9600*l.* However, in many other countries the scales are turned the other way, as, for instance, in Italy, where we do business worth 76,200*l.*, compared with Germany's 8300*l.* It is very gratifying to know that in South Africa our share of this trade has been 90 per cent. of the total, and in Australia nearly 90 per cent.; in New Zealand, 70 per cent.; and so on. We trust that this preponderance will be retained, and that our share may be extended in other markets, some of which are much nearer home, and should prove equally valuable.

NOTES.

Righting a Tilted Grain-Elevator.

In 1913 a very remarkable case of the tilting of a large structure occurred at Transcona, on the Canadian Pacific Railroad, about 6 miles from Winnipeg. The structure in question was a grain-elevator, which had been erected in 1912, on foundations of a type adopted throughout this area for buildings of this description. Load tests indicated that the sub-strata would carry a load of from 4 to 5 tons. The actual load imposed was about 2½ tons per sq. ft. The structure consisted of a working-house and a bin-house. The former, a building of about 162 ft. in height, covered an area of 44 ft. by 90 ft. The bin-house was a structure measuring about 200 ft. by 75 ft., and contained sixty-five circular bins, each 14 ft. 4 in. in diameter, and 93 ft. high. The interstices between the circular bins were also used for storage, and the whole building accommodated a million bushels of grain. This structure was of ferro-concrete, the bin-house having a weight of about 20,000 tons when empty. In October, 1913, when this building contained 875,000 bushels of grain, it began to settle. It first settled 4 ft., and then tilted over until it was leaning at an angle of 27 deg. to the vertical, the movement extending over twenty-four hours. The conveyor and roof slid off the top of the building, which otherwise showed no damage. In its final position, the base of the building on one side was 5 ft. above the normal level, while on the other it was about 30 ft. below it. The building had been erected on a concrete-slab foundation, and was thought to rest on stiff clay extending down to rock. Subsequent investigation showed that the strata were far more treacherous, a layer of wet, soft clay extending below the stiff upper stratum. Below this was gravel and a soft, whitish clay, containing a great deal of water. Under the circumstances, it was decided to underpin the undamaged working house with pillars carried down to bed rock. In order to do this, piers were first sunk outside the building, which was then shored up, the lower ends of the shores resting on the piers. Holes were then cut in the concrete-slab foundation and piers were sunk from small shafts and tunnels. The bin-house had to be righted in the first place, and provided, in the second, with five rows of 7-ft. piers extending to bed-rock. It was first emptied of the grain it contained, and then excavation was carried out on the high side. A long and wide trench was carried down on this side, after which a line of piers was sunk under the low side of the building, which was also shored up on this side. When these piers were completed excavation on the high side was carried under the tilted slab foundation by means of drifts, leaving triangular cores of earth, and shoring to support the slab at intervals. The building was then tilted by jacks on the piers above referred to, and others acting on the sides of the outside bins, while the material remaining in the cores under the high side was removed. In this way the building was returned through 15 deg. The other piers having been sunk, for the remaining 12 deg. the central row of piers was used as the turning-point, jacks being employed on the two outside rows of piers under the low side. In its final position the bin-house will stand considerably lower than it did originally, but this fact will not interfere with its operation. The interesting particulars of this piece of work are derived from our contemporary, the *Engineering News*, which, in November, 1913, contained an illustrated article on the failure, and in its issue of August 27 last gave a complete account of the work.

New Dry Dock and Ship-Repairing Yard at Vancouver, B.C.

The Committee of the Privy Council of Canada approved, with the sanction of His Royal Highness the Governor-General, on September 5, of a report from the Minister of Public Works, stating that the Amalgamated Dry Dock and Engineering Company, Limited, of Vancouver, had lodged, for the approval of the Government, all the necessary plans, specifications, and estimates of the new dry dock and ship-repairing works at Vancouver. These have been officially approved, and a subsidy of 4 per cent. for thirty-five years will be paid by the Dominion Government on the estimated cost of the work. It is understood the estimated cost of the complete scheme is over 1,100,000*l.* The dimensions of the dry dock are to be:—Length, 1150 ft.; width of entrance, 110 ft.; depth over sill at high water, 41 ft. The dock will be divided into two parts, 500 ft. and 650 ft. in length respectively. Mr. A. D. Swan, M. Inst. C.E., Montreal, who was responsible for the construction of several harbour works in this country, is the engineer for the works. On account of the large volume of commerce now being handled at the port of Vancouver, a dry dock such as is proposed by the Amalgamated Dry Dock and Engineering Company, Limited, will be of great benefit to the shipping interests and to commerce in general on the Pacific Coast. Numerous schemes for dry docks have been proposed from time to time during the past five years, but from one reason or another have failed to be carried out. Now that the whole of the negotiations with the Government have been arranged and concluded, it is hoped by the shipping interests that construction will commence forthwith. It is understood that negotiations are now under way for the placing of the contracts.

The Locomotive-Building Industry.

British engineers have been a good deal perturbed at times at the orders for locomotives which have gone to Germany from customers who usually patronise British builders. The reasons for placing these orders with German manufacturers have been various. Sometimes the choice has been due to price, sometimes to promptness of delivery. Every now and then there come times when a railway is short of power and the locomotive staff is hard put to it to handle all the traffic offering. Some years ago, when our contract shops were booked up for months ahead, railways of this country had to purchase locomotives in America. Recently the South-Eastern and Chatham Company went to Germany for a similar reason. The railways at home are naturally somewhat reluctant to introduce foreign stock on to their systems, for though

they may be to their regular specifications and drawings, such contracts usually result in getting something of a rather different standard either as regards material or workmanship, so that the class has to stand by itself instead of being merged with others in one big whole. The same reluctance is not shown by railways on which the rapid development of traffic has entailed many changes in a short time in the type of power adopted, so that standardisation has only become possible on a limited scale. On systems in such a stage of development it is not so necessary to pay for uniformity, and a contract may be decided on price and quality without reference to other factors. It is therefore natural that, if the price offered is favourable, orders should go to Germany from a country like South Africa, where, although much has been done to reduce the stock to standards, the number of classes is still very large. For some reason people in this country are under the impression that we have a right to a large share of this trade in Egypt. Much of the trade of that country is actually in our hands, but there is no reason why British locomotive builders should be specially favoured by the State Railways. A fair field and no favour is to be preferred by the buyers. On the matter of price, large locomotive orders have gone to Germany from Egypt in recent years, and experience, we believe, has shown that this has not been a mistaken policy. In 1913 our total locomotive exports amounted to about 2,782,000*l*, and those of Germany to about 70,000*l*. less. In certain countries, such as India and the Argentine, our trade is on a large scale. India took 838,500*l*. worth of locomotives in 1913 from us, and only 11,100*l*. worth from Germany. However, in other years Germany has done much more business with India than that. Germany's chief markets in recent years have been France, Spain, Brazil, and Chile. In the two latter countries we do a certain amount of business, but in Spain and France our present business is confined almost entirely to light contractor's engines. In the Argentine orders have gone to Germany from the State lines, but British firms retain most of the business with the companies. German trade is well spread out over the globe. Turkey, Russia, Italy, the Dutch East Indies, Japan, and the Argentine all bought German locomotives in 1912 to the value of between 50,000*l*. and 100,000*l*. Our exports to Japan last year amounted to the small figure of 7000*l*. only. We surely ought to do better than that in a friendly market. It is difficult to know why our trade does not secure a greater share of the orders going. Whenever orders are plentiful they seem to pass our shops because they are congested. If this becomes a regular feature of the trade, customers will soon be accustomed to placing orders elsewhere, and we shall have difficulty in securing them when only few are going. The recently issued Board of Trade bulletin on Germany's trade in locomotives gives many instances of that country's successful competition with us in the matter of price and time. If we are to take advantage of the present state of affairs, our shops will have to turn locomotives out more quickly, if possible, and at a price which will ensure favourable consideration of tenders when Germany re-enters this field.

Trade Conditions and Requirements in the British Dominions.

Special interest attaches to a series of reports, received from our Trade Commissioners in the Colonies, regarding the present financial and industrial condition in British dominions, with particular reference to the market requirements of the present moment. As regards Australia, it is pointed out that the financial position is strong, the gold coin held exceeding 40 millions sterling; but there is a tendency to restrict credit in trade to all but the first-class firms, to whom there is little restriction in respect to overdraft. Some of the mines, however, are taking steps to work short time, and some may even close down. None of the public works in progress are affected, but activity in the building trade is falling off. The report from Sydney indicates an expectation of a severe check in the activity of the industrial and commercial community, while that from Adelaide states that British shippers of goods to Australia in British vessels, who have drawn against the documents, need have no fear of the draft not being met, as the goods will represent an even better value to the consignees now than they would under former conditions. Imports are likely to continue, although perhaps on a rather restricted scale. The report from Toronto states that the financial conditions generally are rather good, but there is an unmistakable spirit of economy on the part of the individual, the factory, the wholesale house, and the public authority. At the same time the Trade Commissioner states that this appears to be a good period for a close study of the markets by those British houses desirous of doing business now and in the future. The importance of quoting strictly inclusive prices (to which we referred in a previous article) is enjoined in this communication from Toronto, and ought to be given careful attention. As regards South Africa, the Commissioner states that there seems to be no doubt that British trade in South Africa will receive an enormous impetus as a result of the complications in Europe, although the immediate prospects may not be particularly bright. It is worth quoting the imperative conditions which must be met by British manufacturers desirous of taking advantage of extended possibilities of the South African market. These are :—1. The need for local representation. 2. The enormous advantages that, as a rule, follow the visit of a principal to South Africa for the purpose of becoming intimately acquainted with local conditions of trade. 3. The necessity for meeting foreign competition by the supply of articles identical with those being exploited by our foreign competitors (*e.g.*, enamelled ware, cheap musical instruments, cheap toys, &c.). 4. The adoption of an overhead charge in all cases where South African trade custom makes it necessary. 5. The study of packing, in order that handling, both on the part of the wholesaler and retailer, may be reduced to a minimum of labour with a maximum of convenience. 6. Sympathetic and generous treatment towards the local representative, and a strong endeavour to adjust the exporter's point of view to that of the South African merchant. An important point, brought out by the Collector of Customs at Ceylon, is that in the whole of the East cheapness is the main consideration of the purchaser. His Majesty's Consul at Lyons mentions that among the articles for which there is a ready market are ironmongery and cycle and motor accessories; and here, again, it is pointed out that our competitors have succeeded largely because their goods appeal to the masses, while English makers consider only the better-class buyers, who are far less numerous. Again, we have a suggestion that an inferior quality of article, for which there is undoubtedly a demand, should be produced to meet such conditions. The Director of the Commercial Intelligence Branch of the Board of Trade is ready to give more direct advice on these and other matters.

The Junior Institution of Engineers.—We are informed that the Council of the above Institution have elected the Most Hon. the Marquess of Graham, D.L., C.B., C.V.O., as their President for the year 1914-15, in succession to Sir Boverton Redwood, Bart., D.Sc., F.R.S.E. The Vickers prize, consisting of a gold medal and premium of instruments or books, has been awarded to Mr. James Richardson, B.Sc., Assoc. M. Inst. C.E., for his paper on "High-Power Diesel Engines; their Development for Marine Service." Mr. Richardson has also been fortunate enough in securing the Institution medal for the same paper. The other awards have not yet been announced. It is interesting to note the excellent progress made with the local sections in Birmingham, Manchester and Sheffield. The membership has been considerably increased during the year, and the committees of each section are arranging a full and interesting programme for the coming session.

The Institute of Marine Engineers.—On Monday, September 21, at the Institute of Marine Engineers, a demonstration was given of the Amalgaline system of metal jointing, by Mr. Harden, the inventor of the process. Before giving the demonstration Mr. Harden read a short paper, in which he stated that the process effected a complete fusion between the surfaces joined. In marine work the principal uses to which the system is applied are the flanging of pipes, the seaming of lead used in refrigerating-chambers, and general sanitary work. The system of flanging was first adopted by Messrs. Doxford, of Sunderland, and the process is now in general use among shipbuilders on the Clyde, the Tyne, the Tees, and the Wear. The system is not confined to the use of small pipes, but is used in an ordinary way on pipes varying in bore from 3 in. to 9 in. Like lead-burning, it is an autogenous process, but instead of using an intense local heat the fusion is effected by the action of the amalgaline on the surfaces it is in contact with, forming an amalgamation between the lead of the flange and the lead pipe.

EMERGENCY WORKERS' HOURS AND HUMAN ENDURANCE.

To the Editor of Engineering.

Sir,—I am one of those who recognised the justice of the plea you set out in your issue of the 11th inst. (page 335), that the men engaged in supplying the necessities of our forces in constructing munitions of war were serving their King and country as effectively as if they volunteered for service in the Army. That the warships now in progress, and that the rifles, guns, and other equipment now being made, should be turned out as rapidly and numerously as possible is of vital importance. That is beyond dispute.

But it would be well if those responsible for the organisation and management of the factories engaged on work for the forces would reflect on the influence of unduly stressed human endurance on the efficiency of production. In other words, can work be done as rapidly as possible if the men are becoming fatigued or work-weary?

In many establishments there is absolute continuity of manufacture from twelve midnight on Sunday to twelve midnight on the following Sunday. No doubt the workmen are engaged in shifts—either two or three per day; but to continue at high pressure daily, including Saturday and Sunday, must have an appreciable effect in reducing the amount of work done per hour. The men are now inclining to absent themselves for a day, in which case establishment charges and power-plant expenses are involved without production on the credit side. In fact, I hear of cases where men work on Sunday when an extra rate per hour is paid and stay off on a weekday with an invented excuse or no excuse at all. Even if they do not absent themselves in this way, it is doubtful if, after such a long spate of such uninterrupted work as we have had, they do more than six days' work in the seven days.

The idea of writing you on the point and of pressing the truth home upon employers occurred to me when I read of the troops at the front being given much-needed rest, notwithstanding the terrible consequence of any weakening of our attack on the German lines, or of defence against the counter-attack of the enemy. Contrast this with the fact that although Monday of this week was a public holiday in the Clyde district—designed to let men get off from Saturday at midday until Monday evening—many of the works continued at work all the time.

An even greater danger than the work-weariness of the men is the fatigue of the managers, staff, and the foremen. The men can absent themselves, but the spirit of loyalty of the staff and foremen induces them to continue uninterrupted service every day, with occasional visits to the works at night. The resultant inevitable fatigue must have its effect and defeat the main aim—*i.e.*, rapid output. Moreover, weariness tends to shorten tempers, alike of men and foremen, and there is greater danger of disputes and stoppages which may more than wipe out the gain of the continuity of working time.

I hope, in their own interests, the responsible authorities at all works will at once consider this question of the limit of human endurance from the soundly economic standpoint ere it is too late.

I am, yours truly,

September 30, 1914. B. F. W.

[There is much to be commended in the views expressed by our correspondent, but there is another side to the question. Employers, we are sure, would gladly relieve the pressure on "human endurance" if the trade unions would recognise their duty to the State by encouraging their unemployed members to give their services, or even to transfer their services to establishments employed on work for the use of the Navy and Army.—Ed. E.]

THE FINISH OF MACHINE-TOOLS.

To the Editor of Engineering.

Sir,—In your article on "Foreign Trade in Machine-Tools," you refer to the finish of German machines with burnt (stoved) enamel and polished steel-work as of no mechanical significance and of a commercial value limited to the possibility of favourably impressing an ignorant buyer. I venture to suggest that in relation to all machine-tools that may be used for fine work that the smooth and readily cleaned surface of stoved enamel and polished bright work has a distinct and assessable value in facilitating cleaning, and that this is by no means to be despised or neglected by machine-tool makers who cater for the finer trades in which the production of accurate and highly-finished work renders extreme cleanliness essential. The difference between paint and stoved enamel, and between tooled and polished work, is that the former when wiped down retain enough dirt and grease to soil the hands, and the latter do not.

I have the honour to be, Sir, your obedient servant,

A. H. Shield.

10, Richmond-road, Ealing, September 28, 1914.

GORDON'S FORMULA FOR COLUMNS.

To the Editor of Engineering.

Sir,—As a matter of historical interest, would you allow me to trespass on your space to inquire if any of your readers can give me particulars as to where and when Gordon published his well-known column formula. I am, of course, aware of Rankine's remark to the effect that Gordon revived Tredgold's formula and determined the constants from Hodgkinson's experiments, but Gordon's own work I am unable to find.

Yours faithfully,

S.

11, Victoria-street, London, S.W., Sept. 29, 1914.

THE FRENCH QUADRUPLE-SCREW LINER "LUTETIA."

The French liner Lutetia, which we illustrate in Figs. 1 to 8 on our two-page plate, and on pages 418 and 427, is the latest addition to the fleet of the Compagnie de Navigation Sud-Atlantique, which is controlled by the Compagnie Générale Transatlantique. She was built by the Société Anonyme des Chantier et Ateliers de St. Nazaire, from whose yard at Penhoët she was launched in March of last year. Since November 1, 1913, she has run regularly between France and South America as a passenger and mail liner. Her dimensions were made as large as was compatible with the conditions ruling in the harbours she is destined to serve. They are as follow :—

Length	...	...	...	182.63 m. (599 ft.)
Breadth	...	...	...	19.50 ,, (64 ,,)

She has a displacement of 15,650 metrical tons, and is fitted out to carry 296 first-class passengers, 106 second-class, 80 intermediate second-class, and 570 third-class. The crew, including the deck, engine-room and saloon hands, numbers 345.

In regard to speed, the Sud-Atlantique Company laid down special conditions in the contract ; their aim was to obtain a ship, which, in this respect, constituted a material progress upon the other units on the South-American lines, and they stipulated that the average service speed should be 18 knots for the run from Lisbon to Buenos Aires *via* Dakar and Rio de Janeiro, the total voyage to be covered in thirteen days. In actual service conditions the runs have been made at that speed, and frequently even at higher speeds, the coal consumption being low, about 0.500 kg. (1.10 lb.) per horse-power per hour.

The first-class cabins are 130 in number, there being n addition 32 cabins *de luxe* ; these cabins are distributed as shown in Figs. 4 and 5. The ordinary first-class accommodation is so arranged as to obviate any internal cabins without natural light and ventilation, where there are usually two or three cabins, side by side. There is in the Lutetia, as shown in Figs. 5 and 6, a group of three cabins, all having port-holes for natural light and ventilation, and opening from one vestibule, a central single-berth cabin from the end of the vestibule to the side of the ship, and with a double-berth cabin on each side of the lobby. The arrangement is certainly ingenious. Those on the lower deck (Fig. 6) are for one, two, or three passengers each. All the cabins are provided with fans and with ducts, through which fresh air is delivered by high-capacity fans located on the awning deck. Telephones in the cabins establish communication with the steward's quarters, and all the toilet basins have a constant supply of hot and cold water.

The saloons, dining-rooms, reading-rooms, smoking-rooms, &c., are most comfortable, and are highly decorated. Their position is shown in Figs. 3 and 4, and views in these rooms are reproduced in Figs. 11 to 14, on page 427. The ship is equipped with a powerful wireless telegraphy installation.

The second-class quarters are claimed to be more roomy and better arranged in every respect than those on other ships on the South American lines. The third-class berth accommodation is designed for taking 570 passengers, there being special quarters for women.

The food supply storage for a total of 1400 passengers during a long sea voyage has been carefully arranged. Cold-storage rooms are provided aft, and meat, vegetables, fruit, and fish are stored in separate compartments (Fig. 8). CO_2 apparatus maintains the temperature in these compartments at about 0 deg. Cent. The wine, flour, and other provisions are kept in large separate holds. There are galleys for all the classes, each fully equipped.

The ship is divided into twelve water-tight compartments. The bulkheads of the forward stokehold are provided with rapid-working water-tight doors on the Stone-Lloyd system, operated from the bridge, which isolate completely the forward part of the ship from the aft part. There are eighteen boats, of which sixteen are lifeboats.

The holds for the carrying of cargo have a capacity of 2850 cub. m. (100,652 cub. ft.), served by six electric cranes, which are fitted on the upper deck. Special holds are set apart for carrying the mails, also holds of ample capacity for the passengers' luggage. These latter holds are served by derricks from the awning-deck.

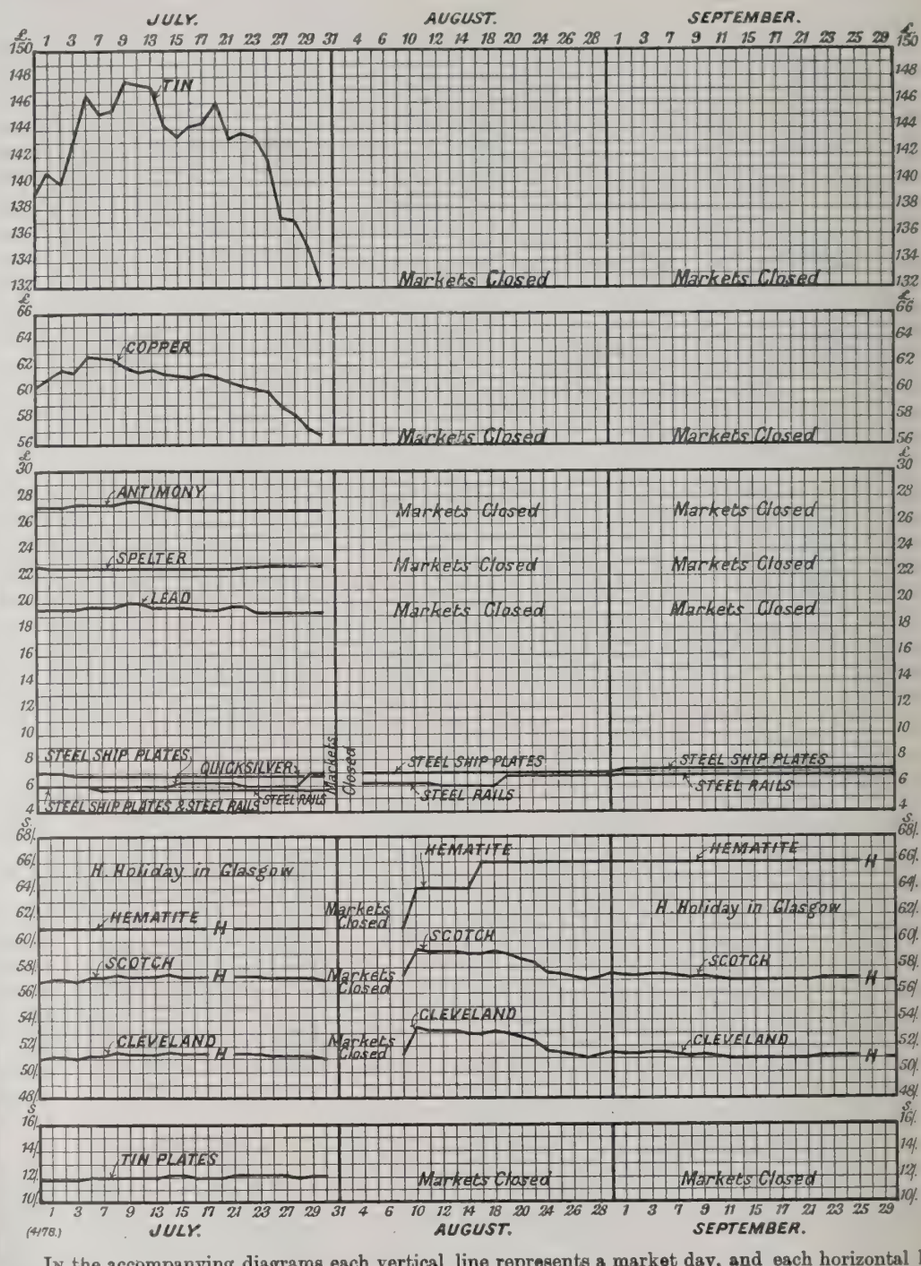
The electric current for power and lighting is generated in a central station, located on the F deck, and containing three 120-kw. dynamos driven by Sautter Harlé enclosed engines. The current both for power and lighting has a pressure of 110 volts. Hot and cold sea-water and hot and cold fresh water are distributed throughout the whole ship. The greater number of the baths are supplied with fresh water.

We understand that the Lutetia arrived at Bordeaux on September 12, and that she has left again on her regular service.

(To be continued.)

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



In the accompanying diagrams each vertical line represents a market day, and each horizontal line represents 1s. in the case of tin-plates, hematite, Scotch and Cleveland iron, and 1*l.* in all other cases. The price of quicksilver is per bottle, the contents of which vary in weight from 70 lb. to 80 lb. The metal prices are per ton. Heavy steel rails are to Middlesbrough quotations. Tin-plates are per box of I.C. cokes.

Note.—The London Metal Exchange still remains closed owing to the European War, so that official dealings are suspended. Private business of a very limited nature has, however, taken place. On the 30th ult. the price of English tin ingots was 135*l.* per ton, having fallen from 140*l.* on the 4th to 137*l.* on the 10th, and to 134*l.* on the 14th. Since this time the price has varied from 134*l.* 10s. to 137*l.* The present price of Straits metal is 135*l.* 10s. a ton for cash. Electrolytic copper stood at 54*l.* 10s. on the 30th ult., having ranged from 54*l.* 15s. to 56*l.* 5s. during the earlier part of the month. Best selected was officially quoted at 57*l.* to 57*l.* 10s. on the 29th ult., the price having gradually fallen to this amount from 59*l.* 10s.-60*l.* 10s. on the 4th ult. Antimony has become rather dearer, and English Regulus now stands at 37*l.* 10s. to 40*l.* per ton, whereas 35*l.* was the nominal price early in the month. Spelter, on the other hand, has fallen in price. American metal only is available, and its price on the 30th ult. was 25*l.* 5s. per ton, to which figure it has fallen from 29*l.* on the 15th ult. Lead has also recently decreased in value, the price of English ingots, which was from 19*l.* 15s. to 20*l.* up to the 28th, dropping to 19*l.* 15s. on the 29th and to 19*l.* 10s. on the 30th. Quicksilver is now firm at from 7*l.* 10s. to 7*l.* 12s. 6d. per bottle. During the greater part of the month the nominal price varied from 6*l.* 12s. 6d. to 6*l.* 15s., rising from these figures to 7*l.* on the 24th, and to its present price on the 29th. Tin-plates vary from 13s. to 13s. 6d. per box of I.C. cokes. The prices of steel ship-plates and heavy steel rails are 7*l.* 5s. and 6*l.* 15s. per ton respectively, as shown in the above diagram, which also gives the Glasgow settlement prices for pig-iron. The Scotch pig-iron warrant markets are open, but little business is being done.

Fire Patrols for Factories Engaged on Government Work.—The British Fire-Prevention Committee desire it to be known that a certain number of reserve firemen (over 35 years of age) of good character and experience, are available from the Committee's Special Fire Service Force, to do either part or full-time watch or patrol service on factories and works engaged upon Government emergency orders. Applications should be addressed to the Registrar, British Fire-Prevention Committee, 8, Waterloo-place, London, S.W.

THE QUADRUPLE-SCREW LINER "LUTETIA," OF

CONSTRUCTED BY THE SOCIÉTÉ ANONYME DES CHA

(*For D*

Fig. 1. DECK A.

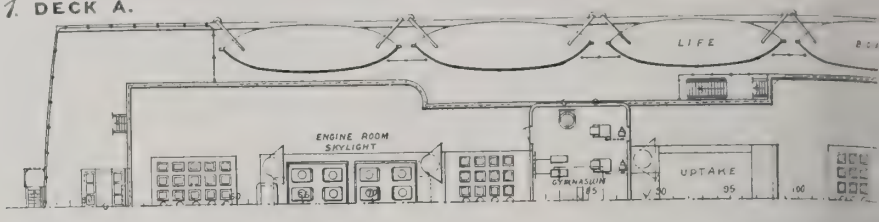
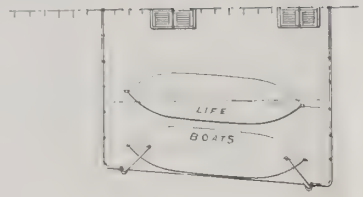


Fig. 3. DECK B.



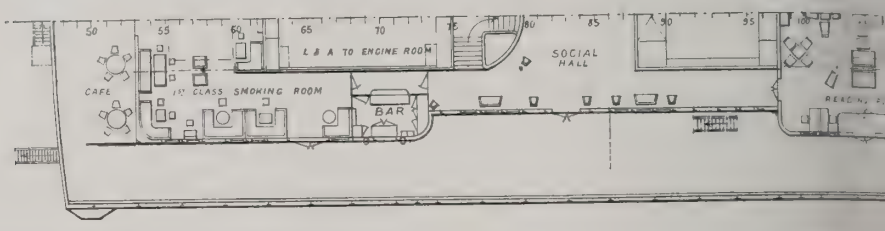


Fig. 4. DECK C.

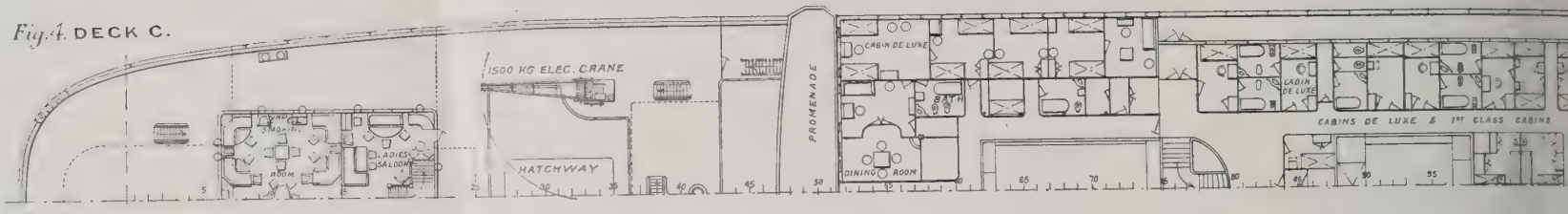


Fig. 5. DECK D.

Fig. 6. DECK E.

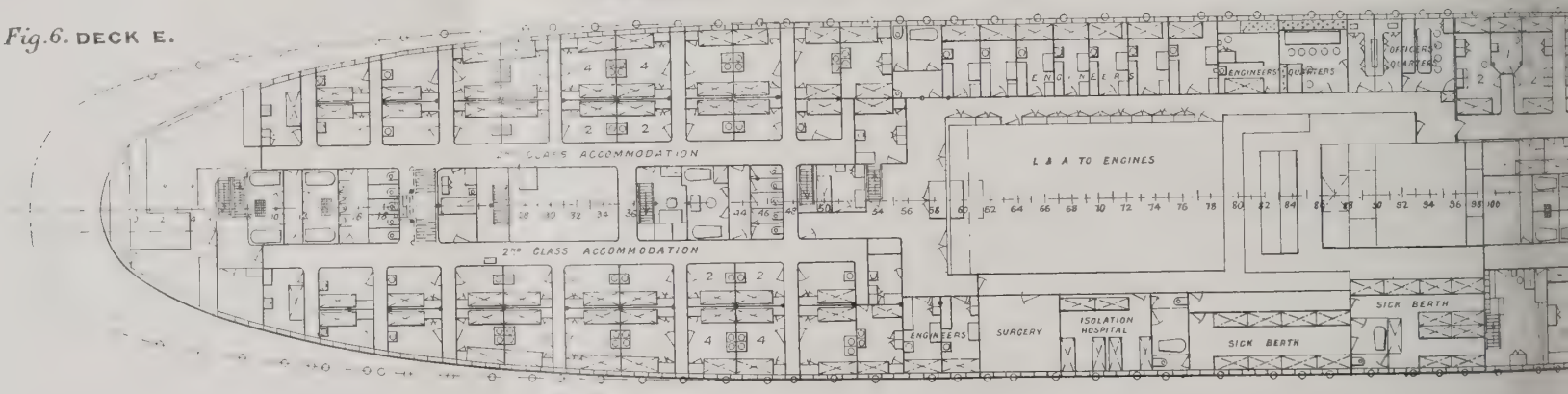


Fig. 7. DECK F.

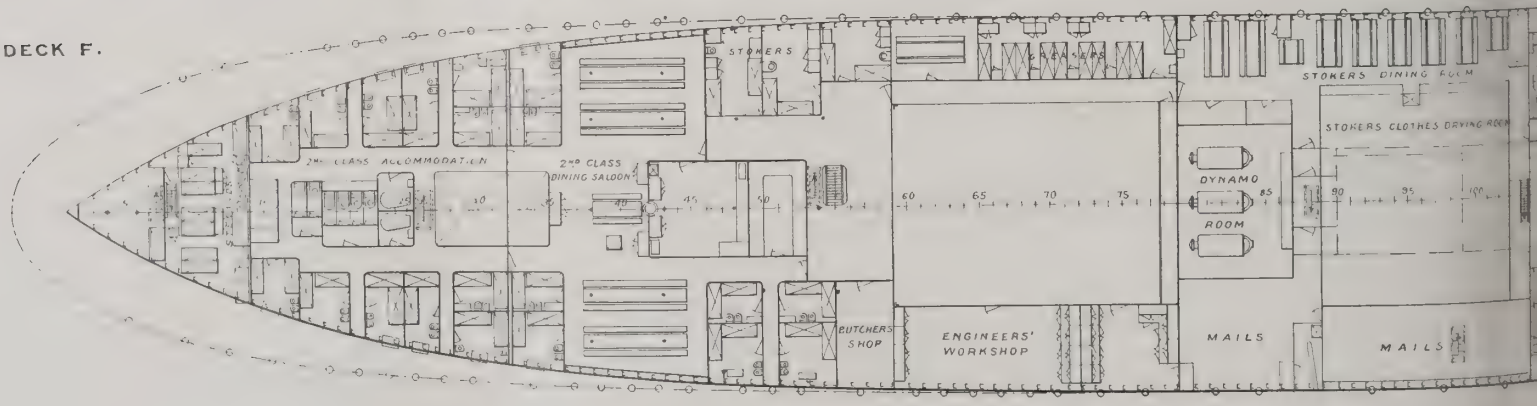
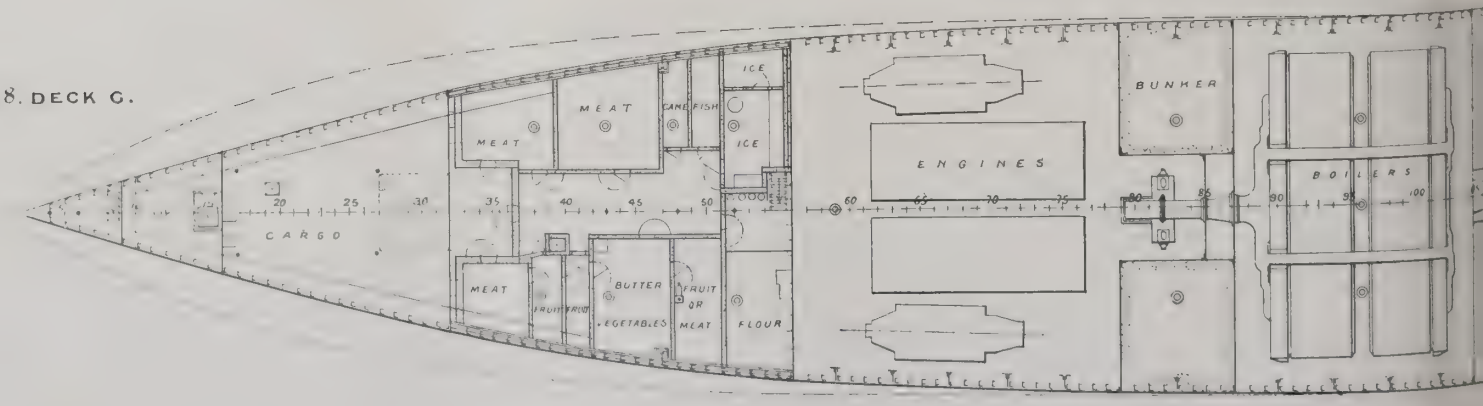


Fig. 8. DECK G.



OMPAGNIE DE NAVIGATION SUD-ATLANTIQUE.

ELIERS DE ST. NAZAIRE, ENGINEERS, ST. NAZAIRE.

, 426.)

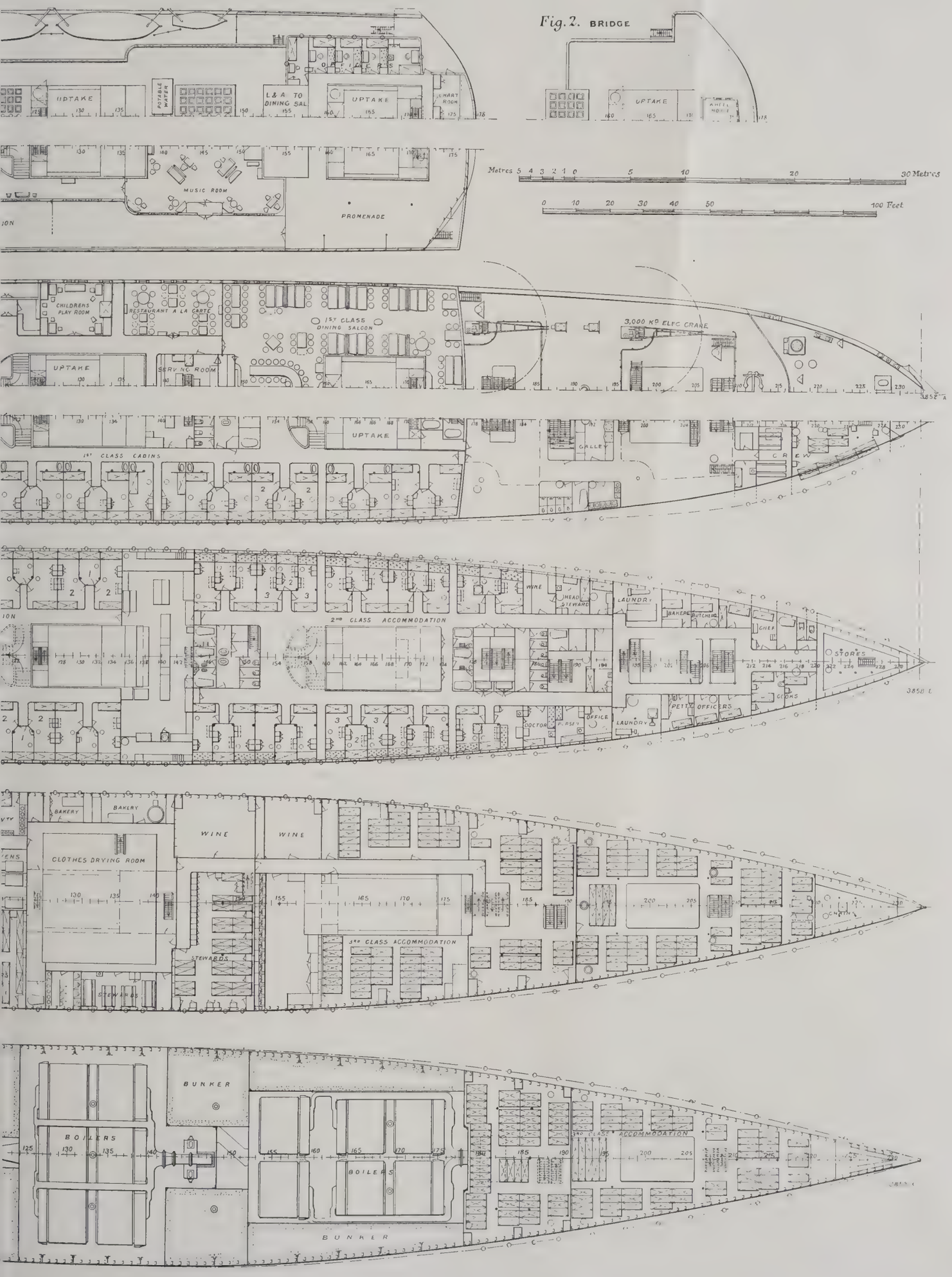


Fig. 2. BRIDGE

THE QUADRUPLE-SCREW LINER "LUTETIA" OF THE COMPAGNIE DE NAVIGATION SUD-ATLANTIQUE.

CONSTRUCTED BY THE SOCIÉTÉ ANONYME DES CHANTIER ET ATELIERS DE ST. NAZAIRE, ENGINEERS, ST. NAZAIRE.

(*For Description, see opposite Page.*)

Fig. 11. Open-Air Café.

Fig. 12 Companion-Way Aft.

Fig. 13. First-Class Smoking-Room.

Fig. 14. Reading-Room.

UTILISATION OF HEAT CONTAINED IN SLAG.*

By Walter L. Johnson (Middlesbrough).

For many years past efforts have been made from time to time to use the heat contained in slags, which at present is wasted. The late Sir Lowthian Bell evaporated brine for the manufacture of salt by means of this heat, but it was not a commercial success. Some four years ago Messrs. Bell Brothers again began experiments with a view to using the steam produced from slag in a low-pressure turbine. The slag used was that produced in the manufacture of ordinary Cleveland iron, and had an average analysis of :—

	Per Cent.
Silica	28.30
Alumina	24.78
Ferrous oxide	0.30
Lime	32.39
Sulphide of lime	3.67
Magnesia	8.94
Manganous oxide	0.36
Alkalies	1.26
	100.00

The apparatus for producing the steam consists of a wrought-iron circular vessel B (Figs. 1 and 2). Near one edge of the top plate of the granulator B is the hole through which the slag is poured (C) ; on the underside of this top plate and round the hole a circular ring 4 in. deep is fixed, which dips into the water to a depth of 3 in., thus forming an hydraulic seal, and preventing the steam from escaping ; inside the granulator are four vanes fixed on a vertical shaft D, which cause the water to rotate. The slag comes from the furnace along the trough or channel A. When the slag drops into the water it granulates, and its velocity causes it to sink to a certain depth. It floats for a time, but the rotation of the water causes it to come to the surface inside the vessel, otherwise it would block up the slag entrance ; the granulated slag is then lifted by the elevator E into a second seal F, and there becomes water-logged, sinks through the seal, and is taken by a second elevator and dropped into trucks. The feed-water is introduced along with the slag at C ; the surplus water which drains from the truck is also pumped back to C by a small pump fixed to the side of the apparatus. The steam generated comes off at G ; at first it was intended to use this steam direct in an exhaust-steam turbine. After numerous experiments on blades of different metal, it was found that duraluminium was affected very slightly, and a 50-kilowatt turbine with blades of this material was experimented with.

The steam produced from ordinary grey Cleveland slag contains about 0.5 per cent. by volume of incondensable gases, the average analysis of which is :—

	Per Cent.
Sulphuretted hydrogen	29
Hydrogen	55
Nitrogen...	16

To deal with these gases a very big air-pump would be required, so it was essential to absorb them between the condenser and the air-pump. This was done by washing first with milk-of-lime, to absorb the sulphuretted hydrogen, and then passing the remainder through a tube containing calcined Cleveland ironstone heated to a temperature of about 750 deg. Cent., and recondensing the water produced. The nitrogen was dealt with by the air-pump. Under these conditions the plant ran for two months ; at the end of that time the turbine was opened out, and the openings were found to be partly blocked up with fine sulphur, which had caused some wear of the blades. The sulphur, which it was impossible to eliminate by filtering the steam, was produced by the reaction :—

$$2\,H_2S + SO_2 = 2\,H_2O + 3\,S,$$

this reaction being the probable cause of the entire absence of sulphur dioxide in the steam. The direct method was then abandoned, and a water-heater and heat-exchanger were introduced between the turbine and the primary generator. The water-heater consists of an outer casing and tube-plates with tubes $1\frac{3}{4}$ in. in diameter fixed therein, placed vertically, the total heating surface being 156 sq. ft.

The one shown in the illustration is an improvement, but the one above described was used in order to see what action, if any, there was on the tubes. They were examined every week, but did not show any undue corrosion ; there was, however, a deposit of fine sulphur on the shell and tubes.

The calandria, Fig. 4 (a Kestner single-effect climbing film evaporator, Fig. 3) consists of two parts, the calandria proper and the separator. The former is composed of a shell or casing containing the evaporating tubes, which are about 23 ft. and $1\frac{7}{8}$ in. in diameter, and are fixed in upper and lower tube-plates. The water is fed into the lower end of the heater H at J, and then passes from the upper end by the pipe K into the separator L. The dirty steam from the generator B passes inside the tubes of the heater, the clean water being on the outside, and the uncondensed remainder enters the calandria at M.

The water in the tubes is caused to boil by the steam with which they are surrounded, and as ebullition takes place, a column of vapour rises up in the centre of each tube. This vapour travels at a high velocity, carrying with it a film of water on the inner surface of the tubes. The water does not "climb" by capillary attraction nor by the liquid and the steam forming alternate links in the same way as in a Pohle air-lift. The operation is performed in a simple manner ; the water begins to boil in the tubes, and is gradually drawn up in a complete film by the vapour itself. As a result of this action a certain amount of water is carried up into the separator L, which acts as a steam-drier ; this water and the feed-water from the heater, which enter at N, flow down the pipe O, entering the calandria at the bottom. The clean steam is delivered by the pipe P to the turbine, which is connected with the condenser in the usual manner. The

* Paper contributed to the Iron and Steel Institute, and now open for discussion by correspondence.

Fig. 1. SECTION THROUGH SLAG STEAM GENERATOR

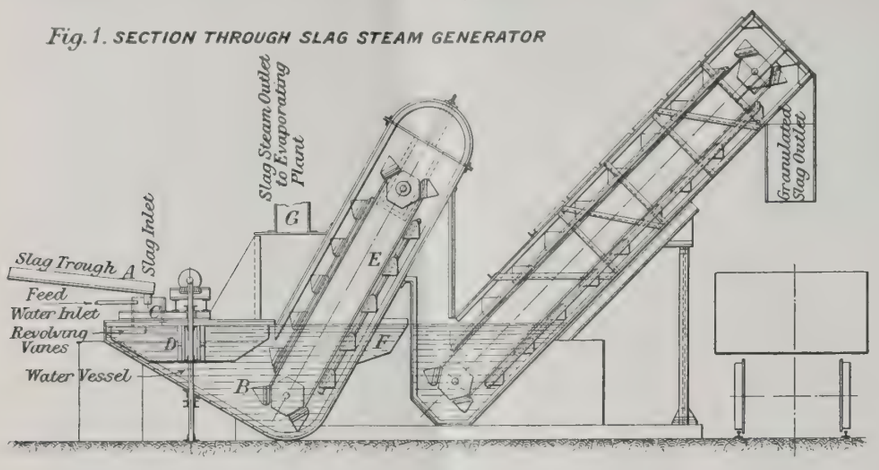


Fig. 2.

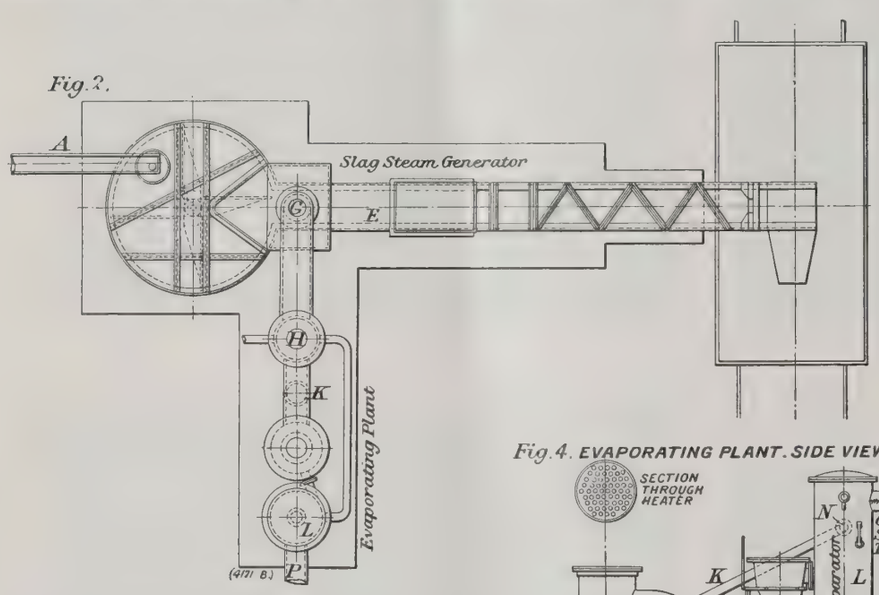


Fig. 3. KESTNER EVAPORATOR.

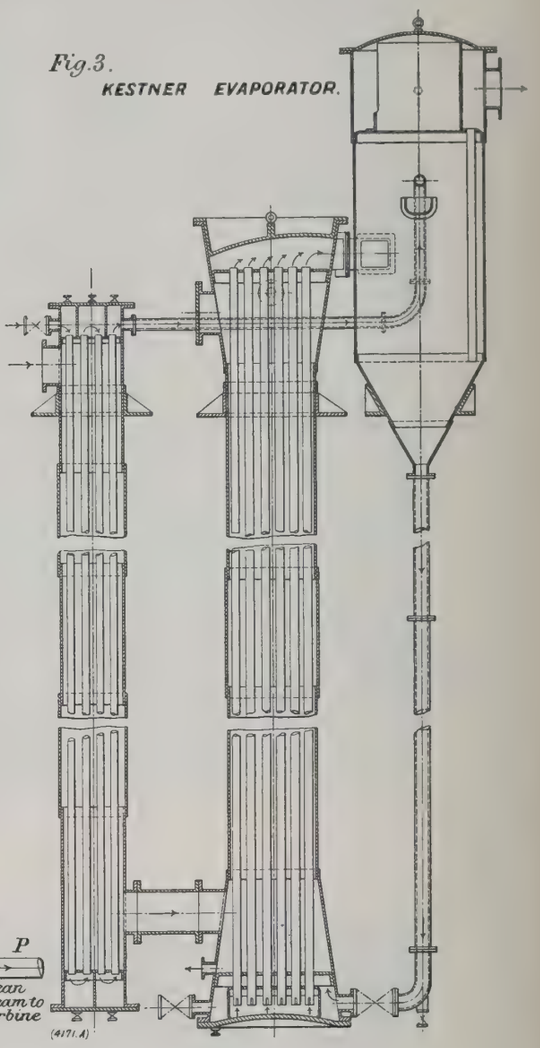
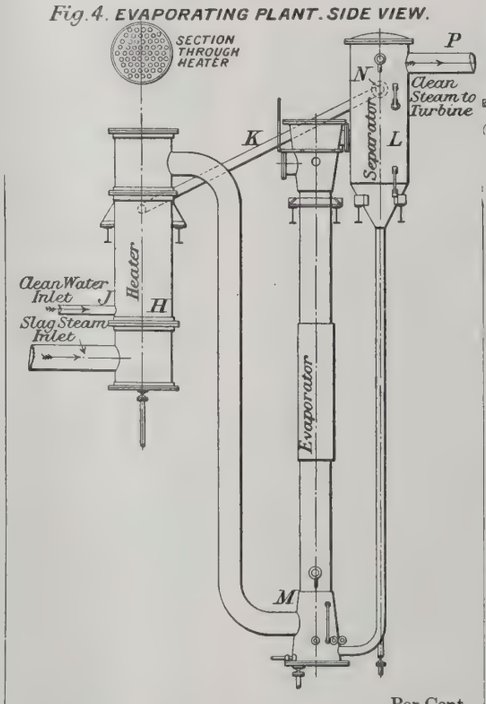


Fig. 4. EVAPORATING PLANT. SIDE VIEW.



sulphur deposited in the tubes of the heater is brushed out, and that in the calandria is removed by occasionally filling the dirty steam space with a dilute solution of caustic soda and heating with steam. There seems to be very little corrosion of the tubes of the heater or calandria; and after four years of intermittent working the primary generator does not show any signs of undue corrosion, the shafts of the elevator having a very thin black skin on the surface only.

The heating surface of the calandria is 548 sq. ft. A vacuum of about 9 in. of mercury is maintained in the separator, so that the water boils at 90 deg. to 91 deg. Cent. With steam from the slag at 100 deg. Cent., and keeping a temperature in the calandria of 91 deg., the mean of twenty-two experiments gave 173 gallons of water evaporated per hour, and the average steam per hour condensed in the calandria and heater was 190.2 gallons. The feed-water entered the heater at an average temperature of 24.6 deg. Cent., and entered the calandria at an average temperature of 89 deg.—that is, 91 lb. of clean water was evaporated for every 100 lb. of steam from the slag. With the steam from the slag at 100 deg. and the temperature of 90.50 deg., the mean of twenty-seven experiments gave 177.2 gallons of water evaporated per hour, and the total steam condensed in the calandria and the heater was 198.3 gallons per hour. The average temperature of the feed-water was 26 deg. Cent., and of the water entering the calandria 89 deg. Cent., or 89.4 lb. of water were evaporated for 100 lb. of dirty steam.

As the condensation of dirty steam takes place, the percentage of incondensable gases naturally increases. When the percentage gets above 7.5, the calandria begins to lose its efficiency, and it is advisable not to allow that percentage to be exceeded. In order to control it a small outlet pipe is arranged on the top of the calandria, where the incondensable gases are drawn off together with a small proportion of steam; with 0.5 per cent. of gas in the dirty steam there will be a loss of 6.6 per cent. of steam.

Experiments were also made to determine the amount of available steam from the slag by condensing and measuring it. The mean of seven experiments gave 1017 lb. per ton of slag, and deducting 6.6 per cent. for escape with the incondensable gases, there are left 950 lb., and 90 per cent. of this gives 855 lb. of clean steam available for the turbine. Since modern exhaust-steam turbines with a full load and a vacuum of 28½ in. can be guaranteed under the above conditions to use not more than about 27 lb. per horse-power, this gives 31.6 horse-power per hour per ton of slag per hour.

Cost.—It is impossible to give the cost of running such a plant, because the practice at different works varies considerably. Apart from handling the slag, the cost of running the electric installation is the same as an ordinary exhaust-steam turbine plant of a similar size, and the attendant can regulate the water in the calandria; there is, however, about 2 per cent. more power required for the greater amount of condensing water per horse-power; where the slag is already being granulated, there is the extra upkeep of the second elevator. One man per furnace should be able to attend to the primary generator and running in the slag, the remainder being all mechanical.

Zinconium Dioxide Crucibles.—Crucibles have been prepared by mixing zinconium dioxide with 1 per cent. of starch and 3 per cent. of magnesia, and moulding the material to the required form. It is then fired, first at 1450 deg. Cent., and next at 2200 deg. Cent., after which it will resist a temperature over 2200 deg. in the vacuum electric furnace.

Metallurgical and Engineering Institute, Wednesbury.—A copy of the programme of the County Metallurgical and Engineering Institute, Wednesbury, has recently come to hand. Evening classes are held in metallurgy, engineering, physics, chemistry, and other subjects, in the new buildings, which were informally opened on the 21st ult. These contain a metallurgical department with a laboratory capable of accommodating fifty-six students, an engineering laboratory, an applied mechanics laboratory, a drawing-office, and a physical laboratory. The programme gives particulars of the equipment of these laboratories, and also contains the time-table and syllabuses of the classes.

War Office: Mechanical Transport.—The War Office, in thanking the Commercial Motor-Users' Association for its "generous and patriotic offer to assist the War Office in the organising and staffing of the mechanical transport formations of the army," has intimated that its present need of commercial motors and drivers is satisfied. There are a few vacancies for competent boiler-makers and skilled artificers, and highly-trained men are requested to communicate at once with Mr. Frederick G. Bristow, F.C.I.S., secretary, the Commercial Motor-Users' Association (Room 58), 83, Pall Mall, London, S.W. The Association is now in a position to concentrate its energies on meeting the situation caused by the dislocation of the country's mechanical transport by the present war requirements, and has opened the following registers to enable users to secure renewed services and increased efficiency for the delivery of their goods:—1. C.M.U.A. Hire Register. 2. C.M.U.A. Drivers' Register. 3. C.M.U.A. Motor Transport Exchange. Fully qualified steam-wagon and petrol-vehicle drivers of not less than two years' driving experience, and with good records, who are available for civil employment, should communicate with the secretary at the above address.

MECHANICAL CHARGING OF BLAST-FURNACES.*

By N. Kapp (Birmingham).

Part I.

The enormous increase in the production of pig-iron in the world during the nineteenth century is shown by the fact that whereas 760,000 tons of pig-iron were produced in 1807, the output in the year 1913 had reached 77,339,000 tons, an increase of nearly 76,579,000 tons within a little over a century. To cope with this rapidly-increasing output it became necessary to improve the methods of charging the furnaces, which up to the beginning of the nineteenth century had consisted in tipping a basket or tub containing the charging mixture into the open furnace-mouth by hand. Mechanical hoists began to develop, and both inclined and vertical elevators driven by water-wheels are recorded in Upper Silesia in 1800. In 1839 the first elevator worked by compressed air was put up at Chatlinot, and in 1892 the first steam-hoist was introduced in America. During all this time inventors had concentrated their attention on means of conveying the material for the charge to the furnace-mouth; but no attempt had been made actually to charge the furnace by mechanical means. The Americans were the first to realise the necessity for automatic charging, and about 1890 brought out the first automatic tipping-skip for a furnace of 120 tons capacity.† The reason why America took the lead in mechanical charging appliances was twofold. That country, paying higher rates for labour than were customary in Europe, was compelled to utilise mechanical labour-saving devices, and, further, when the great Mesabi ore-fields were opened out, it was found that the particular ore used for smelting was reduced so rapidly that it was beyond human physical powers to keep the furnace full. Consequently mechanical charging devices became a necessity, and the automatic tipping-skip came to be universally adopted in America. The visit of the German ironmasters to America in 1890 paved the way for the introduction of American methods into Germany. For several reasons it was not possible to adopt these methods unconditionally. The American ores were of pretty uniform size, whereas Germany used a variety of ores which differed in size considerably. Also the German coke, especially that made in Upper Silesia, was much more brittle than the American coke, so that the difficulties of an even distribution of the charge were greater in Germany than in America.

The great drawback to tipping the charge into the furnace from one point is the well-known fact that the larger lumps of coke fall on the side opposite to the point of charge, and get separated from the finer material. Consequently the furnace burns more rapidly on the side containing the large lumps, and the burning out of the lining is the result. The furnace is so delicate in this respect that in one case where an attempt was made to obtain an even distribution round the furnace by charging at four places round the hopper, the lining burnt out after a few months at four places. The four strips which had been overheated corresponded to the positions midway between two points of charge—namely, where the larger lumps of coke had rolled at each filling. This is a very good illustration of the enormous importance of thoroughly mixing the charge before allowing it to slide into the furnace. The introduction of a distributor above the hopper, which got over the difficulty of uneven charging to a certain extent in America, could not be considered in Germany, as the extra height through which the material had to fall, when using a distributor, caused too much loss in breakage in the brittle German coke.

What this loss may mean in pounds per annum has been investigated experimentally by Pohlig. Pohlig found that every time coke is recharged into another vessel about 1.5 to 2 per cent. of the material is lost. If we consider a plant yielding 800 tons of iron per day, and using approximately the same quantity of coke per day, the daily loss resulting from each recharging operation will come to, roughly, from 180s. to 240s. per day (reckoning coke at 15s. per ton), or an annual loss of from 3200*l.* to 4300*l.*

The disadvantage of tipping the charge into the furnace had not escaped the American designers, and so a new type of skip was devised for Duquesne, near Pittsburg—a cylindrical skip with a cone-shaped drop-bottom, which was lowered into the furnace-mouth, and the bottom dropped, so as to let the charge slide evenly into the furnace. This plant was started up about 1897.‡ The year 1902 is usually regarded as the date when this new method of charging was first introduced into Germany, when F. W. Lürmann exhibited some drawings at the Düsseldorf Exhibition, although Professor Aumund maintains that Mr. Röchling started the idea of central tub-charging in Germany before 1902.§ In 1903 Professor Aumund took out a patent, with J. Pohlig, in Köln-Zollstock, for running the cylindrical skip up the incline, and dropping it into the furnace mouth, where it automatically discharged, all in one movement, by hinging the rails above the furnace, and holding them in position by a counterweight. Later on the Benrather Maschinen Fabrik improved this method by the so-called Stähler-Benrath system, in which the counterweight is dispensed with, and the skip is lowered by giving the rails a peculiar curved shape. These different methods are, however, so well known that I will not enter into a description of their details.

In England the most usual method of conveying the charge is by means of the vertical hoist. This system has one great advantage—it does not take up much space. The ground in the vicinity of a blast-furnace is usually so cramped with ore and coke bunkers, storage grounds, blast-heaters, &c., that the floor space is very limited and vertical hoists can be run up where there may not be room for 2 or 3 inclines. Their action is, however, slow, and in the case of large outputs they would have to be driven at such a rate that the wear and tear would become too great to allow of economical working. Further, the congestion of men, both at the hoppers and below, becomes very awkward: on the one hand, on account of the cramped space, and, on the other, because the conditions are more difficult when a strike occurs.

In recent years, especially in England, the strike question has become a most important one in all trades, but in no trade is the danger of a strike such a "sword of Damocles" as in the coal and iron industry. Every improvement which makes the manager more independent of the men employed—that is, reduces the number of hands needed in the works—places that works on a safer basis, and makes it more immune from the strike danger. It would therefore pay an iron works to put in modern labour-saving plant even if no saving in money were effected thereby, merely in order to safeguard against the strike danger and obtain a more reliable means of working the furnace. But happily the mechanical charging appliances, as they stand to-day, do effect a saving in the annual expenditure to a considerable extent. For these reasons it has been gradually borne in on us that the vertical hoist, with its vast amount of hand labour, is becoming obsolete, and that in order to hold our own successfully against foreign competition we must adopt modern methods of charging.

Two of these methods have been mentioned: the tipping-skip and the drop-bottom skip. Both of these, however, have their faults. The distributors, which are necessary with the American tipping system, besides breaking the coke, need a certain amount of machinery on the hopper to drive them. Now the furnace mouth, with its atmosphere of gases and occasional spurts of flame, is a very bad place to instal machinery which is to run permanently and without supervision.

The drop-bottom skip removes the difficulty of mixing the charge from the hopper to the bunkers, where mixing is usually done by revolving the skip as the material flows in. Even then an uneven distribution cannot altogether be avoided, if the bucket is not well balanced, and tips slightly to one side on discharging.* A great drawback to any mechanical system of this kind is that one is entirely at the mercy of the mechanism. As long as everything works well this is satisfactory, but if slight irregularities occur, there are no means of correcting them immediately. In the old days, when a barrow of coke was tipped into the hopper by hand, the men round the hopper could charge the furnace at any place where it was most needed, and a very even working of the furnace could be obtained. In fact, it comes to this—that the old hand method of charging cannot be beaten as far as the working of the furnace and the quality of iron produced is concerned; only, for reasons already stated, it cannot be considered any longer nowadays. This consideration gives an indication, however, of the line that should be pursued in devising a mechanical charger which will satisfy all conditions. Hand-charging should be imitated, and rendered automatic. This was pointed out already by Messrs. Edgar Richards and Thomas Lewis in a paper submitted to the Cleveland Institution of Engineers in 1910. The authors state:—"It is almost universally admitted that careful filling with barrows conscientiously carried out by experienced labourers is the most successful way to charge, and if a charging appliance having the latter functions could be got to work mechanically in an efficient manner, the initial objection could be removed." The bucket and skip-charging methods depart from the hand-charging method in another way which is inconvenient, and may even be a source of danger—that is, they deal with very large loads at a time. One skip or bucket may hold as much as 7 tons and more. This means much difficulty in the case of a breakdown of any part of the charging apparatus. There is, of course, a stand-by, so that the skips can be run up to the hoppers another way. Provision is usually made for them to be taken up by the elevator of another furnace, and run along the furnace platform by a special crane. That means that each elevator must be designed to take twice the load if need be, or that two furnaces are worked at half load during the course of repairs, neither method being very efficient.† If the charging units were smaller, but more plentiful, the charge of any furnace whose gearing had broken down could be distributed over several elevators, thereby distributing the risk as well as the load. Trusting the whole charge of a furnace to one machine is like putting all one's money in one concern—a risky thing to do.

In order to avoid constantly recharging the skips, and thus breaking the coke, the skips are filled at the coke-ovens and sent up to the hoppers. In order to get them there, however, a crane service is necessary. Taking the case of the works of the Gutehoffnungshütte at Oberhausen,‡ which has a daily output of 1600 tons of pig-iron distributed over four furnaces, the coke is dealt with in

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* Paper contributed to the Iron and Steel Institute, and now open for discusion by correspondence.

† "Pioneer Mining and Manufacturing in Thomas, Alabama."

‡ American patent No. 579,011.

§ *Stahl und Eisen*, No. 16, vol. ii., 1910.

* See Dr. R. Grimshaw in *Ungarische Montan-Industrie und Handelszeitung*, August 15, 1912.

† Actually, furnace managers find that the upkeep of the crane on the hopper platform costs more than it is worth, considering the amount of fitting work necessary before it can be started up in case of need.

‡ *Iron and Coal Trades Review*, April 29, 1913.

the following manner:—It is brought from the coke-ovens in the skips, three at a time, on special platform-cars. At the foot of the furnaces the skips are lifted on to trucks by a crane and run under the elevators, where they are hooked to the traveller on the incline. Each skip holds 4 tons of coke. The ore is dealt with in much the same way. It is the usual practice to draw the ore off into skips from the bunkers, which are arranged in long parallel rows. The skips are then taken to a gap through the bunkers in line with the elevators on special trucks, where they are lifted on to other trucks by a crane, and run under the elevator. Now a crane service is by no means an ideal method of conveyance, on account of the loss of time in hitching the load on and off, and the backward travel when running light. In order to convey large quantities of material in a given time, the conveyor must run continuously in one direction without stopping, the empty vessels returning to be refilled. The only way to get a continuous stream of charging material from the bunkers to the hoppers without recharging is to split up the charge into a number of small units, and to run them in an unbroken line past the coke-ovens and bunkers, up to the hoppers, and back again to the charging-stations. The most continuous stream is obtained by means of a chain-conveyor, and the suggestion has been made to use bucket-conveyors for the purpose of blast-furnace charging.

But although such a conveyor could discharge a continuous stream at the furnace mouth, and enable a very thorough distribution of the charge to be made, it fails in the other important point just discussed—namely, that of drawing off the material into the same vessel which is sent up to the hoppers. The chain-conveyor is bound to one plane. If it travels up to the furnace mouth and down to the charging-platform, it cannot travel sideways as well. But the bunkers or coke-ovens are probably situated in quite another part of the ground, and to reach them the conveyor would have to pass round many corners. This applies more especially to old existing plants, in which new methods of conveyance are to be installed. In a new works, where the lay-out plan is started on a clean sheet of paper, the floor space available and corners do not play such an important part in the consideration of the system to be adopted. But in the case of old works which are already cramped for room, which will be the most usual case in England, the conveying plant must possess the greatest adaptability to the local conditions. The advantages of a bucket-conveyor can, however, be retained without the disadvantages of its inadaptability to corners and curves, by splitting up the chain into separate detached links, and supplying each link with motive power of its own. Such an arrangement is the electric telpher. Here we have a means of conveying material from the most distant and inaccessible places in an unbroken line to the furnace mouth.

Before entering into a discussion of electric telpherage for blast-furnace charging in detail, let us consider what are the most important functions which a works manager demands from his charging plant.

1. Reliability.
2. The coke must not be broken up, for which reason the skips must be filled at the coke-ovens and taken to the hoppers without recharging.
3. Very large outputs must be dealt with.
4. It is an advantage if small loads can occasionally be dealt with by the same plant, in order to enable slight corrections to be made in the composition of the charge if the furnace is not working satisfactorily.
5. The charge must be distributed uniformly in the furnace.
6. The plant must allow of an efficient control of the composition of the charge and the organisation of conveyance.
7. In the case of a breakdown of any part, the working of the furnace must not be interfered with.
8. The plant must be very simple to work.
9. The plant must employ the least number of workmen.
10. The plant must be economical.
11. The plant must not take up much room.
12. Some managers lay great store by a centrally-placed gas outlet on the furnace, although there has been much controversy as to whether this is of any importance. It is an advantage, however, if the charging plant is so constructed that a central gas conduit is possible if desired. Further, in the case of the modification of existing works, as little as possible should need to be rebuilt, and as most furnaces are worked with a cup and bell, it is an advantage if the charging plant can be adapted to the existing hopper without much reconstructional work.

Electric telpherage is comparatively new, and the engineers who have developed this system have therefore had the advantage of learning what is needed by the mistakes and difficulties encountered by others when mechanical charging was first introduced. As the telpher is no longer in its infancy, however (as can be seen on visiting the large number of iron works where a telpher plant has been installed for charging blast-furnaces), there is no doubt that the supporters of this system are following the right principle. As the more recent developments of the telpher for blast-furnace purposes are not so well known as those of the hoists, I will discuss this matter more fully.

The principle of the plant is the same as the old miner's tub pushed by hand, the men who pushed them being replaced by small electric motors which act entirely without supervision from the moment they are sent on their way from the coke-ovens and ore-bunkers to the moment they arrive at the hopper platform and range up round the hopper. All that is left for the men to do is to knock up a catch and empty the skips into the hopper, pull a switch and send the empty cars on their way back to the bunkers.

I am indebted to Messrs. Adolf Bleichert and Co., Leipzig-Gohlis, for much valuable information, and for their kindness in supplying me with many illustrations of charging plant built by them. As I have personal knowledge only of the plants and outfit of this firm, I will confine my description to the Bleichert system of electric telphering for charging blast-furnaces.

The telpher consists of a traveller, fitted with an electric motor, which receives current (usually direct current at 110 volts) by means of a bow collector and a line wire. The skip is suspended from the traveller by a couple of hangers, and is slung in pivots in such a manner that it is in unstable equilibrium when full, and therefore upsets as soon as the catch is knocked up. When empty, however, it is unstable in an inverted position, which makes it very easy to right the skip and throw in the catch. The working of the line being entirely automatic, it is necessary for the safety of the cars to introduce a block system, similar to that on a railway, but entirely self-acting.

Fig. 1.

Fig. 2.

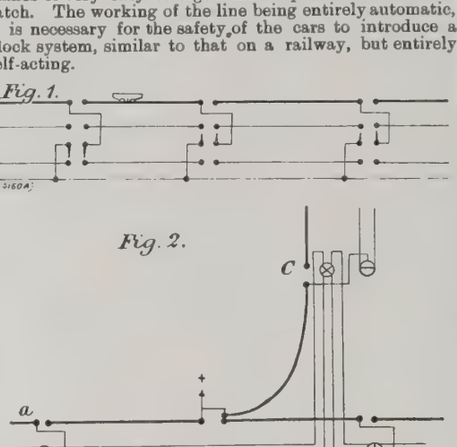


Fig. 3.

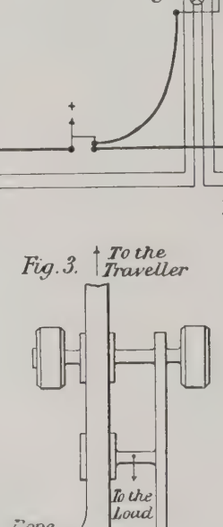
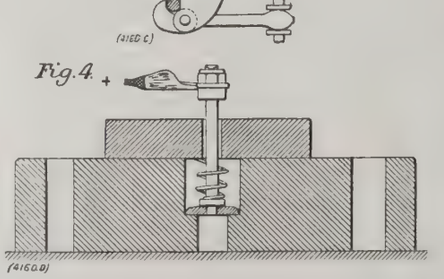


Fig. 4.



For this purpose the telpher line is divided into a number of sections, each section receiving current over a switch. The switches are of a drum type, and are turned by the passing of a car in such a manner as to cut off the current from the section it has just left. At the same time the switch gives current to the section which was deprived of current before, so that there is always a dead section behind every car, and no second can approach closer than the length of one block section. The number of these sections and block-switches depends upon the output of the line. Greater output means more telpher cars and more sections, so that the cars can move closer together. Herein lies a great advantage of this system—namely, the ease with which a telpher plant can be extended if a greater output be desired. To double the output subsequently, all that is necessary is to cut the line into twice as many sections, put in twice as many block-switches, and run twice as many cars as before. The limit to the extension is given by the shortest possible distance allowable between two cars. Experience has shown that this distance is about 12 metres on an open track. At the charging stations or in a siding, 3 metres is ample: 12 metres are, however, necessary where there are points and crossings, to give time for these to work before the next car is ready to enter them. Otherwise a great deal of unnecessary stopping and starting would occur all along the line.

The working of the block switches, which effect the blocking and releasing of the cars, is extremely simple, as illustrated in Fig. 1.

The switches are no different in principle from those to be found in every hotel bed-room, one at the door and one over the bed. If we switch on at the door, we can switch out at the bed, and *vice versâ*. This is just what the car does; it switches off the section it has just left, and switches it on again when it reaches the next section. By means of this simple switching system it has been possible to solve the most complicated problems of interblocking at switches and crossings, of automatically turning the points, and so forth.

The principle underlying the block system in a siding is as follows (see Fig. 2):—

If the line *a* is cut out by a car turning switch A, it must be given current again when the car reaches switch B, or, if the points are set accordingly, when it reaches switch C. The supply of current to *a* must therefore be controlled from two places, B and C.

C is an ordinary reversing switch. Suppose B and A are in step, and supposing a current to pass from B to A *via* C, using the upper lead, then this current will be cut off on a car passing switch A, which throws the switch-blades on to the lower lead. In order again to supply current to A the switch-blades of B may be thrown on to the lower lead by the car passing B, or the upper and lower leads may be crossed against each other by the car passing C. In that case the current will pass from the upper lead at B through the reversing switch into the lower lead at A and into the line.

The great advantage of such a mechanically-operated switch system over all forms of electrically-operated switches, with their delicate solenoid apparatus, is manifest. The switch-gear is totally enclosed, and thus unaffected by weather conditions. The greatest advantage of this system, however, lies in its safety. Should a switch become defective by breakage or some such cause, the contacts can never jam in such a manner as to give current to a section that should be blocked. It can only fail to release a section which has already been blocked by the previous car, and thus cause a stoppage of cars all along the line, which will immediately be noticed.

At the bunkers and charging stations the line is divided into a number of short sections, so that a number of empty skips can wait for filling just outside the stations. Each car, as soon as it is charged, is sent on its way by giving current to the section on which it stands by means of a pull-switch. As soon as it turns the block-switch at the end of this short charging section, all the cars waiting outside the station move up by one section.

The most important part of the plant is the ropeway incline, and a very neat method of automatically coupling the cars to the running-rope is the automatic gripping device invented by Adolf Bleichert. The principle underlying this invention is that of letting the weight of the car act directly on the grip of the rope. Fig. 3 shows the principle, omitting constructive details.

The gripping-jaws are like the jaws of a nut-cracker. One arm of the nut-cracker goes to the traveller, and the other carries the load. The pressure on the rope is therefore directly proportional to the weight of the skip. When the rope is to be released, the weight is taken up by a couple of rollers in connection with the one lever-arm, and the jaws open and release the rope. With this system it is immaterial whether the rope used is thick or thin, and therefore the gripping power becomes no smaller when the rope is old and has decreased in diameter owing to stretching.

At the foot of the incline, where the telpher car is automatically attached to the rope, the suspension rail is bent slightly downwards, so that the car cannot fail to move forwards with the speed of the running rope at the point of coupling, which prevents a sudden load coming on to the rope. As soon as the latter is gripped, and the car starts on its way up the incline, there is no further need for electric power, and the line is interrupted until the top of the elevator is reached, where the cars are automatically uncoupled and run on under current. It once happened that a car was admitted into the incline by a careless workman before the ropeway had been started up; consequently the car was held back by the rope and left under current until the armature burnt out. In order to safeguard against such an occurrence again, the line is now interrupted before the point of coupling, and the section at the beginning of the incline supplied with current over a special fuse, so that the motor cannot burn out.

Recently a further safety device has been added to each car in order to prevent the burning out of an armature, which might occur from such causes as overloading the skip, or, in the case of automatic discharge, allowing the pile to grow to such a height that the cars get stuck in it, whilst the motor is under current. An ordinary fuse is no good in this case, as it would have to be large enough to take the full starting current, which is about three times the normal current; but three times the normal current continuously would be sufficient to burn out the armature. A thermostatic time fuse is therefore used, the action of which depends on the heating of the motor-casing. The principle is illustrated in Fig. 4.

The current from the negative motor-brush passes to earth over a fuse of some metal, which melts at 60 deg. to 80 deg. Cent. A good contact is ensured by a spring. If the temperature of the motor-casing exceeds a given value, the fuse melts, and the plunger-contact drops into a well, where it has no connection to earth, and the motor current is interrupted.

The elevator, being the most important of the whole plant, must be thoroughly reliable, and in the case of a breakdown must have a stand-by which can be started up at once. In the case of a ropeway incline the stand-by consists of a second ropeway driven by an independent motor which is always in readiness. In the case of a breakdown all that is needed is to start up the second machine and move the points at the top and bottom of the incline. In this respect the rope-telpher system has the advantage over almost any other—namely, that a

breakdown of the hoisting-gear means a loss of only a few minutes in getting ready the stand-by, whereupon the work is taken up in exactly the same way as before.

In all the systems where large units are taken up special inclines a breakdown or repair on one of the inclines necessitates the charge for that particular furnace being taken up another incline and carried back by means of a special crane on the hopper platform. Apart from the fact, which I have already mentioned, of the disadvantages of working two furnaces at half load until the faulty incline is repaired, it is necessary to keep a crane on the hopper platform, where it is exposed to the weather, in good repair, although it may hardly ever be used. As I have already mentioned, most managers prefer to dispense with a reserve method altogether.

There is another advantage, which must not be underrated, in the use of only one incline for all the furnaces: it allows an excellent control of the charge sent up to the hoppers, and facilitates the general arrangement of the whole works by separating the different classes of work and keeping them apart. The different classes of work are:—

1. Drawing off the ore from the bunkers.
2. Building up the charge.
3. Conveying the complete charge to the furnace mouth.
4. Tipping the charge into the furnace.
5. The return of the empty skip.

I will endeavour to show the difference in the general arrangement of the working of a plant with one incline, and of a plant using a separate incline for each furnace, by means of a few diagrams.

In the case of charging by telpher, the ore is stored in bunkers. These are cross-divided into a number of cells from which the ore may be drawn into telpher skips running on several lines underneath the bunker. If several different kinds of ore are smelted, as is usually the case, the different sorts are stored next to each other, each kind running across the bunker. Such an arrangement is convenient, as each class of ore is kept to its special portion of the bunker, and not scattered over it in various places, and charging the bunker by rail is thus facilitated. (See Fig. 5.)

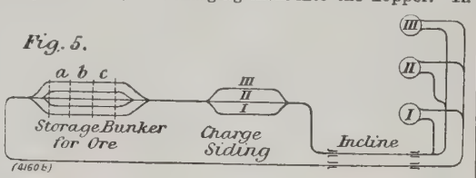
At the entrance and exit of the bunkers the various telpher tracks join up by points to one suspension-rail, which takes the charge to the charge-siding. Each furnace has its particular siding, where the charge is built up by admitting the correct number of skips filled with ore and flux, *a*, *b*, and *c*, for each furnace, until the charge is complete. This is done by one man, stationed in a signal and switch-box at the entrance to the siding. As soon as the charge for one furnace is complete, the whole train is sent up to the hopper at once. The cars automatically grip the rope on the incline, at a distance from each other regulated by the block switches. On arriving at the furnace mouth where they are needed, they range up in a siding one behind the other, from which position they can be brought forward separately by means of a pull-switch, and emptied into the hopper at any desired point. From here the empty skips are sent back to the bunkers on the "down" track, thus completing the loop. It will be seen that one charge never interferes with the working of another, as the motion is continuously a forward one. It is obvious that an arrangement such as this allows of a very thorough supervision of the composition of the charge thrown into the furnace, as building up the charge is in the hands of one responsible person, and does not depend in the least on the rest of the men. At the bunkers a mistake is not possible, as the ores are kept strictly separate. And from the moment the charge leaves the siding where it is built up, it is open to inspection and control right up to the moment when it is thrown into the furnace.

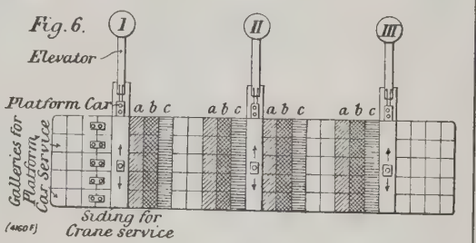
Comparing the above general case with a typical arrangement of a works run with separate inclines for each furnace, it will be seen that the supervision is not so easy in the latter case. The example given (Fig. 6) is taken from Dr. Lilge's work on the economic aspect of blast-furnace charging,* and represents Case II. in his work.

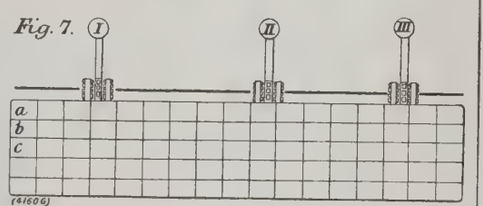
The bunkers are so arranged that the various kinds of ore are stored next to each other transversely, as before; but in this case the same kind of ore occurs again at intervals, to be handy for the several furnaces. It is therefore necessary to move the ore trucks when charging the bunker, and to drop the ore into the proper cells, otherwise the ores will get mixed.

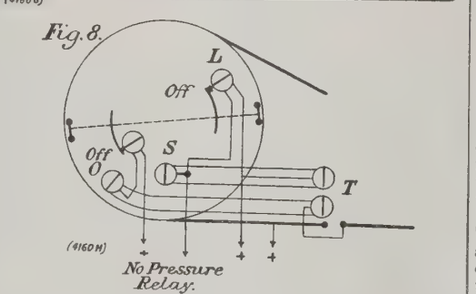
The elevators are of a type using what may be termed a drop-bottom skip or bucket, to distinguish it from the telpher skip. The bucket is carried under the bunkers on platform cars, and filled with the different materials in succession. As the ore flows into the bucket, the latter is revolved by means of a special mechanism on the platform car, and the amount of each kind of ore by weight is ascertained by a weighbridge, also built into the car. The workmen at the bunkers are therefore responsible that the charge in the bucket is built up correctly, for as soon as the material has been run into the bucket, no overseer can check whether the composition is correct or whether it is sufficiently evenly mixed. Now when it is considered that two buckets are filled simultaneously for each furnace—that is, eight filling and mixing operations at the same time in different places—in the case of a works with four furnaces, it is obvious that the control of the charge is entirely in the hands of the men instead of in the hands of one overseer. When one of the buckets is full, it is taken to the foot of the incline on other trucks, on to which it is lifted by a crane, as already mentioned.

A somewhat better general arrangement than this is the plant described as Case I. by Lilge. In this case the ore is disposed in the bunkers in long parallel rows running the whole length of the system (Fig. 7). The bunker is cross-divided into a series of pockets, as in the previous case, and between every two rows of pockets a tunnel runs across the bunker underneath, so that the ore may be drawn off into skips hung from a suspension rail and pushed by hand. In front of the tunnels travelling-bridges run the whole length of the bunker, two bridges to each furnace. Each bridge can take skips from out of any of the tunnels up to the number of eight, which constitutes the charge of one drop-bottom bucket. The eight skips are run to the foot of the incline of the furnace to be charged and emptied into a shoot, which runs the material into the bucket below, the latter being revolved meanwhile to mix the charge. This system is capable of better supervision than the last, as the charge for each furnace is weighed and built up in small units on the travelling-bridge, where it is open to inspection, until it is thrown into the bucket. In fact, the greater supervision in this case, as compared with the last, is based on the principle systematically carried out in the case of telpher charging—namely, that of splitting up the charge into a number of small units, building them up to a complete train, and charging them into the hopper. In









this case, however, the hopper is movable, and brought down to the ground for the purpose of charging. Although the travelling-bridges allow of better supervision than direct bucket-filling, the work of the overseer is not so thorough as in the case of telpher charging, as there are two bridges to every furnace, or eight bridges for four furnaces at work at the bunkers, and it is impossible to overlook the whole lot, so that to a certain extent the composition of the charge is still in the hands of a number of men in charge of the bridges, whereas in the case of telpher charging the building up of the charge for every furnace is controlled by one man.

Before leaving the subject of hoisting the telpher skip from the ground to the furnace mouth I will describe another method besides the ropeway, which has been found to be very successful where the height of the furnace is not very great; that is, the spiral elevator. The principle of this elevator is that of a spirally-bent suspension rail, up which the telpher cars are pushed by means of a vertical bar, which is made to revolve in the spiral and press against a roller at the rear end of the cars. The bar revolves continuously, and the cars are admitted at the correct moment for the bar to carry them to the top. This is done by interblocking in the following manner:—

The last block section is placed a little before the spiral, the line entering the spiral being always under current to ensure the car moving right forward into a position where it may be caught by the revolving bar.

In order to prevent a collision between the revolving bar and the telpher car entering the spiral, two separate blocking devices are arranged for the car and the mechanism of the spiral respectively. Considering the block system for the telpher first: the last block section is cut off from the supply on a car passing switch T (Fig. 8), and will only be signalled free again when the car has passed the switch O—that is, at the foot of the incline up the spiral, when it will be carried away by the mechanism of the spiral, and make room for the next car. In order to prevent a car moving into the spiral just at the moment when the revolving bar might collide with it, the supply to switch T and the block section passes through a switch worked by the mechanism of the spiral, which cuts off the current when the bar sweeps through the dangerous zone. By this means the entrance for the cars is made safe, for a car cannot pass switch T unless the passage is free, and once it is on the live section behind T, it must travel forward to O, where it will be caught by the revolving bar. It might, however, happen that owing to some accident, say a fuse blowing, the car passes switch T, and then stops between T and O in the path of the revolving bar. In this case it becomes necessary to stop the spiral automatically to prevent a collision. The block system for this is as follows:—The motor for driving the spiral is provided with a no-pressure cut out, and the current for holding up the no-pressure relay is supplied from two independent sources: first, over the two block-switches T and S, and, secondly, over a switch L, operated by the spiral arrangement. This switch L is always switched in excepting when the bar passes through the dangerous zone. During this time the no-pressure relay must take its current from T over S. If, however, a car happens to be standing between T and S at this moment—that is, standing in a dangerous position—the two block-switches T and S will be out of step, and no current can flow. Consequently the no-pressure relay will drop out and the spiral mechanism stop as soon as the bar comes into the dangerous zone.

The spiral for conveying the empty skips downwards needs a special arrangement for drawing the cars forward at the right moment, so that they may rest behind the revolving bar which guides them down. The live wire is interrupted about 1½ ft. before the entrance to the spiral, so that the speed of the car will be greatly diminished in travelling over this short dead section against the brakes. At the end it is caught by a hook, which prevents it running freely down the spiral. The top of the revolving mechanism is provided with an outrigger of a peculiar curve shape, so constructed as to catch a projecting lug on the traveller, and draw the car forward as it revolves. The hook, which hitherto held the car back, is raised by a saddle-shaped angle-iron engaging with a roller on the hook. As the car is guided into the spiral it slides into position behind the revolving-bar, and is now ready to start on the descent. The curved outrigger is so constructed that the pressure on the car is always in the direction of motion of the latter, so that there is no tendency for the car to jump the rails. Moreover, the curve is extremely gentle at the first impact, so that the traveller is moved forward only a little for a big movement of the outrigger, and gradually speeded up on entering the spiral. By this means there is no jar on the mechanism, nor sudden load on the driving motor of the elevator when a car enters the spiral on the descent.

Part II.

In the first part of this paper the general principles of telpher charging are discussed, and are compared to a certain extent with other methods. I will now describe a furnace works using the telpher charging system in detail. The works are those of Gebrüder Röchling in Völklingen, near Saarbrücken. The reason these particular works have been chosen is that its charging plant is typical of a well-arranged telpher line, and, moreover, there are a few recent improvements added to the line which are missing in others.

The works of Röchling is one of the largest in Germany. There are five furnaces with a daily output of 240 tons, and one of 300 tons. Two further furnaces are in course of construction. Both the ore and the coke are conveyed to the hoppers by an extensive telpher plant, and to obtain a thorough insight into the working of the plant we will begin at the ore-bunkers and follow the path of the cars.

The bunker is divided into 135 cells, each one ending in an ore-trap below. The different kinds of ore are stored in the bunker in groups. Three telpher tracks pass lengthwise below this bunker. The bunker is about to be enlarged and three further tracks added. The empty skips pass along below the ore-traps, and can be stopped at any particular one by a pull-switch. Here they are filled by opening the shutter in the trap and allowing the ore to slide out. As soon as a skip is full, it is sent on its way by closing the pull-switch. After running back along the outside of the bunkers it comes to the central weighbridge and switch-house for the ore-siding. This position may be called the heart of the whole charging plant, for the foreman in charge here is solely responsible for the correct composition of all the charges, and any irregularities are traced to this one man.

The way this important centre is worked is as follows:—

The necessary composition for each furnace is determined by the furnace manager, and written down on a board by the foreman at the weighbridge, so that this man has before him a list of the ores and their weights for each furnace. As the skips, filled with various sorts of ore and flux, pass the weighbridge their weight is made up to the correct amount by adding or taking away a few lumps of ore, and they are then admitted into one of the tracks which form the charge-siding, where they wait until the furnace fed from that siding needs a charge of ore. The foreman sets the weighbridge to the amount corresponding to the figures on the charge-board, and prints this weight on a weighing-card when the correct amount has been made up in the skip. He cannot print a wrong figure, as the printing mechanism will not work unless the beam is poised. The weighing-cards are sent up

* Dr. Fr. Lilge, *Hochofenbegichtungsanlagen, mit besonderer Berücksichtigung ihrer Wirtschaftlichkeit.*

to the office every night as a check on the charge thrown into the furnaces. Each furnace has a differently coloured card, so that it is easy to keep them apart. The number of the cards sent to the office must tally with the number on an automatic counting mechanism, so that the correct composition is checked in every possible way.

In order to show the switch-men at the subsequent stages the furnace for which any train of ore-skips is destined, a large number, corresponding to the number of the furnace, is hung on to the first and last skip of the train, at the central weighbridge. Looking down the tracks of the charge-siding, rows of ore-trains waiting to be sent to the hopper-platform can be seen. The switch-points for admitting the cars to the several tracks are worked by the man in charge of the weighbridge, which again places the correct distribution of the charge into the hands of the one responsible man.

At the outlet of the charge-siding is a signal-box fitted with pull-switches, one for each track. The man stationed here need know nothing of the composition of the charge, or of the number of skips required. He merely waits for a signal from above that a particular furnace requires ore, whereupon he pulls the switch of the corresponding siding until the whole train is through. The attendant can overlook all the sidings from his window. The signal system, by means of which ore and coke is ordered from above, will be mentioned later.

From the charge-siding the train of skips moves towards the rope incline, where each car couples itself automatically to the running rope at distances from each other regulated by the block-switches. There are three ropes in all on the "up" track, and three on the "down" track. One of these is used as a stand-by, and the other two are used alternately. This is done by means of an automatic point, which switches the cars alternately on to one or other of the three ropeways. The point is thrown over by on electro-magnet operated by a couple of block-switches, which are turned by the cars on passing. These automatic switch-points work very smoothly without the least attention. They are, of course, only used in such cases where the traffic is too heavy to be dealt with by one rope alone. At the foot of the incline the rail is curved slightly downwards, so that the car may run forward and grip the rope without any sudden shock or current peak on the driving motor for the hauling-gear. The rope-gripping device is that explained previously. The weight of the skip is taken up by a couple of extra rails which cause the jaws of the apparatus to open and receive the rope, which gently drops between them. As the skip is gradually lowered again off the secondary rails, the jaws close round the rope and firmly hold the skip, which is immediately carried up the incline. At the top of the incline it is released in exactly the same manner. On the downward path the rope is gripped well before the cars come to the descent, so that there is no fear of them running away.

When a car has arrived at the top of the incline it is sent down the hopper platform to the furnace requiring the charge. Before each furnace there is a siding, in which the cars stand until they are wanted. One skip after another is brought forward by means of a pull-switch and tipped into the hopper.

The empty skips return to the bunkers to be refilled, using the "down" track of the incline.

The points for directing the cars to the proper hoppers are worked from a central switch-box at the top of the incline, just as the points on a railway are set from the signalman's cabin. The switch and signal at the top of the incline is, however, important in another respect, as it contains the signalling apparatus for ordering and checking the ore-trains. All the signals are given by small lamps; the system for ordering a charge of ore or coke from any of the hoppers is as follows:—

Each hopper is fitted with a little lamp-board with a red light and a green light, and, further, three push-buttons: one button for "ore," one for "coke," and one extinguishing button for "lights out." A lamp-board in the switch-box is in connection with all the hopper-boards, so that an order for "ore" at furnace No. 3 will show a red lamp marked "ore" on the third panel in the switch-box, at the same time showing a red light at the hopper No. 3. The attendant in the switch-house will at once check the order by pressing a button marked "furnace 3," causing a green light to appear on the hopper-board, at the same time showing a similar light at his own board. These lights are then extinguished by the man at the hopper by pressing the "lights out" button, as soon as he sees that his order has been understood and checked by a green light. In the meantime the attendant in the switch-house above passes on the order to the man in the switch-box below in command of the charge-siding, where the charge for furnace No. 3 is presumably waiting. The system for passing on the order is exactly the same. A red "ore" light appears on a panel No. 3 below, which is checked back with a green light and finally extinguished from above. Now the attendant below sends off the train waiting in siding No. 3, and the attendant in the switch-box on the hopper plantform sets the points to admit the whole train into the siding in front of hopper No. 3.

So far the signal system for ordering a charge is very simple. But when all the furnaces are in full swing, the traffic on the hopper platform is very heavy, and so the attendant wants to know the earliest possible moment when he can set the points to send the next charge to another furnace—that is, when the whole train is in the furnace-siding. The hopper platform is too long to observe the cars, and by night or in a fog this would be impossible in any case. A very ingenious signalling mechanism has therefore been fitted, by means of which the attendant can see at a glance where any particular car is at any moment without leaving the hut. Moreover, the attendant can set his apparatus by pressing a button, so that any particular furnace-siding will admit only a certain number of cars, and ring a bell when all the cars are through, so that the man in charge may know when to set his points.

The coke is brought up to the hoppers over a separate incline directly from the coke-ovens. There are 400 ovens in all, arranged in two long rows. A telpher track is laid down in front of the coke-platforms on either side, and, in order to facilitate loading operations, four travelling-bridges sweep over the coke-platforms, so that coke may be thrown into the skips at any point. Each bridge can carry four skips, which are sent on their way to the incline over drag-switches, by means of which the bridge is connected to the main track. The skips hold 650 kg. of coke each. By this means it is very easy to load the coke into the skips without breakage, as the coke need not be moved to any fixed loading place, the skips being carried by the bridge to any place where the coke happens to be. Just before the incline there is an arrangement for making up the correct weight of each skip. This arrangement consists of a balance-arm in connection with a hinged portion of the suspension rail like an arm of a weighbridge. The trolley line over this portion of the rail is supplied with current only when the balance-arm is poised, so that every skip whose weight is not correct will come to rest at this point. Coke is then added or taken off until the weight is correct, whereupon the skip will move off automatically. The exact weight of each coke-skip is registered automatically on passing a selfregistering weighbridge on the hopper platform. A special coke-siding is provided on the hopper platform, so that there may always be a sufficient quantity of coke in readiness to draw from. Should the coke supply from the company's own ovens not be sufficient for any reason, coke may be brought from a storage ground near by the ore-bunkers, in which case the ore-incline is used for the transport of coke as well as ore. For this reason the signalling apparatus is arranged to order coke from the ore-siding if necessary.

CATALOGUES.

Oxy-Acetylene Welding and Cutting Plants.—A catalogue of acetylene-generators, cutting and welding blow-pipes, oxygen-pressure regulators, and other accessories and supplies for welding and cutting by the oxy-acetylene process, has been issued by the Messer Engineering Company, of 296-300, City-road, E.C.

Pattern-Making Machine.—A catalogue illustrating and describing their semi-automatic wood-milling machine for making patterns and core-boxes has reached us from the Pattern-Making Machine and Mechanical Tools Company, of 89, Forest-road, W., Nottingham. This machine, which is made under Wadkin's and Scott-King's patents, was illustrated and described in ENGINEERING of July 12, 1912, on page 39, so that we need not deal with its many special features here. The catalogue illustrates the great variety of work done by the machine, which can be used for plain and ornamental wood-working of all descriptions, as well as for pattern-making.

Saws.—Messrs. C. D. Monninger, Limited, 124, Clerkenwell-road, E.C., have sent us a copy of their latest catalogue of saws and accessories. Wide band-saws, for band-mills and re-saws, are first dealt with, prices being quoted for saws ranging from 3 in. to 10 in. in width, and these are followed by particulars of stretching-machines, swages, sharpening-vices, brazing apparatus, saw-setting machines, and other appliances for the care of band-saws. Prices are also stated for narrow band-saws, from $\frac{1}{4}$ in. to $2\frac{3}{4}$ in. wide, as well as for rotary band-saw guides, circular saws, grooving saws, "drunken" saws, cross-cut saws for hand use, and Simonds' circular saws with inserted teeth. The firm undertake the repairs to saws of all kinds, and prices for this work are mentioned.

Driving-Chains.—"The Coventry" Chain Company, Limited, of Spon End, Coventry, have issued a handbook of data relating to their noiseless driving-chains. The hand-book first explains the principles of these chains and points out their advantages. Dimensions, weights, and breaking loads are then given in tabular form for chains varying from 8 mm. to $2\frac{1}{2}$ in. in pitch. These are followed by tables of clearances in chain cases, data for chain-wheel teeth, dimensions of chain-wheels, and hints to users, while the remainder of the book is occupied by illustrations of the firm's shock-absorption wheel, examples of chain-drives, and illustrations of chain-gear boxes for speed reduction. The book is attractive in appearance and conveniently arranged, so that it cannot fail to be appreciated by the firm's customers.

Electric Cables.—We have received from the St. Helens Cable and Rubber Company, Limited, of Warrington, a pamphlet dealing with their cab-tyre sheathed cables. These cables are very suitable for wiring work in factories, and for supplying portable apparatus in workshops where they are likely to be exposed to hard wear or corrosive fumes; they are also used for house wiring. They are made in 600 and 2500 megohm grades, with conductors varying from one No. 22 wire to 127 wires each 0.101 in. in diameter, giving an area of 1 sq. in. Single-core, flat-twin, round-twin, and three-core cables are listed, as well as small-twin flexible cords. Special corrosion-proof junction-boxes for use with these cables are illustrated, and some wiring installations on this system are also shown.

Driving-Chains.—A pamphlet, giving prices and full particulars of Westinghouse silent rocker-joint driving-chains, which they manufacture under Morse patents, has been issued by the Westinghouse Brake Company, Limited, of 82, York-road, King's Cross, N. The construction of these chains, which are made with pitches ranging from $\frac{1}{2}$ in. to 3 in., is illustrated and described, and instructions for the installation and maintenance of chain-drives are also given. The remainder of the pamphlet (rather more than half of it) is occupied with illustrations of typical chain-drives transmitting from 1 to 1000 horse-power. The largest drive employs a 3-in. pitch chain, 24-in. wide, running at a speed of 1450 ft. per minute. It is used for driving the line-shafting in a rubber-mill; another drive, transmitting 500 horse-power, is also used in the same mill.

Cranes, Transporters, &c.—We have received from Sir William Arrol and Co., Limited, of 56, Victoria-street, Westminster, S.W., an album of illustrations of cranes, transporters, and other lifting machinery constructed by this firm. Several examples of giant cantilever cranes are first illustrated, among them being the 250-ton crane for Portsmouth Dockyard, which was illustrated and described in our issue of April 17 last, on page 514; this is claimed to be the largest crane built in this country. Numerous examples of floating cranes, wharf cranes, large overhead travelling cranes (one having a lifting capacity of 200 tons), railway-breakdown cranes, locomotive cranes, grabs, Temperley transporters, overhead runways, bridge cranes, electric capstans, &c., are also illustrated as examples of the firm's productions. Several pages of the album are devoted to tower cranes and other cranes for shipbuilding yards, and some examples of shipbuilding berths, complete with crane equipment, are also included, so that an interesting comparison can be made between these and the separate shipbuilding cranes.

Cables and Joint-Boxes.—Messrs. Siemens Brothers and Co., Limited, of Woolwich, S.E., have sent us copies of two of their latest catalogues dealing respectively with paper-insulated cables and cable-joint boxes. In the former prices are stated for low-tension cables of the single, concentric, twin, and three-core types, suitable for pressures up to 660 volts, and also for high-tension concentric and three-core cables; the latter are suitable for pressures up to 11,000 volts. Extras for armouring and serving are also mentioned, and a number of useful tables are included in this catalogue. The joint-box catalogue, which is probably one of the most complete publications of its kind in existence, is divided into sections relating to feeder pillars, disconnecting fuse and link-boxes, sealing ends and end-dividing boxes, straight joints, T and service boxes, house-service fuse-boxes, crane connection-boxes, special boxes and appliances for use in mines, and general accessories. The catalogue is very fully illustrated by means of reproductions from drawings and photographs, and prices are stated in all cases. The Home Office Rules relating to the use of electricity in mines are also reprinted in an appendix.

Steam-Engines and Boilers.—We have received from Messrs. Ruston, Proctor and Co., Limited, Sheaf Iron Works, Lincoln, a catalogue giving full particulars of their portable steam-engines. Single-cylinder, double-cylinder, and compound engines are listed in sizes ranging from 4 to 92 horse-power. Another catalogue from this firm deals with engines and boilers specially designed for use in oil-fields. The engines are of the single-cylinder type, and are listed in six sizes ranging from 21 to 35 horse-power. The fly-wheels of these engines are provided with two detachable rims, which can be added or removed as desired. The boilers are of the horizontal multitubular type, and are usually mounted on wheels to facilitate transport, and to enable them to be moved conveniently from one well to another. They have extra large fire-boxes, with water spaces under the ashpits, and are also provided with large steam-domes to render them suitable for working rotary drilling outfits. The catalogue gives full particulars, including weights, dimensions, and capacities, of both engines and boilers. A four-page pamphlet relating to boilers heated by the exhaust gases from internal-combustion engines has also reached us from this firm. It is pointed out that about 2 lb. of steam per brake horse-power hour can be produced in these boilers with full load on the engine.

POLYTECHNIC SCHOOL OF ENGINEERING.—A prospectus giving full particulars of evening classes in engineering and mechanical science has come to hand from the Polytechnic, Regent-street, W. These include complete courses of lectures and laboratory work in mechanical, civil and electrical engineering subjects, as well as special courses in motor-car engineering, aero engineering, power-plant design, mathematics, and theoretical mechanics.

LONDON COUNTY COUNCIL TRADE SCHOLARSHIPS FOR BOYS, 1915.—Courses of instruction are provided in London at day trade schools for boys and girls who intend to enter skilled trades with a view to becoming skilled workers, foremen, and managers. The Council offers about 231 scholarships for boys and 300 for girls tenable at these schools. By means of these scholarships, boys and girls may secure free education (with a maintenance grant) to prepare them on leaving school to take up either apprenticeships or employment in skilled trades. The Council does not, however, guarantee employment, and it is expected that parents will take definite steps towards the end of the course of training to secure suitable positions for their boys in the trades in which they have been trained. The next school year in the trade schools will commence in April, 1915, when successful candidates for these scholarships will begin their training. Further details of the scholarships and of the courses of study at the various schools are set out in the L.C.C. Scholarships Hand-Book, which may be obtained directly or through any bookseller from Messrs. P. S. King and Son, 2 and 4, Great Smith-street, Westminster, S.W., price 1d., or by post 3d.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

GUNS AND EXPLOSIVES.

19,337/13. Sir W. G. Armstrong, Whitworth and Co., Limited, and S. M. Murray, Newcastle-on-Tyne. Projectiles. [2 *Figs.*] August 26, 1913.—This invention relates to improvements in fuzes for projectiles of the type in which pivoted arms are employed, which spread out when the projectile is fired, and on engaging with a light target, such as a balloon or airship, cause the projectile to explode. According to this invention, the pivoted arms act on impact positively upon the striker and explode the charge. The striker *a* which carries the needle *b* is normally held stationary by a shearing wire *c*, and it has in it a longitudinal slot *d* to receive a second shearing wire *e*. The striker *a* has fixed to it a disc or head *f*, the front face of which

Fig. 1.

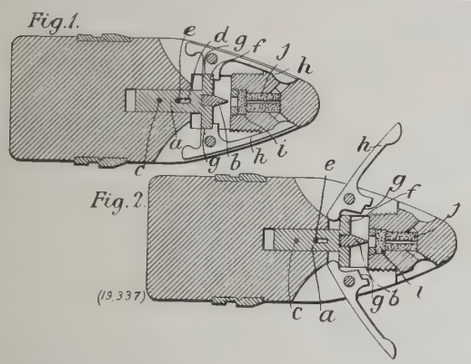
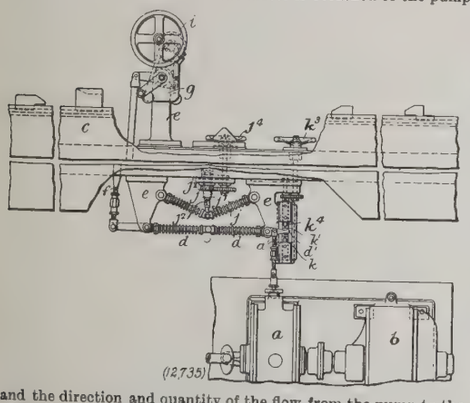


Fig. 2.

engages with notches *g* in the pivoted arms *h* and normally holds them in recesses in the nose of the projectile. The shock of discharge causes the striker *a* to shear the wire *c* and to move rearwards, thus releasing the pivoted arms *h*, which are then caused by air pressure and centrifugal force to fly outwards until their tail-ends, coming against the rear face of the head *f*, carry the striker *a* forward again until it is arrested by the shearing-wire *e* coming to the end of the slot *d*. On impact, the arms *h* are forced further backwards, and their tail-ends force the striker *a* forwards, causing it to shear the wire *e* and force the needle *b* against the detonator *i*, thus exploding the charge *j*. (*Sealed August* 27, 1914.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

12,735/13. R. H. S. Bacon and W. S. Roe, Coventry. Variable-Speed Drive. [2 *Figs.*] May 31, 1913.—According to this invention, the table of a planing or like machine is driven at varying and variable speeds on either the forward or return stroke by means of a system of toggle joints controlling the action of a variable-speed liquid-power transmission system, such as the Hele-Shaw pump and motor or similar power system. The toggle joints are operated by reversing and accelerating cams attached to the machine table. The toggle joints may be adjusted to give a varying range of cutting speeds; and a varying range of return speeds, and to accelerate the machine table during part or parts of the cutting stroke. *a* is a pump driven at a constant speed by an electric motor *b* and delivering liquid to a motor (not shown) which drives the table *c* of a planing machine. The exhaust from the motor is returned to the pump



and the direction and quantity of the flow from the pump to the motor is regulated in a manner well understood by the movement of a rod a^1. This rod is connected to one of a pair of telescopic spring toggle levers *d* pivoted to the frame *e* of the machine. The other of the pair is connected by a link *f* to a quadrant *g* pivoted to the frame *e*, and having fast with it rollers which lie in the path of cams on the table. When these two levers are in the same straight line, into which position they may be set by actuating the quadrant by a hand-wheel *i* and toothed gearing, no liquid passes to the motor, and the machine table stops; when they are not in the same straight line, the speed of the motor depends on the angle between them. This angle for the normal speed of the cutting stroke is determined by a stop which consists of another pair of spring telescopic toggle levers *j* that can be set by means of a screwed spindle j^2 working in a nut j^1 which slides through but turns with a pinion j^3 actuated by gearing from a hand-wheel j^4; but should it be desired to accelerate the speed above the normal, the first toggle is forced by means of one of the before-mentioned cams further over against the toggle stop until a prolongation d^1 of the first member of the first pair of toggle levers comes against another stop *k* which can be set for this accelerated speed by means of a right and left-hand screwed spindle k^1 actuated by gearing from a hand-wheel k^3. When it is desired to return to the normal speed, another of the cams on the table restores the toggles to their normal position. The spindle k^1 also carries a stop k^4 determining the return speed of the table. (*Sealed August* 27, 1914.)

MOTOR ROAD VEHICLES.

13,728/13. Vickers, Limited, and G. H. Challenger, London. Aeroplanes. [3 *Figs.*] June 13, 1913.—This invention relates to aeroplanes of the kind that are provided with a fixed shield so constructed and arranged with reference to the engine that the exhaust gases and oil emanating therefrom are prevented from reaching and inconveniencing the pilot by being discharged into the atmosphere through an opening situated at some suitable part of the aeroplane, as, for instance, at the underside thereof. With aeroplanes of this type the propeller is sometimes provided with a dome-shaped member secured thereto by means of a dished disc, for example, the said member revolving with the propeller in proximity to the aforesaid fixed shield, whilst the relative diameters of the adjacent ends or edges of the member and shield are such that an annular space or gap exists between them to permit a stream of air to pass into the shield, during the flight of the aeroplane, to cool the engine and carry away the exhaust gases and other matter issuing from the engine. According to the invention, the aforesaid annular gap between the dome-shaped member (hereinafter referred to as the cowl) and shield is dispensed with, and the cowl is so arranged and designed that it conforms, as nearly as practicable, to the ideal stream-line shape of the aeroplane, whilst an opening or openings in the nose or crown of the cowl is or are provided for the admission of air to the interior of the shield during the flight

Fig. 1.

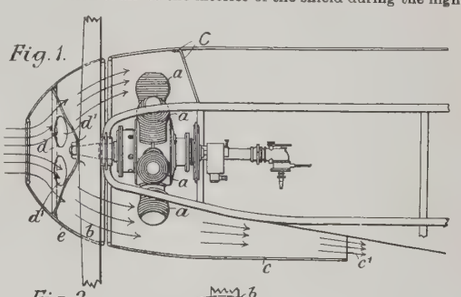
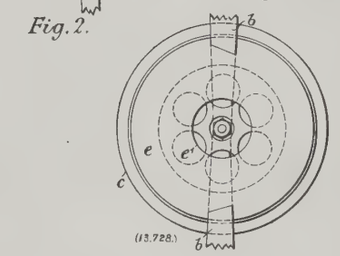


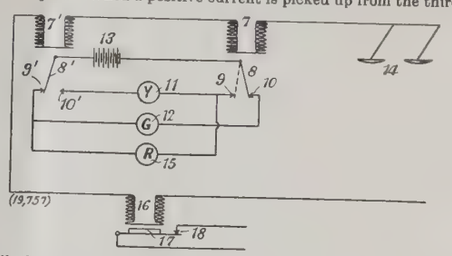
Fig. 2.



of the aeroplane. By this arrangement the air-resistance to the machine is lessened. *a* indicates the engine and *b* the propeller of the aeroplane, whilst *c* represents the fixed shield so constructed and arranged relatively to the engine that the waste gases and surplus oil are emitted through an opening c^1, by the inrush of air into the shield, during the propulsion of the machine. The propeller *b* is mounted in front of the shield *c* and carries the dished disc *d* and cowl *e*. The nose or crown of the cowl *e* is cut away or formed with a central aperture e^1 for the admission of air, whilst the base of the cowl, which encloses or envelops the blades of the propeller near the root, lies in close proximity to the front edge of the fixed shield in such a manner that the external peripheries of the cowl and shield together form a practically continuous surface of tapering form from the nose of the cowl to the largest diameter of the shield. The dished disc *d*, which is secured to the boss of the propeller, and which also serves to assist in supporting the cowl *e*, is formed with a number of openings d^1, through which the air passes, after entering the aperture e^1, to cool the engine and carry away the exhaust gases and other matter. In addition to the openings d^1, which may be of any desired size, shape, and number, in the disc *d*, a series of vanes, louvres or their equivalent may be provided and arranged at suitable angles on the disc to enable it to act as a fan, and thereby accelerate the induction of air to the chamber or passage formed by the shield *c*. (*Sealed August* 20, 1914.)

RAILWAYS AND TRAMWAYS.

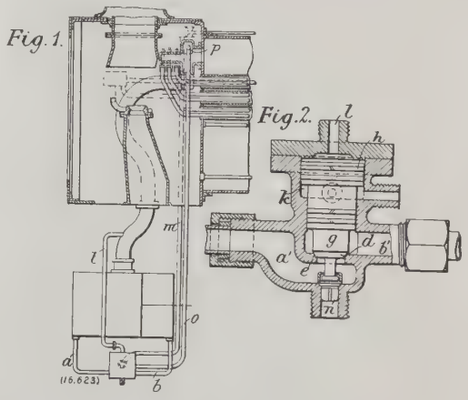
19,757/13. H. W. Firth, Shenfield, and F. W. Leake, Leytonstone. Railway Signalling. [2 *Figs.*] September 1, 1913.—The object of this invention is to provide signals to indicate the condition of traffic of the two sections immediately in advance of a train, this being accomplished by means of relays connected with insulated sections of the rail, which, by means of their contacts (dependent on whether the relays are energised or not), transmit to a third rail a current of one character or another—*e.g.*, a positive or a negative direct current—according to whether either only the next preceding section is unoccupied, or the next preceding two sections are unoccupied. This current of positive or negative sign is collected by a shoe attached to the engine, or by other suitable means, and is used to operate relays; these relays, by means of their contacts, giving either of three indications, according to the condition of the two sections ahead of the train. One of the indications would correspond with a positive current received from the third rail, and might indicate that the two next sections ahead were unoccupied; another indication would correspond with a negative current received from the third rail, and might indicate that the second section ahead was occupied, while the third indication would correspond with no current being received, and might represent that the first section ahead was occupied, or both the first and second sections ahead were occupied. The invention may be applied to track circuits and fixed signal arrangements, or to cases in which indicators are carried on the train, or to a combination of such systems. The drawing shows the arrangement when the indicators are carried on the train. Two polarised relays 7, 7^1 are included in the circuit, one operating when a positive current is picked up from the third rail by the contact-shoes 14, while the other is operative with a negative current. When the third rail is dead, both armatures, 8, 8^1, are held against the contacts 9, 9^1, and the circuit of the local battery 13 is completed through an indicator 15, which may conveniently be a red lamp, showing that the section upon which the train is entering is occupied. When the train picks up a negative current from the third rail, the armature 8^1 is brought against contact 10^1, and the local circuit is completed through indicator 11, which may conveniently be a yellow lamp, showing that the section next in advance of that upon which the train is entering is occupied. When a positive current is picked up from the third



rail, the armature 8 is brought against the contact 10, and the local circuit completed through indicator 12, which may conveniently be a green lamp, showing that the two sections in advance of that upon which the train is entering are both unoccupied. The train circuit may also include a non-polarised relay 16 which controls by its armature 17 and contact 18 the circuit which holds the brakes off when the armature is attracted by the energised magnet 16 against the contact 18. When the train enters a section which is occupied, the failure of the current in the train circuit releases the armature 17, breaking the contact at 18, and automatically causing the brakes to be applied. (*Accepted June* 10, 1914.)

16,623/13. H. A. Stenning and Schmidt's Superheating Company (1910), Limited, London. Locomotives. [2 *Figs.*] May 19, 1913.—It has heretofore been proposed in conjunction with locomotive cylinders to interconnect the ends of each cylinder by means of a controlled by-pass so that under certain working conditions the by-pass is opened and the pressure on both sides of the piston equalised. This invention has for its object to provide an improved controlling device in arrangements, as indicated above, in which the bye-pass valve is controlled in a more certain and positive manner than heretofore. The invention consists in a fluid-operated controlling device for the by-pass interconnecting the ends of a cylinder, the device being actuated in one direction by steam from the valve-chest or main steam-pipe, and in the other direction by steam supplied independently of the main steam-pipe, and preferably by a pipe leading directly from the boiler. A controlling device, as hereinafter described, is provided for each cylinder, and is connected by means of connectors *a* and *b* to the front and back cylinder covers respectively. The controlling device is preferably arranged so that the passages a^1 and b^1 leading to the connections *a* and *b* from the front and back cylinder-covers respectively, are disposed one above the other, communication between these passages being effected by the operation of a valve, the working face *d* of which co-acts with a valve-seat *e* disposed on the ring of metal which separates the two passages. The stem *g* of the valve is of cylindrical form, and carries at its upper end a circular enlargement *h*, which acts as a piston. The enlarged end of the valve is disposed in a chamber *k* formed in the controlling device, the top of which is placed in communication with the steam-chest or main steam-pipe by the pipe-connection *l*. The under side of the enlargement is connected to a supply of steam independently of

Fig. 1.



the main steam-pipe, and preferably to the boiler steam-cock by the pipe *m*. In some cases the bottom of the controlling device is provided with an outlet to the atmosphere, and is controlled by a relief-valve *n* attached loosely to a short spindle formed on the under side of the valve before described. The operation of the device is as follows:—When the regulator is in such a position that steam is being admitted to the engine-cylinders, the connection *l* on the top of the device admits steam from the main steam-pipe or the valve-chest to the upper side of the enlargement or piston *h* formed on the valve-spindle. Steam from the boiler will also be admitted below the piston directly from the boiler-cock by the pipe *m*, but as the area beneath the piston is less than the area above the same by the area of the spindle, the valve-face *d* is forced upon its seat *e*, and no connection is made between the front and back ends of the cylinder by means of the by-pass. If, however, the regulator is closed, the steam pressure on the upper side of the piston is withdrawn, and steam from the boiler-cock entering below the piston by the pipe *m*, will force the piston upwards, lifting the valve-face *d* off its seat *e*, and allowing communication to be effected between the front and back ends of the cylinder by means of the by-pass, thus equalising the pressure on the piston in the engine-cylinder. The device above described is especially suitable when used in conjunction with locomotives provided with superheaters in which a small supply of steam is allowed to circulate through the superheater elements when the main supply of steam to the engine-cylinders is cut off. In this case connection is made by means of a pipe *o* between the space beneath the piston of the controlling device and the saturated chamber *p* of the superheater, so that the steam from the boiler-cock, as well as operating on the piston *h* of the controlling device, may also pass to the superheater elements, and prevent overheating of the same when the regulator is closed. The steam,

after circulating through the superheater elements, passes through the steam-chest and cylinders, and finally to the atmosphere by the relief-valve *n*. (*Sealed August* 7, 1914.)

12,119/13. The Metropolitan Carriage, Wagon, and Finance Company, Limited, Saltley, H. C. Grigg, Brades Village, and N. Swift, Oldbury. Rolling-Stock. [7 *Figs.*] May 24, 1913.—This invention relates to means for automatically gathering up slack in operating mechanism or gear, such as brake-operating mechanism, used on cars, wagons, and other rolling-stock, and has for its object to provide means whereby considerable inconvenience may be prevented, due to the loosening or slackening of the various joints of the brake-operating connections, and the consequent rendering thereof out of adjustment, and to provide a more efficient and simple device than those heretofore proposed. In particular the invention relates to a slack-gathering device of the type comprising a moving operating member travelling over or across a stationary member, with a series of engaging detents or other devices between the members adapted to co-operate in any of a series of relative positions. According to this invention, the moving member comprises an oscillating arm to which the brake-operating rod is directly or indirectly articulated, and carrying a spring-pressed plunger which traverses across a quadrant, or other member, having a series of notches, teeth, detents or other engaging devices with one or other of which the spring-pressed plunger co-operates according to the amount of slack to be taken up. The slack-gathering device is arranged upon the shaft 1 carrying the usual rocking-lever 2, to which the screw-threaded extremity 3*a* of the rotating brake-operating rod 3 is connected, this connection being made in the known manner by a nut 4 loosely mounted in the extremity of the rocking-lever 2. Keyed or otherwise affixed to this shaft is another rocking-lever 5, the end of which is articulated to the second or "tension" connecting-rod 6 which operates the brake levers. Suitably disposed upon or within this last-mentioned lever, hereinafter referred to

Fig. 1.

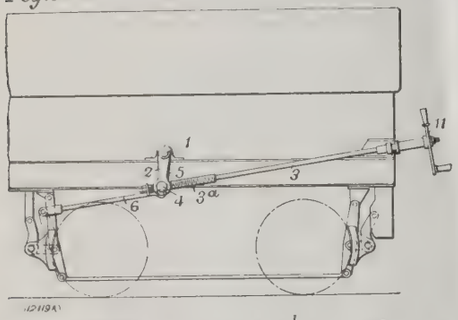


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Fig. 2.

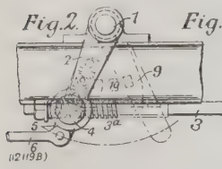
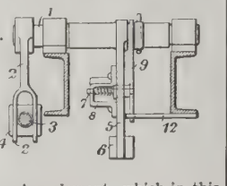


Fig. 3.



(12119B)

as "the rocking-lever," is the engaging element, which in this case takes the form of a spring-pressed plunger 7 mounted at one end in a bracket 8 affixed to the rocking-lever 5, and at the other end in the rocking-lever 5 itself, the portion of the plunger which projects from the surface of the rocking-lever 5 constituting the part which engages with the retaining element. This plunger is slightly rounded on its forward face, but is quite square on the rear face. Loosely mounted upon the shaft, and adjacent to the rocking-lever, is a flat quadrant member 9, having a series of radially-cut perforations therein at a distance from the rocking-shaft equal in amount to the radial distance of the engaging plunger 7 from the shaft 1, so that during movement of the rocking-lever 5 this plunger 7 will describe an arc over the quadrant member 9, which will be the axis of the holes or perforations 10 therein. It will be understood that this quadrant member and the perforations therein constitute the "retaining member," the plunger 7 in the rocking-lever 5 engaging with one or other of the holes in this retaining member according to the amount of slack in the joints to be taken up. In operation, supposing the brake-operating handle 11 to be turned so as to bring the brakes into action, the rocking-lever 5 will traverse the surface of the quadrant member 9 to a certain extent, this depending upon the amount which the handle 11 has to be turned before the brakes act. If this amount is excessive, the rocking-lever will traverse the quadrant member to such an extent that the spring-pressed plunger 7 therein will, by reason of its rounded face, ride out of the first hole or notch 10 in the quadrant member 9, and advance and snap into the next hole therein, and owing to its square rear face it cannot return, so that upon the brakes being next applied undue turning of the handle will not be necessitated. The quadrant member 9 is not absolutely stationary, but is allowed to rock about the shaft 1 for a certain amount, determined by the length of a slot in a fixed plate member 12 in which it works. (*Sealed August* 7, 1914.)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

26,434/13. J. Clayton and R. Taylor, Blackpool. Valves. [2 *Figs.*] February 24, 1913.—This invention relates to that class of valve having two separate cylindrical bodies within the casing, and a concentric cross-sectional area of flow between the cylindrical bodies forming the valve and the valve casing, which bodies engage with one another, one of which is fixed and the other is provided with a seating surface and is movable through a spindle to determine the flow of liquid or fluid, the object being to provide improved means for operating a valve of this type and means for protecting the surfaces of the valve and the interior of the valve casing. In accordance with this invention, the means for operating the valve comprises a stationary tubular casing, within the valve casing, formed with an internal screw-thread, a valve externally threaded to fit within the casing, a spindle connected by one end to the inner end of the valve, whilst its other end is supported freely in a bearing formed within the tubular casing, a crown, spur, bevel, or worm-wheel fixed on the valve-spindle, and an operating spindle passing from the outside of the main-valve casing to the inside of the tubular casing, where it is provided with a pinion or worm to engage with one or other of the types of wheel referred to. *a* indicates a stationary casing, while *b* is a valve movable within it. The casing *a* is preferably made in halves, coupled at or about the centre, so that the valve *b* may be examined or changed when required. Internally it is provided with a fixed casing 17 supported by arms 18, the whole formed in one with or secured to one half of the outer casing *a*, but leaving passages 19 for the liquid or fluid. The foregoing parts are all of usual construction. In accordance with this invention, the inner casing 17 is bored out and chased internally to receive the threaded inner end of the valve *b*, a tight joint being formed between the two parts by a stuffing-box 20 and gland 21 at the forward end of inner casing 17. The valve is supported by the long bearing formed, and is moved towards and from the seating *c* by a spindle 22 journalled freely at its ends in the valve *b* and inner casing 17 respectively. The central portion of the spindle is of hexagonal section or otherwise adapted to have firmly fixed on it a crown, spur, bevel or worm-wheel operated by a corresponding complementary pinion, bevel pinion or

Fig. 1.

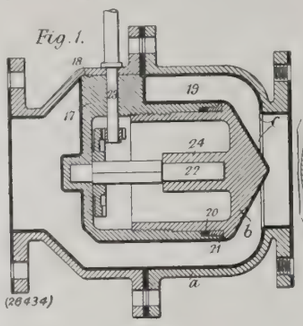


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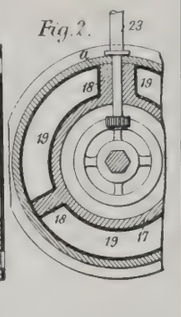
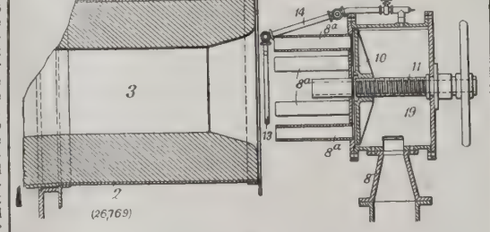
Fig. 2.



worm on a spindle 23 passing to the outside of the main casing *a* from where it can be operated. In place of forming a screw connection between the valve *b* and its inner casing 17, the parts may be plain and slidable, and the valve be moved by tapping its boss 24 and forming a thread on the spindle 22 to correspond. The latter would be rotated as before, and the valve be held from rotary movement by a feather or other means between it and its casing. The external part of the valve *b* and inner casing 17, and likewise the interior of the outer casing *a* and flanged ends and joints, are lined or faced with a non-corrosive metal or alloy, or other suitable material, or with rubber. In the latter case, the rubber may be partially vulcanised on to the inner casing 17, but be left free to stretch when the valve is being closed, so leaving a perfectly tight joint between the valve and its casing. (*Sealed September* 3, 1913.)

26,769/13. P. St. G. Kirke, and Bonecourt Surface Combustion, Limited, London. Gas-Fired Steam Generators. [2 *Figs.*] November 21, 1913.—This invention has reference to the generation of steam, feed-water heating, and the heating of liquids generally by the combustion of fuel normally in a gaseous condition, such as coal-gas, producer-gas, blast-furnace gas, natural gas, hereinafter referred to as gaseous fuel. The invention further has relation to apparatus for the generation of steam, feed-water heating, and the heating of liquids generally of the kind or type in which heat contained in the hot products of combustion can only pass therefrom to the liquid to be heated through the plates or tube-walls comprising the heating surface of such apparatus. The invention also has relation to the generation of steam, feed-water heating, and the heating of liquids generally by the employment of heat due to that process of combustion known as surface combustion. In apparatus, according to the present invention, refractory material is disposed and arranged adjacent to the plates or tube-walls, which comprise the heating surface of the apparatus, and in contact with, or in the neighbourhood of, a portion of this refractory material an accelerated surface combustion of the homogeneous combustible mixture of gaseous fuel and air formed as herein set forth takes place, the products of such combustion passing over or through the remainder of said refractory material, so that the greater part of the heat contained therein may be more rapidly transmitted through the heating surface to the liquid to be heated than would be the case if this baffling radiating material were absent. There is also provided a mixing-chamber, as herein



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set forth, which is also advantageously provided with one or more constricted outlets, which accelerate the formation of a homogeneous combustible mixture, and help to localise combustion where desired. Combustion of the mixture formed is commenced in the mixing-chamber, and combustion of the homogeneous combustible mixture issuing therefrom is completed in an accelerated manner in contact with, or in the neighbourhood of, a portion of, the refractory material beyond. The gaseous fuel and air are introduced to the mixing-chamber in substantially the proportions required to ensure full and complete combustion. The drawing shows the invention applied to a Lancashire boiler, only so much of the boiler being shown as is necessary for the present description. 3 is the mixing-chamber, partly within and partly without the flue 2. 8 is the gas-supply pipe in connection with a gas-chamber 19, from one face of which extend a plurality of pipes 8*a* towards the outer end of the mixing-chamber 3. 10 is a disc-valve contained within the chamber 19 and mounted on a screw-threaded and rotatable spindle 11 mounted in the walls of the chamber. When the spindle is rotated, the valve 10 is moved towards or from the ends of the pipes 8*a*, rotation of the valve being prevented by engagement with a flange in the chamber 19. 13 is a ring-lighting burner, and forms a pilot light. It is pivotally connected with one end of a gas-arm 14, pivotally connected at its other end with a gas-pipe in communication with the chamber 19. On starting up, the gas issuing from the jets of the burner 13 is ignited, and the burner is brought into position in front of the outlet ends of the tubes 8*a* (there being one jet to each tube 8*a*). The gas issuing from the tubes 8*a* is thus ignited. The burner 13 may then be moved out of the way and the procedure hereinbefore described adopted. The plurality of tubes 8*a* is to get a better preliminary mixing, so that mixing can be completed more rapidly and in less space. The valve-spindle 11 is hollow, and serves as an inspection orifice. In connection with a steam generator or liquid heater, fired in accordance with this invention, or in combination with a steam generator or liquid heater so fired, tubes, flues, ducts, or channels, packed or charged with refractory material, may be provided in another liquid receptacle to assist in the abstraction of further heat from the products of combustion. (*Sealed August* 20, 1914.)

211/14. Babcock and Wilcox, Limited, and J. H. Rosenthal, London. Steam-Generators. [2 *Figs.*] January 3, 1914.—This invention, which is an improvement on or modification of that forming the subject of the prior application for Letters Patent No. 13,971, of 1913, relates to an improved means for effecting the regulation of the superheat of steam by diverting the superheated steam, wholly or in part, from its passage to the stop-valve or main, and leading the diverted steam through an attemperator fitted in the steam-generator drum. With the arrangement described in the prior specification, the minimum limit of temperature to which the superheated steam could be brought was necessarily above that of saturated steam, as the temperature of the water or steam immediately surrounding the attemperator is not sufficiently low to provide the requisite thermal head for the transference of heat required to convert the superheated steam into the saturated steam. According to the present improvement or modification, in order to extend the range of reduction of the temperature of the superheated steam, so that the latter may, if desired, be reconverted into saturated steam, and/or to permit of reduction of the dimensions of the

Fig. 1.

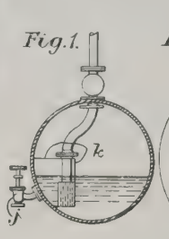
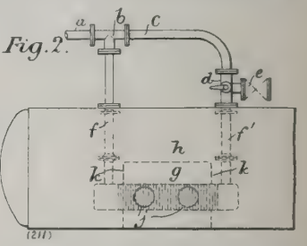


Fig. 2.



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attemperator, &c., the attemperator is fitted within a compartment of the steam-generator drum to which is connected the feed-water inlet, and the feed-water in which compartment is separated from the main body of water in the drum by diaphragms or partitions. The connection *a* from the superheater diverges at *b* into two branches, one branch *c* leading directly to the mixing-valve *d*, and thence to the main stop-valve *e*, and the other branch leading to the mixing-valve *d* by way of the attemperator *g* fitted within the boiler-drum *h*. The attemperator *g* is of the form described in the specification of the prior application, being constituted by a long box into the side walls of which are expanded cross-tubes, and to the ends of which are coupled the limbs *f*, *f*1 of the second-mentioned branch of the superheater connection. The attemperator *g* is so positioned in relation to the feed-water inlets *j* that inflowing feed-water will impinge thereon, and is enclosed within a compartment formed by the wall of the drum and diaphragms or partitions *k*, whereby the feed-water is cut off from the main body of water, and the temperature within the compartment may be maintained considerably lower than that in the rest of the interior of the drum. At the junction of the branches *c* and *f*1 is fitted the mixing-valve *d*, adapted to control the communication between the branches *c* and *f*1 and the main stop-valve *e*. (*Sealed August* 7, 1914.)

TEXTILE MACHINERY.

14,654/13. T. Cotton, Longwood, and T. W. Stead, St. Petersburg, Russia. Ring-Spinning. [2 *Figs.*] December 24, 1913.—In spindles for ring-spinning it has been customary to employ two pegs on the wharle, and recesses were made in the bobbin to fit over these pegs in order that the bobbin should be constrained to rotate in unison with the spindle. If the bobbin was not correctly adjusted, slack twist resulted; and when the recesses became worn with use the bobbin was liable to jump off the pegs. To avoid these disadvantages by making the correct engagement of the bobbin and spindle dependent on centrifugal force instead of on the attention of the operative, it has been proposed to employ springs on the spindle, either flat or spiral; but in such devices the thickness of the springs has been added to the diameter of the spindles, which renders them unsuitable for use with small-bore bobbins of the ordinary type. Now, according to this invention, the diameter of

Fig. 1.

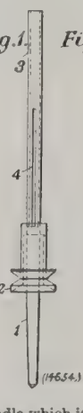
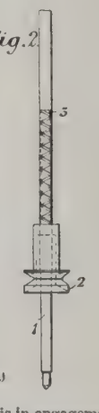


Fig. 2.



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the portion of the spindle which is in engagement with the bobbin is reduced at the part where the spring is applied. 1 indicates the spindle, 2 the wharle, 3 (Fig. 1) a closed tube of spring metal passed over the top of the spindle, the bottom edge of this tube entering a small recess formed for its reception in the boss of the wharle. Vertical slots 4 are cut in the tube. The loose arms or strips of metal between the slots, when expanded by centrifugal force, fly out slightly so as to bind against the inside of the bobbin (not shown), and hold the same tightly on the spindle until the spinning-frame is stopped. Referring to Fig. 2, instead of a tube being slipped on to the spindle, a portion of the spindle above the wharle is reduced in diameter, and on this reduced part is spirally or helically wound a strip of spring metal 5, the expansion with which when the spindle rotates has the same action as before described with reference to the spring arms. The top of the outer tube 3 or spring strip 5 may be pinned, brazed, soldered, or cemented to the spindle, or otherwise suitably secured thereto in order to ensure its rotation with the spindle. (*Accepted May* 27, 1914.)

LITERATURE.

Coast Sand-Dunes, Sand-Spits, and Sand-Wastes. By Gerald O. Case. London: St. Bride's Press, Limited. [Price 5s. net.]

Favoured by Nature with a long and indented coast-line, offering many advantages to industry and commerce, we have entailed upon us the duty of resisting the encroaching ocean and of preventing the wind-swept sands from carrying destruction inland. The Ordnance Survey Department shows that in thirty-five years the tireless waves beating on our coasts have washed away 6640 acres, and in the same time 48,000 acres have been reclaimed and added to the superfices of our islands. The loss is due to the erosion on the coast, and varies according to the nature and form of the shore; the reclaimed land is the product mainly of the accretion of material brought down in suspension by rivers. Little organised attempt has been made to set back the high-water line, or even to strengthen the natural protection of the coast afforded by the accumulation of sand and shingle derived from the abraded rocks and cliffs. The material eroded travels as it may along the coast, in directions governed by the action of the winds and waves and tides. This travel will depend upon the size of the particles, the character of the material, and the irregular formation of the coast. The work of transportation goes on continually, and very considerable watchfulness is necessary to prevent depletion on the one hand and undue accumulation on the other. The amount of material available for protection is not unlimited, and once carried from the station where it was created, is not recoverable. The knowledge of the behaviour of the disintegrated rock, and of the way it safeguards the coasts, but is capable of injuring adjacent lands, can hardly be over-estimated. Yet the author tells us that no book on this important subject has been published in Great Britain. We fear he is right; certainly the Commissioners on Coast Erosion, who have recently published a report, believed they were attacking a new question, for the subject had not been dealt with in any previous inquiry.

There is therefore room for a comprehensive treatise on this subject, but we doubt if the author has quite met the want. He offers rather the materials for a book than the book itself. There is more evidence of the collection of facts than of assimilation and comparison. We are carried all over the world and told what is being done in nearly every country that is washed by the sea, but we are not made to appreciate clearly the different circumstances that have necessitated a different treatment, or have compelled the adoption of particular methods. If a few typical cases had been selected and the peculiarities of each discussed with exactness and discrimination, the book would have been more instructive and better adapted for technical reference than when cumbered by the mention of so many instances. The author is not altogether to be blamed for the absence of instructive details concerning constructional methods. In many cases the necessary information is wanting. Very much haphazard work has been done in coast protection; we may say that the want of a well-ordered, definite system has been most marked. Local authorities have been left to carry out their plans in their own way. Sound engineering has been allowed little scope, with the inevitable result that a large amount of money has been wasted on groynes, sea-walls, and other defensive works, as well as on the maintenance of fairways and harbour approaches. The problems involved in erosion and transportation often cover a larger area than local authorities have recognised, and the narrow outlook has operated so adversely that works designed solely to afford protection to a particular line of coast have led to increased erosion of the coast on the leeward side, owing to the stoppage of travel of the beach material. If the publication of Mr. Case's book directs more attention to the important subject of erosion and protection, and induces experts to give systematic attention to the perpetual changes of the coast, with the view of securing adequate protection or judicious extension of its boundary, he will have accomplished a very useful purpose. At present no one seems responsible for the maintenance or the enlargement of sea defence. The enterprise of frontagers leads occasionally to spasmodic efforts to train sand-dunes for the protection of private property, but it is not yet recognised that the adoption of adequate measures against sea encroachment is a national service. Probably we shall not get uniform treatment and well-considered plans till some central authority, as the Board of Trade, is made responsible for the preservation of our coast-line.

The general principle underlying the construction of sand-dunes is very simple. Sand is carried freely over a level surface by the wind, but an obstruction, as a wall or a line of trees, causes the sand or other incoherent deposits to collect on the windward side, where an eddy is formed which throws the finer grains to leeward. In this way accumulation takes place on both sides of the obstruction, the coarse sand lying to windward, and the more finely-divided particles to leeward, the slope being different on the two sides. This simple fact shows what is necessary to be done when the formation of a sand-dune is needed, or it is desirable to give direction to its continual accumulations. Easy access to materials, or the cost of transport, will dictate the character and form to give to the obstruction. A continuous row of open-work fencing, with movable planks, placed just above the high-water line, is frequently adopted, the fencing being so arranged that the separate boards of which it is composed can be heightened as the sand accumulates. The sand should be disturbed as little as possible when shifting the fence, and various contrivances, which can be easily imagined, have been suggested to lift the planks singly without disturbing the angle of repose assumed by the sand. The regulation of the slope is a matter, too, of some importance, and it is usual to erect a second fence a short distance inland of the former. This device prevents the sand that has passed the first fence being carried inland, and allows the slope to be nicely regulated. This slope is especially important when the next stage is reached—that of seeding or cultivating suitable plants on the sand that will grow upwards through the slowly-rising sand surface, binding the loose sand together by the deeply-seated roots. Marram grass is frequently used in this country to consolidate the sand, and is a very effective agent. An instance is quoted in which, during a storm, the seaward face of a sand-dune was cut away. After the storm had subsided a small cliff of sand, 8 ft. high, was left standing, and it was seen that the whole depth was penetrated by a thick network of marram roots from top to bottom. A dune unprotected by vegetation would have been easily destroyed by the winds and waves, but when fixed and matted by close-grown roots the protection is very efficient, and the sand mass can only be eroded by the waves with great difficulty.

The author is inclined to dwell upon the destructive effects of sand, and the necessity of converting moving sand into a protecting embankment. In this connection his chapter on groynes is satisfactory. But grievous are the tales he tells of the evil consequences wrought by sand when, out of control, it is carried inland. His illustrations are as effective as his statistics in proving the enormous devastation and havoc due to this cause. Houses and cities have been buried under the sand-dune, as it has been compelled to travel forward by the transference of the accumulated material on the gentler windward slope to the steeper leeward incline. Certainly, if slowly, the incoherent mass advances. A well-known case is that of the burial and reappearance of a church in the neighbourhood of the Kurisches Haff, as the sand-dune gradually enveloped the building and as slowly revealed the ruins, as the sand accumulations marched steadily landwards towards more distant prey. In that case, the sand dune travelled about 500 metres in seventy years. It should, however, be remembered that sand, driven forward by the wind, can be of great economic service, giving rise to a fertile soil. The productivity of the Nile Valley is rightly attributed in the first place to the fine silt and loam of the Nile overflows, but the sands of the desert have also added their share to the soil of Egypt. Similarly, wind-swept dust has played an important part in the formation of the loess accumulations of China and the East. The author regards the fertility of Holland as traceable to the long-enduring sand-dunes that protect the country from inundation. While, therefore, Mr. Case has rather in view the evil consequences of unrestrained sand motion, he gives attention to possible reclamation by careful control of sand-dunes. He urges the feasibility of economic farming, and can point to satisfactory results. He indicates how it is possible to convert sand-wastes or useless belts of sand-dunes into pine woods by a system of afforestation. We should rather be inclined to regard such plantations as beneficial by reason of their assistance in preventing encroachment on more fertile lands, than as a source of revenue in themselves. The author gives figures showing the cost of reclamation, but they differ very considerably among themselves. The variations probably arise from the different degrees of fertility attained. Given time, the agricultural result would no doubt be satisfactory; but while we are told that on reclaimed sand it is possible to maintain one beast per acre for five months in the year, we feel that the opportunity for profitable farming is remote. It will too frequently happen that a layer of rock underlying the newly-rescued surface interferes seriously with the movement of the soil water, and places a limit upon the possible usefulness of the land. The small power possessed by sand and light soils of retaining water is a serious disadvantage, because such soils become liable to drought, and partly also because of the ease with which manurial substances are washed away and lost. But with the instances of Holkham and Norfolk before us there is no need to despair, though we can hardly share the author's optimism.

Trading with the Enemy: The Effect of War on Contracts. By Leslie Scott, K.C., M.P. Second Edition. London: Stevens and Sons. [Price 2s. 6d.]

In October, 1913, Mr. Leslie Scott read a paper at the Conference of the International Law Association which was held at Madrid. His object was to evoke discussion which might lead to the preparation of rules of international law as to "trading with the enemy" and the effect of war on contracts. He has now reproduced his paper, with certain valuable additions designed to assist in the solution of some of the problems which have arisen to trouble the minds of commercial men in England whose business has been seriously affected by the present war.

The first part of the book deals with relations between subjects of belligerent States. Mr. Scott reminds us (at page 9) of the celebrated dictum of Mr. Justice Willis that "the force of a declaration of war is equal to that of an Act of Parliament prohibiting intercourse with the enemy except by the King's licence." He reminds us, moreover, that it is for the King—or, in practice, the Executive—to decide what persons are to be regarded as hostile, neutral, or friendly; but it is for the Courts to determine what persons have in fact been put by the Executive in the category of enemies.

In the main it seems that, according to the common law, persons who have a commercial domicile in England are treated as being subjects of Great Britain, but the question arises whether this rule is modified, and if so, in what respects, by the various proclamations issued since the war began. Mr. Scott gives his readers the benefit of a very full discussion of this question at pages 17 to 23.

He has also propounded and answered two questions of considerable interest. The first is, what is the position of alien enemies who are in the British Isles, but have not a civil or commercial domicile here, nor any licence from the Crown, but have observed the requirements of the Alien Restriction Orders? Founding, apparently, upon the rule that help to the enemy is the touchstone of illegality, he expresses the opinion that "such aliens are, in English law, under existing proclamations still enemies, and subject to the disqualifications of enemies."

The second question relates to contracts made with enemy subjects before the war. Mr. Scott expresses the view that the majority of such contracts must be regarded as dissolved, and not merely suspended.

It has always been a recognised rule that the outbreak of war involves the suspension of contracts between subjects of belligerent States. Mr. Scott points out (at page 28) that "in many types of contract interruption of performance means so radical an interference with the whole essence of the business that dissolution of the contract results." As instances, he refers to commercial contracts for the sale of goods for future delivery. He is of opinion that these are dissolved by the war, and his view is, no doubt, a sound one. A contract to deliver steel ingots over a series of years at so much per ton must inevitably be affected by delay, not

to mention the other respects in which war will affect those who deal with steel ingots.

The second part of the work deals with the relations between neutrals and belligerents. It has not, apparently, been supplemented with any notes written since the whole paper was read at Madrid.

The recent Acts of Parliament, proclamations, and Orders in Council are printed in an appendix, and the work is one which we are convinced will be most useful to the lawyer who has to advise his client under the novel conditions which now obtain in commercial circles.

THE MANHATTAN BRIDGE, NEW YORK.

By Frank W. Skinner, Member of the American Society of Civil Engineers.

(*Continued from page* 381.)

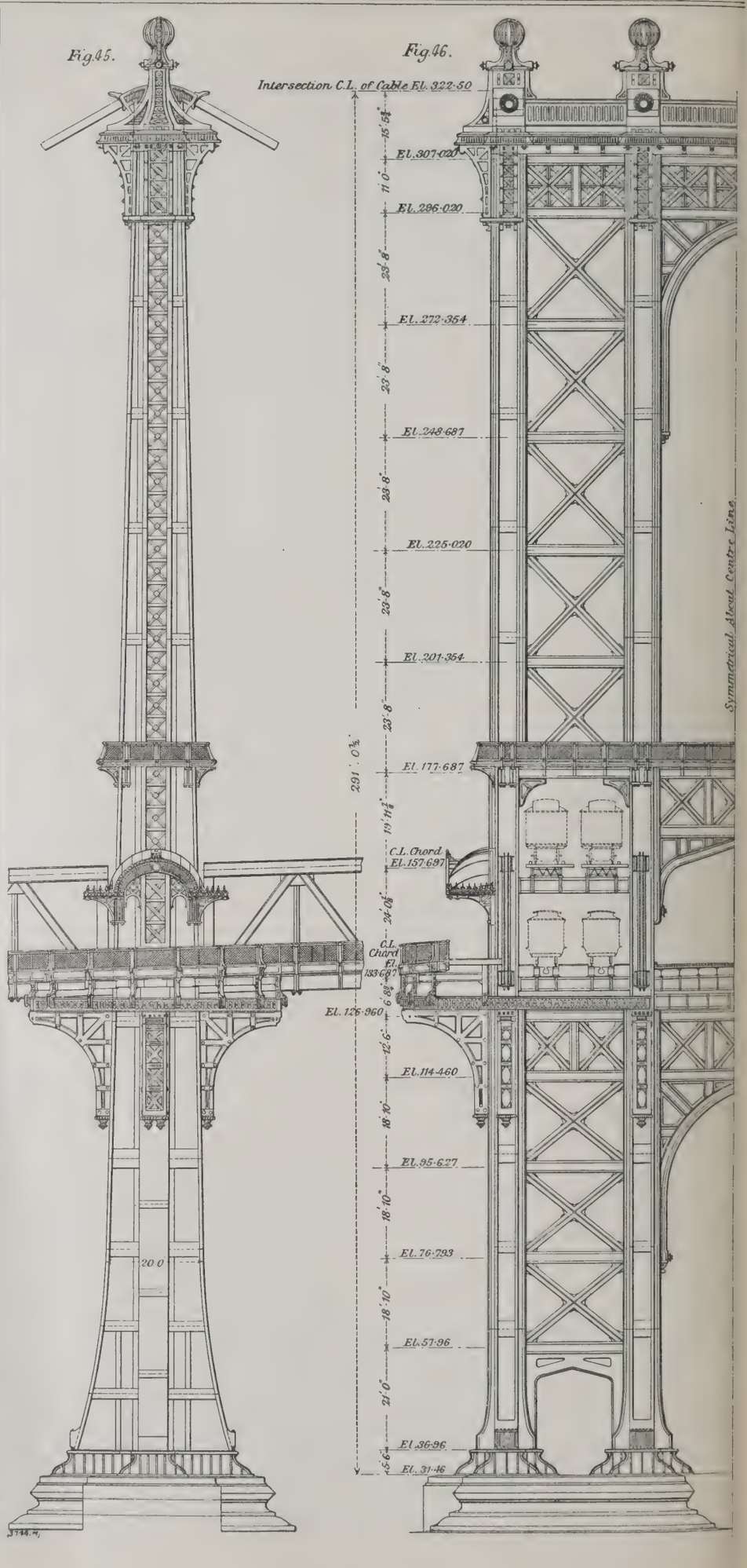
Superstructure.

The Towers.—The towers, of one of which elevations are given in Figs. 45 and 46, annexed, and of which the architectural features will be seen in Figs. 4 and 5, on Plate XXVIII., published with our issue of the 25th ult., weigh about 12,500,000 lb. each. They are of acid open-hearth steel made from pig or washed pig containing not more than 25 per cent. scrap and having an elastic limit of at least 33,000 lb., and an ultimate strength of between 60,000 lb. and 68,000 lb. per sq. in., a percentage of elongation in 8 in. equal to at least 1,500,000 ÷ ultimate strength in pounds, and a minimum reduction of area of 44 per cent. at point of fracture.

The towers are single transverse vertical bents (see Figs. 45 and 46), each with four tapered columns cross-braced in pairs, which are connected by three deep horizontal lattice girders with knee-braces. The columns are 281.89 ft. high from top of masonry to base of cable-saddle, and each has a cruciform cross-section made up entirely of plates and angles, and having an average sectional area of about 1800 sq. in., a uniform transverse width of $7\frac{1}{2}$ ft., except at the base, which is flared out to $12\frac{1}{2}$ ft., and in a plane parallel with the bridge axis has a width of 10 ft. at the top and 33 ft. at the base. Typical constructional features of these columns are illustrated in Figs. 47 to 54, Plate XXXIV., and Figs. 55 to 61, page 437.

The centre section of each column has uniform longitudinal and transverse dimensions of 5 ft. It has two solid webs parallel and six transverse to the bridge axis, connected by horizontal solid plate diaphragms 10 ft. apart, with manholes in the centre. The lower part of each column, which is illustrated in Figs. 51 and 52, is stiffened by twelve additional transverse webs to distribute the 21,000,000-lb. maximum vertical load on the pier masonry pedestal. Each column was shop-riveted in thirteen sections from 12 ft. to 24 ft. long, each section being shipped in two or three pieces, the heaviest weighing about 64 tons. The 12-ft. lower section is made up with plates from 1 in. to $1\frac{1}{2}$ in. thick, four 8-in. by 8-in. by 1-in., twenty-eight 6-in. by 6-in. by $\frac{15}{16}$-in., and 5-in. by $3\frac{1}{2}$-in. by $\frac{3}{4}$-in. main vertical angles, besides many pairs of short angles for diaphragm connections.

The columns are spaced 20 ft. and 48 ft. from the bridge axis, as shown in the sketch plan, Fig. 55, page 437. The upper and lower decks are supported on pairs of transverse plate-girders, and the bracing-girders and portal struts are very massive. Brackets on the faces of the columns are bored for the end pins of the lower chords of the stiffening trusses. The lower ends of the columns are filled solid with concrete to a height of 8 ft. The columns are seated on separate pedestals, illustrated in detail in Figs. 56 to 61, page 437, distributing their loads across the full width of the pier masonry, and reducing the unit pressure on it to 64,000 lb. per sq. ft. at the toe under maximum bending. These pedestals, 41 ft. 4 in. long, parallel to the bridge axis, 21 ft. 10 in. wide, and 5 ft. 6 in. high, were originally designed to be made of webbed cast steel, about $2\frac{1}{2}$ in. thick, weighing about 780,000 lb. each. On account of the great difficulty and delay in securing similar steel pedestals for the Queensborough Bridge, it was finally decided to substitute riveted steel pedestals of the same dimensions and outlines, which the contractor agreed to build for the same price as the cast steel. Each pedestal has a bearing area of 695 sq. ft. and is designed for a total maximum stress due to congested load on half of the main span and the



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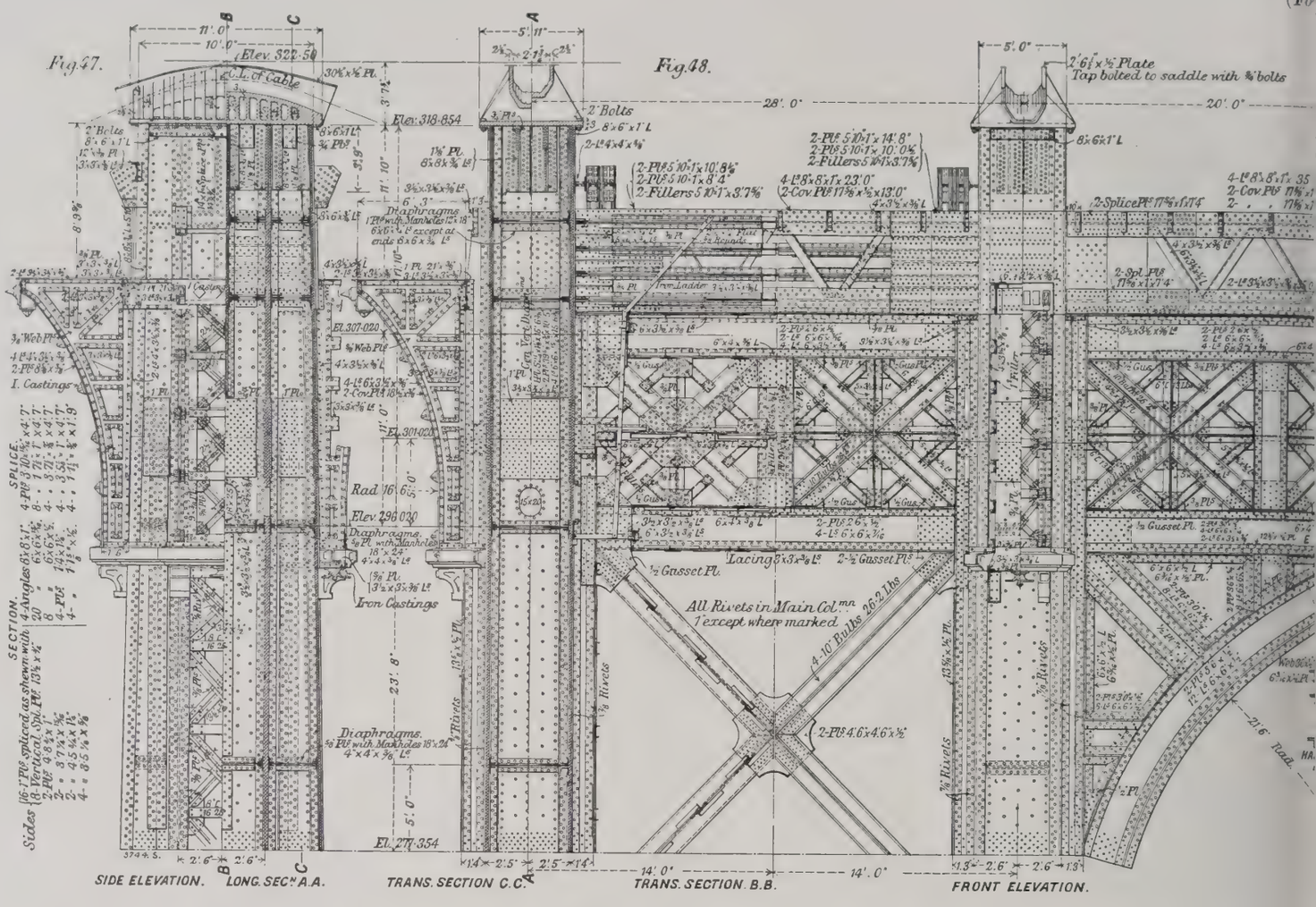

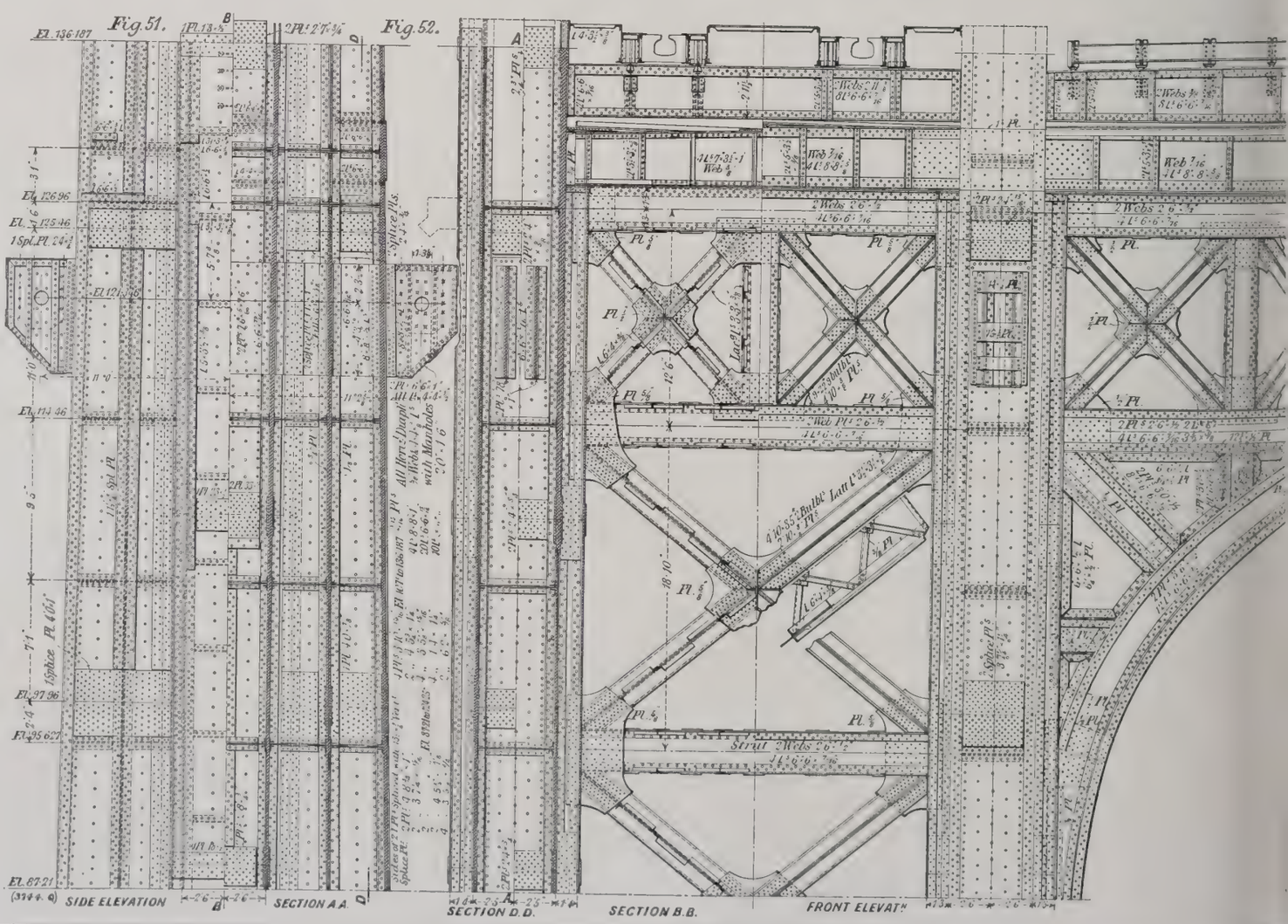

ER AT NEW YORK; DETAILS OF TOWERS.

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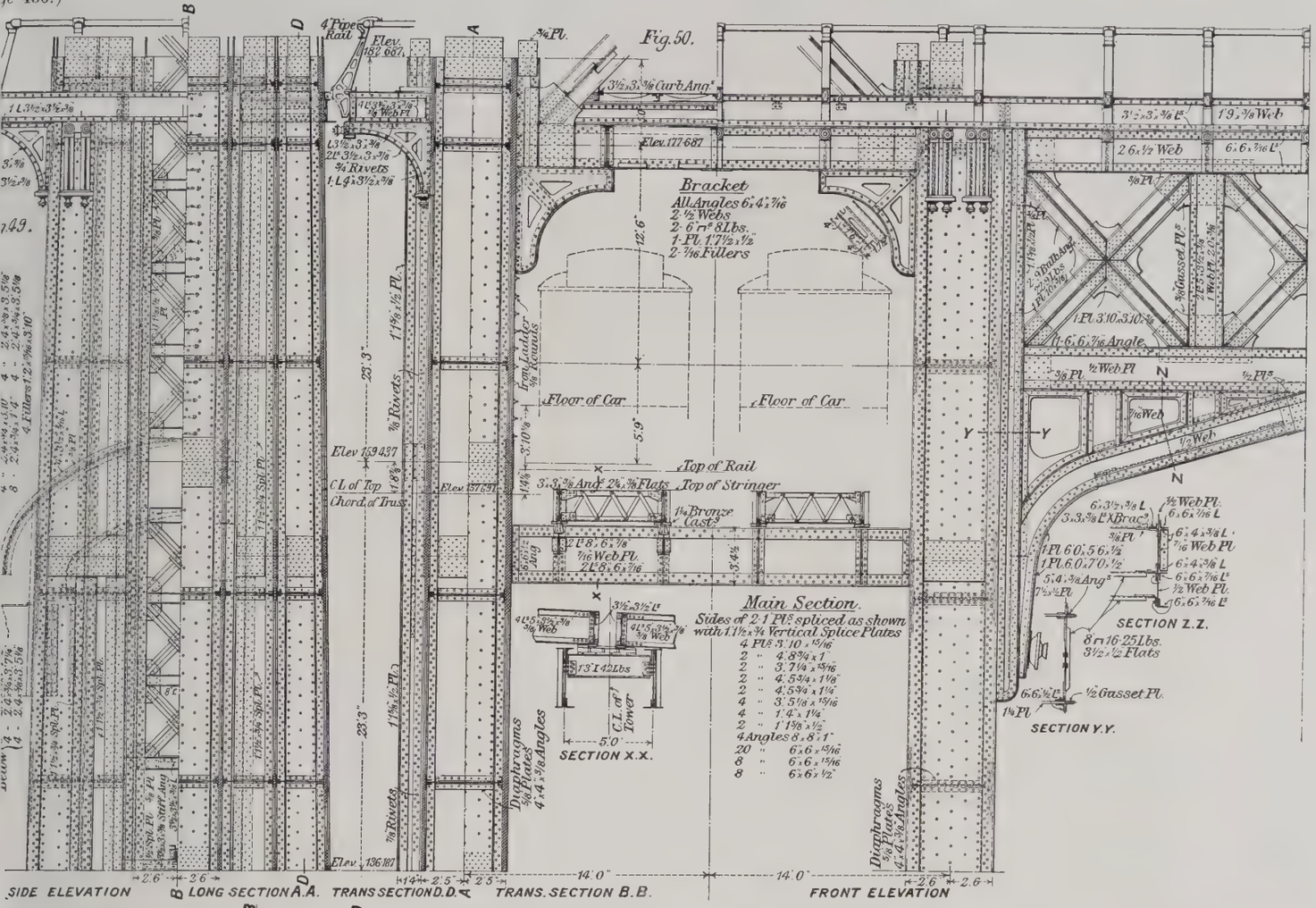


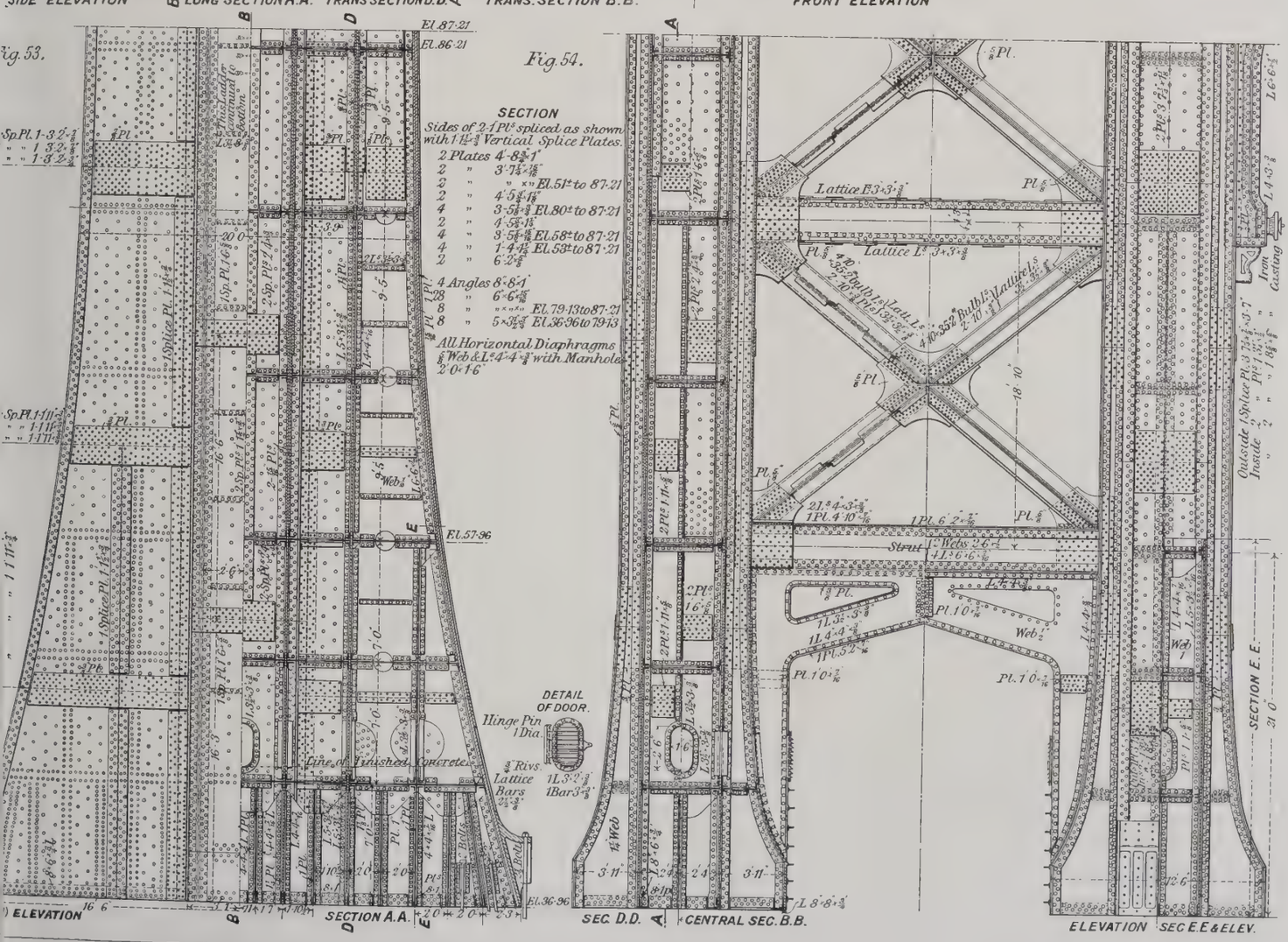
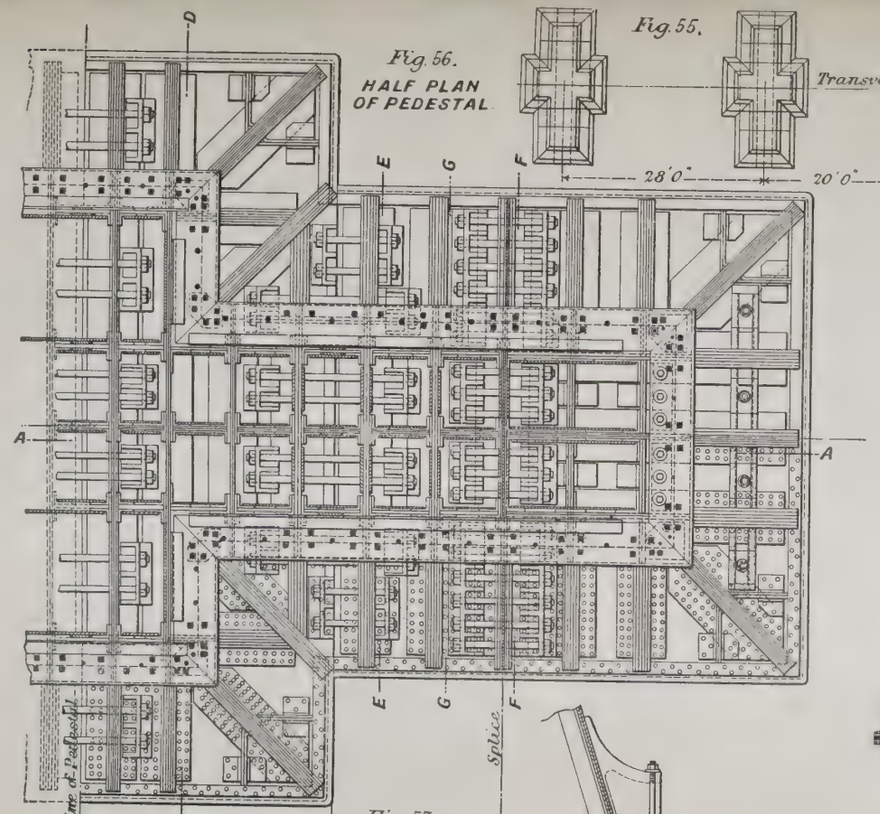
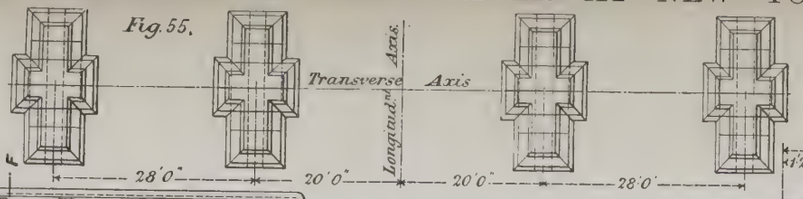
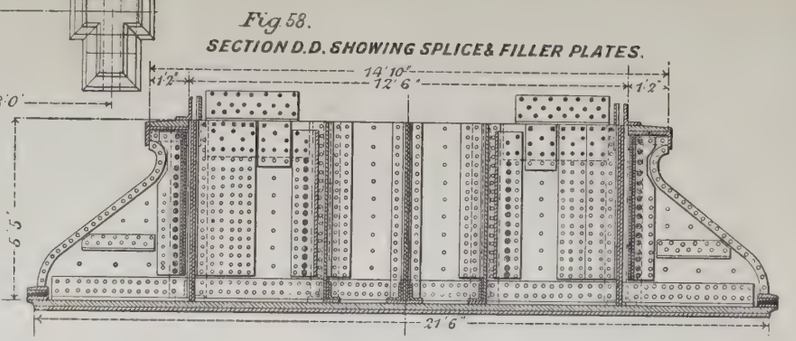
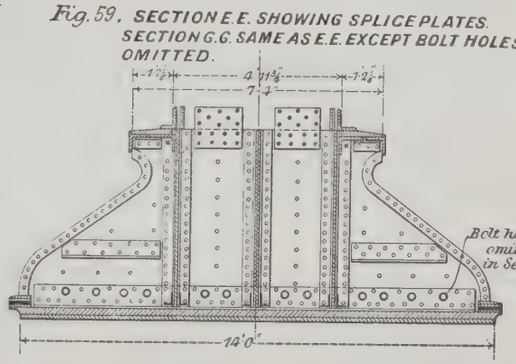


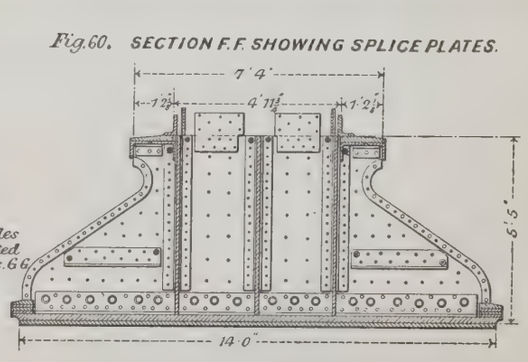
Fig. 53.
Fig. 54.
SECTION
Sides of 2-1 Pls spliced as shown with 1-11-¾ Vertical Splice Plates.
2 Plates 4'-8¾"x1"
2 " 3'-7¼"x15/16"
2 " " x " El. 51± to 87·21
2 " 4'-5¾"x1⅛"
4 " 3'-5⅛"x15/16" El. 80± to 87·21
2 " 4'-5⅜"x1⅛"
4 " 3'-5⅛"x15/16" El. 58± to 87·21
4 " 1'-4¼"x1¼" El. 53± to 87·21
2 " 6'-2⅝"x⅝"
4 Angles 8"x8"x1"
28 " 6"x6"x⅞"
8 " " x " x " El. 79·13 to 87·21
8 " 5"x3½"x⅝" El. 36·96 to 79·13
All Horizontal Diaphragms ⅜ Web & L 4'-4"x⅜" with Manholes 2'-0"x1'-6"
DETAIL OF DOOR.
Hinge Pin 1" Dia
Line of Finished Concrete
Lattice Bars
Lattice Bars
Struts
Web
SECTION A.A.
SEC. D.D.
CENTRAL SEC. B.B.
SECTION E.E.
ELEVATION SEC E.E & ELEV.

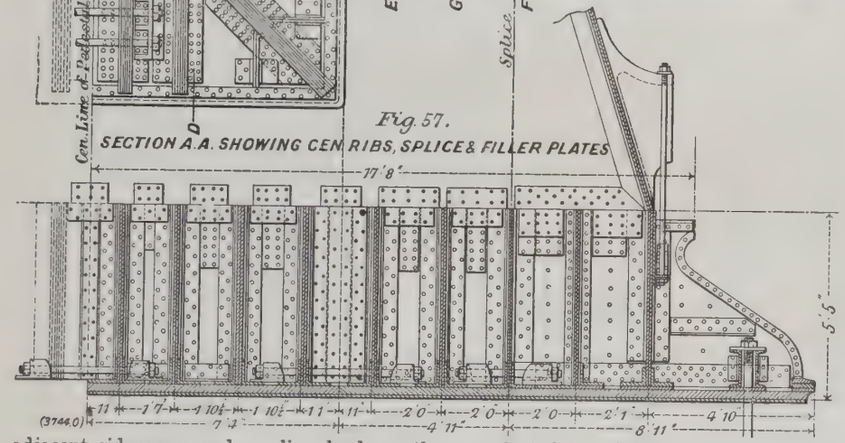


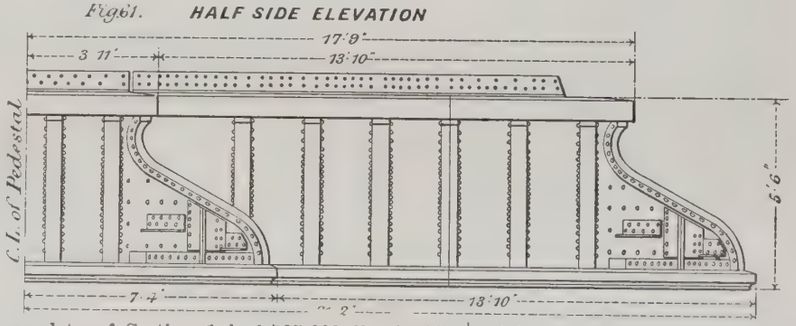












adjacent side-span, and no live load on the remainder of the bridge, a condition which would produce the maximum deflection of 2 ft. at the top of the tower. Although this deflection could be sustained without injury to the tower, it is expected that, on account of practical limitations of loading, it will rarely or never exceed 8 in. The reaction of the masonry under one edge of the pedestal may, theoretically, attain a maximum of 64,000 lb. per sq. ft., with a corresponding uplift of 334,000 lb., equal to a maximum of 9000 lb. per sq. ft. on the opposite edge.

Each pedestal weighs 390,000 lb., and was shop-riveted in six pieces of a maximum weight of 80,000 lb., which have vertical, longitudinal, transverse, and diagonal webs, through some of which the sections are bolted together. The centre section has an 80-in. by 2-in. base-plate, 21 ft. 10 in. long, twenty-four web-plates from $\frac{5}{8}$ in. to 1 in. thick, and flange-angles chiefly 8 in. by 8 in. by $\frac{7}{8}$ in. Horizontal angles were riveted to the webs, with their flanges bedded in the concrete with which the spaces between webs are filled solid.

Under maximum load, with an assumed coefficient of 25 per cent., the friction under the base-plate of Section 1 is 1,725,000 lb., besides which the maximum bending moment in the tower can produce a horizontal stress at the base-plate of 3,700,000 lb. To prevent the transmission of these stresses to the masonry, each pedestal is seated on three full-length 56-in. by $\frac{7}{8}$-in. planed bed-plates anchored to the pier masonry by eight $2\frac{3}{4}$-in. bolts 11 ft. long. The plates are considered as partial outside splices between the sections of the pedestal, sufficing with the anchor-bolts to resist all transverse displacement.

Each column is capped by a cast-steel cable-saddle about 11 ft. long, 6 ft. wide, and $3\frac{1}{2}$ ft. high, which weighs about 50,000 lb., and is rigidly fastened to the tower. These saddles for two of the columns are shown in position in Figs. 49 and 50, Plate XXXIV. To expedite the work and reduce its cost, the contractors installed machine-tools at their quarry plant, about 450 miles from New York, where they possessed abundant pneumatic and electric power, and shipped these and the other castings there, finished them, and returned them to the bridge site, effecting an economy which, after paying for transportation both ways, was estimated at 25,000 dols. for the whole bridge.

(To be continued.)

A STUDY OF SOME AUSTRIAN LOCOMOTIVE TESTS.

By Lawford H. Fry.

It is proposed to give herewith an account of and to discuss a series of tests recently carried out on a two-cylinder saturated-steam express locomotive on the Austrian State Railway. The first engine of the type was put into operation in 1901, and now some sixty locomotives are in service giving satisfactory and economical results. Dr. Sanzin, after carrying out a large number of tests on these locomotives, has published* an elaborate study of their operation in all its phases.

This is quite the most extended analysis which has been made of locomotive operation without the use of a locomotive-testing plant. The information presented is of considerable value, but one cannot help being struck by the fact that on a testing plant it could have been obtained much more easily, and in some cases more accurately, than was possible in tests carried out in service.

The type of locomotive on which the tests were carried out is illustrated in Figs. 1, 2, and 3. It is a 4-4-0 machine, with single-expansion cylinders, using saturated steam. The main dimensions are:

Cylinder diameter	425 mm. (16.8 in.)
,, stroke	600 ,, (23.6 ,,)
Driving-wheel diameter	1700 ,, (67.0 ,,)
,, base	2400 ,, (7 ft. 2 in.)
Total wheel base	6230 ,, (20 ,, 6 ,,)
Boiler pressure	12.5 kg. per sq. cm. (177 lb. per sq. in.)
Tube-heating surface (measured on the fire side)	110.6 sq. m. (1190 sq. ft.)
Fire-box heating surface (measured on the fire side)	8.6 ,, (92 ,,)
Total heating surface (measured on the fire side)	119.2 ,, (1282 ,,)
Grate area	2.33 ,, (25 ,,)
Number of tubes	191
Diameter of tubes outside	50 mm. (2.0 in.)
,, ,, inside	45 ,, (1.75 ,,)
Length of tubes between tube-sheets	4100 ,, (13 ft. 6 in.)
Length of grate	2142 ,, (84.5 in.)
Width of grate	1092 ,, (43.0 ,,)
Total weight in working order	47,700 kg. (105,000 lb.)
Weight on drivers in working order	28,000 ,, (62,000 ,,)
Weight, empty	43,000 ,, (95,000 ,,)
Tender weight in working order	32,500 ,, (72,000 ,,)
Tender weight, empty	13,400 ,, (30,000 ,,)
,, capacity, coal	4,000 ,, (9,000 ,,)
,, ,, water	14,000 ,, (3,100 gals.)

The resistance of the locomotive and tender in running condition, when their total weight was about 80,000 kg. (say 176,000 lb.), was found to be given by the formula :—

$$w = 3.8 + 0.015\,v + 0.00075\,v^2 \quad . \quad . \quad (1)$$

where w is the resistance in kilogrammes per ton weight, and v is the speed in kilometres per hour; or, in pounds and miles :—

$$w_1 = 3.8 + 0.024\,v_1 + 0.00195\,v_1^2 \quad . \quad (1a)$$

where w_1 is the resistance in pounds per 1000 lb. of engine weight, and v_1 is the speed in miles per hour.

The trains of four-wheeled passenger-coaches for which this type of engine is used showed resistances in accordance with the formulæ :—

$$w = 1.6 + 0.184\,v + 0.00046\,v^2 . \quad . \quad (2)$$

and

$$w_1 = 1.6 + 0.296\,v_1 + 0.00119\,v_1^2 \quad . \quad (2a)$$

where the symbols have the same meanings as above.

Boiler Performance.

The results of the experiments are analysed under three headings :—(1) boiler performance; (2) engine performance; and (3) locomotive performance, the last standing for the combined action of boiler and engine which determines the power of the locomotive in actual service.

The fuel is the first element to be considered in studying the boiler performance. In the majority of the experiments the boiler was fired with run-of-mine Ostrauer locomotive coal, consisting of approximately equal parts of lump, nut, and small coal, having an ultimate analysis averaging about as follows :—

	Per Cent.
Carbon	70.00
Hydrogen	3.50
Oxygen	4.00
Nitrogen	4.00
Sulphur	0.75
Water	3.00
Ash	14.75
	100.00

The coal is a long-flame coal, with a slight tendency to coke in the fire, and in spite of its high percentage of ash it gave excellent results in service.

The heating value calculated from the above analysis in 6518 cal. = 11,700 B.Th.U.; but the calorimetric bomb showed somewhat lower figures, so that for the calculations the mean heating value was taken as 6250 cal. = 11,220 B.Th.U.

In firing it was found advisable to carry a greater depth of fire at the back of the grate than at the front, and to keep the fire deeper at the back corners and along the fire-box sides than in the middle. Under ordinary conditions the depth of the fire was from 12 cm. to 20 cm. (say 5 in. to 8 in.), with a depth of 30 cm. (say 12 in.) when the boiler was forced to the highest power.

Fig. 1.

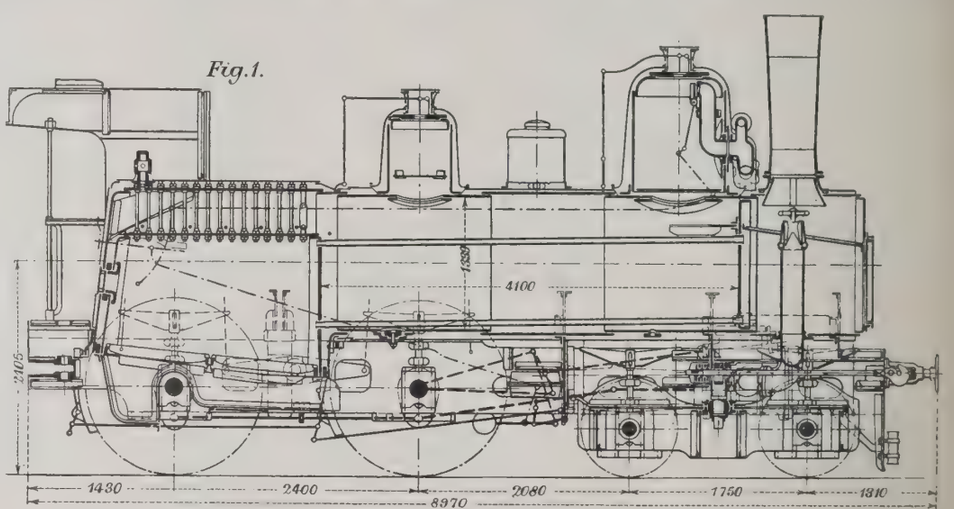


Fig. 2.

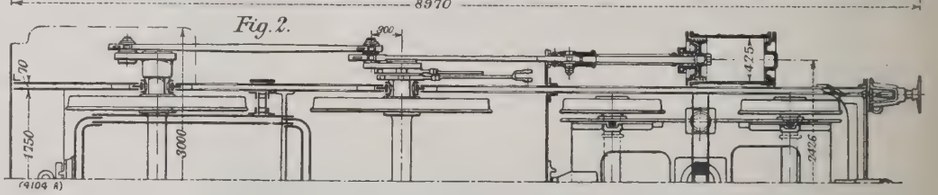
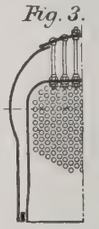


Fig. 3.



The annexed tables and figures show Dr. Sanzin's results for the boiler performance, compared on a basis of coal consumption per square foot of grate per hour. The range examined is from 200 kg. to 600 kg. of coal per square metre of grate per hour, say from 40 lb. to 120 lb. per sq. ft. per hour. The lower limit of 40 lb. per sq. ft. per hour is so low as to be of little practical importance, while the maximum rate of firing obtainable with the coal used was from 120 lb. to 135 lb. per sq. ft. per hour. The coal has in its favour the fact that its low heating value is offset by the high rate at which it burns.

The relation between rate of firing and the water evaporated per pound of coal is shown by Fig. 4 and Table I. The evaporation is from feed-water at 10 deg. Cent. (50 deg. Fahr.) to a boiler pressure of 12.5 kg. per sq. cm. (178 lb. per sq. in.), corresponding to 655 cal. per kg. (1180 B.Th.U. per pound). On this basis the theoretical evaporation is 9.55 lb. of water per pound of coal. The actual evaporation per pound of coal fired varied from 8 to 5.59 as the rate of firing varied from 41 lb. to 123 lb. of coal per sq. ft. of grate per hour. As shown in Fig. 4, as the rate of firing increases, the evaporation per pound of coal drops more rapidly at first than it does later, but the relation does not at any time depart greatly from a straight-line law. Dr. Sanzin does not give any results from individual tests, so that we cannot ascertain the weight of the evidence which determined a departure from the straight-line law which has been found to obtain so generally in boiler-performance tests. Possibly the upward turn of the evaporation line is due to the use of larger-sized coal for the tests at the higher powers. Dr. Sanzin says that the decrease in the evaporation as the rate of firing increased was considerably less marked with lump coal than with the run-of-mine, while the small coal gave an even smaller evaporation, although the heating value was the same for all sizes. When firing 100 lb. per sq. ft. of grate per hour, the evaporation per pound of coal was a pound less with the small coal than with the run-of-mine, and this rate of firing was the highest which could be maintained with the small size.

Table I.—*Combustion and Evaporation.*

Coal Fired per Square Foot of Grate Area per Hour.	Total Coal Fired per Hour.	Total Weight of Water Evaporated per Hour.	Pounds of Water Evaporated per Pound of Coal Fired.	Water Evaporated per Square Foot of Heating Surface per Hour.	Draught in Inches of Water. In Smoke-Box Above the Spark-Arrester.	Draught in Inches of Water. In Fire-Box.	Mean Difference in Temperature Between Smoke-box and Atmosphere.	Weight of Dry Ashes and Cinders as per Cent. of Weight of Coal Fired. In Smoke-Box.	Weight of Dry Ashes and Cinders as per Cent. of Weight of Coal Fired. In Ash-Pan.
lb. p. sq. ft.	lb.	lb.	lb.	lb. p. sq. ft.	in.	in.	deg. Fahr.	p.c.	p.c.
41	1035	8,300	8.00	6.4	0.87	0.28	342	0.7	2.1
51	1295	9,350	7.59	7.6	1.34	0.43	450	1.0	4.2
62	1552	11,200	7.22	8.7	1.97	0.63	540	1.6	6.2
72	1815	12,500	6.88	9.6	2.64	0.87	630	2.2	7.5
82	2075	13,500	6.53	10.4	3.55	1.15	700	3.1	8.3
92	2335	14,600	6.26	11.3	4.37	1.50	745	4.4	9.0
102	2590	15,500	5.99	12.0	5.45	1.89	790	5.7	9.3
113	2850	16,430	5.77	12.9	6.55	2.36	815	7.3	9.7
123	3110	17,400	5.59	13.4	7.8	2.96	828	9.2	10.0

While the specific evaporation or pounds of water per pound of coal falls as the rate of firing increases, the total evaporation naturally increases. With an increase from 200 kg. per sq. m. —that is, from 41 lb. to 123 lb. of coal per sq. ft. of grate per hour, or three-fold—the weight of water evaporated per unit of heating surface per hour increases from 31.3 kg. to 65.5 kg.—that is, from 6.1 lb. to 13.4 lb., or only 2.09 fold. Expressed in relation to the grate area, the hourly evaporation ranges from 1600 kg. to 3354 kg. per sq. m., from 328 lb. to 685 lb. of water per square foot of grate per hour. The higher figure is reached with the run-of-mine coal at 600 kg. per sq. m. =

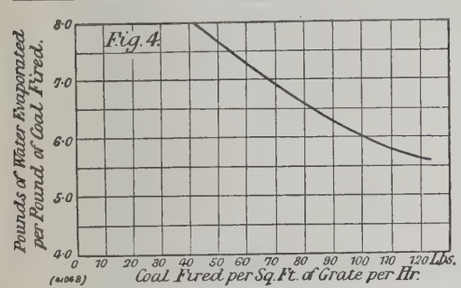
* *Versuche an einer Nass-dampf-Zwillings-Schnellzug-lokomotive.* Published by the Verein deutscher Ingenieure as vol. cl. and cli. of *Forschungsarbeiten aus dem Gebiete des Ingenieurwesens.*

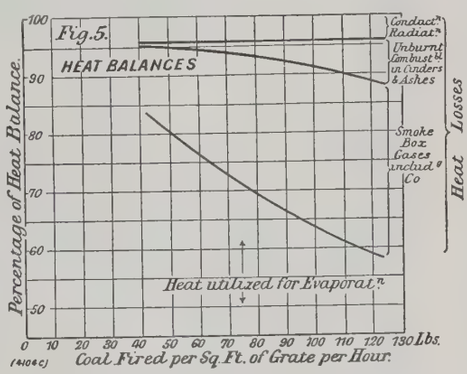
123 lb. of coal fired per square foot of grate per hour. It was found that this size of coal fired at the rate of 500 kg. per sq. m. (102 lb. per sq. ft.) per hour evaporated 3000 kg. per sq. m. (615 lb. of water per square foot of grate per hour). With the fine coal this rate of evaporation could not be obtained, the maximum being only 2500 kg. per sq. m. (510 lb. of steam per square foot of grate per hour), when the coal was fired at the rate of 500 kg. per sq. m. (102 lb. of coal per square foot of grate per hour).

Dr. Sanzin does not analyse in detail the reasons for the failure of the boiler to reach the highest steaming capacity with the small coal, but for the average conditions he gives gas analyses, and from these draws up heat balances. The results are reproduced in Fig. 5 and Table II., and are

TABLE II.—Heat Balances and Smoke-Box Gases.

Coal Fired per Square Foot of Grate per Hour.	Heat Balance. Heat Lost in Smoke-Box Gases, including that by CO.	Heat of Unburnt Combustible in Cinders and Ashes.	Heat Lost by Radiation, Conduction, and Soot.	Heat Effective in Evaporating the Water.	Efficiency Of Combustion.	Of Heat Absorption.	Total Boiler.	Mean Volumetric Analysis of Smoke-Box Gases. O.	N.	CO_2.	CO.	Weight of Air per Pound of Coal Fired.	Specific Heat of Smoke-Box Gases.
lb. per sq. ft.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	lb.	
41	11.5	0.7	4.0	83.8	99.3	84.4	83.8	7.1	81.6	11.3	0.0	14.04	0.256
51	15.3	1.1	4.0	79.5	98.9	80.4	79.3	—	—	—	—	—	—
62	18 7	1.7	4.0	75.6	98.3	76.9	75.6	7.1	81.6	11.3	0.0	14.04	0.260
72	21.8	2.1	4.0	72.0	97.9	73.5	72.0	—	—	—	—	—	—
82	24.6	3.0	4.0	68.4	97.0	70.5	68.4	7.0	81.6	11.3	0.1	14.04	0.265
92	26.8	3.8	4.0	65.5	96.2	68.1	65.5	—	—	—	—	—	—
102	28.4	4.9	4.0	62.7	95.1	65.9	62.7	6.4	81.4	11.3	0.5	13.58	0.270
113	29 4	6.1	4.0	60.4	93.9	64.3	60.4	—	—	—	—	—	—
123	30.0	7.5	4.0	58.5	92.5	63.2	58.5	5.7	80.9	12.2	1.2	13.13	0.270





remarkable for the very high efficiency of combustion and the low efficiency of heat absorption which they show. At the highest rate of firing—that is, 600 kg. per sq. m., or 123 lb. of coal per sq. ft. of grate per hour—the over-all boiler efficiency is 58.5 per cent.; that is to say, this percentage of the heat in the coal fired is utilised in producing steam. This is good, but not abnormal. The losses are given as 4 per cent. by actual radiation and otherwise unaccounted for, 2 1 per cent. by the production of CO, 7.5 per cent. by unburnt fuel, and 27.9 per cent. by sensible heat in the smoke-box gases. Of these last two figures the first appears extremely small, and the latter unusually high; but in the absence of figures of individual tests criticism is difficult. It would have been of interest to have had individual gas analyses for both the run-of-mine and the small coal, so that the heat balances could have been compared. It seems certain that if the boiler capacity was limited by the small coal to a firing rate of 102 lb. per sq. ft. of grate per hour, the loss by unburnt coal at this rate must have very considerably exceeded 7.5 per cent. of the coal fired, and it is difficult to believe that this loss was not exceeded at the upper limit of firing for the run-of-mine coal—that is, when 123 lb. of coal were fired per square foot of grate per hour. The figures given for the loss by incomplete combustion of the fuel were found by determining the heating value of the cinders and ashes which were retained in the smoke-box and ash-pan at the end of the run, and taking this value as the total heat lost by unburnt fuel. Now, if the locomotive-testing plants in America have shown anything, it is the difficulty of entrapping the whole of the fuel which escapes unburnt from the fire-box, and this even when elaborate contrivances are provided to catch the cinders which pass the smoke-box netting and get out of the stack. Therefore in the present tests, which were made in regular service, it seems highly unlikely that the smoke-box netting retained all of the unburnt fuel carried out of the fire-box and into the smoke-box by the draught. We cannot help thinking that a casual observation from a carriage window would have shown that more fuel was lost unburnt than that caught in the smoke-box. Further, while the loss ascribed to unburnt fuel is low, the loss by sensible heat in the smoke-box gases is exceptionally high. At the highest rate of firing, 123 lb. of coal per square foot of grate per hour, the quantity of air taken through the fire, 13.13 lb. per pound of coal fired, the temperature of the smoke-box, 460 deg. Cent. = 830 deg. Fahr. above the atmosphere, and the specific heat of the gases given as 0.27, all have high values, and as a consequence the heat calculated as lost in the gases is so great as to reduce the heat absorbed by the boiler to only 63.2 per cent. of the heat produced by combustion. The American testing-plant figures show that 80 per cent. is a more usual figure for the efficiency of absorption of a locomotive boiler.

Even on a testing plant it is a difficult matter to run a test under such uniform conditions as to obtain analyses of the smoke-box gas which correctly determine the amount of air taken through the fire, and on service tests the difficulty is very greatly increased. It is not unusual to find values for the air supply vary by as much as 100 per cent. under conditions supposed to be similar, and if, as Dr. Sanzin has done, the smoke-box and ash-pan cinders are taken to be the whole of the unburnt fuel, a heat balance can only be closed by favouring the higher values for the air supply. If Dr. Sanzin really has an efficiency of absorption of only 63.2 per cent., it should be possible to obtain considerably better results by remodelling the boiler so as to make it take up as large a proportion of the heat as has been shown to be possible by the American testing plants. When the design of the boiler is examined with this in view, it is difficult to see how the efficiency of absorption could be greatly increased, as all the proportions of the boiler are normal. As a matter of fact, instead of considering the boiler as deficient in heat absorption, it is much easier to suppose that the actual air supply was somewhat less than that indicated by the analyses, and that consequently the loss by unburnt fuel was greater, and the loss in the smoke-box gases less, than shown. The table below shows for the boiler fired at 600 kg. per sq. m. (that is, 123 lb. per sq. ft.) of grate per hour, the heat balance, as given by Dr. Sanzin, together with the figures which the present writer considers more probable:—

	Given. Per Cent.	Suggested. Per Cent.
Heat used in evaporation ...	58.5	58.5
Heat lost by external radiation, &c.	4.0	4.0
Heat lost in producing CO ...	2.1	2.1
Heat lost in unburnt fuel ...	7.5	19.4
Heat lost in smoke-box gases (sensible heat)	27.9	16.0
	100.0	100.0

However the losses be divided as between unburnt coal and smoke-box gases, it must be recognised that an over-all efficiency of 58.5 per cent. is extremely good, particularly when the quality of the fuel available is considered.

Before leaving the analysis of the boiler tests, attention must be drawn to Dr. Sanzin's use of Strahl's method of connecting the quantity of air taken through the fire with the smoke-box draught. Strahl has attempted to show* that the relation between the air supply and the smoke-box vacuum is of the form:—

$$h = K\left(\frac{L}{R}\right)^2 \quad . \quad . \quad . \quad (3)$$

where

h is the smoke-box vacuum in inches of water.
L is the volume of the air at the smoke-box temperature and pressure.
R is the grate area; and
K is a factor representing the resistance of the passages traversed by the air from ash-pan to stack.

This total resistance is built up of the resistances of the ash-pan openings, of the fire, of the tubes, and of the smoke-box netting, so that if h_1 be the vacuum in the ash-pan, and F_a the area of the openings into the ash-pan,

$$h_1 = k_1\left(\frac{L}{F_a}\right)^2 \quad . \quad . \quad . \quad (4)$$

and if h_2 be the vacuum in the fire-box, and R the grate area,

$$h_2 - h_1 = k_2\left(\frac{L}{R}\right)^2 \quad . \quad . \quad . \quad (5)$$

and if h_3 be the vacuum at the smoke-box below the netting, and F_2 be the area of the passage offered to the gases by the tubes,

$$h_3 - h_2 = k_3\left(\frac{L}{F_2}\right)^2 \quad . \quad . \quad . \quad (6)$$

and h being the vacuum in the smoke-box above the netting, and F_n the area of the netting,

$$h - h_3 = k_3\left(\frac{L}{F_n}\right)^2 \quad . \quad . \quad . \quad (7)$$

If the vacua h, h_1, h_2, and h_3 are measured at the different points for various rates of firing, and if the corresponding volume of air L is determined, the values for the various resistance factors, k_1, k_2, k_3, and K, can be determined. It is Strahl's theory that the partial-resistance factors are constants with the exception of k_2 in equation (5), which measures the resistance of the fire, and which consequently increases with the depth of the fire. Dr. Sanzin's figures confirm this theory, but, as has been pointed out above, there is some doubt about the accuracy of his determination of the amount of air taken through the fire, so that the confirmation must be accepted with some reserve. In any case Strahl's theory as simplified by Dr. Sanzin is most interesting, and deserves careful consideration in any locomotive tests where the quantity of air is determined accurately.

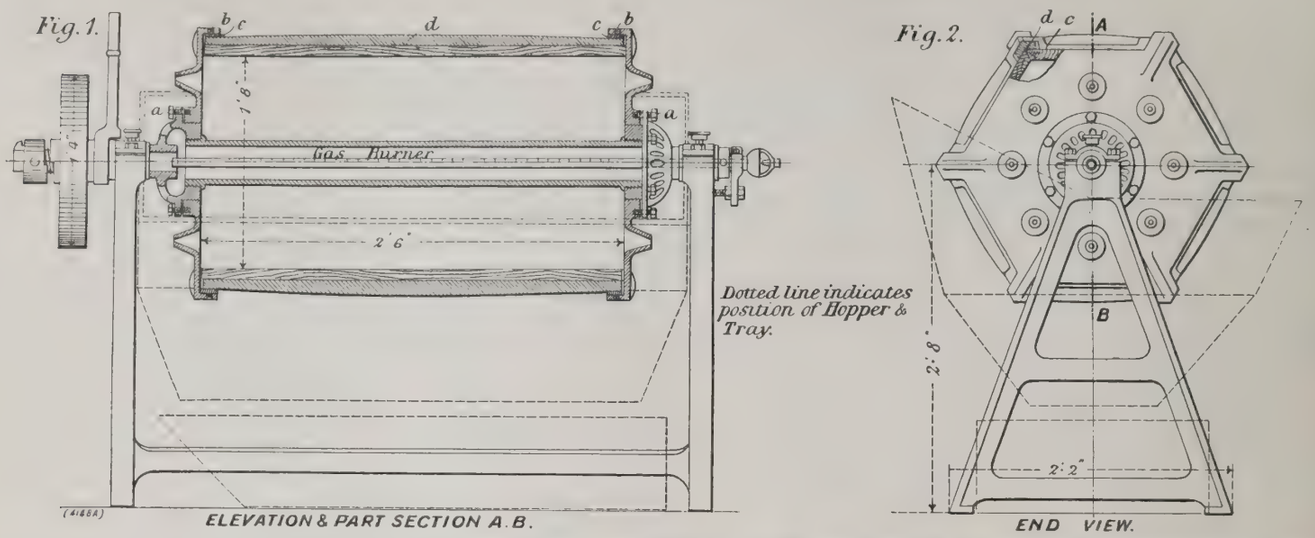
(To be continued.)

The Franklin Medal.—In addition to the medals already at the disposal of the Franklin Institute, one, to be known as the Franklin Medal, has been founded for the institute by Mr. Samuel Insull, of Chicago. This medal will be awarded twice a year on an average, and without regard to nationality, to those workers in physical science or technology whose efforts have, in the judgment of the institute, done most to advance the knowledge of physical science or its applications. In awarding the medal, the institute will consider the total contributions of individuals to science, or to the applications of science to industry, rather than any single invention or discovery, however important the latter may be. The medal, which is of gold, has been designed by Dr. R. Tait McKenzie, of the University of Pennsylvania. On the obverse is a medallion of Benjamin Franklin, taken from a portrait by Thomas Sully in the possession of the institute, while the reverse side bears the words: "Awarded by the Franklin Institute for Signal Eminent Service in Science," with a space for the recipient's name. The cost of preparing the designs and dies for the medal, and for an accompanying diploma, has been borne by the founder, who has also provided a fund, the interest from which will be used for awarding the medal from time to time. Any excess of income from this fund may be used as premiums to accompany the medal. In thanking Mr. Insull for founding the medal, the board of managers of the institute expressed the opinion that in doing so he had rendered a notable service in stimulating workers in physical science and technology, and had materially extended the useful activities of the institute. We are confident that this opinion will be endorsed by scientists and engineers on this side of the Atlantic.

* *Untersuchungen und Berechnungen der Blasrohre und Schornsteine von Lokomotiven*, by Strahl. Kreidel, Wiesbaden, 1912.

THE WALKER GAS-HEATED DRYING-BARREL.

CONSTRUCTED BY MESSRS. ARNOLD AND LARGE, LIMITED ENGINEERS, WOLVERHAMPTON.



THE machine shown in the annexed illustrations, which is known as the Walker drying-barrel, has been developed in one of the largest electro-plating shops in this country for the purpose of drying and finishing large quantities of small metal objects after dipping, burnishing, plating, &c. It is especially useful for drying out metal cartridge-cases and caps.

Figs. 1 and 2 are respectively a part longitudinal section and an end elevation of the machine, while Fig. 3, which is reproduced from a photograph, illustrates its general appearance. The machine will be seen to consist of a hexagonal barrel with oak sides and cast-iron ends, mounted on trunnions which run in bearings carried by a pair of A-frames. As will be seen by Figs. 1 and 3, the barrel is driven by a belt-pulley connected to one of the trunnions through a claw-clutch operated by a hand-lever. An interesting feature of the machine is the construction of the barrel itself, which has been designed so as to enable the oak sides to be renewed easily, and also to allow shrinkage of the timber to be taken up when necessary. For this purpose the timber sections are held in place entirely by external pressure. Longitudinal pressure is provided by the set-screws *a*, Fig. 1, which pass through tapped holes into plain holes in the cast-iron end-plates, so that they press the latter together when tightened up. Radial pressure is exerted by the grub-screws *b*, which bear on to clamping-bars *c*. The latter press against the timber sides, and their ends bear on longitudinal bars *d* which fit on to the angles of the hexagon, and thus hold the sides firmly for the whole length of the barrel. An inspection of Fig. 3 will make this arrangement clear.

As shown in Fig. 1, the barrel is provided with an internal heater, which, in this case, consists of a cast-iron tube revolving with the barrel and containing a stationary Bunsen gas-burner; the machines are, however, also made with electric heaters. The gas-burner consumes from 20 cub. ft. to 25 cub. ft. of gas per hour, and maintains the heater at a temperature of about 400 deg. Fahr. The work to be dried is placed in the barrel, together with a quantity of sawdust, which is kept hot and dry by means of the heater. It has been found that the heat not only greatly expedites the drying process, but also enables a much better and more lasting finish to be imparted to the work. The heat also enables work to be thoroughly dried while the barrel is revolving very slowly, at, say, 12 to 14 revolutions per minute, so that jewellery and other delicate articles are not injured by the barelling process. Nozzle-shaped openings, visible in all the illustrations, are provided in the end-plates of the barrel to allow the vapour to escape; but their shape is such that there is practically no loss of sawdust. When the work is dry, and sufficiently polished, it may be separated from the sawdust by inserting a screen in the door of the barrel, as shown in Fig. 3. If the barrel continues to revolve, the sawdust falls through the screen, and is directed into a suitable receptacle by means of the hopper. The screen can then be removed from the barrel-door, and the work dropped into another suitable receptacle placed to receive it.

The machines described are constructed by Messrs. Arnold and Large, Limited, of Derry-street, Wolverhampton, who make several sizes and patterns for different classes of work.

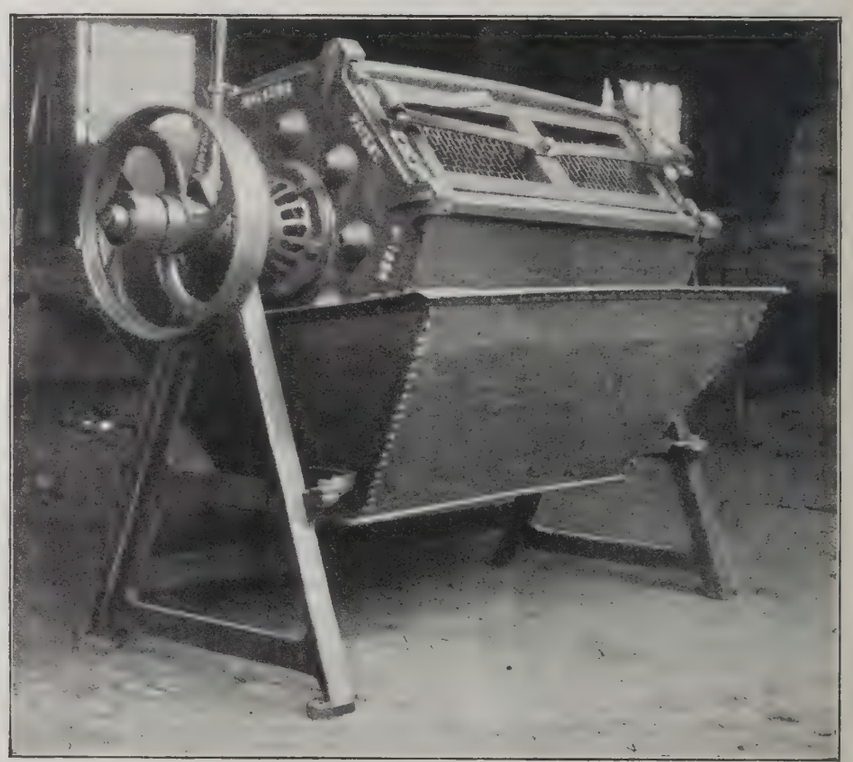


FIG. 3.

POPULATION AREAS.—Europe has an area of 3,860,000 square miles, Asia an area of 17,000,000 square miles, Africa an area of 11,500,000 square miles, North America an area of 8,548,000 square miles, South America an area of 7,342,000 square miles, and Australasia and Polynesia an area of 3,400,000 square miles. Europe has an average population of 114¼ per square mile, Asia an average of 56 per square mile, Africa an average of 13 per square mile, North America an average of 15½ per square mile, South America an average of 6½ per square mile, and Australasia and Polynesia an average of 2¾ per square mile. The last-named regions are beginning to fill up a little, but only slowly.

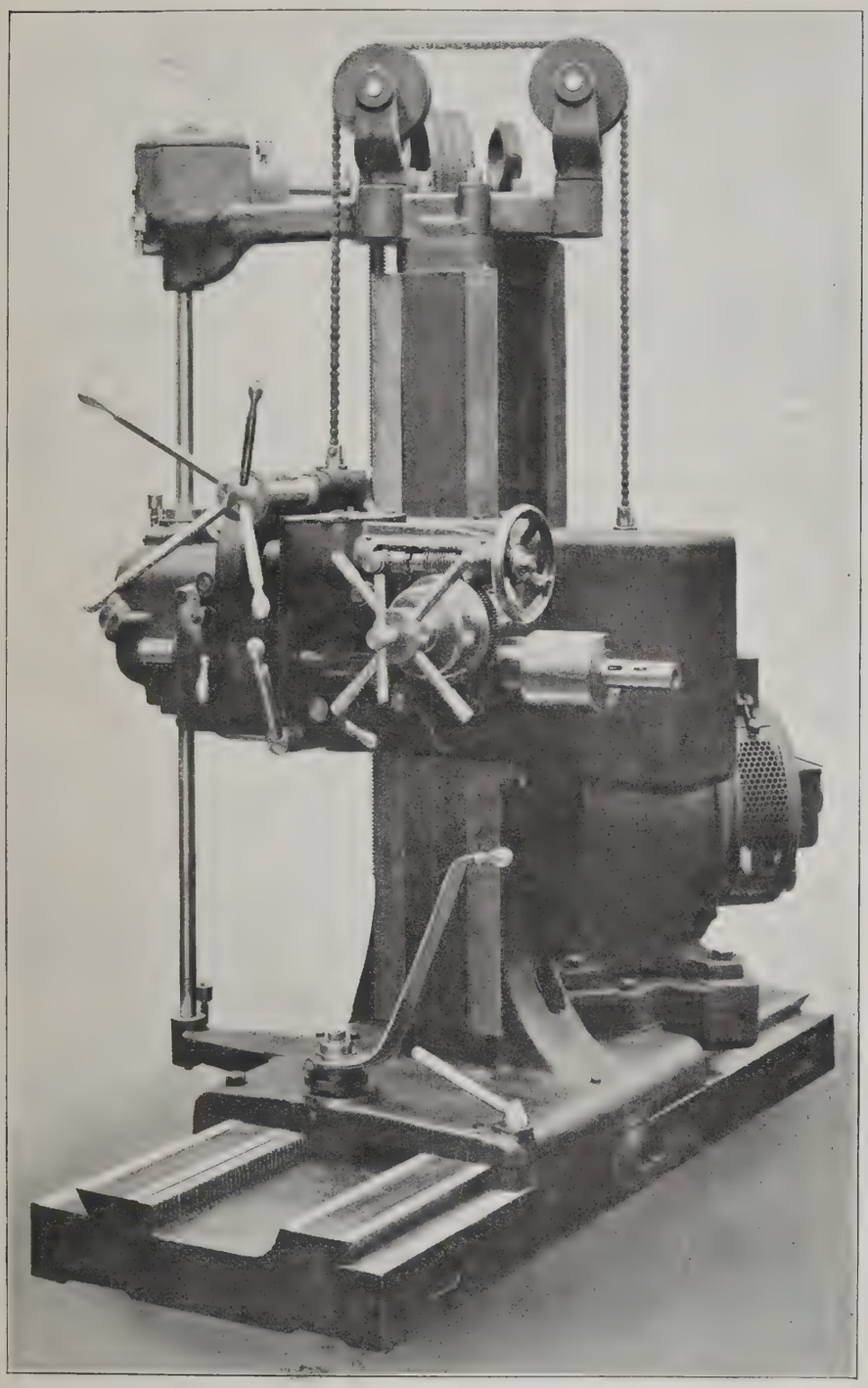
THE POWELL-DUFFRYN STEAM-COAL COMPANY, LIMITED.—This company, which was formed in the year 1864, is this year celebrating its jubilee. It has issued an illustrated booklet giving the history of the company since its formation. Interesting figures are included in it; among these are statistics showing the output of the company's collieries at different periods. The output in 1864 was 400,000 tons; it was 3,874,000 tons in 1913. The various installations are described and illustrated. The quantity of coal still unworked in the company's properties is calculated to amount to a total of 448,000,000 tons, or sufficient to furnish an annual output of 4½ million tons for a hundred years.

WATER SUPPLY IN QUEENSLAND.—Water supply is a very expensive item in starting a station in Queensland. Tank-sinking costs about 800*l.* for a 10,000 cubic yards excavation, and nothing less than this has much hope of holding out for long against the loss through evaporation. Many of the tanks are nearer 30,000 cubic yards capacity. The alternative to a surface tank is an artesian bore, and this again involves great risk and expenditure. The boring may have to go down to between 1000 ft. and 4000 ft.; in fact, the deepest bore in Queensland is over 5000 ft. Roughly speaking, boring works out at about 1*l.* per ft.

"EVERY BRITON'S WAR-BOOK."—The Motherland League, of 4, Johnson's-court, Fleet-street, E.C., have sent us a copy of "Every Briton's War-Book," which is stated to answer every question about the war, and which also contains maps of Europe, of the North Sea, and of Paris as London. This latter is specially interesting, as it prints Paris in block plan on a map giving the environs of London, and shows all the forts in their relative positions. These are widely spread. That on the north west is at a position corresponding to Rickmansworth; on the north-east at Enfield; on the south-east between Bromley and Croydon, and on the south-west beyond Kingston. The book contains 93 pages of information, arranged alphabetically, and costs sixpence.

PORTABLE DRILLING AND BORING-MACHINE.

CONSTRUCTED BY MESSRS. WILLIAM ASQUITH, LIMITED, ENGINEERS, HALIFAX.



The illustration above shows a new portable machine with horizontal spindle for drilling, tapping, and studding, also for light boring. This machine is of very compact design, and is especially suited to work of cumbersome and heavy nature, such as large gun-mountings and other armament work, as also large turbine and marine-engine work.

The spindle is 2¼ in. in diameter in the driving part, and is of high-carbon steel, accurately ground. The end pressure of the spindle is taken by heavy ball-thrust washers, and the spindle revolves in ball-bearings to ensure easy running. Self-acting and hand-feed motions are provided, in addition to quick hand-adjustment and slow hand-feed. The feed traverse is 9 in., and four rates of self-acting feed are available for any of the spindle speeds. Single and double gear are provided, so as to give a wide range of speeds to the spindle. Reversing motion is supplied in order to permit of tapping and studding; this is operated by a lever on the saddle.

The saddle is carefully balanced in order to facilitate easy and quick adjustment on the standard. The traverse of the saddle on the standard is 3 ft. 6 in., and the spindle will go down to 1 ft. 6 in. from the ground. The various hand-wheels and levers are all conveniently arranged to ensure a quick rate of output. Locking arrangement is provided for the saddle on the standard.

The standard is of strong box section, well ribbed to give great rigidity, with wide, accurately-planed and surfaced slides to form good bearing for the saddle. A broad base adds to the rigidity of the standard, which is arranged to traverse a distance of 4 ft. by hand motion, along a strong bed of heavy section. Secure locking arrangement is provided. All gears are machine-cut, in steel, and hardened where necessary. The drive is by variable-speed electric motor, direct coupled, and placed at back of the standard. This gives a very compact form of drive, highly suitable for a machine that has to be transported about the shop to different positions.

The machine is constructed by Messrs. William Asquith, Limited, of Halifax.

FATAL STEAM-PIPE EXPLOSION.

A formal investigation has been conducted by the Board of Trade at the Town Hall, Manchester, with regard to the circumstances and cause of the explosion of a steam-pipe, which occurred at the works of Sir W. G. Armstrong, Whitworth and Co., Limited, Openshaw, on August 16, 1913, by which two men lost their lives.

The Commissioners were Mr. George Warner, barrister-at-law, presiding, and Mr. Maginnis, consulting engineer. Mr. J. H. Payne, solicitor, appeared for the Board of Trade, and Mr. Acton, barrister-at-law, for Messrs. Armstrong, Whitworth and Co., and five of their officials who were parties to the inquiry.

In opening the proceedings, Mr. Payne said that there were twenty-six boilers in use at the works, but at noon on the day of the explosion only seven were at work. The pressure was 150 lb. per sq. in. About 1.45 p.m. an explosion occurred, and it was found that a pipe had become displaced. Several workmen who were near at the time were severely scalded, two of them dying from injuries received. When the displaced pipe was examined, immediately after the explosion, by the foreman millwright, it was found that the shoulder of the bottom pipe had been worn down, so as to reduce it to a conical form. Beyond that portion of the pipe the surface was quite bright, indicating that it had been drawn through the flange, and had been subjected to a great deal of friction in the process. It was afterwards suggested in the evidence given by one of the witnesses that the wearing action at the joint of the pipe with the flange was due to the vibration which was produced by the working of the armour-plate rolling-mill for 1½ or 2 hours a day. The effect of this vibration was never suspected before this explosion; but afterwards a series of tests revealed the fact that the working of the rolling-mill caused the range of steam-pipes to oscillate to the extent of ⅛ in. The boilers were regularly inspected by the Manchester Steam-Users' Association, but the pipes were not inspected or insured by that firm. Before being put into use the pipes were always tested by hydraulic pressure to 225 lb. per sq. in.

After various witnesses had given evidence, the presiding Commissioner gave judgment, and said that the Court found that the pipe in question was made of suitable material, that it was properly tested before being fitted up ten or eleven years ago, and that the range of steam-pipes generally had been regularly inspected by a competent person. They also found that Messrs. Armstrong, Whitworth and Co. had taken proper steps to see that this particular pipe was in safe and proper working condition, and that it was efficiently inspected from time to time. In these circumstances the Court attached no blame to the company nor to any of the company's employees, and considered it would be an injustice if an order were made upon them to pay any part of the costs of that investigation. The Commissioners expressed their deep sympathy with relatives of the men who had lost their lives.

Mr. Payne, on behalf of the Board of Trade, and Mr. Whitworth (Messrs. Briggs, Crosse and Whitworth), who had been instructing Mr. Acton, barrister-at-law, on behalf of Messrs. Armstrong, Whitworth and Co. and their servants, tendered their thanks to the Commissioners for the courtesy and patience with which they had conducted the inquiry.

Engineer Units, Royal Naval Division.—The following have received temporary commissions as lieutenants in the Royal Marines, for duty with the Engineer Units of the Royal Naval Division:—R. G. Aston; L. H. Rugg, A.M. Inst. C.E.; G. H. Spittle, A.M.I.E.E.; A. J. D. Chivers, A.I.M.E.; H. Dobell, A.M.I.E.E.; R. Grierson, A.M.I.E.E., A.M.I. Mech. E.; A. Williamson, A.M. Inst. C.E.; T. C. Aveling, A.M. Inst. C.E.; R. Stoltenhoff, Graduate I. Mech. E.; G. W. Revell, A.M. Inst. C.E.; and G. E. Morgans, A.M. Inst. C.E. It will be remembered that these units consist very largely of members of the Institutions of Civil, Electrical, and Mechanical Engineers.

German Exports of Tin-Ware and Tinfoil.—German exports of tin-ware and tinfoil amount to the value of 662,000*l.* per annum, in which tinfoil figures to the amount of 430,100*l.* The largest customer for German tinfoil is Great Britain. We purchase from her 193,800*l.* worth of tinfoil per annum, while France, her next best customer, only takes to the value of 60,600*l.* Switzerland ranks third, buying to the value of 31,000*l.* We buy spoons, forks, tea-strainers, cans, &c., from Germany to the value of 13,000*l.* per annum, while the German exports of these goods to the United States are valued at 58,400*l.* per annum. Germany's more important other markets in this trade are Russia, Spain, France, Denmark, &c.

The New Army.—A war relief fund was organised by the employees of the India-Rubber, Gutta-Percha and Telegraph Works Company, Limited, Silvertown, London, E., four weeks ago, since which time 100*l.* has been voluntarily contributed for distribution to the National (Prince of Wales) Relief Fund (50*l.*), to the British Red Cross Society (25*l.*), and to the Belgium Relief Fund (25*l.*). The intention is to send similar sums at least to each fund every four weeks for as long as may be necessary. About 20 per cent. of the company's male employees of military age have joined the colours.—The "Coventry" Chain Company, Limited, Spon End, Coventry, inform us that 130 of their employees have rejoined the colours or enlisted since the beginning of the war. They hope to reinstate all those who re-apply at the conclusion of hostilities. The company are paying reservists' wives 7s. per week and 1s. for each child.

INDUSTRIAL NOTES.

The Board of Trade have announced that they are now prepared to entertain applications for the payment from the Exchequer during the present emergency of special grants to voluntary associations which provide benefits for their unemployed members.

These emergency grants will be paid by the Board of Trade as an addition to the refunds of one-sixth payable under Section 106 of the National Insurance Act. The payment of the emergency grant will be subject to the conditions that the association is suffering from abnormal unemployment; does not pay unemployment benefit above a maximum rate of 17s. per week (including any sum paid by way of State unemployment benefit); and agrees to impose levies over and above the ordinary contributions upon those members who remain fully employed.

The amount of the emergency grant (in addition to the refund of one-sixth already payable) will be either one-third or one-sixth of the expenditure of the association on unemployment benefit (exclusive of strike benefit). The rate of the grant will be determined by the amount of the levy in accordance with the following scale:—

Maximum Rate of Unemployment Benefit Paid by Association.	Rate of Weekly Levy Required to Obtain Emergency Grant of	
	One-Sixth.	One-Third.
	d.	d.
Not more than 17s.	3	6
,, 15s.	2	4
,, 13s.	1	2

Forms of application for associations desiring to become qualified for the emergency grant are being prepared, and will shortly be obtainable from the Board of Trade Central Office for Labour Exchanges and Unemployment Insurance, Queen Anne's Chambers, Westminster, S.W., to which all communications on the subject should be addressed.

It is announced that the French Government have placed an order for 1,500,000 horse-shoes with the Scottish Iron and Steel Company, Coatbridge. One of the works acquired by the company—that of the Coatbridge Iron Works—held an exclusive patent for Great Britain for the manufacture of horse-shoes by mechanical means, and at one period did an enormous business. Competition from Germany proved too strong, and the making of the shoes had to be discontinued two years ago. These works were entirely stopped. Now that this order by the French Government has been secured, the works are to be re-opened.

We read in the *Yorkshire Post* that a prolonged stoppage in the Lancashire cotton trade is threatened. The Federation of Master Cotton-Spinners and Manufacturers have discussed the present situation, and have sent out to their members grave warnings as to how they should act during this unprecedented time. All the mills running are working short time, and they are comparatively few; many mills closed down shortly after the declaration of war, and weekly, since the beginning of August, the Federation have received notice of mills closing their gates for an indefinite period—in all probability until the end of the war.

The mills are working off old orders, and a general closing order will inevitably follow their completion. Millions of spindles in Lancashire are already idle. The manufacturing side, too, is inactive. Fortunately the operatives belong to wealthy trade-union organisations, from which they will draw stated sums weekly, but there is bound to be considerable distress in the cotton districts until the trade revives. The cotton-masters are making every effort to get cheaper cotton, and if they are successful in this, the position will be greatly relieved. But in any event there is a hard time ahead, and both the masters and the operatives are preparing to meet it as best they can.

Matters are worse still with the German and Austrian cotton trade, for, according to German journals, owing to the military service of the men, production has been reduced by about 50 per cent., and the greater part of the output is required to meet the needs of the army. A number of mills are maintained in operation solely to provide work, which means accumulating stocks under unfavourable conditions. The price of cotton has risen considerably. Cotton of the new crop cannot be imported, and in order to keep going in the interests of the workpeople, the necessary supplies of the old crop are purchased at very high prices in Bremen in so far as the cash required for payment can be provided.

In Austria, an inquiry instituted by the Cotton-Spinners' Association showed that at 79 manufacturing concerns the reduction in working hours was 41.5 per cent., and the shrinkage in the production 44.7 per cent. The number of workpeople fell from 28,836 to 15,519, although only 1270 had been called up for military service. Lack of cotton will soon make matters worse still.

The average cash selling price of hematite iron warrants, according to the quarterly ascertainment under the sliding scale in force in Cumberland, has risen from 61s. per ton to 63s. 10d. per ton, owing to the present increased demand for Cumberland hematite iron. The furnacemen's wages are accordingly advanced by 5 per cent. to 30 per cent. above the standard.

The text of the arrangements adopted by the North of England coal-trimmers and teemers for week-end working during the continuance of the war, copies of which have been forwarded to the Admiralty and the Board of Trade, has been officially issued; it reads as follows:—

"That this representative conference of the North-East Coast Trimmers and Teemers (Warkworth Harbour to the Hartlepools) decide to notify the Government that they are prepared during the period of the war crisis to respond to the call of the nation at all times, including Sundays, but request that means be devised to notify and assure the men concerned that such work is on behalf of the Government.

"That on Government work the rate for overtime shall be as per agreement dated August 7, 1913:—Saturdays, 12 noon to 4 p.m., 9d. per man per hour; 4 p.m. to 12 p.m., all day Sunday, and up to 6 a.m. Monday, 1s. 6d. per hour per man, these conditions to cover all men concerned—Warkworth Harbour to the Hartlepools inclusive.

"That, with the exception of Government work, we recommend our men on the North-East Coast to adhere to the agreement of August 7, 1913."

A meeting between representatives of the railway companies and of the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen was held on the 1st inst., when, in view of the national crisis, it was decided that the existing Conciliation Board scheme and all agreements thereunder should continue in force for the present and until such time as either of the parties gave notice to determine otherwise.

It was further decided that the present members of the men's side of the Board should continue in office, and that no fresh elections should be held during the suspensory period.

The accountant to the Board of Conciliation and Arbitration in the manufactured iron and steel trade of the North of England certified at the end of last month that the average net selling price of iron bars, plates, and angles for the two months ended August 31 last was 6*l.* 14s. 2.15d. For the previous two months the average net selling price was 6*l.* 13s. 1.91d. In accordance with the sliding-scale arrangements the wages for October and November will be the same as those for the preceding two months.

According to the result of the ascertainment of the average net selling price of steel plates at Consett during May, June, and July, the wages of the steel-mill men will be reduced by 2½ per cent. in the quarter commencing on the 1st inst. The wages will still be 12½ per cent. above the standard. Three months ago the Consett men suffered a similar reduction.

On September 30 the second ascertainment under the new sliding scale for regulating wages in the Northumberland coal trade was made known. It covers the three months ending August 31, and applies to the wages for the three months beginning with October. The ascertained selling price is 0.21d. higher than in the previous three months, but wages will remain unaltered. Wages rise and fall under the sliding scale by 1 per cent. for each 1d. change in the selling price. The last ascertainment showing, as above stated, a rise of only about a fifth of a penny, wages for the next three months will remain as they now stand.

On Monday last the Board of Trade issued a statement dealing with the present state of employment. According to this, in the trades compulsorily insured against unemployment—building, works of construction, engineering, shipbuilding, vehicle-making—the percentage of unemployment on October 2 was 5.1, as compared with 5.4 a week previous and 6.3 a month previous. These figures relate to the whole of the United Kingdom, and include all unemployed workmen in the insured trades.

As regards the uninsured trades, the number of men and women on the registers of the Labour Exchanges on October 2 showed a decrease on the figures of the previous week, being 64,916 as compared with 66,954. For men alone the corresponding figures were 29,278 and 30,336, and for women 35,637 and 36,618.

THE DECARBURISATION OF STEELS IN THE SALT-BATHS USED FOR HEATING PRIOR TO HARDENING.*

By A. M. Portevin, Paris.

The use of baths of molten alkaline salts for heating steel parts prior to hardening is becoming more and more widespread in industry. They allow, indeed, of the much more rapid heating of small parts, and of adjusting, as accurately as possible, the temperatures of heating. It is, as a matter of fact, easy to secure uniformity of temperature in a liquid bath, and to ascertain that temperature to any required degree of accuracy and precision by means of a Le Chatelier thermo-couple or of a platinum resistance pyrometer. Besides this, superficial oxidation is avoided, or at any rate considerably reduced. But—and in the author's opinion insufficient attention has hitherto been paid to this fact—superficial decarburisation occurs, and this becomes strongly marked in cases where the heating is prolonged.

Table I.—*Decarburisation of Steels in a Molten Potassium Chloride Bath at* 1000 *Deg. Cent.*

Steel employed:—	Per Cent.
Carbon	1.46
Manganese	0.28
Silicon	0.10
Phosphorus	0.025

Results of the Micrographic Examination.

Duration of Heating.	Thickness of the Hypo-Eutectic Layer.	Thickness of the Eutectic Layer.	Percentage of Carbon at Surface.
hours	mm.	mm.	
0½	0.0	0.18	0.9
2	0.48	1.00	0.4
5	0.84	1.50	0.2

Results of the Hardness Tests after Quenching at 750 *deg. Cent.*

Duration of Heating, Hours.	Brinell Test, Ball 10 Mm. in Diameter, Pressure 3000 Kg.	Shore Test, Average of Five Rebounds.
0½	2.39	79.8
2	2.94	41.0
5	2.89	32.0

A second test yielded similar results.
The samples were small cylinders, 20 mm. in diameter and 10 mm. in depth.

Table II.—*Decarburisation in a Bath of Molten Potassium Chloride at* 900 *Deg. Cent.*

Steel employed:—	Per Cent.
Carbon	0.78
Manganese	0.28
Silicon	0.37
Sulphur	0.013
Phosphorus	0.011

Duration of Heating, Hours.	Thickness of Decarburised Layer, $\frac{1}{10}$ Mm.	Percentage of Carbon at Surface.
0½	1	0.5
2	2	0.3
5	3	0.15

Decarburisation in a Brayshaw Bath of Molten Salts at 900 *deg. Cent.*

Same steel as above.
Composition of Brayshaw mixture:—

Potassium chloride	0.56
Sodium chloride	0.39
Soda	0.5
Potassium ferro-cyanide	0.2

Duration of Heating, Hours.	Thickness of Decarburised Layer, $\frac{1}{10}$ Mm.	Percentage of Carbon at Surface.
0½	1	—
2	3	0.20
5	4	0.15

No carburisation occurred.

Table III.—*Decarburisation and Carburisation at* 900 *Deg. Cent. in a Bath of Potassium Chloride to which* 10 *per Cent. of Ferro-Cyanide has been Added. Steel Containing* 0.78 *per Cent of Carbon.*

Duration of Heating, Hours.	Thickness of Decarburised Layer, $\frac{1}{10}$ Mm.	Percentage of Carbon at Surface.*
0½	2.0	0.5
2	4.0	0.35
5	6.5	0.25
	Lancashire Iron.	
0½	2.5	0.25
2	3.5	0.3
5	4.5	0.3

* Estimated microscopically.

The author has carried out a series of experiments with the object of investigating this decarburisation, the results of some of which will be quoted.

Samples of a hyper-eutectic steel containing 1.46 per cent. of carbon, and in the form of little cylinders 20 mm.

* Paper contributed to the Iron and Steel Institute, and now open for discussion by correspondence.

in diameter and 10 mm. deep, were maintained for varying periods in molten potassium chloride at 1000 deg. Cent. For each period of remaining in the bath a sample was examined, after heating without quenching, under the microscope; another was heated to 750 deg. Cent. and quenched in water. This served for the hardness determinations. The results have been tabulated in Table I.

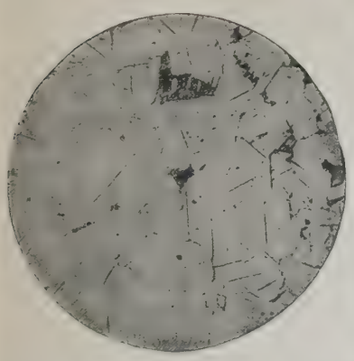


Fig. 1. Etched with Picric Acid. Magnified 250 Diameters.

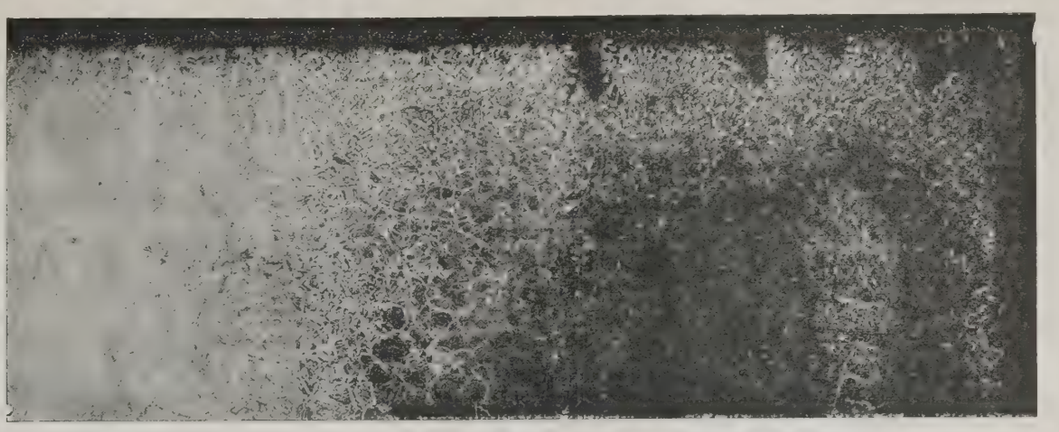


Fig. 2.

It will be very clearly seen that with an increase in the length of time the sample remains in the bath there is an increasing decarburisation, marked both by an increase in the depth of decarburised layer and by the lowering in the carbon percentage of the surface, which falls to 0.2 per cent. This decarburisation is most noticeable after quenching, being revealed more particularly by testing with the Shore sclerometer, which is readily explained by the fact that this test applies only to a small depth, whereas the result of the Brinell test is influenced by the hardness of the subjacent layers.

By experimenting at 900 deg. Cent., instead of at 1000 deg., the decarburisation is naturally less deep. but almost as great, so far as the superficial lowering of the carbon percentage is concerned, as shown in Table II. It should, however, be noted in the comparisons that may be drawn from these results that the steel employed in the experiments at 900 deg. Cent. contained only 0.78 per cent. of carbon (manganese, 0.28 per cent.; silicon, 0.37 per cent.).

Experiments were made with this same steel in the salt bath described by Brayshaw for use in his hardening furnaces. The composition of the salts and the results obtained at 900 deg. Cent. are summarised in Table II. The degree of carburisation is, so far as its importance is concerned, quite comparable with that found with the pure sodium-chloride bath; in any case the influence of the small amount of ferro-cyanide added with the object of counteracting the decarburisation does not appear very efficacious. It seems improbable, however, that the ferro-cyanide can have no action, and besides, the experiments were made over again after the addition of a larger proportion of ferro-cyanide to the potassium chloride (10 per cent.).

By working under the same conditions as those for the experiments described in Table II.—that is to say, at a temperature of 900 deg. Cent. on the same steel (0.78 per cent. of carbon)—and with the periods of remaining in the bath of one quarter, two, and five hours, a decarburisation is again found which is even deeper, but less intense, in the sense that the superficial carbon percentage does not fall so quickly (Table III.). Care had been taken to place in the bath, at the same time, samples of carbon-free iron (Lancashire iron), which remained immersed for similar periods, and it was found that these

Table IV.—*Decarburisation at 900 Deg. in a Bath of Potassium Chloride to which 10 per Cent. of Potassium Cyanide and 3 per Cent. of Potassium Cyanate have been Added.*

Steel Containing 0.78 per Cent. of Carbon.

Duration of Heating, Hours.	Thickness of the Decarburised Layer, $\frac{1}{10}$ Mm.	Percentage of Carbon at Surface.*
$0\frac{1}{4}$	2.5	0.25
2	4.5	0.2
5	6.5	0.1

Lancashire iron. No carburisation.

* Estimated microscopically.

samples had simultaneously undergone carburisation. The interesting point is that the depth of this carburisation increases with the duration of the heating, whereas the percentage of superficial carbon appears to remain very nearly constant. Unfortunately, the phenomenon becomes complicated by the decomposition of the ferro-cyanide, which is evidenced by the production of a muddy deposit at the bottom of the salt bath. The author has followed up the investigation of this phenomenon by replacing the ferro-cyanide by cyanide, and it is therefore solely with mixtures of potassium chloride and potassium cyanide that he will at present concern himself. He would like, however, before giving the results obtained, to point out the influence of a small addition (3 per cent.) of cyanate of potassium on the preceding salt bath; as shown in Table IV., where the results are given, it will be seen that the decarburisation is increased, but that, on the other hand, no carburisation of the iron was observed.

Mixtures of Cyanide and Cyanate of Potassium.—The employment of these mixtures has enabled the author to establish equilibria of carburisation between the steel and the bath, equilibria which he has described in a note to the Academie des Sciences,* and of a nature that it is possible to observe, simultaneously, in the same bath, the decarburisation of hard steels and the carburisation of dead-soft steels. To do this there were added to the potassium chloride increasing quantities of potassium cyanide up to a proportion of 75 per cent. of the total weight of the mixture, and there were immersed in the molten mixture at 900 deg. Cent. samples of hard steel (0.78 per cent. of carbon, 0.37 per cent. of silicon, and 0.28 per cent. of manganese) and of carbon-free iron, which were left for varying periods. Subsequently the depths of decarburisation and of carburisation were ascertained under the microscope, together with the percentage of carbon superficially.

Table V. gives the principal results obtained.

Table V.—*Decarburisation and Carburisation in Mixtures of Chloride and Cyanides of Potassium.*

Steel Containing 0.78 per Cent. of Carbon.

Percentage of KCN in Bath.	Duration of Heating.	Thickness of the Decarburised Layer.	Percentage of Superficial Carbon.	Thickness of the Carburised Layer.	Percentage of Superficial Carbon.
	hours	mm.		mm.	
25	$\frac{1}{4}$	0.09	0.25	0.18	0.25
	2	0.37	0.30	0.37	0.25
	5	0.75	0.25	0.62	0.30
50	$\frac{1}{4}$	0.12	0.35	0.10	0.15
	2	0.37	0.20	0.37	0.20
	5	0.68	0.25	0.50	0.25
75	$\frac{1}{4}$	0.06	0.25	0.12	0.25
	2	0.41	0.20	0.44	0.25
	5	0.69	0.25	0.44	0.25

It will be seen that under the same conditions, decarburisation and carburisation occur simultaneously, according to the grade of steel; and if the longest period of heating (five hours) be taken into consideration, there will be found, as the average superficial percentage of carbon in the steel, for all three mixtures, in the carburised layers, 0.26 per cent.; in the decarburised layers, 0.25 per cent.

The two phenomena appear, therefore, to tend towards a common limit which would be the carbon concentration of the steel, which remains in equilibrium at 900 deg. Cent. in the chloro-cyanide bath. This limit appears, in the mixtures experimented on, to be independent of the quantity of potassium cyanide present in the bath.

Incidentally it has been noted, microscopically, that very frequently, when these baths contain cyanide of potassium, and likewise when they contain ferro-cyanide of potassium, there appear, in the ferrite, subjacent to the carburised layer, needles of an appearance similar to those described by Braune† in his researches on the influence of nitrogen on iron and steel. Fig. 1, above, gives an example taken at the boundary of carburisation. Some areas of pearlite are still distinguishable on one side of the figure, but the ferrite grains are traversed by needles. These needles are present in too small a number for it to be possible to ascertain whether, within one and the same grain, there may be (which is improbable) more than, at most, four directions.

This phenomenon of carburisation equilibrium can be brought out in an even more striking manner as follows:—A highly case-hardened iron is taken, and a section made at right angles to the case-hardened surface. By these means there is obtained in the section a progressive decrease in the percentage of carbon, or, in other words, a complete and continuous scale of the different shades of steel. On the samples thus prepared the preceding experiments are carried out, and there will be found, on examining under the microscope, a section perpendicular to the surface just referred to, the simultaneous decarburisation of the zones rich in carbon, and the carburisation of the zones low in carbon. This is brought out very clearly and very strikingly in Fig. 2, herewith, which is given by way of a commentary on and a conclusion to this paper.

* *Comptes Rendus*, vol. clviii., 1914, page 1025.

† *Revue de Métallurgie*, 1905, vol. ii., page 497.

Personal.—We are informed by Mr. A. G. Cloake, 54, Holborn Viaduct, E.C., that the important works of La Société du Familistère de Guise (Colin and Co.), France, ironfounders, stove-makers and enamellers, well known in England on account of the fine quality of their iron castings, have escaped destruction, although the town of Guise itself, which is situated in the Aisne Department, was taken and retaken by the enemy, after heavy bombardments, and is reported to be entirely devastated. All offices, show-rooms, and available warehouses in the "Familistère" have been transformed into hospitals. Their works in Brussels are intact, but have been closed since the Germans entered the town.

The Panama-Pacific International Exposition.—We have recently received a pamphlet setting forth some of the attractions which California will offer to a visitor to the Panama-Pacific Exhibition in 1915. This pamphlet is attractively illustrated and printed. It has a coloured-picture cover, the front representing a gigantic male figure engaged in forcing apart a rift in the hills at the Isthmus, a legend underneath hinting that the construction of the Panama Canal is the thirteenth labour of Hercules. The contents of the pamphlet consist in a brief history of the Canal undertaking, followed by a description of the forthcoming Exhibition, its scope, buildings, grounds, decorative schemes, &c. Many of the important buildings are already completed, and the general progress promises well, it is said, for the opening in February next. The latter half of the pamphlet consists of a description of the city of San Francisco and some of the chief points of interest in California. The selection of views reproduced, with the accompanying notes, will, we feel sure, arouse in many a desire to visit this most interesting State, while those already acquainted with its beauties and pleasures will surely find themselves longing to visit it again.

Foreign Trade in Cast-Iron Goods.—The Commercial Intelligence Branch of the Board of Trade has recently issued a bulletin dealing with Germany's and Austria's export trade in cast-iron goods, principally cooking and other stoves, baths, cooking-utensils, lamps, &c. In these classes Germany's total exports amount to 2,208,300*l.* in a year; those of Austria are comparatively small, amounting to less than 44,000*l.* The largest class of the German trade is that comprised within the classification "cooking-utensils, baths, lamps, and other wares of cast iron, worked." Her total exports of these lines are valued at 1,578,100*l.*, the dealings with four countries having a value of over 100,000*l.* As in other trades, Russia is one of Germany's best customers, taking goods of this type to the value of 124,300*l.* Belgium, the Netherlands, and Switzerland each import from Germany just over 100,000*l.* worth per annum, while our imports from the same source are valued at 96,000*l.* per annum. France takes rather more (98,100*l.*), while nineteen other countries buy these goods from Germany to a value of more than 10,000*l* per annum. In the matter of cooking-stoves, ovens, boilers, &c., of cast iron, Germany does a total export trade valued at 610,000*l.*, her principal customers being the Netherlands (82,700*l.*), and Switzerland (75,300*l.*). Italy comes next, taking goods to the value of 61,100*l.*; but Russia, in this instance, is not so good a customer, purchasing only to the value of 35,500*l.* The total imports of this character into Great Britain from Germany and Austria are valued yearly at about 113,000*l.*, the Austrian contribution, however, being negligible. From the foregoing figures it will be evident that the bulk of our imports from Germany consist of cooking-utensils, baths, &c., though stoves also contribute to an appreciable amount.

HIGH-SPEED FLOORING AND MATCH-BOARDING MACHINE.

A WOOD-PLANING machine adapted for dealing with any sections up to 9 in. wide by 4 in. thick is illustrated in Figs. 1 to 5, on pages 445 and 448. The machine planes all four sides of a board and tongues and grooves floor-boarding or match-boarding at one operation. Beadings may also be cut at the same time. The work may be carried out at various rates of feed between 30 ft. and 250 ft. per minute. The machine is constructed by Messrs. A. Ransome and Co., Limited, of Stanley Works, Newark-on-Trent. In connection with it there is a patent feeding-in table recently introduced by Messrs. Ransome. This table is a most interesting part of the complete tool, but before dealing with it we will describe the details of the planer. Of our illustrations, Figs. 1, 2, and 3 show the planing-machine proper, while Figs. 4 and 5 are views of the feeding-in table. This latter appliance stands a short distance from the front end of the planer. It would lie to the right-hand side if included in Fig. 3.

The planing-machine consists of a box-frame planed throughout its entire length, to form a bed on which the timber is held down, and provided with openings for carrying two pairs of feed-rollers, a bottom revolving cutter, and side, top, and beading cutter-blocks. The frame is provided with the necessary planed facings and seatings. The feed-rollers are at the front end of the machine, shown to the right hand in Figs. 1, 2, and 3. They are 12 in. in diameter, and the first pair is grooved to ensure a grip of the wood. All are driven by spur-gearing, with machine-cut teeth. The train of wheels is indicated by broken circles in Fig. 1. As will be clear from this figure and Fig. 3, the upper rollers are mounted on swinging levers pivoted at the centre of the spur-wheel which drives the roller-spurs. This arrangement allows the rollers to be moved up or down to adjust for varying thicknesses of wood. The outer ends of the swinging levers are connected by vertical rods to a cross-bar carried in the lower part of the frame. This cross-bar carries a gun-metal nut, and by means of a steel screw and worm gearing the bar may be raised or lowered, carrying the rollers with it. The arrangement is actuated through a mitre gear from the hand-wheel, which can be seen at the side of the machine in Figs. 1 and 3. Pressure is applied to the rollers by a lever with an adjustable weight, which bears upon the cross-bar. The arrangement is fixed inside the lower part of the frame. The upper rollers and gearing are provided with guards, as shown in Fig. 3. The bottom rollers have a slight vertical adjustment, being carried on screw supports.

The drive of the feed-rollers is through a variable cone friction-gear, which is fixed below the floor. The arrangement is shown in outline in Figs. 1 and 2. As will be seen, there is a countershaft at the back end of the machine, which drives the various motions through a series of belts. The feed-belt is the top one (Fig. 2). It has fast and loose pulleys on the countershaft, and drives on to a second short countershaft fixed below floor level at the front of the planer. This shaft carries one of the variable friction-cone members of the chain-belt friction-drive, the other member being fixed on a further short shaft directly above it. From this shaft a crossed belt transmits the drive to a pulley on the planer-frame, and so to the gearing driving the rollers. The rate of feed is varied by moving the cone-pulley members in or out, these being operated from a hand-wheel fixed above the floor on a pedestal, as shown in the figures. Power is transmitted from the hand-wheel shaft to the shaft carrying the operating screw of the cone-pulley members, by a chain-belt. The feed is started or stopped by moving the main belt from the loose to the fast pulley or *vice versâ*. This operation can be carried out, or the rate of feed can be altered, while the machine is running. At the front of the machine there is a flat spring which presses the board against the guide-fence as it enters the rollers.

The machine has five revolving cutter spindles. (There are no fixed cutters.) Of the five spindles, one operates on the top of the work, two on the sides, and two on the bottom. All the spindles are of forged steel, and the top and bottom cutter-blocks are solid with their spindles. The spindles run in ball-bearings, and have adjustable phosphor-bronze end plugs to take the thrust. The cutter-blocks are of the circular type, and are each fitted with six knives. Taking the various cutter-spindles in their order from the feed-roller end of the machine, we must first deal with the bottom one which carries the block for truing the underside of the work. This has a cutter-track 8 in. in diameter, and runs in three ball bearings, 45 mm. in diameter, at 3400 revolutions per minute. The spindle pulley can be seen in Fig. 2 driven by a crossed belt from the counter-shaft at the left-hand end of the machine. The belt runs at 4800 ft. per minute. The spindle is carried in a movable drawer fitted into the main frame of the machine, so that the whole can be pulled out sideways to examine the cutters. The arrangement can be partly seen in Figs. 1 and 2. A loose pulley is carried on the main frame of the machine, and the belt remains in position on this pulley when the drawer is withdrawn; this pulley is not shown in Fig. 2. The vertical position of the block determining the thickness of the cut may be regulated by a wedge and screw arrangement, which may be adjusted without stopping the feed. Directly above the bottom cutter there are pressure rollers which press on top of the work and prevent it lifting. These rollers are clearly shown in Figs. 1 and 3. They are carried on hinged arms and are pressed down by spiral springs. The arms are pivoted to a slide which can be moved up and down by a screw and hand-wheel. This allows the necessary adjustment for different thicknesses of work, and the rolls to be raised for jointing the cutters.

The revolving side spindles for planing to width are fitted with steel cutter-blocks and have cutter-tracks 8 in. in diameter. They are arranged to take, when required, a pair of Bolinder or Wood's patent disk cutter-heads for tongueing and grooving at a high rate of feed. Each of the spindles runs in two ball-bearings 45 mm. in diameter, the one nearest the cutter being of the double-row type. The spindles are not placed immediately opposite one another, one being 6 in. in advance of the other. This ensures a better class of work. This disposition can be seen in Figs. 1 and 2. These figures also show the individual belt-drives from the counter-shaft to the two vertical spindles. The side cutter-blocks are adjustable transversely by means of horizontal screws operated by a loose handle from the side of the machine. The squared end of these screws, with the handle in place on one of them, can be seen at the centre of Fig. 3. Each cutter-block has also a vertical adjustment by means of a screw and hand-wheel. The cutter-blocks are provided with hoods to facilitate the removal of chips, the hoods being hinged to allow easy access to the cutters. The front hood, alongside which is the hand-wheel for vertical adjustment, is clearly shown in Fig. 3. These parts can also be seen in Figs. 1 and 2. The work is firmly held in the neighbourhood of the side-cutters by two top and one side-pressure rollers. These rollers are mounted on levers with adjustable weights. The hinged hood over the front-side cutter-block also acts as a side-pressure on the work. Pressure is obtained from a weighted lever which bears against the hood. Where the hood bears against the work it has a curved face and carries a steel projection acting as a chip-breaker.

The top cutter-block, which has a cutter-track 8 in. in diameter, and runs in three 45-mm. diameter ball bearings, is carried by a slide actuated by a screw and hand-wheel to adjust for thickness. The arrangement is clearly shown in the figures. A hinged pressure-block, backed by a spring, holds the work down at the front of the cutter, while a similar pressure-block carried on a steel rocking shaft holds it down behind. Both pressure-blocks rise and fall with the slide which carries the cutter spindle. The beading-block spindle, for cutting a bead or moulding on the face of the boards, is carried on brackets at the back end of the machine. This fitting is not an essential part of the planer, and may be omitted if beading or moulding are not required. The spindle is 1⅜ in. in diameter, and is suitable for cutters having a cutter track of 7⅛ in. in diameter. The cutters are fixed by set-screws. The spindle runs in two ball-bearings 55 mm. in diameter, carried in a carriage capable of vertical adjustment by means of a wedge and screw. Three steel pressure-shoes, which hold down the boards, are fixed above the spindle. They have a screw and hand-wheel adjustment.

Before leaving the machine, we may say something of the way in which the cutters in the cutter-blocks are set up. In each block there are six cutters, and to ensure that each shall do its fair share of work it is clear that very accurate setting is necessary. The process is carried out by means of what in America is known as a "jointing device." This consists of two round rods ground very true, and carried by adjustable bearings across the bed of the machine opposite the cutter-heads. On the rods there runs a little carriage carrying a small piece of material of the same nature as that used in emery-wheels. This piece can be adjusted like a tool in a slide-rest. When the cutters are put in place and set rotating, this emery-tool is fed up to them until it just touches them as they revolve. It is then traversed across the full width of the cutters by hand. The result is that it trims off the whole of the edges to an absolutely straight line, such that each cutter is of precisely the same radius as all the others, and therefore does the same amount of work. The fact that the emery-tool touches each cutter, and that none are too short, is adequately provided for by the fact that a small spark is produced at each contact, and the absence of the spark at any time shows that the tool concerned should be set a little further out. Any little burr which may be left on the cutters by the setting-up process is removed by an oil-stone before work is commenced. In concluding this description of the machine, we should say that it weighs 6 tons, and requires 47 horse-power to drive it at the maximum rate of feed in material 5½ in. by 1 in.

We may now turn to the feeding-in table, which is illustrated in Figs. 4 and 5. This table, which is patented, is a very simple device, and requires but little description. Its purpose is to feed continuously the planing-machine, and its action is so automatic that one man can maintain a constant supply of boards to the machine at rates up to 300 ft. a minute. As we have already stated, the table is fixed in front of and in line with the planer. A pile of planks is placed alongside, and a man simply takes them one by one and throws them on to the table with their ends pointing approximately towards the planing-machine. The planks do not require to be adjusted to position after they alight on the table, except that if one falls on its edge, it must be pushed over. It does not matter if the planks lie one on top of another. As the planks lie on the table they come under the action of a series of continuously-running rollers, which can be seen in Fig. 4. Each of these rollers has a coarse spiral thread cut round it, and the effect of the thread gripping the underside of the planks is to feed them towards, and lay them parallel with, the guide-fence which lies above the back side of the table. At the front end of the table there is a gauge opening just large enough to pass one plank, and the spiral rollers, after bringing the planks into position alongside the guide-fence, feed them forward through the gauge opening one at a time to the planing-machine.

The rollers on the feed-table are geared to a higher speed than the rollers of the planer, with the result that the stuff which is being fed in is constantly overtaking that in the machine, and butts hard up against it. The advantage of this is that no space is left between the board which has just been planed and the one that is following. With the boards butting hard against each other, as is ensured by the feeding-in table, boards of perfectly even thickness throughout are produced. For feeding the boards, one by one, into the correct position in front of the gauge opening there is, in addition to the main rollers, a further roller fixed above the entrance to the opening. This roller can be seen in Fig. 4. It is known as the "pine-apple" roller, and, as will be clear, is of conical form, with a deep spiral thread. The special purpose of the roller is to hold the plank firmly against the guide-fence as it travels through the gauge-opening, and so ensure that it arrives at the planing-machine in the correct position. If a plank on the table falls on top of another, the two simply travel together up to the fence, and the upper is then held back, while the lower travels through. The upper then falls on to the table and passes through in turn.

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.—The Goldsmid Entrance Scholarship, tenable in the Faculty of Engineering, of the value of 90*l.*, has been awarded to Mr. John Sinclair Fraser, of Dulwich College. Mr. Patrick Alexander Curlett was placed *proxime accessit*.

GERMAN CAPITAL IN RUSSIA. — The aggregate of German capital invested in the electro-technical industry in Russia has increased from 20,600,000 roubles in 1911 to 41,000,000 roubles in 1914. Of this sum, 7,000,000 roubles has been found by the Russian Siemens-Schuckert Company, and 12,000,000 roubles by the Russian Allgemeine Elektricitäts Gesellschaft.

THE COPPER MARKET.—In the monthly report dated the 1st inst., Messrs. James Lewis and Son state that during the past month the London Metal Exchange has remained closed, and no transactions in Standard copper have been officially recorded. Private purchases and sales had, however, been made at prices varying from 54*l.* 5s. to 52*l.* per ton for cash, and about 1*l.* more for three months prompt, the value of cash being 52*l.* 5s. on the 1st inst. American electrolytic copper sold from 59*l.* down to 54*l.* 10s. per ton for prompt delivery, ex quay or warehouse, closing at 55*l.* c.i.f. to arrive. It was freely offered in New York at 12 cents per pound. Best selected ingots were quoted 60*l.* on the 1st ult., and 57*l.* 5s. on the 1st inst. A considerable quantity of refined copper had been exported, and there had been large deliveries to the British Government.

GERMAN EXPORTS OF WIRE AND WIRE-ROPE GOODS.—The exports of Germany of manufactures of wire or wire-rope amount to a yearly value of about 783,300*l.* In this figure, wire-rope, &c., figure for 196,200*l.*; wire-netting and gauze, 315,100*l.*; and wire brooms, hooks, handles, springs, &c., for 272,000*l.* Our own exports in these lines aggregate about twice those of Germany. The German exports to this country are valued at about 28,300*l.* per annum, the bulk being manufactured articles such as brooms, baskets, hooks, &c. In the matter of wire-rope, &c., Germany's best customers are Belgium (28,200*l.*), Roumania (23,100*l.*), Russia (18,700*l.*), the Netherlands (16,800*l.*), &c. The largest purchaser of German wire-netting in 1912 was Australia, whose imports from this source amounted in that year to a value of 147,000*l.* In no other country did Germany's trade amount to more than 24,000*l.* in this class of goods. German competition in this class in Australia is very keen, while elsewhere her competition in mosquito gauze has been very much alive.

9-IN. × 4-IN. HIGH-SPEED FLOORING AND MATCH-BOARDING MACHINE.

CONSTRUCTED BY MESSRS. A. RANSOME AND CO., LIMITED, ENGINEERS, NEWARK-ON-TRENT.

(*For Description, see opposite Page.*)

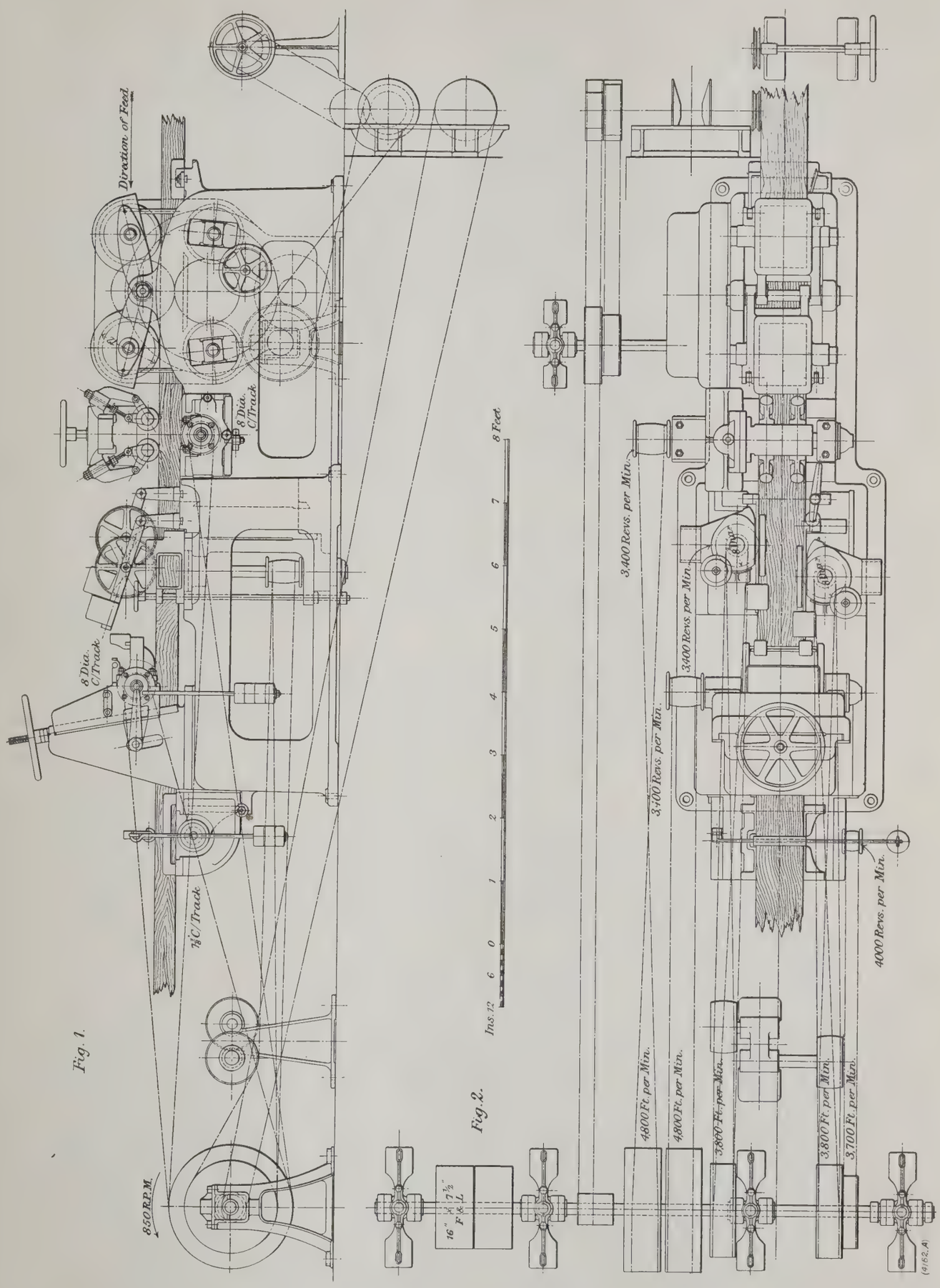

Direction of Feed
8 Dia. C Track
8 Dia. C Track
8 Dia. C Track
16 C Track
850 R.P.M.
16" × 7⅞" F.E.L.
Ins. 12 6 0 1 2 3 4 5 6 7 8 Feet
3,400 Revs. per Min.
3,400 Revs. per Min.
3,400 Revs. per Min.
4000 Revs. per Min.
4800 Ft. per Min.
4800 Ft. per Min.
3,800 Ft. per Min.
3,800 Ft. per Min.
3,700 Ft. per Min.
(4162.A)

Fig. 1.

Fig. 2.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, September 23.

THE volume of domestic business in iron and steel has not increased during the week. The railroads remain out of the market for rails, rolling-stock, and structural material. The financial stringency holds back general structural buying, and contracting for new work is at a standstill. The most encouraging fact in the otherwise serious situation is that most manufacturing shops have enough work on hand to keep them busy to the end of the year. Hence the comparative indifference for new work at the present time and the confidence prevailing. Prices are firm, notwithstanding that production is under 60 per cent. of capacity. There is, however, more or less contracting done for the first quarter of next year, and it is to be noted that on most of this business prices are 1 dol. per ton higher than for delivery in the last quarter. Rather exaggerated anticipations prevail as to certain foreign business. The two difficulties in the way are the lack of ships and the lack of exchange facilities which banks could afford in countries with which business might be done. The Government and the private banking interests are vigorously engaged in meeting these two difficulties. Arrangements are practically completed to furnish 100,000,000 dols. of gold to meet European obligations. The shipping problem has not yet been adjusted. The plan of the Government to purchase ships, mainly from Germany, is being and will be vigorously opposed. Private enterprise is cautious, and hesitating to step into the breach, owing to several apparent uncertainties. At present the steel industry is merely holding on, looking to foreign demand for relief.

September 30.

Another week of watchful waiting has passed without a single encouraging development in iron or steel. Mills and furnaces have slowed down. Several more furnaces will blow out. Local steel requirements are restricted to business of which no notice would be taken in ordinary times. More foreign steel business could be done if manufacturers accepted prices offered. There are even more inquiries from abroad, especially for billets and sheet bars, with sales for 125,000 tons pending. Also boatplates are asked for, with trifling orders placed. There are very few large projects now looking for steel, but many have been stowed away until the situation warrants action. The Government is lecturing the hard-fisted banks which refuse to loan money on ample security. It is a case of excessive caution. Decreasing output may be expected until there comes a radical change or until foreign demand returns. Prices this week show no change. From all quarters a very heavy demand for basic steel is looked for. Manufacturers regard the present situation as a lull before the storm. With such possibilities in view there is scarcely any effort made to contract ahead. At present rate of decline it will be a very short time before 60 per cent. of mill and furnace capacity will be idle.

PIG-IRON SHIPMENTS FROM MIDDLESBROUGH. — The latest circular issued by Messrs. William Jacks and Co. shows that the shipments of pig-iron from Middlesbrough, including Skinningrove, amounted to 29,573 tons coastwise (as against 47,154 tons in September of last year); 29,350 tons to foreign ports (70,660 tons in September of last year); making a total of 58,923 tons, equal to about half the total shipments of September of last year, but an improvement on the total for August last, which was 31,870 tons. No shipments whatever of pig-iron were made last month to France, Belgium, and Germany. The total shipments from Middlesbrough and Skinningrove in 1913 were 1,246,884 tons; they amounted to 783,439 tons for this year down to September 30.

THE MECHANICAL ENGINEERING COLLECTION AT SOUTH KENSINGTON.—The authorities of the Science Museum at South Kensington have published a fifth edition of Part I. of the catalogue of the mechanical engineering collection under their charge. This collection is worthy of much wider recognition than it obtains, for it includes a great number of models and objects of great engineering and educational value. The subjects included in the present volume are steam-engines and other motors; locomotives and railways; mechanical measuring appliances; pumps and lifting machinery; and power transmission. Part II. refers to mining and metallurgical appliances; chemical manufacture plant; textile machinery; paper-making and printing machinery; agricultural implements; machine-tools; lighting appliances; telegraphic apparatus, &c. Part I. begins with a brief history of stationary engines, and then gives descriptions of 129 exhibits in this section. Then follows the section on locomotives, with 97 models. Steam-engine details and accessories are represented by 85 objects and models, boilers by 32, boiler fittings by 46, heat engines (other than steam) by 42, and so on, the total number being 1046. There is a supplement filled with photographic engravings, in which the more important exhibits are illustrated. Both teachers and students will find it advantageous to know what is to be seen in the collection. The price of each part (including supplement) is 1s. 6d.; post free, 1s. 10d.

DURABILITY OF CONCRETE IN SEA-WATER.

IN *Science Conspectus*, a publication of the Society of Arts of the Massachusetts Institute of Technology, we find some particulars of an interesting series of experiments now being carried out by the Aberthaw Construction Company in order to disprove the theory that the combined effects of sea-water and frost rapidly destroy concrete structures.

With this object in view, twenty-four concrete columns, 16 ft. long, 16 in. square, and reinforced with bars near the corners, were constructed in January, 1909, and immersed in the water at Boston Navy Yard. They were suspended in such a manner that at high tide the water reaches nearly to the top of the column, and falls at low tide nearly to the bottom. In cold weather the columns are thus alternately thawed and frozen as the tide rises and falls. The columns were made with various qualities of concrete mixed dry, plastic, and very wet. Different qualities of cement were used, and the effects of waterproofing materials, clay, and other additions to the concrete are being studied. One of the columns was mixed with salt water, but this was unfortunately lost in handling.

No final conclusions are, of course, possible yet; many years must, in fact, elapse before it will be possible to say which kind of concrete is most permanent. When examined in December last many of the specimens were practically unaffected, but others were badly eroded. As might be expected, the best results were given by the specimens richest in cement and mixed wet. For instance, of two columns made with 1 part of cement to 1 of sand and 2 of stone, the one mixed dry was badly eroded over the whole of its length; whereas the other, which was mixed very wet, was only slightly pitted. Again, of two specimens made with slag cement in the ratios of 1 : 1 : 2 and 1 : 3 : 6, respectively, and both mixed wet, the former was in excellent condition, with only very slight pitting, while in the latter all the corners had gone and the reinforcement was exposed in places. The part of this specimen which was continuously immersed was, however, in very fair condition. The experiments are being continued, and doubtless some very interesting results will be obtained in time.

BRITISH TRADE WITH ARGENTINA.—British engineering manufacturers desirous of increasing their business with Argentina are invited to send copies of their catalogues to the Institution of Engineers of the River Plate. The catalogues, which will be filed for reference, need not be printed in Spanish, as the majority of the members of the Institution are English speaking. The address of the Institution is Calle 25 de Mayo No. 195, Buenos Aires, and the catalogues should be directed to the secretary, Mr. George Cooke.

SHIPBUILDING IN GERMANY.—The German yards are said to be well employed again. The Imperial dockyards, naturally, are very busy, but the private yards also have plenty to do, and could work with full force if only the necessary contingent of engineers and skilled workmen could be obtained; but in this connection the war, of course, has made a serious difference. Overtime and Sunday work is the rule at the dockyards, and the Vulcan yard at Stettin, the Schichau yard, and that of Blöhm and Voss, Hamburg, are all fairly busy and are expecting increased activity.

FIRE TESTS WITH PARTITIONING MATERIAL. — Red Book No. 192, published by the British Fire-Prevention Committee, of 8, Waterloo-place, Pall Mall, S.W., contains a report on two tests of "Calno" boards, supplied by Fireproof Fibre Building Boards, Limited, of London. In the first test three openings in the side of one of the Committee's testing-huts were filled in with "Calno" boards, 2 in. thick, held in place by teak fillets. The object of the test was to record the effect on the boards of a fire of 45 minutes' duration, the temperature to reach 1500 deg. Fahr., and not to exceed 1650 deg. Fahr. One minute after lighting the gas (which, it will be remembered, is used to produce the heat in these tests) the inner surface of the panels was burning, and the outer layer was peeling off. The surface of the panels continued to peel off on the fire side, and burnt in continuous layers; it remained incandescent until the end of the fire test (45 minutes). After this, water at a pressure of 60 lb. per sq. in. was applied to the fire side for a period of two minutes. The water did not pass through the panels (all of which remained in position), and only slightly round the edges. The test was therefore considered satisfactory, and the material was accordingly classified as affording "Temporary Protection" (Class A). Another test was carried out, under similar conditions, to ascertain at what period the fire would break through boards of different thicknesses. Three openings were accordingly filled with boards 1 in., ½ in, and ¼ in. thick respectively. Flames appeared on the outside of the ¼-in. panel 18 minutes after the commencement of the test, and with the ½-in. panel flames passed through after 22 minutes. After 24 minutes the test was stopped, and the 1-in. panel had not then burned through. It, however, continued to burn on the fire side, and after a further 22 minutes flames appeared on the outside. No water was applied to the panels in this test, and eventually the ¼-in. and ½-in. panels were completely consumed; the 1-in. panel was mostly, but not entirely, destroyed. "Calno" fibre boards are made by the Thames Paper Company, Limited, of Purfleet, under licence from Fireproof Fibre Building Boards, Limited. A fire-proofing solution is applied during the course of manufacture, so that the fibres are thoroughly impregnated, and the different layers are combined with a mineral cement.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was steady, and 1000 tons of Cleveland warrants were done at 51s. 3d. one month, with sellers over at that figure, and at 51s. cash and 51s. 10d. three months. In the afternoon there was nothing doing, and the quotations for Cleveland warrants showed little change at 51s. cash, 51s. 3½d. one month, and 51s. 10d. three months sellers. On Friday morning the market was idle, but Cleveland warrants were fractionally firmer, with closing sellers naming 51s. 0½d. cash, 51s. 4d. one month, and 51s. 10½d. three months. The afternoon session was also idle, and sellers of Cleveland warrants quoted ½d. down for cash and one month, and 1d. down for the three months position. The market opened with a weak tone on Monday morning, and some 4000 tons of Cleveland warrants were put through at from 51s. 7½d. to 51s. 6½d. three months. At the close sellers named 50s. 10d. cash, 51s. 2d. one month, and 51s. 7d. three months. In the afternoon the business was limited to one lot of Cleveland warrants at 51s. 4½d. December 16, and the closing prices were nominally unchanged from the morning. On Tuesday morning the market was quite idle, and Cleveland warrants were called 50s. 10d. cash, 51s. 1d. one month, and 51s. 7½d. three months sellers, but buyers only offered 50s. 6d., 50s. 9d., and 51s. 3d. respectively. In the afternoon there was no change in the state of the market, and while buyers of Cleveland warrants were a shade firmer, sellers' prices were nominally unaltered. When the market opened to-day (Wednesday) Cleveland warrants were very weak, and buyers still held off. The closing quotations were down to 50s. 5½d cash, 50s. 9d. one month, and 51s. 3d. three months sellers. The afternoon session was also quite idle, and although sellers' prices for Cleveland warrants were the turn firmer at 50s. 6d. cash, 50s. 9½d. one month, and 51s. 3d. three months, buyers' quotations were nominally easier.

Sulphate of Ammonia.—The demand for sulphate of ammonia does not yet show much sign of improvement, although a fair business is going through. Prices are practically unchanged.

Malleable-Iron Trade.—No change can be reported in connection with the malleable-iron trade of the West of Scotland, but there is a slightly better home demand for iron bars. On export account the business passing is of very moderate dimensions. Rumours have recently been circulated of the placing of some very nice lines, but unfortunately confirmation is still lacking.

Scotch Pig-Iron Trade.—The past week has been rather a quiet one in the Scotch pig-iron trade, as the inquiry has been limited. Orders for lots booked forward are not coming in as satisfactorily as they might, with the result that some storing has had to be resorted to, although not heavily. Furnaces in blast number sixty-seven, and prices are called a trifle easier. The following are the market quotations for makers' (No. 1) iron:—Clyde, 69s. 6d.; Calder, Gartsherrie, and Summerlee, 70s.; and Langloan, 72s. (all shipped at Glasgow); Glengarnock (at Ardrossan), 71s.; Shotts (at Leith), 70s.; and Carron (at Grangemouth), 70s. 6d. Hematite iron is dull.

Scotch Steel Trade.—The Scotch steel trade continues to move along on quiet lines, and buying is certainly not one of the strong features at present. The scarcity of specifications for ship-plates is rather marked and is keenly felt, but as there is little new tonnage being ordered, the demand for material must necessarily be slow. Makers of black and galvanised sheets are quieter, and there is little activity except for a moderate request for the heavier gauges. The position of sectional material has not altered and makers are slack. The general home inquiry, while keeping within narrow limits, is quite encouraging, and commendation cannot be withheld from those who are endeavouring to "keep the flag flying" by placing orders for new work at the earliest opportunity. Export business is inclined to quieten down, but this is only expected to be a temporary lull. Prices are nominally unchanged.

HOW TO IDENTIFY BRITISH SHIPS.—One of the principal characteristics of "Jane's Fighting Ships" is the number of silhouettes published of warships and of such merchant ships as are likely to be employed by any nation in war service. "Jane's Fighting Ships" is, however, a volume of a size suitable only for the desk, and, in view of the intense interest in all warships at the present time, the publishers of that compilation (Messrs. Sampson Low, Marston and Co., Limited, London) have done well to issue a book, suitable for the pocket, of silhouettes of all British fighting ships. The intention obviously is to follow it with volumes of the silhouettes of ships of other nations. This publication, which is issued at 1s. net, is entitled "Naval Recognition Book: How to Identify Ships at Sea," the first issue being British ships. The series is under the editorship of Mr. Fred T. Jane. In addition to charts of the various naval harbours of Britain, and of the distinguishing stripes of the various officers of the Fleet, and views of the naval flags, a silhouette is given of the ships of every class in the Navy, along with a note of the names of the ships belonging to each class, and their fighting qualities. There is added an alphabetical index of all the ships. Anyone possessing this book, and noting the particular characteristics disclosed by the silhouette of a ship at sea, can at once determine, at least, the class to which she belongs, and, further, the fighting qualities of the class. We think a few more particulars might have been given of merchant cruisers. We hope that a corresponding book for the German and other navies will soon be issued.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The South Yorkshire coal-owners who wished to enlarge the usual October advances, so as to cover the extra cost of timber and other pit material, found themselves in a very small minority, and were obliged to abandon their proposal, the almost general opinion being that the tone of the market was not strong enough to warrant anything out of the ordinary in the way of advanced selling prices. As a result, the actual increases adopted average not more than 9d., and in no case exceed 1s. Steam hards have lost some of their firmness, owing to difficulties of financial settlement, and for industrial purposes consumers are able to obtain full supplies without any difficulty. The house-coal section maintains an even tone, though the brisk inquiry for winter stocking purposes has somewhat abated with the upward movement of values. A big tonnage of gas fuels is going away under contract, outside sales are larger, and there is an improvement in the general outlook. The closing of additional mills in the Lancashire cotton area has brought about increased weakness in the market for slacks. The output is much in excess of the demand. Special lots are selling at low rates. Both steel coke and blast-furnace coke are easier, the former selling at 25s. 6d. per ton delivered, and the latter at about 12s. 6d. Quotations:—Best branch hand-picked, 16s. to 16s. 6d.; Barnsley best Silkstone, 12s. 6d. to 13s. 6d.; Derbyshire best brights, 12s. 6d. to 13s. 6d.; Derbyshire house, 11s. to 12s.; best large nuts, 11s. to 11s. 9d.; small nuts, 9s. 3d. to 10s. 3d.; Yorkshire hards, 11s. to 12s.; Derbyshire hards, 9s. 9d. to 10s. 9d.; best slacks, 7s. to 8s.; seconds, 4s. 6d. to 5s. 6d.; smalls, 1s. 9d. to 2s. 9d.

Iron and Steel.—Government orders are still supplying the bulk of the work in the South Yorkshire iron and steel industries, and are assisting works to maintain an appearance of great activity where otherwise they would have difficulty in keeping open half the week. So far as the raw-material market is concerned there has been no diminution in the number of inquiries, but the gross amount of business done has been on a smaller scale. This is accounted for by the fact that the majority of users have now acquired substantial stocks upon which they are working until prices assume a more reasonable level. Forge iron has already declined to 56s. 9d., and foundry brands are weaker. Hematite makers are also feeling the effect of the consumers' attitude. Some sharp declines are reported. East Coast mixed Bessemer numbers, for instance, have during the latter part of the week shed as much as 4s., the latest quotation being 76s. Makers, however, are not greatly perturbed at the trend of events, being satisfied that prices will be readjusted when further heavy buying is necessitated by the rate at which consumption is proceeding. The position at the bar-iron mills is not very satisfactory. New business is slow, and makers are disappointed at the amount of German trade that has been diverted into local channels. An improvement in rolling-stock construction would brighten the outlook. The heavy steel trades continue busy. The future is regarded with great confidence, though there are certain sections where a somewhat gloomy view is held. Crucible-steel departments, for instance, could handle a much greater volume of business, but, on the other hand, a marked improvement is evident in the demand for heavy forgings and castings for shipbuilding purposes, and for special steels for army motor and aeroplane construction. Some good orders are being booked for implements and machinery for South Africa and other mining parts, but as regards the replacement of Germany's trade in inferior grades of steel goods, this is being very largely undertaken in other districts, principally in the Midlands, where makers have specialised in cheap output. One of the most hopeful signs of revival in the heavy trades is the increased number of inquiries for railway tyres, wheels, and axles. Export business has been on a larger scale with the United States, South Africa, and Canada. The demand for tools for engineering purposes is one of the most satisfactory features of the lighter trades. Work at the armament factories proceeds night and day at the highest pressure. Basic-steel departments are regularly employed, but new business is scarce. Prices are considered prohibitive. The rolling-mills are running short time.

CONVERSION OF A MOTOR FIRE-TENDER TO A MOTOR-PUMP.—A petrol motor-tender belonging to the Bath Fire-Brigade has just had its sphere of usefulness extended, a "Hatfield" pump having been fitted to the chassis by Messrs. Merryweather and Sons, who built the tender five years ago. The work has been carried out at Bath by one of the firm's mechanics, the new pump being geared to the existing propelling engine through silent chain transmission. The engine is a 50 horse-power four-cylinder, and the capacity of the pump is 350 to 400 gallons per minute. Tests were carried out to show the pumping power of the converted machine, the tender being run into Spring Garden's-road and a supply of water drawn from the River Avon, with a suction lift of 15 ft. A 1⅛-in. jet was shown at work and was sent well above the Empire Hotel, which is the tallest building in Bath. The pump pressure obtained was 150 lb. to the square inch, and the members of the Fire-Brigade Committee, who watched the tests, were very pleased with the results obtained. The tests were directed by the Fire Brigade's chief officer (Mr. W. A. England). This is the first occasion on which Messrs. Merryweather have fitted a fire-pump to an existing machine of their own make, but examples of "Hatfield" pumps fitted to other makers' chassis are in service at Huddersfield and Radcliffe.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The market is quiet, and pig-iron quotations are falling. Such a movement was quite expected, and, indeed, the wonder is that values have been so well upheld under the conditions that have prevailed. The business passing is on a limited scale, and, so far as Cleveland pig is concerned, it is confined almost entirely to transactions in small lots for early delivery. Pig-iron producers hope to keep furnaces working, but they declare that current quotations for Cleveland pig are unremunerative, the cheapening of raw material having been nothing like equal to the fall in pig. If pig values are reduced much below the present level, manufacturers intimate that they will have to put more furnaces out of operation. The total number of blast-furnaces blowing on the North-East Coast stands at 69. Messrs. Pease and Partners have transferred a furnace from Cleveland pig on to hematite iron. No. 3 g.m.b. Cleveland pig is now on sale at 50s. 9d. f.o.b.; No. 1 has become 53s.; No. 4 foundry, 50s. 6d.; No. 4 forge, 50s. 3d.; and mottled and white iron, each 50s.—all for early delivery. The foregoing quotations are the lowest that have ruled for the past six months. Values of East Coast hematite pig have been sufficiently lowered to tempt buyers into the market. Producers are now burdened with rather heavy stocks, owing to consumers failing to take out full supplies, and they have been rather pressing sales. So far as is known no sales of moment for early delivery have occurred, but forward business has been done, three firms of makers having made contracts with Sheffield consumers for delivery of mixed numbers over periods next year. The price paid is understood to be in the neighbourhood of 64s. 6d., which is now regarded as the general market quotation for either early or forward delivery. Foreign ore shows a downward tendency. Some business is understood to have occurred at 17s. 6d. ex-ship Tees for best Rubio, and that is now the basis of quotations. Coke is rather plentiful and weaker. Durham bee hive blast-furnace coke of average quality is 17s. 6d. to 17s. 9d. delivered at Tees-side works.

Stocks and Shipments.—The stock of Cleveland pig-iron in the public warrant stores now stands at 105,446 tons. Since the beginning of the month the stock has been increased by 2482 tons. Shipments of pig-iron from the Tees are on only a moderate scale. To date this month they average 1386 tons per working day, the total despatches being returned at 8320 tons, 6655 tons of which have gone from Middlesbrough, and 1670 tons from Skinningrove. To the same date last month the loadings were given at 15,285 tons, or a daily average of 2547 tons, and for the corresponding part of October a year ago the clearances reached 21,166 tons, or an average of 3527 tons per working day.

Manufactured Iron and Steel.—There is little new to report concerning the different branches of the manufactured iron and steel trades. A good deal of work is being turned out. Principal market quotations stand:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 10s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 8*l.*; iron ship-rivets, 9*l.*; iron girder-plates, 7*l.* 5s.; steel bars (basic), 6*l.* 15s.; steel bars (Siemens), 6*l.* 15s.; steel ship-plates, 7*l.* 5s.; steel ship-angles, 7*l.*; steel boiler-plates, 8*l.* 5s.; steel joists, 7*l.* 2s. 6d.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 15s.—all less the customary 2½ per cent. discount; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 15s.; steel railway sleepers, 7*l.* 15s.—all net at works.

Cleveland Blastfurnacemen's Wages.—The ascertained average net selling price of No. 3 Cleveland pig-iron for the months of July, August, and September has been certified at 51s. 4.13d. per ton, as compared with 51s. 0.70d. per ton in the preceding three months, and 57s. 8.08d. for the same quarter a year ago. In accordance with the sliding-scale arrangements wages will be advanced by 0.25 (a quarter of one) per cent., bringing them from 23.75 per cent. above the standard to 24 per cent. above the standard.

AGRICULTURAL MACHINERY.—The war is likely to reduce the demand for British agricultural machinery in Europe, but the results established to August 31 were, upon the whole, satisfactory. The value of the shipments in all directions in August was 54,939*l.*, as compared with 135,917*l.* in August, 1913, and 116,411*l.* in August, 1912. The value of the deliveries to European countries sank in August to 29,626*l.*, as compared with 93,291*l.* and 61,005*l.* The aggregate value of our exports of agricultural machinery to August 31, this year, amounted to 1,073,860*l.*, as compared with 967,983*l.* in the corresponding eight months of 1913, and 930,486*l.* in the corresponding eight months of 1912.

AMERICAN TIMBER.—The United States Department of Agriculture has reported upon the production of timber—or, as the Americans style it, "lumber"—in the United States in 1913. The cut for the year is returned at 38,387,009,000 ft., as compared with 39,158,414,000 ft. in 1912, and 37,003,207,000 ft. in 1911. There was, accordingly, a reduction of 771,405,000 ft. last year as compared with 1912. There was an increase in production in Washington, Oregon, and the Lower Mississippi Valley, while there was a decrease in the northern, central, and Atlantic States. The cut of yellow pine last year was 14,839,363,000 ft.; of Douglas fir, 5,556,096,000 ft.; of oak, 3,211,718,000 ft.; of white pine, 2,568,636,000 ft.; of hemlock, 2,319,982,000 ft.; of western pine, 1,258,528,000 ft.; of cypress, 1,097,247,000 ft.; and of spruce, 1,046,816,000 ft.

NOTES FROM THE SOUTH-WEST.

Cardiff.—There has been no increase of activity in the steam-coal trade, buyers holding back in anticipation of obtaining easier terms; while, on the other hand, abundant supplies of large have been offering. In some instances sellers have been willing to make concessions to prompt buyers so as to clear trucks quickly. Smalls have been in fair request at late rates. House coal, patent fuel, and coke have shown little change. The best Admiralty large has made 20s. to 22s.; best secondary qualities have brought 18s. to 19s.; other secondary descriptions, 17s. to 18s.; best bunker smalls, 8s. to 8s. 6d.; and cargo smalls, 5s. to 6s. 6d. per ton. The best household coal has been quoted at 18s. to 20s.; good households have made 17s. to 18s.; No. 2 Rhondda large has brought 13s. to 13s. 9d.; and No. 2 smalls have realised 6s. 6d. to 7s. 6d. per ton. Patent fuel has brought 17s. to 18s. per ton. Special foundry coke has made 22s. to 29s.; good foundry coke, 20s. to 24s.; and furnace coke, 17s. 6d. to 18s. 6d. per ton. As regards iron ore, Rubio has been quoted at 18s. 3d. to 18s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Newport.—The steam-coal trade has shown little change. The best Newport black vein large has made 17s. to 17s. 6d. per ton; Western Valleys have brought 16s. 6d. to 17s. per ton; and Eastern Valleys, 15s. 9d. to 16s. 3d. per ton.

The Tirdonkin Collieries.—Mr. D. Howells, undermanager of the Efaldau Collieries, Pontycymmer, has been appointed manager of the Tirdonkin Collieries, near Swansea. Mr. Howells commenced his career as a labourer at Messrs. D. Davis and Sons' collieries, Bodringallt, in 1883. Later he became a collier and worked at the Ocean Collieries, Nantymoel. At the Gelli Steam Collieries, Rhondda Valley, he was repairer and shotsman; and subsequently fireman. While employed at Gelli he qualified for a first-class certificate as colliery manager. He then removed to fulfil an appointment in the anthracite coal-fields, and afterwards he accepted the post of under manager at the Efaldau Collieries, a position which he held for the past ten years.

BRITISH RAIL EXPORTS.—The disorganisation of British trade occasioned by the war was adverse in August to our rail exports, the shipments for the month amounting to only 22,763 tons, as compared with 44,637 tons in August, 1913, and 31,315 tons in August, 1912. Shipments to British South Africa amounted to only 180 tons in August this year, as compared with 5372 tons in August, 1913, and 4748 tons in August, 1912. There was also a contraction in shipments to Australia. The exports to Argentina in August were 3225 tons, as compared with 4060 tons and 4682 tons. In the eight months ended August 31 this year we shipped 24,048 tons of rails to Argentina, as compared with 36,662 tons in the first eight months of 1913, and 31,804 tons in the first eight months of 1912. The falling off observable is explained by the depression existing in Argentine railways and in the Argentine Republic generally. The Colonial demand for British rails in the first eight months of the last three years was as follows:—

Colonial Group.	1914. Tons.	1913. Tons.	1912. Tons.
British South Africa	43,706	44,210	31,772
British India ..	113,235	94,451	69,271
Australia	95,030	89,103	74,720
New Zealand ..	4,971	26,053	15,288
Canada	120	300	380

Our aggregate rail shipments in all directions to August 31 this year amounted to 326,754 tons, as compared with 352,822 tons and 262,035 tons in the corresponding periods of 1913 and 1912. The most satisfactory features in this year's business has been a good demand for British rails in India and Australia; the shipments to Australia nearly equalled those made to India.

TESTS OF FIRE-EXTINGUISHERS.—A record of some tests carried out by the British Fire-Prevention Committee on two fire-extinguishing appliances supplied by the Great Western Railway Company is contained in Red Book No. 191, recently issued by the Committee. One of the appliances was a cylinder capable of holding from 2 to 2½ gallons of a solution of calcium chloride, which is expelled by CO_2 gas contained in a steel cartridge. Several tests were made to try the effect of the appliance on different kinds of fires, including boxes loosely filled with wood wool, heaps of straw, pyramidical stacks of wood filled in with wood wool, heaps of oily rags, &c. The results of the tests clearly demonstrated that, when properly handled, these appliances were efficient in extinguishing or checking fires in their early stages. The liquid used also prevented the fire from easily re-kindling in several of the tests. The other appliance was in the form of a hand-cup from which a liquid (calcium chloride solution) could be thrown on to the fire. It was tested in a similar manner to the pressure extinguisher, and was shown to give excellent results in experienced hands. These appliances have been constructed for the Great Western Company for installation on trains, in order to extinguish fires which frequently occur in railway accidents. The pressure extinguisher is considered by the Committee to be rather too heavy to allow of its being conveniently handled for ordinary purposes. The hand-cup appliance could, however, be easily used. In an Appendix the results of some tests made to ascertain the effect of calcium chloride solutions on solder are given. These tests show that the lead is slightly attacked by pure water, but very much more so by weak solutions of calcium chloride. Tin is also slightly attacked by stronger solutions.

HIGH-SPEED FLOORING AND MATCH-BOARDING MACHINE WITH PATENT FEED TABLE.

CONSTRUCTED BY MESSRS. A. RANSOME AND CO., LIMITED, ENGINEERS, NEWARK-ON-TRENT.

(*For Description, see Page* 444.)

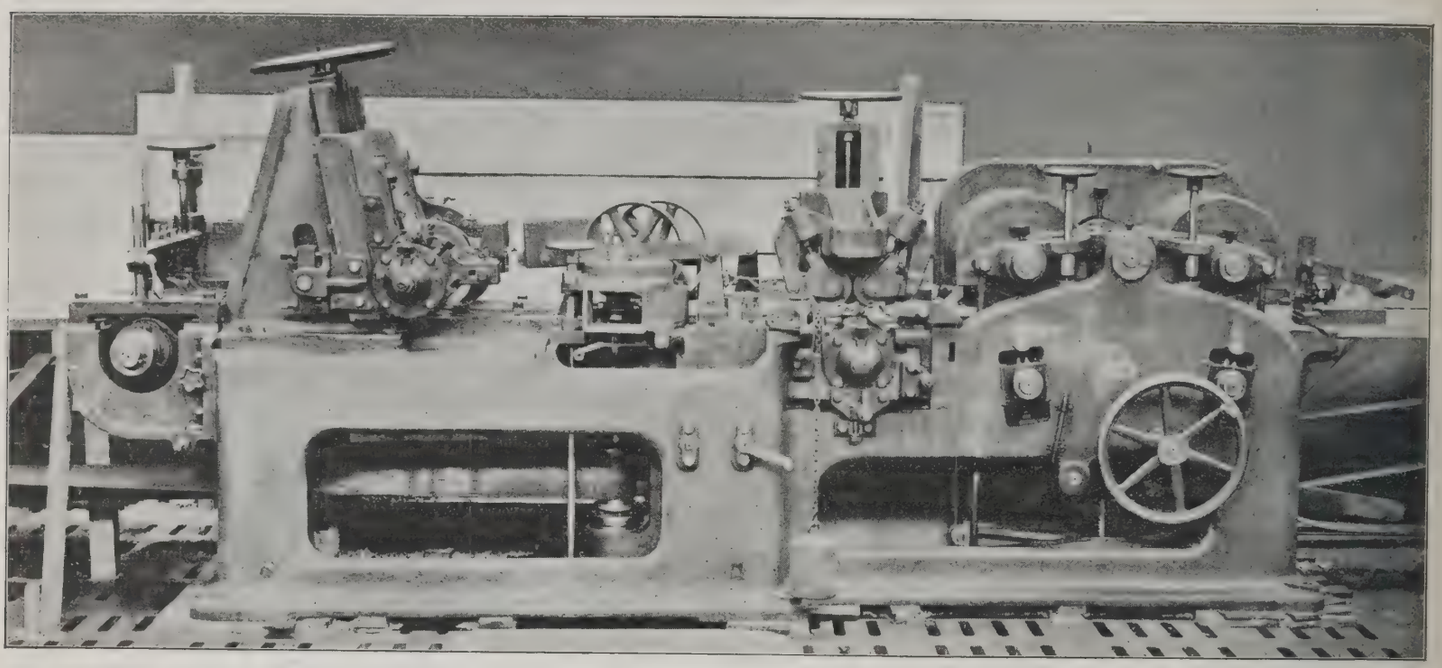


Fig. 3. General View of Planing-Machine from Front Side.

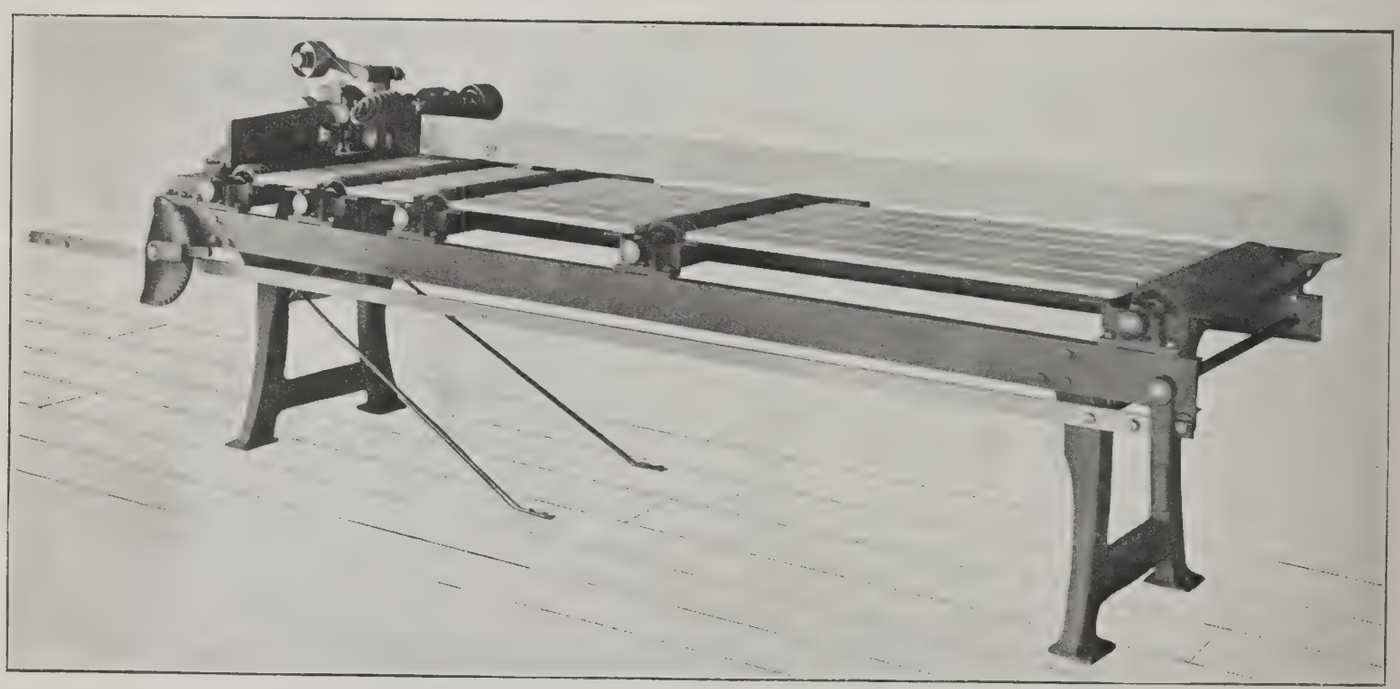


Fig. 4. General View of Feeding-In Table from Front Side.

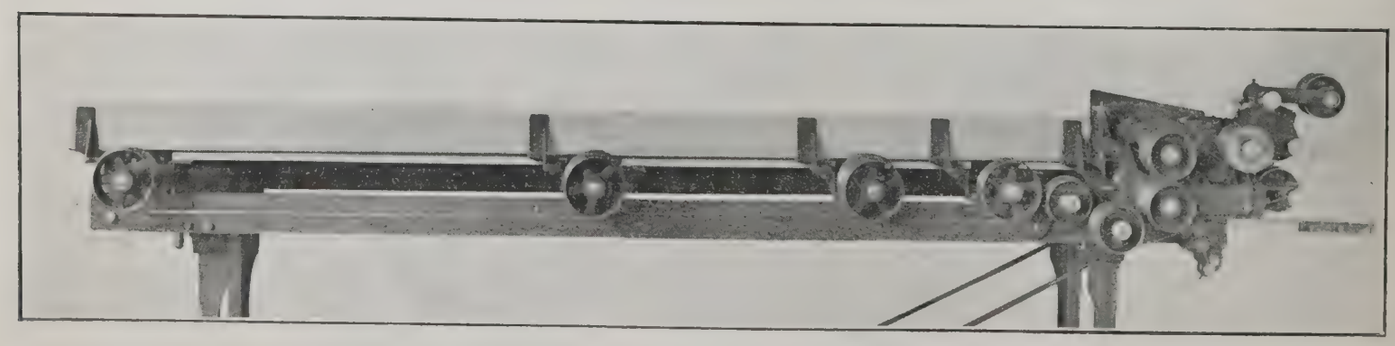


Fig. 5. Rear View of Feeding-In Table showing Roller-Drive.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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Thin paper copies	£1	16	0
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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With a Two-Page Plate of the MANHATTAN BRIDGE OVER THE EAST RIVER AT NEW YORK; DETAILS OF TOWERS.

NOTICES OF MEETINGS.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, October 10, at 3 p.m., in the Heriot Watt College, Chambers-street, Edinburgh. Mr. James Black's paper on "The Rosehall Signal Indicator" will be discussed. Mr. Thomas Bryson's paper on "Fan Testing, with Special Reference to the Measurement of Pressure," will be discussed. A paper on "Tests on False Links for Cut-Chain Braes" will be read by Mr. John T. Wight. A demonstration and explanation of the Mechan Mechanical Signalling Apparatus will be given at the close of the meeting.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday, October 10, at 2.30 p.m., visit to the British Westinghouse Electric and Manufacturing Company, Limited. At 7 o'clock the President will deliver his inaugural address.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, October 10, in the Wood Memorial Hall, Newcastle-upon-Tyne, at 2 o'clock. The following paper will be open for discussion: "The Utilisation of Exhaust Steam for Collieries, Iron Works, &c., and the Cost of Electric Current Generated," by Mr. W. C. Mountain. The following papers will be read or taken as read: "A Portable Electrical Gas-Detecting Device for Use with Miners' Lamps," by Mr. George J. Ralph (with experimental illustrations); "Notes on Coal-Mining in the State of Illinois, United States of America," by Mr. Samuel Dean; "Hydraulic Stowing in the Gold-Mines of the Witwatersrand," by Mr. B. C. Gullachsen. A firedamp indicator or methanometer will be exhibited, described, and demonstrated by Mr. Alfred Williams.

BRITISH FOUNDRYMEN'S ASSOCIATION (LANCASHIRE BRANCH).—Saturday, October 10, at 4 p.m., in the Municipal School of Technology, Manchester, when the President (Mr. T. W. Markland) will deliver the presidential address.

THE INSTITUTE OF MARINE ENGINEERS.—Monday, October 12, at 8 p.m. Discussion on "Gyroscopic Compasses."

THE INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.—Monday, October 12, at 8 p.m., the Graduates' annual report for the session 1913-14 will be presented, after which a paper entitled "The Reclamation of Waste Products in Industrial Undertakings" will be read by Mr. George H. Ayres (Graduate), of Huddersfield. Chairman: Captain H. Riall Sankey (Member of Council).

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, October 14, at 8 p.m., at St. Bride's Institute. Presidential address by Mr. Frank Bailey, M. Inst. C.E., on "The British Empire, and Our Work in It." Mr. R. T. Glazebrook, C.B., M.A., D.Sc., F.R.S., President (retiring), in the chair.

THE NOTTINGHAM SOCIETY OF ENGINEERS.—Wednesday, October 14, at the Welbeck Hotel, Nottingham, at 8 o'clock. Annual meeting for the report and balance-sheet, election of officers, and President's address.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 16, at 8 p.m., at the Institution, Storey's Gate, Westminster. Paper, "Report of the Refrigeration Research Committee," by Sir J. Alfred Ewing, K.C.B., LL.D., F.R.S., Chairman.

NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to some Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, OCTOBER 9, 1914.

PURIFICATION OF PUBLIC WATER SUPPLIES.

SOME five-and-twenty years ago we reviewed a book on water supply in which it was gravely urged that the London water companies should be expropriated, on the ground that they were supplying purified water, while they had received their powers on the understanding that they should provide pure water. The suggestion that it is possible to supply pure water raises a smile at the present day. Even for scientific purposes in a laboratory it is difficult to obtain pure water. When the new remedy, salvarsan, was first introduced, the method of use was to mix it, immediately before injection into the blood-stream of the patient, with distilled water which had just been boiled to ensure its sterilisation. Very often the injection was followed by a serious rise of temperature, which lasted a day or two. This was ascribed to the drug, but as it did not always occur, a surgeon tried the effect of injecting the water alone. Even then fever often supervened, and it seemed as if pure water was capable of giving rise to a dangerous reaction. The experiment was then tried of distilling the water immediately before it was injected, and all the trouble ceased. It was found that although the distilled water usually employed was rendered sterile by boiling before injection, yet it contained the dead bodies of bacteria, and these gave rise to the unpleasant symptoms that had been noted. Freshly-distilled water, delivered through sterile pipes, would ensure a pure supply to the public; but that is a consummation not likely to be attained. All that we can hope for is fairly purified water.

Purification, being a comparative quality, can never be defined with exactitude. It is little more than sixty years ago that the chairman of a London water company declared before a Parliamentary Committee that the liquid his company pumped out of the Thames at Battersea was excellent water for domestic purposes. Scientific tests in those days were far from decisive, but an outbreak of cholera carried conviction, at least to the public, that the water was not what was claimed for it, and that the pumping-stations needed to be moved upstream, and supplemented by filters. For years after that we had to rely on the chemists for our knowledge of the qualities of potable waters, and they could tell us little beyond the proportion of organic matter they contained. Instinct warned us against the use of badly-contaminated supplies, although we knew little of the real cause of the danger experience showed them to involve. Meanwhile engineers achieved great successes in purification by methods of the action of which they had no real understanding. It was only when the science of bacteriology began to be established that we comprehended how disease was spread by potable water, and how the death-rate was affected by its degree of purification. Koch announced that 100 bacteria in a cubic centimetre of water, as demonstrated by incubation for three days, was a reasonable standard of purity, and water engineeers were well pleased if they could keep below this limit. This was evidently only a quantitative measure of purity, and as there are about 580 cub. cm. in a pint, the number of bacteria was by no means negligible. Of course it was well known that the great majority of bacteria were perfectly harmless, and that it was only a few which were the cause of epidemic disease. If 95 or 99 per cent. of the bacterial population of the water could be removed, the chances of infection from that source were reduced in that proportion, at least. It was not known, and it is not known now, in what numbers our microbic foes must attack us in order to establish themselves. Probably there is no standard even for a given individual, the powers of resistance varying from day to day, and gradually increasing with age. But there is a consensus of opinion that the attack must be in force, and that incursions in feeble numbers can only produce serious results when they meet with a debilitated constitution. Hence the risk of disease may be reduced by water purification in a greater degree than is suggested by the percentage of elimination of bacteria.

Considerations of public health demand that we should not rest satisfied with protecting only the robust members of society. Every sufferer from epidemic disease is a potential centre of virulent infection, and, even apart from that, the weaker portion of the community have the right to demand that protection should be afforded to them as far as is practicable. Water engineers have always recognised this, and have never ceased to strive for a greater degree of purity, although the introduction of the slow sand filter was such an immense improvement as to produce a general feeling of confidence and content in the public mind. Side by side with the increase of sand filtration there have been great strides made in mechanical filtration, which fulfils an important function, especially in relation to acid and stained upland waters which are not seriously polluted with sewage; while great success has attended the attempt to improve the efficiency of sand filters by the use of roughing and pre-filters to take out the grosser impurities, leaving the sand filter to deal with the remaining soluble organic matter and bacteria. Absolute sterilisation on a considerable scale has also been attempted by the aid of chlorine, of ozone, and even of ultra-violet rays, and more or less encouraging results have been attained; but it cannot be said that these methods promise, as yet, a final solution of the problem. The great magnitude of all important water supplies precludes the use of any but the most simple means of purification, in which the chances of breakdown, either from accident or carelessness, are extremely remote.

It is quite possible for a pessimist to cast a cloud of suspicion even upon the integrity of the sand filter, for it works in cycles, during which its efficiency as a remover of bacteria constantly increases, while its permeability gradually declines until it becomes nil. When its output has fallen below a reasonable limit—in other words, when it has become commercially inefficient—the surface has to be removed, and then the filtering efficiency falls very low indeed, and remains in that condition until a new surface has formed. At such a time it is conceivable that a careless attendant might pass a quantity of practically unfiltered water into the

mains, with serious results. Experience shows that this does not happen, but, nevertheless, it is a danger that all water engineers and chemists would like to see removed. In the London area the crusade for greater purity of water has been consistently and ably preached by Dr. A. C. Houston, the Director of Water Examination to the Metropolitan Water Board. Among the inhabitants of London there is a general feeling of confidence and pride in the water supply, but in spite of this the officers of the Board are constantly endeavouring to raise the standard and to eliminate all source of accidental contamination. This is in itself a remarkable feature, for we know that official bodies usually need the stimulus of popular dissatisfaction to rouse them to increased effort, and do not generally strive for an ideal which is higher than that held by the public. In this instance the contrary is the case, and this is the more noticeable since the situation and the size of London would justify the contention that a moderate degree of purification is all that can be attained. The chief sources of supply—the Thames and the Lee—are badly contaminated with sewage, and must always remain so, since they drain highly-populated districts, and the increase of inhabitants will probably negative any improvements in the processes for the treatment of sewage. In spite of this, water of a high degree of purity is delivered through the mains, and if we could guard absolutely against failures in connection with filtration and supply, the officers of the Board would have good reason to rest satisfied with the present condition of affairs.

Unfortunately, neither mechanism nor the human machine is exempt from failure, and therefore engineers who are responsible for the public health continue to seek for further safeguards. Even if they are satisfied with the filters, there is the possibility of accident in connection with drainage, with the health of workmen, with the suction of impure water into the water-mains, with the laying of new mains and alterations to existing mains, and with service reservoirs. Evidently another link in the chain of defences is needed, and this, in the case of London, was added for quite a different reason. Originally the rivers offered a fairly ample supply, even in time of drought. But as the population increased, this became insufficient, and it was evident that storage must be resorted to, as is customary in gravitation supplies. Gradually reservoirs were built, and of late years the rate of construction has been accelerated until, at the present time, the amount of storage and subsidence reservoirs' capacity in use is 1982 acres, of which 1026 acres are in the Thames Valley, and 956 in the Lee Valley. There are in all 49 reservoirs, of a total capacity of 12,907,700,000 gallons. Three other reservoirs at Littleton and Stanwell are in immediate contemplation, and these will afford capacity for 10,300,000,000 gallons. It is estimated that these will meet all requirements for the next twenty years, and in that respect will be of great advantage.

The purpose of a storage reservoir is, of course, to enable water to be taken from the river when it is full, to supplement the supply when the stream is low. But experience shows that storage fulfills other most important functions, so that it would be worth while to construct reservoirs for London even if the rivers gave an adequate supply in the dry season. In the first place, storage allows time for subsidence, and thus prevents bad coloured water being delivered to consumers. A slight discoloration is probably of little consequence as regards health, but it always leads to complaint on the part of users, and is therefore to be avoided. Concurrently with subsidence there takes place a process of equalisation by which water taken in during a period of several days becomes mingled and averaged until it attains something approaching uniformity. As we have already suggested, it takes an appreciable dose of pathogenic bacteria to set up active disease in an individual; we none of us lie at the mercy of a single microbe Further, the number of typhoid patients—whether in the acute or chronic stage—is not so great at any time that the sewage of a district is uniformly pervaded by the typhoid bacillus. Probably these sources of contagion come down in gulps or freshets, and although they may spread in the river somewhat, yet the degree of pollution will vary very much from place to place. If water from such a river be pumped directly into the mains, and thence to the filter bed, it is only the latter that opposes an obstacle to some members of the community getting a concentrated dose of bacteria. If, from any cause, the filter should fail, there will be probably an outbreak of disease, attacking possibly one person in a thousand. But if, between the intake and the filter, there is interposed a reservoir of several days' capacity, then the inequalities of supply will be smoothed down, and the strength of the pathogenic pollution reduced many hundredfold, so much indeed that it ceases to be seriously dangerous, even if the filters are not as efficient as they might be.

If this subsidence and equalisation represented the full result of storage, apart from uniformity of supply, a most valuable outer defence would have been erected around the public health, supplementary to the inner ring of the filters. But it has been shown by Dr. Houston that another most important action takes place in a reservoir, and this he names "devitalization." It must be remembered that the *habitat* of pathogenic bacteria is in the animal body, and that it is only there that it finds the best conditions for life and reproduction. It can exist in water for some time, but the conditions are not favourable for its continuance or its multiplication. How fatal are the effects of continued sojourn in water is shown by a series of experiments made for the Metropolitan Water Board during the year 1907-8 at Hampton. During that year the raw Thames water at Hampton was tested about twice a week, and was found to contain on an average 4465 microbes per cub. cm. At more than half the tests typical *B. coli* were found in $\frac{1}{10}$ cub. cm., and on nine occasions in $\frac{1}{100}$ cub. cm. On the same dates tests were made of water that had been stored on an average 15 days in the Chelsea reservoirs, with the result that the average number of microbes per cubic centimetre was 208, and only on two occasions were typical *B. coli* found in quantities of $\frac{1}{10}$ cub. cm., and on nine occasions in 1 cub. cm. Very often none was found at all in 100 cub. cm. In effect, the number of bacteria per cubic centimetre developing on gelatine at 20 deg. to 22 deg. Cent. was reduced 95.3 per cent.; and the number developing on bile-salt agar—practically all intestinal—was reduced 87.8 per cent. Further, under the same conditions, the chemical impurities were reduced as follow:—Ammoniacal nitrogen, 63 4 per cent.; and albuminoid nitrogen, 29.4 per cent.

These figures show that storage provides the necessary supplement to the filter. In spite of its wonderful success and its proved ability to remove some 98 per cent. of the bacteria from water, the filter is certainly open to the accusation of being dependent upon the skill and vigilance of those in charge, and if either of these fails, the results may be serious. So far there has been no disaster to chronicle, but it must be remembered that the "long arm of coincidence" has to be very long before negligence can be brought home to the man in charge of a filter. He may let insufficiently treated water into the mains many times without ill-effects, for the bacillus typhosis is, as already explained, by no means evenly disseminated in a river even when it is entering the sewers in considerable numbers. It may not reach the filter at the moment when the film is inefficient, and even if it does it may be delivered to consumers who are more or less immune. It must be remembered that it is very difficult to assign a cause to a slight outbreak of typhoid fever. There are so many avenues by which infection can travel, and it leaves so few traces on the way, that detective abilities of a high order are needed to track it to its source. It is only when the outbreak is severe and localised that the origin can be definitely assigned either to milk or water. It may be a defect in a filter, or it may arise from many other causes.

It is therefore a matter of congratulation to us that a second ring of defences has been erected around the water supply of London, and that it will be completed in the near future. The period of storage may not be as long at all times of the year as may be theoretically desirable, but storage even for two days exercises such a valuable influence that no one will cavil at the authorities if they cannot attain to their ideal. They will probably attain to something in excess of twenty days at the worst, and that in itself is such an immense advance in security that the pride London feels in its water supply will deepen into an assurance which nothing will disturb. It is a most fortunate coincidence that the measures which were forced on the Board by the necessity of providing for the growing population have at the same time added to the security. We might otherwise have had to wait long before attaining our present condition of safety. There are other means by which we could secure something approaching sterility in our supply, but none quite so certain and simple, and so well adapted to the needs of the largest city in the world. They all need vigilance in their operators, and we know by experience that the most careful men are apt to suffer from lapses of mind when repeating the same proceedings day by day and year by year. With storage the processes are carried out by Nature, and need little or no supervision. Given the condition, the result follows as a matter of course, and the bacteria disappear with greater certainty than a regiment under the fire of a machine-gun. Fortunately the pathogenic varieties are among the most feeble when taken out of their proper environment, and are among the first to perish.

THE DEVELOPMENT OF THE MILITARY SMALL ARM.

It is, perhaps, too soon to form stable conclusions as to the relative values of the different arms as established by the war now in progress, but it appears to be pretty definitely settled that many theorists have over-rated the possibilities of artillery and under-rated that of the rifle. Napoleon's battle tactics culminated in a furious attack by massed artillery on what he considered to be the decisive section of the enemy's line, this was followed by an attack by columns of infantry, who were seldom called upon to take their arms from the slope, but merely "presented the cheque" against the assets already placed by the artillery. It has been argued that the enormous improvements in artillery would render possible a repetition of these Napoleonic tactics, and that infantry were needed merely to protect the guns and take a position already won by the fire of the latter. Hence, was argued, the relative unimportance of training in markmanship, or with the white arm. Given adequate artillery, it was asserted infantry could capture any position practically without fighting, if only pressed forward in sufficient numbers, since, the professors declared, the defending infantry would be easily reduced to a state of panic by the attacking artillery. As matters have turned out, this theory of the classroom has been falsified in practice, and, as proved to be the case 100 years ago, properly trained infantrymen cannot be easily reduced to a state of helplessness by hostile artillery, and smash up attacking columns even more readily than they did in the Peninsula War. The military small arm is, accordingly, very far from being a back number, and is no doubt still capable of much further improvement.

An interesting record of the development of this class of weapon is to be found in a paper printed in the Transactions, just published, of the Barrow Association of Engineers. In this paper Mr. C. C. Humphris states that the portable firearms appear to have been first used about 1375. The charge was fired by means of a slow match apparently much in the fashion of ancient ordnance. It is difficult to believe that any reasonable accuracy of fire was possible under these conditions, and it is perhaps a little remarkable that so crude a device should have even found a trial in competition with relatively accurate weapons, such as the long-bow and the cross-bow. Presumably it must have been the penetrative power of the new weapon that caused those interested to persevere. A cock and trigger were introduced, Mr. Humphris states, in 1485, the ignition still being by slow match, which was fitted to the cock, and brought into contact with the priming on pulling the trigger. The wheel-lock, in which the priming was ignited by sparks generated by revolving a roughened steel wheel against a piece of iron pyrites, dates from 1517. The flint-lock was introduced in 1635, and held the field till the invention of percussion ignition by the Rev. A. J. Forsyth in 1807. This was probably the greatest improvement ever made in small arms, but came very slowly into favour with military authorities, although sportsmen were less conservative.

The early introduction of rifling is very noteworthy. Mr. Humphris says that straight grooved rifling was tried before 1520, in which year spiral grooving came into use. Others, however, state that the oldest existing specimens of the rifle have all spiral grooves, and that their makers seem to have fully understood that spiral

rifling led to more accurate shooting. The great drawback was, of course, the slowness of fire owing to the necessity of driving the bullet into the grooves, so as to make certain that it should take the rifling when fired. Napier, if our memory serves, says that the rapidity of fire was three times as great with the smooth bore as with the rifle, and declared the musket the queen of weapons accordingly. The difficulty of loading the rifle rapidly was surmounted by Greener, who invented the expanding bullet in 1835, an invention for which the British Government paid Minié 20,000*l.* in 1852, though they were ultimately badgered into giving Greener a solatium of 1000*l.*

It was the success of the needle-gun in 1864 that led to a general adoption of military breech-loaders. Most of the earlier forms were more or less makeshifts, such as the Snider, which was the result of converting existing muzzle-loading weapons into breech-loaders. It was with the Snider rifle of 1867, Mr. Humphris states, that the metallic cartridge-case was first used. This was undoubtedly an innovation of very great value, as perfect obturation was secured. In the chassepot, we believe, a rubber obturator was employed. The Martini-Henry dates from 1871. This breech action Mr. Humphris holds to be the best yet devised for a non-magazine weapon, and it is still largely used for miniature rifles and the like.

The necessity of adopting the magazine principle led, however, to its abandonment in favour of the more clumsy and less mechanical bolt action, as exemplified in the Lee-Metford and its successors. This rifle was originally used with compressed black powder, and unfortunately its breech is not as strong as is desirable with the propellants now available. As a consequence, with the new pointed bullet, the muzzle velocity of the short Lee-Enfield, which is the standard arm of our Expeditionary Force, gives a muzzle velocity of 2440 ft , as compared with the 2882 ft. of the German Mauser. The latter is, however, helped somewhat by its longer barrel, that of the Mark III. Lee-Enfield being but 2 ft. 1¼ in. long, and also by its lighter bullet. The difference in initial muzzle velocity gives the Mauser a much flatter trajectory. Thus when sighted to 1000 yards, the culminating point of the short Lee-Enfield is 18.1 ft. above the line of sight, as against 12.6 ft. in the case of a Mauser.

Mr. Humphris states that the barrels for the Lee-Enfield are drawn down from round steel bars, originally 10 in. long, the forging being finished in dies. The larger details, such as body bolt, nose-cap, &c., are all drop-forgings, on which a very small allowance is made for cleaning-up. The barrels are drilled with a hollow D-drill, fed with oil under pressure. Both barrel and drill rotate, the former rapidly, and the latter slowly in the opposite direction. The hole is started from the breech end, and a finishing drill follows the roughing drill, after which the barrel is chambered, reamered and polished inside, and turned and screwed outside. The rifling is, Mr. Humphris says, accomplished with a single cutter, which makes five passes to each groove, and the grooves are made a little deeper at the muzzle end. After finish machining the barrel is lapped, the lap being formed by pouring molten lead into the muzzle, this lead setting round a jagged rod introduced at the breech end. This lap is fed with oil and emery, and the grooves are lapped out by working the rod up and down.

Many charges have been made on both sides during the present campaign of the use of unfair bullets. With the old weapons of 300 years ago the results must have been serious, some of the Spanish fire-arms taking balls weighing 2½ oz. each. The Snider also made very bad wounds, though the penetrative power of the bullet seems to have been small. At any rate, Sir Samuel Baker mentions the case of a rhinoceros being fired at by a whole company of Sniders, without suffering material damage, the bullets failing to penetrate the animal's thick hide. With the Martini, however, and the original Lee-Enfield bullet, very clean wounds resulted. Mr. Humphris, however, states that this is not the case with the new pointed bullet introduced by the Germans, which, unless it hits absolutely perpendicularly to the surface struck, is liable to turn round and proceed flatlong. He showed at the meeting a block of oak fired at by Mark VI. and by Mark VII. ammunition, the latter having the new pointed bullet. The former made a clean whole 30 in. deep, whilst the latter turned round after entering the block, leaving a lacerated hole. This experiment confirms similar experiences by Mr. Roosevelt, recently described in the papers ; but, according to Mr. Roosevelt, the tendency for the sharp-pointed bullet to turn this way is only notable at short ranges. The sharp-pointed Lee-Enfield bullet has, Mr. Humphris states, a solid-drawn envelope of an alloy of 80 parts copper and 20 nickel. This envelope is slightly thickened at the point, where it is backed by a core of aluminium supported by a mass of almost pure lead. As compared with the Mark VI. bullet, it weighs 174 as against 215 grains, and gives a muzzle velocity of 2440 in place of 2060 ft. per second. The corresponding German bullet weighs 154.5 grains, and has a muzzle velocity of 2882 ft. per second. Mr. Humphris expresses the opinion that ultimately the Lee breech will be abandoned in favour of one similar to the Canadian "Ross" rifle. The bore will, he thinks, be reduced to 0.276 in., and rifled with four or five Enfield grooves. It will be wood-cased as at present, and will have a blade foresight and an aperture sight placed close to the eye.

THE NEW SOUTH WALES GOVERNMENT RAILWAYS.

When commenting some time ago on the ups and downs of the State railways of Australia we referred to the large reduction in the net revenue which some of the systems experienced between the years ending in June, 1912 and 1913. The State of New South Wales was one of the sufferers, its railway surplus having fallen from 415,513*l.* for the year ending in June, 1912, to 186,904*l.* for the succeeding twelve months. The figures for last year, for which the report has recently been issued, show that the position has been maintained, with, indeed, a slight improvement, the surplus for the twelve months ending June, 1914, amounting to 209,367*l.* The year has seen considerable changes, both in earnings and expenses, and the small expansion of the net revenue, is, under the circumstances, rather disappointing.

The earnings of the system increased in the year by just about 1 million sterling, to 7,742,241*l.*, but the working expenses at the same time increased by nearly 800,000*l.* to 5,409,820*l.*, and, with increased interest charges, the net result, as shown above, is only slightly better than in the previous year. In the report for 1913 it was shown that a large part of the expansion of the working expenses was due to increased wages and salaries. Part in the last year has been caused by a considerable increase in train-mileage, but again a large amount is due to wages and salary awards, the effect of which has been felt fully in this twelvemonth for the first time. No less a sum than 555,305*l.* in the working expenses for the year 1913-14 represents extra cost of wages, of which 253,036*l.* is purely due to increased scales of pay. The awards made, to which the Railway Commissioners have to conform, are continually placing additional burdens upon the system. During the year under review an additional sum of 144,578*l.* was due directly to new awards of wages boards. A sum of 18,439*l.* was disbursed in compliance with an industrial arbitration Act of 1912 ; 23,203*l.* went in promotions to higher grades ; 37,594*l.* to classification advances to drivers, &c. ; 21,870*l.* in merit advances, and so on. Recently the hours of duty have been the subject of review, with the result that though this year the effect is small, next year the cost to the system will be about 64,000*l.*, and in the year following to 130,000*l.* Next year also will be affected by awards made in connection with locomotive labourers and iron-workers, while other claims are constantly coming forward.

In face of these increases it is not surprising that the State railways have had recourse to measures similar to those adopted elsewhere. Rates and fares have been increased on a scale which, it is estimated, should bring in additional revenue to the sum of 350,000*l.* A 10 per cent. increase has been made on various classes of goods traffic rates. As regards passenger traffic, season-ticket rates have been raised 20 per cent., outer suburban fares 5 per cent., and cheap excursion fares and workmen's-ticket rates have both been advanced. The estimated sum of 350,000*l.* is about equally divided between goods and passenger traffic. These advances will probably do something to bring home to the public the inevitable effect of making constant concessions. The railways are public property, and awards made by the public authorities have to be met at the expense of the public. In part the beneficiaries have to contribute, directly or indirectly, to the sum required. The remainder is contributed by people who do not benefit. Much the same thing happens here, though the public usually flatters itself that the "companies" have to meet the bill. This they do, of course, either by passing the expense directly to their thousands of shareholders, or by transferring the burden to their patrons.

The increased train-mileage of about 1,465,000 miles on the figure for 1913, bringing the total, last year, to 20,549,695 train-miles, was due primarily to an all-round increase of traffic. The number of passengers travelling showed an increase of 7,000,000 on the year before, while the goods traffic increased by 1,579,592 tons. This was nearly all accounted for by increased intensity of traffic, the new lines opened during the year only totalling about 36½ miles. The number of miles open for traffic at the end of the last financial year (June, 1914) was 3967½, but though the building programme is large, little appears to have been done recently in adding to the mileage, since attention has been concentrated on completing some of the duplications which are considered essential to a satisfactory service. New lines are constructed by the Public Works Department, and then handed over to the railways. We understand that new work was largely suspended in 1913-14, and the staff transferred to the Railways Department, by which it was employed last year on duplications equivalent to 49 miles of line completed, another 122 miles of duplications and deviations being in hand. These, for the most part, are on the lines converging on Sydney and Newcastle.

The programme of new work involves lengths of railway aggregating about 907 miles in hand, and a further 516 miles in prospect. The most important works in hand are the North Coast Railway, of which about 149 miles remained to be opened at the close of the financial year, and a line from Dubbo to Werris Creek, 157½ miles in length. The latter is a cross-country line, running roughly north-east and almost parallel to the coast, from Dubbo, which is 283 miles from Sydney on the western system, to Werris Creek on the northern system, a few miles less from Sydney. This line will be crossed by another line now in progress from Dunedoo, 239 miles from Sydney on the north-western system. The first 76 miles of this line is in hand, but it is planned ultimately to push it right on to Burren Junction, on the northern system, and 403 miles from Sydney. Another line of considerable length in hand is that from Wagga to Tumberumba, a distance of 76 miles, stretching towards the Victoria border and the Murray River, into a district hitherto poorly served. One of the most interesting lines in hand, or perhaps by now completed, is that from Finley to Tocumwal, which has been called for for long years past. Other lines are extensions of existing branches, in many cases opening up districts far inland. We have frequently pointed out that much of the New South Wales railway traffic is long-distance traffic, and as time goes on the distances will tend to become longer. This is clearly evident from figures in the various yearly reports. For instance, the report for 1903 showed the average mileage per ton of grain, flour, &c., to up-country stations was 177.47 miles ; to-day the corresponding figure is 252.57 miles. In the case of wool, the average distance per ton used in 1903 to be 243.76 miles ; to-day it is 304.13 miles. Live stock has not increased its distance to quite the same extent, but instead of 243.76 miles, the average is now 251.16, and so on. Of course, not all the development is proceeding in the back blocks. Changes have come over some of the earlier settled districts, which have resulted in more traffic, but of an altered character, so that the increase does not always show up in figures. The general tendency, however, is very evident.

NOTES.

Unpatriotic British Workmen.

We have on several occasions referred gladly to the splendid patriotism of all classes of workmen engaged in providing the war munitions for our fighting forces alike in the Navy and the Army ; but we regret now to learn of some who continue to pursue tactics of questionable equity in peace times, but specially unjustifiable and reprehensible in the present great national emergency. All classes

of workers, with the co-operation of the executive councils of their unions, have agreed to waive, during the progress of the war, all matter of dispute which vex and annoy most men and all employers in normal times, and to meet the call of Mr. Churchill and Lord Kitchener to work as continuously and diligently as possible in order to provide all requirements of the fighting forces, and to complete without delay ships, guns, &c., in progress and ordered. They have been doing nobly, and their work, we hope, will be recognised as abounding in patriotism. We regret, however, to learn that in many of the naval shipbuilding yards serious delay is being involved by the action of drillers, and that, too, without the full sanction of the executive officers of their union. As is well known, the high-tensile steel used in modern ships has to be drilled instead of punched, and it can be understood that if there is delay in this work the fitters and riveters, who are showing commendable loyalty, are kept waiting, and the whole progress of construction delayed. With modern appliances of great precision the work requires little training and less physical effort. The remuneration is satisfactory, the time rates enabling a man to earn between 50s. and 60s. per week ; at present piece-work rates this can easily be exceeded. Unfortunately, however, the men are taking advantage of their inflated earning power, and in some cases are working for only 50 to 75 per cent. of the time. A still greater difficulty, however, is that the unionist workers refuse to allow non-unionists to be engaged, although there is not a sufficient number of trade-union drillers available. Thus ships would be delayed even if those in the unions did a full week's work every week. It will be recognised that the attitude taken up by the men is untenable as well as highly unpatriotic. Our Fleet to-day is supreme ; but no one knows when an action may take place, and then there are bound to be losses. The First Lord of the Admiralty has given great satisfaction by indicating that there are many new ships approaching completion. It may be that in the ultimate issue these new ships will turn the balance in our favour. In any event, it is of the most vital importance that nothing should be left undone by the great industrial army to support the efforts of our brave sailors and soldiers in the hour of our national emergency by giving them the best and latest munitions of war. Men who fail in meeting this call of King and country, notwithstanding liberal consideration by employers, are, to say the least, selfish and unpatriotic, and are unworthy to-day to be ranked with their fellows who are doing so well.

The French and German Field Artillery.

The French journal *Le Génie Civil* gives the following comparison of the French 75-mm. (2.953-in.) field-gun with the German one, 77-mm. (3.032-in.) in calibre :—

	French Gun.	German Gun.
Length of the gun	2.475 m. (8 ft. 1⅞ in.)	2.400 m. (7 ft. 10½ in.)
Maximum range	6500 m. (7110 yards)	5300 m. (5800 yards)
Weight of the projectile	7.200 kg. (15.8 lb.)	6.850 kg. (15 lb.)
Weight of the gun charge	0.700 kg. (1.540 lb.)	0.570 kg. (1.250 lb.)
Muzzle velocity	529 m. (1735 ft.)	465 m. (1525 ft.)
Velocity at 1000 metres	413 m. (1355 ft.)	369 m. (1210 ft.)
Velocity at 2000 metres	334 m. (1095 ft.)	310 m. (1017 ft.)
Velocity at 3000 metres	290 m. (950 ft.)	275 m. (902 ft.)
Kinetic energy at muzzle	103.5 T.-m. (340 ft.-T.)	75 T.-m. (247 ft.-T.)
Kinetic energy at 2000 metres	40.9 T.-m. (134 ft.-T.)	33.6 T.-m. (110 ft.-T.)
Number of balls in the shrapnel	300	300
Weight of each shrapnel ball	12 grammes (0.423 oz.)	10 grammes (0.353 oz.)
Thickness of gun-shield	3 mm. (0.118 in.)	5 mm. (0.197 in.)
Weight of gun in battery	1100 kg. (2424 lb.)	950 kg. (2094 lb.)
Weight of gun and limber (less the gunners—5 in Germany, 3 in France)	1900 kg. (4187 lb.)	1800 kg. (3967 lb.)
Weight of caisson with charges (less the men)	1950 kg. (4297 lb.)	1850 kg. (4077 lb.)

Field artillery has to be sufficiently mobile to travel over all ground, and in order to meet this, it is considered that the weight to be hauled by each horse should not exceed from 350 kg. to 360 kg. (780 lb.). The weight of a unit drawn by six horses should therefore be in the neighbourhood of 2000 kg. (4400 lb.), which is the case for both the above French and German guns. If the gunners be reckoned in the weights given in the above table, both the French and the German units have practically the same total weights ; the weight of the French ammunition wagon filled with shrapnel is comparable to that of the German wagon, but the French one contains 96 rounds as against the 90 rounds of the German. When carrying high explosive shells, the French wagon weighs 200 kg. (440 lb.) less than the German one similarly loaded. It is wrong therefore to state, as is sometimes done, that the mobility of the German field armament is greater than that of the French. The German armament, on the other hand, is much inferior to the French in regard to stability, facility for aiming, sweeping action, rapidity of firing, and ballistics. The superiority of the French field armament more than compensates for the lesser number of guns in a French army corps compared with the number in a German army corps—*i.e.*, 30 batteries of four guns, or 120 guns, in France, as against 144 guns divided over 24 batteries of six guns in Germany ; or five guns in France per 1000 infantrymen, as against 5.7 in Germany. The French projectiles and their bursting charge are superior to the German.

British and German Trade and the War.

The Italian journal *L'Industria* gives publicity to data prepared by Professor Einaudi on the international commercial relations of Great Britain and Germany. These figures refer to the year 1912, and show that in value the imports to Great Britain from the British Colonies were 20.5 per cent. of the total ; from the United States they were 19.5 per cent. ; from Germany, 10.4 per cent. ; from France, 6.3 per cent. ; from the Argentine, 6.2 per cent. ; from Russia, 6 per cent. ; and so on in decreasing proportions from other countries. In the same year the exports from Great Britain to the British Colonies were 36.3 per cent. of the total ; to Germany they were 8.2 per cent. ; to the United States, 6.1 per cent. ; to France, 5.2 per cent. ; to the Argentine, 4.2 per cent., &c. During the same year Germany imported from Great Britain and her Colonies, in value, 18.6 per cent. of her total imports ; 14.8 per cent. from the United States ; 14.3 per cent. from Russia ; 7.8 per cent. from Austria-Hungary ; 5.2 per cent. from France ; 4.2 per cent. from the Argentine ; 3.6 per cent. from Belgium ; and so on from other countries in decreasing proportions. On the other hand, Germany exported to Great Britain and her Colonies 16.9 per cent. of her total exports ; to Austria-Hungary, 11.6 per cent. ; to the United States, 7.8 per cent. ; to France, 7.7 per cent. ; to Russia, 7.6 per cent. ; to Holland, 6.8 per cent. ; to Switzerland, 5.8 per cent. ; to Belgium, 5.5 per cent. ; to Italy, 4.5 per cent. ; to Denmark, 2.8 per cent., &c. From these figures, adds our contemporary, it is easy to see that the war is much more damaging to German commerce than to British commerce. Taking Great Britain, Russia, France, and Belgium, and leaving out Servia and Japan, for which separate figures are not available, the above figures show an annual rate of loss to Germany of 41.7 per cent. on her imports, and of 37.7 per cent. on her exports. Great Britain, by reason of the war, directly loses only at the annual rate of 10.4 per cent. on imports and 8.2 per cent. on exports, or about one-fourth of Germany's loss. Seeing, moreover, that the British Fleet is completely blockading the German ports, Germany's commercial loss is much greater than is shown by the above proportions. Should the war, says Professor Einaudi, leave Germany without any further commercial efficiency, Great Britain and her colonies would lose their best customer, since Germany imports from them annually at the rate of 18.6 per cent. of her total imports, and sells to them at the rate of 16.9 per cent. of her total exports. Dealing with the point, our contemporary asks : "Is it not possible that Great Britain may, eventually, easily find a buyer to take the material which she could no longer sell to Germany ?" To this our contemporary replies in the affirmative, adding the following :—"Without presuming to divine people's thoughts, we may hazard the opinion that if, besides the political motives, Great Britain entertained an economical one for taking part in the present conflagration, this was precisely the hope not so much to destroy her best customer as, in some measure, to take the breath away from the most troublesome of her competitors." In a recent drawing in *Punch*, a German sailor is represented tied up close to packages marked "German Trade." In preparing to shoulder these, John Bull remarks : "Well, I didn't start out for this ; but there can't be any harm in picking up a good thing."

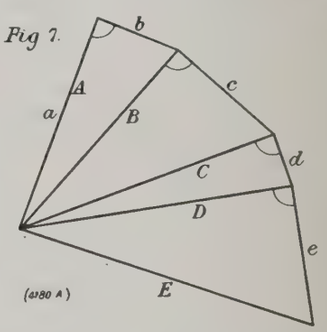
AIRCRAFT IN WARFARE : THE DAWN OF THE FOURTH ARM.—No. VI.

By Frederick William Lanchester, M. Inst. C.E.

The Principle of Concentration—*(continued).*

In the preceding article it was demonstrated that under the conditions of modern warfare the fighting strength of a force, so far as it depends upon its numerical strength, is best represented or measured by the square of the number of units. In land operations these units may be the actual men engaged, or in an artillery duel the gun battery may be the unit ; in a naval battle the number of units will be the number of capital ships, or in an action between aeroplanes the number of machines. In all cases where the individual fighting strength of the component units may be different it has been shown that if a numerical fighting value can be assigned to these units, the fighting strength of the whole force is as the square of the number multiplied by their individual fighting strength. Where the component units differ among themselves, as in the case of a fleet that is not homogeneous, the total fighting strength of a force will be *the square of the sum of the square roots of the strengths of its individual units.*

Before attempting to apply the foregoing, either as touching the conduct of aerial warfare or the equipment of the fighting aeroplane, it is of interest to examine a few special cases and applications in other directions and to discuss certain possible limitations. A convenient graphic form in which the operation of the n^2 law can be presented is given in Fig. 7 ; here the strengths of a number of separate armies or forces successively

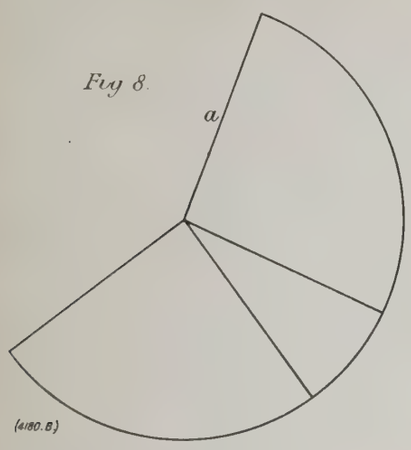


mobilised and brought into action are represented numerically by the lines *a*, *b*, *c*, *d*, *e*, and the successive added fighting strengths of these armies are given by the lengths of the lines A, B, C, D, E, each being the hypotenuse of a right-angle triangle, as indicated. Thus two forces or armies *a* and *b*, if acting separately (in point of time), have only the fighting strength of a single force or army represented numerically by the line B. Again, the three separate forces, *a*, *b*, and *c*, could be met on equal terms in three successive battles by a single army of the numerical strength C, and so on.

From the diagram given in Fig. 7 arises a special case that at first sight may look like a *reductio ad absurdum*, but which, correctly interpreted, is actually a confirmation of the n^2 law. Referring to Fig. 7, let us take it that the initial force (army or fleet), is of some definite finite magnitude, but that the later arrivals *b*, *c*, *d*, &c., be very small and numerous detachments—so small, in fact, as to be reasonably represented to the scale of the diagram as infinitesimal quantities. Then the lines *b*, *c*, *d*, *e*, *f*, &c., describe a polygonal figure approximating to a circle, and which in the limit becomes a circle, whose radius is represented by the original force *a*, Fig. 8. Here we have graphically represented the result that the fighting value of the added forces, no matter what their numerical aggregate (represented in Fig. 8 by the circumferential line), is zero. The correct interpretation of this is that in the open a small force attacked by one of overwhelming magnitude is wiped out of existence without being able to exact a toll even comparable to its own numerical value ; it is necessary to say *in the open*, since, under other circumstances, the larger force is unable to bring its weapons to bear, and this is an essential portion of the basic hypothesis. In the limiting case when the disparity of force is extreme, the capacity of the lesser force to effect anything at all becomes negligible. There is nothing improbable in this conclusion, but it manifestly does not apply to the

case of a small force concealed or "dug in," since the hypothesis is infringed. Put bluntly, the condition represented in Fig. 8 illustrates the complete impotence of small forces in the presence of one of overwhelming power. Once more we are led to contrast the ancient conditions, under which

Fig 8.



the weapons of a large army could not be brought to bear, with modern conditions, where it is physically possible for the weapons of ten thousand to be concentrated on one. Macaulay's lines

> "In yon strait path a thousand
> May well be stopped by three,"

belong intrinsically to the methods and conditions of the past.

The n^2 Law in Naval Warfare.

We have already seen that the n^2 law applies broadly, if imperfectly, to military operations, on land; however, there frequently exist special conditions and a multitude of factors extraneous to the hypothesis whereby its operation may be suspended or masked. In the case of naval warfare, however, the conditions more strictly conform to our basic assumptions, and there are comparatively few disturbing factors. Thus when battle fleet meets battle fleet, there is no advantage to the defender analogous to that secured by the entrenchment of infantry. Again, from the time of opening fire the individual ship is the mark of the gunner, and there is no phase of the battle or range at which areas are searched in a general way. In a naval battle every shot fired is aimed or directed at some definite one of the enemy's ships; there is no firing on the mass or "into the brown." Under the conditions of the sailing-ship and cannon of some 1000 or 1200 yards maximum effective range, advantage could be taken of concentration within limits; and an examination of the latter 18th century tactics makes it apparent that with any ordinary disparity of numbers (probably in no case exceeding 2 to 1) the effect of concentration must have been not far from that indicated by theory. But to whatever extent this was the case, it is certain that with a battle-fleet action at the present day the conditions are still more favourable to the weight of numbers, since with the modern battle range—some 4 to 5 miles—there is virtually no limit to the degree of concentration of fire. Further than this, there is in modern naval warfare practically no chance of coming to close quarters in ship-to-ship combats, as in the old days.

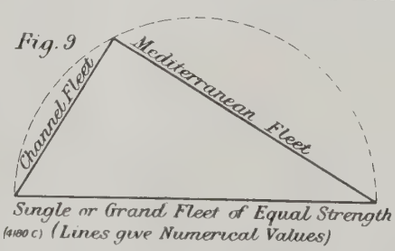
Thus the conditions are to-day almost ideal from the point of view of theoretical treatment. A numerical superiority of ships of individually equal strength will mean definitely that the inferior fleet at the outset has to face the full fire of the superior, and as the battle proceeds and the smaller fleet is knocked to pieces, the initial disparity will become worse and worse, and the fire to which it is subjected more and more concentrated. These are precisely the conditions taken as the basis of the investigation from which the n^2 law has been derived. The same observations will probably be found to apply to aerial warfare when air fleets engage in conflict, more especially so in view of the fact that aeroplane can attack aeroplane in three dimensions of space instead of being limited to two, as is the case with the battleship. This will mean that even with weapons of moderate range the degree of fire concentration possible will be very great. By attacking from above and below, as well as from all points of the compass there is, within reason, no limit to the number of machines that can be brought to bear on a given small force of the enemy, and so a numerically superior fleet will be able to reap every ounce of advantage from its numbers.

The factor the most difficult to assess in the evaluation of a fleet as a fighting machine is (apart from the *personnel*) the individual value of its units, when these vary amongst themselves. There is no possibility of entirely obviating this difficulty, since the fighting value of any given ship depends not only upon its gun armament, but also upon its protective armour. One ship may be stronger than another at some one range, and weaker at some longer or shorter range, so that the question of fleet strength can never be reduced quite to a matter of simple arithmetic, nor the design of the battleship to an exact science. In practice the drawing up of a naval programme resolves itself, in great part at least, into the answering of the prospective enemy's programme type by type and ship by ship. It is, however, generally accepted that so long as we are confining our attention to the main battle fleets, and so are dealing with ships of closely comparable gun calibre and range, and armour of approximately equivalent weight, the fighting value of the individual ship may be gauged by the weight of its "broadside," or more accurately, taking into account the speed with which the different guns can be served, by the weight of shot that can be thrown per minute. Another basis, and one that perhaps affords a fairer comparison, is to give the figure for the *energy per minute* for broadside fire, which represents, if we like so to express it, the horse-power of the ship as a fighting machine. Similar means of comparison will probably be found applicable to the fighting aeroplane, though it may be that the *downward fire* capacity will be regarded as of vital importance rather than the broadside fire as pertaining to the battleship.

Applications of the n^2 Law.

The n^2 law tells us at once the price or penalty that must be paid if elementary principles are outraged by the division of our battle fleet into two or more isolated detachments. In this respect our present disposition—a single battle fleet or "Grand" fleet—is far more economical and strategically preferable as a defensive power to the old-time distribution of the Channel Fleet, Mediterranean Fleet, &c. If it had been really necessary, for any political or geographical reason, to maintain two separate battle fleets at such distance asunder as to preclude their immediate concentration in case of attack, the cost to the country would have been enormously increased. In the case, for example, of our total battle fleet being separated into two equal parts, forming separate fleets or squadrons, the increase would require to be fixed at approximately 40 per cent.—that is to say, in the relation of 1 to $\sqrt{2}$; more generally the solution is given by a right-angled triangle, as in Fig. 9. It must not be forgotten that, even with this enormous increase,

Fig. 9



Single or Grand Fleet of Equal Strength
(4180 C) *(Lines give Numerical Values)*

the security will not be so great as appears on paper, for the enemy's fleet, having met and defeated one section of our fleet, may succeed in falling back on his base for repair and refit, and emerge later (possibly even reinforced by a few prizes put into commission), with the advantage of strength in his favour. Also one must not overlook the demoralising effect on the *personnel* of the fleet first to go into action, of the knowledge that they are hopelessly outnumbered and already beaten on paper—that they are, in fact, regarded by their King and country as "cannon fodder." Further than this, presuming two successive fleet actions and the enemy finally beaten, the cost of victory in men and *matériel* will be greater in the case of the divided fleet than in the case of a single fleet of equal total fighting strength, in the proportion of the total numbers engaged—that is to say, in Fig. 9, in the proportion that the two sides of the right-angled triangle are greater than the hypotenuse.

In brief, however potent political or geographical influences or reasons may be, it is questionable whether *under any circumstances* it can be considered sound strategy to divide the main battle fleet on which the defence of a country depends. This is to-day the accepted view of every naval strategist of repute, and is the basis of the present distribution of Great Britain's naval forces.

The question of fire concentration is again found to be paramount when we turn our attention to the consideration and study of naval tactics. It is worthy of note that the recognition of the value of any definite tactical scheme does not seem to have been universal until quite the latter end of the 18th century. It is even said that the French Admiral Suffren, about the year 1780, went so far as to attribute the reverses suffered by the French at sea to "the introduction of tactics" which he stigmatised as "the veil of timidity;"* the probability is that the then existing standard of seamanship in the French Navy was so low that anything beyond the simplest of manœuvres led to confusion, not unattended with danger. The subject, however, was, about that date, receiving considerable attention. A writer, Clerk, about 1780, pointed out that in meeting the attack of the English the French had adopted a system of defence consisting of a kind of running fight, in which, initially taking the "lee gage," they would await the English attack in line ahead, and having delivered their broadsides on the leading English ships (advancing usually in line abreast), they would bear away to leeward and take up position, once more waiting for the renewal of the attack, when the same process was repeated.† By these tactics the French obtained a concentration of fire on a small portion of the English fleet, and so were able to inflict severe punishment with little injury to themselves.‡ Here we see the beginnings of sound tactical method adapted to the needs of defence.

Up to the date in question there appears to have been no studied attempt to found a scheme of attack on the basis of concentration; the old order was to give battle in parallel columns or lines, ship to ship, the excess of ships, if either force were numerically superior, being doubled on the rear ships of the enemy. It was not till the "Battle of the Saints," in 1782, that a change took place; Rodney (by accident or intention) broke away from tradition, and cutting through the lines of the enemy, was able to concentrate on his centre and rear, achieving thereby a decisive victory.

The accident or experiment of 1782 had evidently become the established tactics of the British in the course of the twenty years that followed, for not only do we find the method in question carefully laid down in the plan of attack given in the Memorandum issued by Nelson just prior to the Battle of Trafalgar in 1805, but the French Admiral Villeneuve§ confidently asserted in a note issued to his staff in anticipation of the battle that:—"The British Fleet will not be formed in a line-of-battle parallel to the combined fleet according to the usage of former days. Nelson, assuming him to be, as represented, really in command, will seek to break our line, envelop our rear, and overpower with groups of his ships as many as he can isolate and cut off." Here we have a concise statement of a definite tactical scheme based on a clear understanding of the advantages of fire concentration.

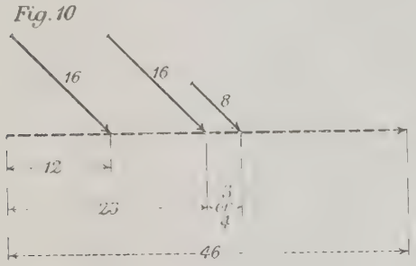
It will be understood by those acquainted with the sailing-ship of the period that the van could only turn to come to the assistance of those in the rear at the cost of a considerable interval of time, especially if the van should happen to be to leeward of the centre and rear. The time taken to "wear ship," or in light winds to "go about" (often only to be effected by manning the boats and rowing to assist the manœuvre), was by no means an inconsiderable item. Thus it would not uncommonly be a matter of some hours before the leading ships

* Mahan, "Sea Power," page 425.
† Compare Mahan, "Sea Power," page 162.
‡ Incidentally, also, the scheme in question had the advantage of subjecting the English to a raking fire from the French broadsides before they were themselves able to bring their own broadside fire to bear.
§ "The Enemy at Trafalgar," Ed. Fraser; Hodder and Stoughton, page 54.

could be brought within decisive range, and take an active part in the fray.

In order further to embarrass the enemy's van, and more effectively to prevent it from coming into action, it became part of the scheme of attack that a few ships, a comparatively insignificant force, should be told off to intercept and engage as many of the leading ships as possible; in brief, to fight an independent action on a small scale; we may say admittedly a losing action. In this connection Nelson's memorandum of October 9 is illuminating. Nelson assumed for the purpose of framing his plan of attack that his own force would consist of forty sail of the line, against forty-six of the combined (French and Spanish) fleet. These numbers are considerably greater, as things turned out, than those ultimately engaged; but we are here dealing with the memorandum, and not with the actual battle. The British Fleet was to form in two main columns, comprising sixteen sail of the line each, and a smaller column of eight ships only. The plan of attack prescribed in the event of the enemy being found in line ahead was briefly as follows:—One of the main columns was to cut the enemy's line about the centre, the other to break through about twelve ships from the rear, the smaller column being ordered to engage the rear of the enemy's van three or four ships ahead of the centre, and to frustrate, as far as possible, every effort the van might make to come to the succour of the threatened centre or rear. Its object, in short, was to prevent the van of the combined fleet from taking part in the main action. The plan is shown diagrammatically in Fig. 10.

Fig. 10



(4180 D)

An examination of the numerical values resulting from the foregoing disposition is instructive. The force with which Nelson planned to envelop the half—*i.e.*, 23 ships—of the combined fleet amounted to 32 ships in all; this according to the n^2 law would give him a superiority of fighting strength to the nearest integer,* almost exactly two to one, and would mean that if subsequently he had to meet the other half of the combined fleet, without allowing for any injury done by the special eight-ship column, he would have been able to do so on terms of equality. The fact that the van of the combined fleet would most certainly be in some degree crippled by its previous encounter is an indication and measure of the positive advantage of strength provided by the tactical scheme. Dealing with the position arithmetically, we have:—

Strength of British (in arbitrary n^2 units),

$$32^2 + 8^2 = 1088$$

And combined fleet,

$$23^2 + 23^2 = 1058$$

British advantage ... 30

Or, the numerical equivalent of the remains of the British Fleet (assuming the action fought to the last gasp), $= \sqrt{30}$, or $5\frac{1}{2}$ ships.

If for the purpose of comparison we suppose the total forces had engaged under the conditions described by Villeneuve as "the usage of former days," we have:—

Strength of combined fleet,	46^2	...	$= 2116$
,, British ,,	40^2	...	$= 1600$
Balance in favour of enemy ...		...	516

Or, the equivalent numerical value of the remainder of the combined fleet, assuming complete annihilation of the British, $= \sqrt{516} = 23$ ships approximately. Thus we can appreciate the commanding importance of a correct tactical scheme. If in the actual battle the old-time method of attack had been adopted, it is extremely doubtful whether the superior seamanship and gunnery of the British could have averted defeat. The actual forces on the day were 27 British sail of the line against the combined fleet numbering 33, a rather less favourable ratio than assumed in the Memorandum. In the battle, as it took place, the British attacked in two columns instead of three, as laid down in the Memorandum; but the scheme of concentration followed the original idea. The fact that the wind was of the lightest was alone sufficient to determine the exclusion of the enemy's van from the action. However, as a study the Memorandum is far more important than the actual event, and in the foregoing analysis it is truly remarkable to find, firstly, the definite statement of the cutting the enemy into two *equal* parts—according to the n^2 law the exact proportion corresponding to the reduction of his total effective strength to a minimum; and, secondly, the selection of a proportion, the nearest whole-number equivalent to the $\sqrt{2}$ ratio of theory, required to give a fighting strength equal to tackling the two halves of the enemy on level terms, and the detachment of the remainder, the column of eight sail, to weaken and impede the leading half of the enemy's fleet to guarantee the success of the main idea. If, as might fairly be assumed, the foregoing is more than a chance coincidence, it suggests itself that Nelson, if not actually acquainted with the n^2 law, must have had some equivalent way of figuring his tactical values.

* $23 \times \sqrt{2} = 32.52$.

Electrical Engineers and the War.—The London Electrical Engineers (Territorials), of 46, Regency-street, Westminster, have now received permission to recruit. An opportunity therefore occurs for members of the electrical profession to join a corps where their technical abilities will prove a valuable asset to their country. Application is to be made personally or by letter to the commanding officer at the address given above.

German Patents in Great Britain.—On Monday last, the 5th inst, at the Patent Office, the ex-Comptroller (Sir Cornelius Dalton) had before him an application for the suspension of two German patents. One of these patents was owned by a Berlin manufacturer or financier named Braun, and covered a crowbar on wheels used for moving heavy objects. The applicant, Mr. Robert Lasch, a naturalised Englishman and a freeman of the City of London, proposed to pay to the Treasury or to a trustee for the patentee a royalty of 6d. to 9d. on each article sold, according to the size. Mr. Tennant, who appeared on behalf of the alien owner of the patent, suggested a royalty of 9d. to 1s. He further urged that there should be a minimum royalty of 100*l.* a year to prevent the "locking up" of the patent. Sir Cornelius Dalton said that as the applicant had been negotiating for the exclusive rights of sale, and would probably expect to get them after the war, it would be to his advantage to push the patent, and he did not think there was any danger of it not being kept alive. The second application, which will be reported to the Board of Trade, was that of Messrs. Witting, who claimed the suspension in their favour of the patent of an air-filter used for cooling in connection with turbine plant. It was stated that applicants had hitherto obtained the apparatus from the German patentees; but this was no longer possible, and it was necessary to enable them to carry out existing contracts that they should be allowed to undertake the manufacture of the article. Mr. Tennant, on behalf of the patentees, said that the offer of a 10 per cent. royalty on the selling price made by Messrs. Witting was entirely acceptable.

Industrial Chemicals.—The trade in industrial or heavy chemicals is one in which the United Kingdom holds a strong position. This is, however, no reason why efforts should not be made further to improve it. In a White Paper just issued by the Commercial Intelligence Branch of the Board of Trade it is stated that the exports of such chemicals from the United Kingdom in the year 1913 were of a total value of 6,684,900*l.* The figure is a large one, but when it is stated that the similar exports from Germany (for 1912) had a value of 4,066,600*l.*, it will be seen that there should be plenty of opportunity of increasing our already very important export. These figures exclude artificial manures, and cover aluminous sulphates, arsenic compounds, bleaching materials, coal products (not including dyes), sulphate of copper, cyanide of potassium and sodium, soda compounds, and sulphuric acid. The corresponding total for Austria-Hungary is relatively very small, and amounted only to 164,565*l.* for 1913. German competition has apparently made comparatively little progress in our home markets, our imports from this country amounting only to 255,100*l.* in 1912. This figure is very small in comparison with the value of the total annual production of the United Kingdom. In Colonial and neutral markets, however, there is ample scope for all our possible efforts to secure business up to the present in German hands, and it is to be hoped that our manufacturers will study and make all possible use of the White Paper, which gives particulars of the various exports to different markets in considerable detail.

THE LATE MR. WILLIAM ROBERT GALBRAITH.

We regret to have to announce the death, which occurred on the 5th inst., at 91, Finchley-road, London, N.W., of Mr. William Robert Galbraith, M. Inst. C.E.

Mr. W. R. Galbraith was born in 1829, and was the son of William Galbraith, solicitor, of Stirling, town clerk of the burgh, and sheriff clerk of the county. On completing his education at the Stirling Academy and at Glasgow College, he was articled at the age of seventeen to Messrs. Locke and Errington, railway engineers. Whilst serving his apprenticeship and down to the year 1855, Mr. Galbraith was entrusted both with office work and outside work on a number of British railways, among which we may mention the Aberdeen Railway, the Scottish Central Railway (now a part of the Caledonian Railway), the London and North-Western Railway, the East Lancashire Railway, and the London and South-Western Railway.

From 1855 his services were mostly given to the latter railway's extensions westward of Yeovil; in 1856 he was appointed resident engineer to the Yeovil and Exeter Railway, then to the Exeter-Exmouth Railway. In 1862, on the death of Mr. Errington, the London and South-Western Railway appointed him their engineer for new works, and entrusted him with the care of their Parliamentary business. For the next forty years following the latter date he had charge also of the construction of the greater part of their new lines in the counties served by the system, also of a number of branch lines and extensions promoted separately and ultimately acquired or worked by the company. Among the branch lines in question we may mention those to Swanage, Seaton, Sidmouth, Ilfracombe, the extensions being those west of Exeter to Okehampton, Plymouth, Devonport, and several others in Cornwall.

In the year 1892 the railway company acquired the Southampton Docks, where work was later on carried out under Mr. Galbraith's supervision, including warehouses, deep-water quays, and graving docks.

Besides his activities as briefly enumerated above, Mr. Galbraith acted as consulting engineer from 1880 to 1890 for the North British Railway in the matter of their Parliamentary work. During the same period he built that company's Inverkeithing and Burntisland and their Glenfarg railways, and prepared and carried through Parliament the plans for the enlargement of the Waverley Station, Edinburgh.

In 1892, and during the following years, he was with Mr. Greathead, and, later, with Sir Alexander Kennedy, engineer of the Waterloo and City Railway, with Sir Benjamin Baker and Mr. R. F. Church on the Baker Street and Waterloo Railway, also with Sir Douglas Fox on the Charing Cross, Euston, and Hampstead Railway.

Mr. Galbraith became a member of the Institution of Civil Engineers in 1865; he was elected on the Council of that Institution in 1894, and became senior Vice-President in 1906. Owing to a serious illness he was unable to accept the nomination for the Presidency in 1907, and again in 1908. He retired from active business in 1907.

The Decimal Association.—The metric system of weights and measures prevails in the great majority of neutral countries with which hitherto Germany has carried on a very large trade, and the Decimal Association states that if the efforts to capture that trade are to be successful, British manufacturers and shippers must adapt their methods to those of their customers. This is made quite clear, adds the Association, by the recent Board of Trade reports. The Decimal Association will be glad to do its best to help manufacturers and merchants who need advice on this subject, and if sufficient support is forthcoming, a series of lectures, under the auspices of Chambers of Commerce, will be held during the winter.

Continuous Photo-Printing Machine: Addendum.—We illustrated and described, on page 274 *ante*, a machine for printing, washing, and drying photo-prints, constructed by the C. F. Pease Company, of Chicago. The firm have since sent us some further particulars of the machine, and from these particulars we gather that the system of rollers previously referred to as being used for removing wrinkles are not for this purpose, but for carrying a series of elastic bands, which run in opposite directions, and form part of a device for rolling up the finished prints. These are not wound up on a shaft, but the end of the paper, as it descends from the roller at the top of the machine, is formed into a loose roll, and this roll, being placed upon the bands, continues to roll itself up automatically until the operator chooses to cut it off and start a new roll. The makers inform us that no device for removing wrinkles is necessary, as the drying takes place so evenly that none is formed; the paper, in fact, comes down to the rolling-up device as smooth as when it first entered the printing-machine. When the roll of finished prints is opened out on the trimming-table they lie quite flat, without wrinkles or distortions, and owing to the fact that they are dried while in tension, the shrinkage is very much less than would otherwise be the case.

ELECTROLYTIC IRON.

To the Editor of Engineering.

Sir,—Mr. Cowper-Coles has asked me to give publicity to the enclosed communication, which he has drawn up in reply to statements made by Mr. Guillet in the paper on "Electrolytic Iron: Its Manufacture, Properties, and Uses," a copy of which has already been sent to you for publication.

Yours faithfully,
G. C. Lloyd.

The Iron and Steel Institute, 28, Victoria-street, London, S.W., October 5, 1914.

The paper in question was reproduced in our columns last week on page 413, and the following is the enclosure received from Mr. Lloyd:—

Correspondence on Paper by Mr. L. Guillet.

"'Mr. Sherard Cowper-Coles, Sunbury-on-Thames, wrote that he had read the paper by Mr. Guillet and considered it very misleading in regard to some of its statements. In 1908 he (Mr. Cowper-Coles) read a paper before the Iron and Steel Institute, entitled "The Production of Finished Iron Sheets and Tubes in One Operation," describing in considerable detail his electrolytic process for the direct production of iron tubes, cylinders, and sheets. In that process a mandrel revolving at a critical speed, so as to give sufficient skin friction between the electrolyte and deposited metal, was employed to obtain a close homogenous deposit, and at the same time enable a high-current density to be employed, the solution being kept neutral by bringing it in contact with iron oxide, as described in Mr. Guillet's paper. In the following year Mr. Boucher approached him (Mr. Cowper-Coles) regarding the process, and asked if he would grant him a licence to work the process in France and Switzerland. This was done, and a small trial was thereupon set up in Switzerland, and Mr. Boucher produced a number of tubes. A company was ultimately formed, called "Le Fer," to acquire the licence that had been granted to Mr. Boucher.

"Mr. Cowper-Coles's object in setting out these facts was to show that all the preliminary work was carried out in Great Britain, at great expense and much labour. That that was so could hardly be gathered from the somewhat ungenerous statement which constituted the only reference to the process in Mr. Guillet's paper:—

"'In 1907 Mr. Cowper-Coles took out a patent involving the use of a 20 per cent. solution of sulphocresylate of iron and endeavoured to manufacture weldless tubes, using a rotating cylindrical mandrel. This process, which was analogous to the Elmore process for making copper tubes, has not yielded results of much importance.'

"His (Mr. Cowper-Coles's) process was in no way analogous to the Elmore copper process, which, as most people knew, consisted of using an agate burnisher. He thought it should be known that the process described in Mr. Guillet's paper had been worked out in England, and that works were to be erected in the Midlands to carry out the process on a commercial scale. He (Mr. Cowper-Coles) had all the necessary documents for proving the statements he had given."

BRITISH MANUFACTURERS AND GERMAN TRADE.

To the Editor of Engineering.

Sir,—There are endless letters on this subject, but few with any tendency to improve existing conditions. In the first place, to depose the Germans after the war we must be prepared with cheap and good articles to take the place of their specialities, and above all the British manufacturers must revolutionise their methods of sale.

In the past British manufacturers have made little effort in their selling organisations as compared with Germany and America, and under existing conditions the people who will mostly benefit will be the Americans, as they appreciate and are prepared to make good use of this opportunity.

It is unfortunate in this country that with many manufacturers there is continual friction between the salesmen and the working staff, arising chiefly from the cause that British firms have in many cases not admitted the superior position salesmen should occupy and the attention their expression of opinion should receive; this friction is aggravated by the continual employment of correspondents at the works who have never been salesmen, and who never knew or will never appreciate the difficulty of developing and promoting trade. Immediate efforts should be made to improve in this direction if we are to succeed.

We have also the growing system of manufacturers short of funds, or who pay no heed to their sales organisations, or, having none, seek to employ a large number of agents on commission only, to make up the discrepancy. Here again there must be complete change; good salesmen should only be employed on this very important work of promotion and extension, and they must be provided with reasonable and ample funds to carry out what is expected of them, being rewarded by commission or in other ways for their success; payment by commission only for such a purpose is a system of sweating important labour, completely destroying the sympathies that should exist between salesmen and the works staff.

Again, we have the want of confidence existing between commission salesmen or agents and their principals, arising, perhaps, in the first stages at the works, from neglect or want of method, but, it must be said with regret, in many cases from other reasons, and from complete failure to appreciate the necessary position of salesmen to achieve their object. It would be of great interest to know the proportion of good salesmen and agents that prefer or have been forced to sell foreign goods for this reason alone, although their natural instincts are patriotic in the extreme.

Lastly, we have the payment of salesmen. It is an admitted fact that the works employees must be paid weekly or monthly; not so the salesmen and agents on commission, as many firms seem to think weeks, months, and years may elapse before they are paid; and by this shortsighted policy they send, in hundreds of cases, trade and the salesmen's sympathies abroad.

Yours faithfully,
Victor H Coates, M.I. Mech. E.

121, Victoria-street, London, S.W., October 9, 1914.

BRITISH WOOD-WORKING MACHINERY.

To the Editor of Engineering.

Sir,—Directors of the British wood-working engineering firms whose signatures are appended to the letter enclosed have recently held conferences with a view to arriving at some concerted course of action to combat the unfair German competition which has and still exists in stocks of German machines being held by certain firms who before and since the outbreak of the war have sold German-made machines as of British manufacture. At a recent meeting of the above-mentioned directors it was unanimously decided to address the enclosed letter to the editors of the trade Press with a request for its insertion.

We have no doubt you will render all the assistance in your power to endeavour to expose what constitutes undoubted injustice to British trade.

Yours faithfully,
For and on behalf of the signatories,
T. Robinson.

Railway Works, Rochdale, England, October 6, 1914.

The following is the enclosure in the above letter:—

British Wood-Working Machinery.

We believe no other class of British mechanical engineering has suffered so much during the last ten years from persistently unscrupulous German competition as wood-working machinery. This competition has been unscrupulous in that such machines made in and imported from Germany to this country, and to which name-plates bearing English addresses have been attached, have not only been sold in considerable quantities to users in the British Isles, but have also been exported to overseas markets as ostensibly of British manufacture.

Now that it is of supreme importance to the welfare of the United Kingdom that we should have work to keep our workpeople, not called away in the defence of the country, fully employed, we beg to warn our clients that there still exists in this country for sale stocks of German-made machines, which, under the protection of name-plates bearing English addresses, may still be offered as of British manufacture. Contrary to the declared position of such so-called English concerns, we are not able to supply renewal parts for such German machines, as *we* do not stock them.

There is no German capital or German influence in any way whatever connected with the undersigned British firms, neither are there any persons of German nationality on the directorates, offices' or works' staffs.

T. and R. Lees, Hollinwood.
J. McDowall and Sons, Johnstone.
John Pickles and Son, Hebden Bridge.
A. Ransome and Co., Limited, Newark.
T. Robinson and Son, Limited, Rochdale.
J. Sagar and Co., Halifax.
Wadkin and Co., Leicester.

The late Mr. George Findlay Loudon.—We regret to have to place on record the death of Mr. George Findlay Loudon, of the well-known engineering firm of Messrs. Loudon Brothers, Limited, of Glasgow and Johnstone. He died at his residence Orangefield, Monkton, Ayrshire, on Sunday, the 4th inst.

Engineering in Denmark.—The Elsinore Iron-Ship and Engine Company has issued its report for the last financial year, showing net profits of 504,827 kr., of which 340,000 kr. were applied to various funds and writings-off, the shareholders receiving 6 per cent. Last year's dividend was 7 per cent.; but although the year had been very good, the board found it advisable, under the existing circumstances, further to consolidate the company.

Colonial Engineering Project.—According to the *Board of Trade Journal*, the Imperial Trade Correspondent at Toronto reports that the construction of a concrete roadway between the cities of Toronto and Hamilton has practically been decided upon by the public authorities involved. The length of the road will be approximately 40 miles, and the estimated cost is 589,500 dols. (about 121,200*l.*). Further information concerning this work can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Applications to the Light Railway Commissioners.—The Board of Trade has issued an additional rule with regard to applications to the Light Railway Commissioners under the Light Railways Acts, 1896 and 1912. This amends Rules 1 and 33 of No. 1111 Statutory Rules and Orders, 1913, by the addition of the words "or in any other month with the consent of the Light Railway Commissioners," to be inserted therein after the words "in the month of May or in November." Copies of the rule can be purchased through Messrs. Wyman and Sons, Limited, Fetter-lane, E.C., at the price of 1d.

THE TRANSVERSE TESTING OF CAST IRON.*

By George Hailstone, Birmingham.

Introduction.

The object of this paper is to suggest the cast-iron test-bar that should be used to obtain the most reliable and consistent results with breaking load and deflection, also the relation that exists between the two English standard test-bars. Some engineers in their specifications for cast iron give the contractor the option which test-bar he shall cast—namely, the bar 2-in. by 1-in. section tested on 36-in. centres, or the 1-in. square bar tested on 12-in. centres. They also state the load and deflection each size of bar should stand. An example of one of these specifications is as follows:—

Test-Bar.	Deflection. In.	Breaking Load. Cwt.
2-in. by 1-in. bar tested on 36-in. centres ...	0.375	28
1-in. square bar tested on 36-in. centres ...	0.070	21

From these figures it will be observed that the 1-in. square bar, tested on 12 in. centres, is required to stand three-quarters of the load of the 2-in. by 1-in. section bar tested on 36-in. centres.

Professor Turner states, in his "Metallurgy of Iron," pages 235-236, second edition:—

"For transverse tests many shapes and sizes of test-bar have been adopted, and, for scientific purposes, the results so obtained are converted by calculation into values for a bar 1 ft. long and 1 in. square. The common test-bar in use by founders is 3 ft. long, 2 in. deep, and 1 in. broad. By multiplying hundredweights recorded with such a bar by 84, the results may be converted into pounds on the standard bar. Or, conversely, divide pounds on the standard bar by 84 to obtain hundredweights on the ordinary 3-ft. bar."

An example of this is as follows:—

3-ft. bar, 2 in. by 1 in. in section. Breaking load, 28 cwt.

28-cwt. × 84 = 2352 lb. = 21 cwt., being the calculated breaking load of a 1-in. square bar tested on 12-in. centres.

From the two examples given a simple calculation shows the breaking load of a cast-iron bar 2 in. by 1 in. in section tested on 36-in. centres is 1.333 times as great as a 1-in. by 1-in. bar tested on 12-in. centres.

The author has made a series of tests, the results of which do not appear to bear out this relation.

Experimental.—The material used in this investigation was cast iron of fairly good quality, but of the non-chilling type, melted in the cupola. Two sets of two test-bars, 2½ in. by 1½ in. in section, and 50 in. long, were poured from the same ladle in immediate succession. The bars were cast in green-sand moulds horizontally, the down- and in-gates being of the same size in each case. Fig. 1, page 456, illustrates the method of casting the bars and also the method of "gating." After casting, the bars were allowed to stay in the sand until the following morning, when they were fettled and machined down to 2 in. by 1 in. in section, and marked A, B, C, and D. A and B were cast in one mould, and C and D in the other.

Testing-Machine.—As a special type of machine was designed and used for these transverse tests, it will be as well to point out its principal features. The machine shown in Fig. 2 is designed for ascertaining the transverse breaking strength and deflection of rectangular cast-iron bars 2 in. by 1 in. in section at 36-in. centres, 1½ in. by 1 in. and 1 in. by 1 in. in section at 24-in. centres, and 1 in. by 1 in. in section at 12-in. centres. The machine consists generally of a cast-iron frame carrying a steel-yard and poise for indicating the strain, and a hand-wheel and screw for applying the strain.

The test-bars are pulled upwards by the central straining stirrup, the ends of the bars press against two turned case-hardened steel pins which can be inserted in holes in the frame of the machine at either 12-in., 24-in., or 36-in. centres. The steelyard is graduated from zero up to a capacity of 40 cwt. in 28-lb. divisions. The travelling poise runs upon turned rollers, and is propelled by means of a handle carried upon the main column, through machine-cut gearing and a screw.

In this improved arrangement the meeting-point of the gear-wheel upon the steelyard and that upon the frame is at the fulcrum, thus avoiding the pressure of the hand upon the poise, and therefore eliminating the possibility of the specimen being broken prematurely, and of the poise moving after fracture. The quick return of the poise to zero after a test is obtained by raising a knob at the top, which disengages the nut of the poise from the screw, so that the poise can then be pushed back by hand.

The straining-screw is actuated by a hand-wheel, the lower end of the screw being formed into a hardened-steel conical point, which bears upon a steel bearing-block resting upon the rear knife-edge of the steelyard.

A mild-steel stirrup is threaded on to the straining-screw, and has a loop at its lower end, having a blunt knife-edge which comes into contact with, and applies the strain to, the specimen. The deflection scale consists of two parts—namely, a brass drum attached to the straining-screw and a vertical scale fastened to the stirrup. The drum is accurately turned, and bears an engraved circle, which is divided into one hundred parts. The scale is sub-divided into 0.1-in. divisions, this also being the pitch of the straining-screw.

Each revolution of the hand-wheel which applies the

* Paper submitted to the Iron and Steel Institute, and now open for discussion by correspondence.

strain produces a deflection of the specimen of 0.1 in. It will be seen, therefore, by combining the rotary movement of the drum with a vertical movement of the vertical scale deflections of 0.001 in. can be measured. For observation purposes during a test an index finger is attached to the left-hand end of the steelyard, also one to the carrier pillar, the position of these always showing if the machine is in equilibrium under any given load.

Method of Testing.—The test-bars A, B, C, and D were tested in the following manner on 36-in. centres:—Each A and B were machined to 1 in. by 1 in. in section, and tested on 24-in. centres. These bars are marked A A A and B B B. Two of the broken halves of the two bars C and D were machined to 1.5 in. by 1 in. in section and tested on 24-in. centres, and these bars were marked

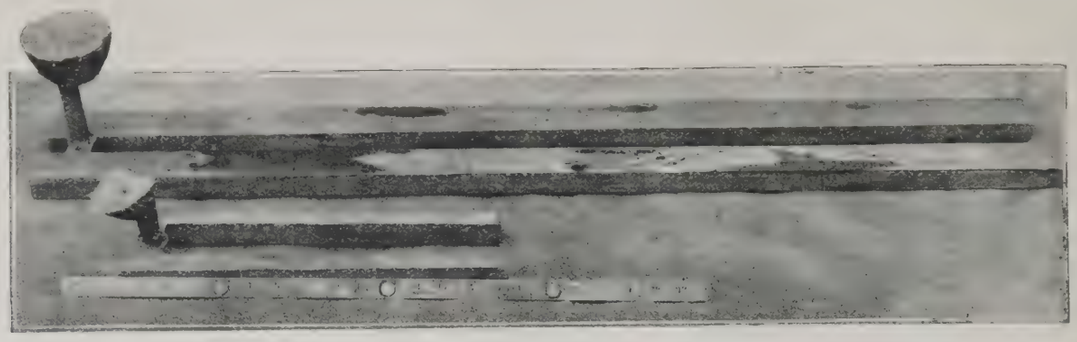


Fig. 1.

Table II.—*Test-Bars A, B, C, and D, Machined to 2 In. by 1 In. in Section and Tested on 36-In. Centres.*

Load in Cwts.	Test-Bar A, Deflection in Inches.	Test-Bar B, Deflection in Inches.	Test-Bar C, Deflection in Inches.	Test-Bar D, Deflection in Inches.
3	—	—	—	—
4	0.011	0.009	0.013	0.011
5	0.022	0.020	0.023	0.022
6	0.035	0.033	0.035	0.033
7	0.049	0.044	0.047	0.045
8	0.061	0.056	0.060	0.058
9	0.074	0.070	0.073	0.070
10	0.087	0.081	0.086	0.084
11	0.101	0.095	0.100	0.095
12	0.115	0.108	0.112	0.108
13	0.130	0.121	0.125	0.122
14	0.143	0.135	0.141	0.137
15	0.162	0.149	0.154	0.150
16	0.173	0.164	0.168	0.165
17	0.188	0.179	0.183	0.180
18	0.205	0.195	0.200	0.195
19	0.221	0.211	0.216	0.212
20	0.237	0.227	0.234	0.229
21	0.255	0.242	0.249	0.246
22	0.273	0.261	0.267	0.264
23	0.292	0.279	0.286	0.283
24	0.312	0.289	0.305	0.303
25	0.332	0.317	0.326	0.323
26	0.352	0.340	0.347	0.346
27	0.373	0.363	0.371	0.369
28	0.396	0.387	0.396	0.395
29	0.415	0.408	0.420	0.423
29.5	—	Test-bar broken	Test-bar broken	Test-bar broken
30	Test-bar broken	—	—	—

Table III.—*Test-Bars A A and B B.*

Machined to 1 in. by 1 in. in section, and tested on 12-in. centres.

Load in Cwts.	Test-Bar A A, Deflection in Inches.	Test-Bar B B, Deflection in Inches.
5	—	—
6	0.001	0.002
7	0.004	0.006
8	0.009	0.010
9	0.013	0.114
10	0.018	0.018
11	0.022	0.023
12	0.026	0.028
13	0.031	0.032
14	0.036	0.037
15	0.041	0.042
16	0.047	0.049
17	0.052	0.055
18	0.058	0.061
19	0.064	0.068
20	0.070	0.074
21	0.078	0.083
22	0.085	0.092
23	0.091	0.101
24	0.102	0.112
25	0.109	Test-bar broken
25.75	Test-Bar Broken	—

Table IV.—*Test-Bars AAA and BBB.*

Machined to 1 in. by 1 in. in section, and tested on 24-in. centres.

Load in Cwts.	Test-Bar A A A, Deflection in Inches.	Test-Bar B B B, Deflection in Inches.
1	—	—
2	0.008	0.010
3	0.032	0.033
4	0.061	0.059
5	0.089	0.087
6	0.122	0.117
7	0.155	0.150
8	0.195	0.187
9	0.239	0.228
10	0.288	0.277
11	0.344	0.333
12	0.414	0.403
12.5	—	0.445 Test-bar broken.
13	0.475 Test-bar broken.	—

Fig. 2.

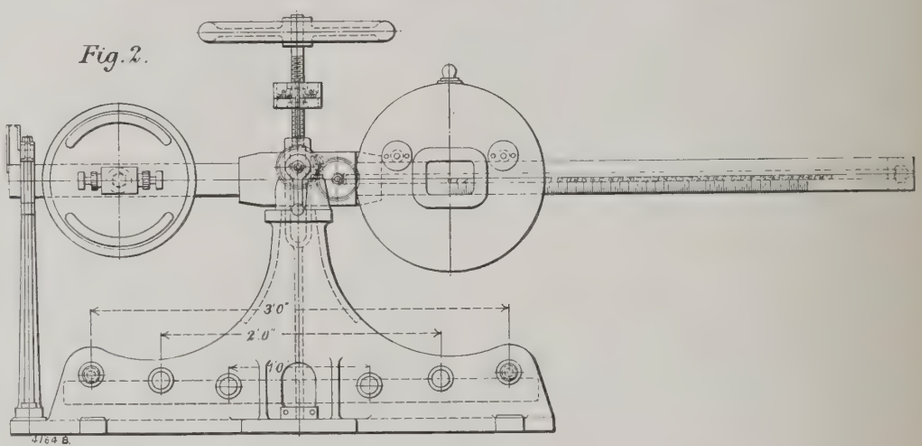


Fig. 3. TRANSVERSE STRENGTH AND DEFLECTION OF CAST IRON TEST-BARS.

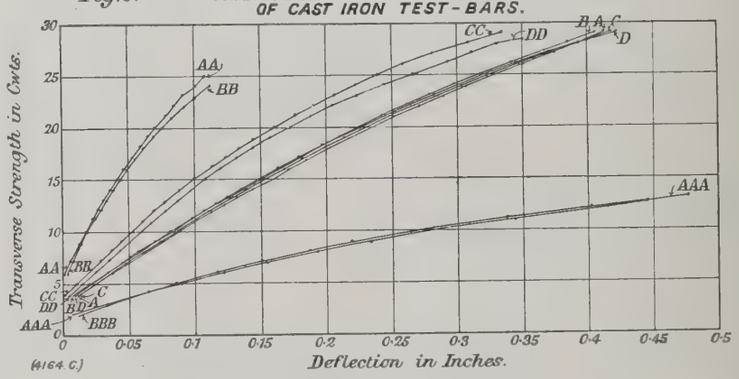


TABLE I.—Chemical Analysis of Test-Bars.

——	A.	B.	A A.	B B.	A A A.	B B B.	C.	D.	C C.	D D.
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Total carbon	3.168	3.166	3.164	3.162	3.165	3.163	3.172	3.178	3.173	3.176
Graphitic carbon ..	2.556	2.550	2.551	2.547	2.551	2.548	2.563	2.566	2.563	2.563
Combined carbon ..	0.612	0.616	0.613	0.615	0.614	0.615	0.609	0.612	0.610	0.613
Silicon	1.612	1.616	1.613	1.612	1.613	1.614	1.615	1.613	1.612	1.613
Sulphur	0.110	0.109	0.111	0.108	0.110	0.109	0.108	0.109	0.110	0.111
Phosphorus	0.876	0.873	0.874	0.873	0.875	0.873	0.875	0.876	0.876	0.873
Manganese	0.510	0.510	0.513	0.511	0.510	0.512	0.511	0.512	0.512	0.513

bar was placed in the machine, and the hand-wheel of the straining screw rotated until the test-bar was rigid. The deflection scale was set at zero, and the poise propelled until the steelyard was just floating as observed from the position of the index fingers, when the first load reading was taken and recorded. The poise was then propelled another hundredweight, the steelyard brought into equilibrium again, and the deflection taken; a further hundredweight load was put on the test-bar, the steelyard again brought into equilibrium, and the deflection taken, and so on hundredweight by hundredweight until the bar finally fractured. The load was applied in each case at the rate of 1 cwt. per 15 seconds—that is, 5 seconds for propelling the poise, 5 seconds for putting the strain on the specimen, and 5 seconds for taking the deflection reading.

The results of the tests on bars A, B, C, and D tested on 36-in. centres will be discussed later. Two of the broken halves of the two bars A and B were machined down to 1 in. by 1 in. in section, and the two bars thus obtained were tested on 12-in. centres, and were marked A A and B B respectively. The other halves of the bars C C and D D. Drillings were taken from each of the bars after test, a hole being drilled right through the bar. Table I. gives the chemical analysis of the bars.

It will be observed that they are all of the same approximate composition, which would be expected, considering that they were cast from the same ladle, and that the smaller test-bars were machined from the large ones.

The actual figures obtained from these tests are given in the Tables Nos. II., III., IV., and V., and are also plotted as a curve in Fig. 3.

From these tests it will be observed that the bars A, B, C, and D give the most consistent and comparable results both in breaking strain and deflection. The bars A A and B B, and also the bars A A A and B B B give widely different results with regard to the deflection, the bars C C and D D also showing the same fault.

Actual Relation between the Two English Standard Test-Bars.—A number of test-bars were cast from mixtures of very weak to strong cast iron, 2½ in. by 1½ in. section 42 in. long, in the same way as previously described; they were then machined to 2 in. by 1 in. in section and tested on 36-in. centres. The results are given in the first column

of Table VI. It will be noted there is a good range of strengths. One of the broken halves of each of the broken test-bars was machined to 1 in. by 1 in. in section and tested on 12-in. centres, the result of which is given in the second column of Table VI. The ratio of the 2-in. by 1-in. bar, tested on 36-in. centres, to the 1-in. by 1-in. bar tested on 12-in. centres is given in the fourth column, which, it will be noticed, only varies from 1.142 to 1.162 in the whole series, as against 1.333 mentioned in the introduction to this paper.

TABLE V.—*Test-Bars C C and D D.*

Machined to 1.5 in. by 1 in. in section and tested on 24-in. centres.

Load in Cwts.	Test-Bar C C. Deflection in Inches.	Test-Bar D D. Deflection in Inches.
4	0.0015	0.005
5	0.009	0.014
6	0.017	0.023
7	0.026	0.032
8	0.034	0.041
9	0.042	0.051
10	0.052	0.059
11	0.060	0.069
12	0.069	0.078
13	0.080	0.088
14	0.089	0.098
15	0.100	0.109
16	0.111	0.120
17	0.123	0.133
18	0.136	0.146
19	0.148	0.159
20	0.161	0.174
21	0.176	0.190
22	0.191	0.206
23	0.206	0.224
24	0.223	0.245
25	0.240	0.266
26	0.260	0.291
27	0.281	0.312
28	0.310	0.331
28.5	—	0.352
29	0.335 Test-bar broken	Test-bar broken —

TABLE VI.—*Actual Relation between Cast-Iron Test-Bars 2 In. by 1 In. in Section, Tested on 36-In. Centres, and Test-Bars 1 In. by 1 In. in Section, Tested on 12-In. Centres.*

Cast-iron test-bars machined to 2 in. by 1 in. in section and tested on 36-in. centres, one of the broken halves then machined to 1 in. by 1 in. in section and tested on 12-in. centres.

Breaking Load in Cwt.		Difference in Cwts.	Ratio of 2-In. by 1-In. Bars Tested on 36-In. Centres to 1-In. by 1-In. Bars Tested on 12-In. Centres.
2-In. by 1-In. Bars Tested on 36-In. Centres.	1-In. by 1-In. Bars Tested on 12-In. Centres.		
23.00	20.00	3 00	1.150
23.25	20.25	3.00	1.148
24.00	20.75	3.25	1.156
24.25	21.00	3.50	1 154
24.50	21 00	3.50	1 166
25.00	21.50	3.50	1.162
25.50	22.00	3.50	1.159
26.00	22.75	3.25	1.142
26.50	23.00	3.50	1.151
27.75	24.00	3.75	1.156
28.00	24 25	3.75	1.154
28.75	25.00	3 75	1.150
29.00	25.25	3.75	1.148
29.75	25.75	4.00	1.154
30 00	26.00	4.00	1.151
30.50	26.25	4.25	1.161
30.75	26.50	4.25	1.160
31.25	27.00	4 25	1 157
31.75	27.50	4.25	1 154
32.00	27.75	4 25	1.153
32.25	28.00	4.25	1.151
33.25	29.00	4.25	1.146
33.50	29.00	4.50	1.155
34.00	29.75	4.25	1.142
34.50	30.00	4.50	1.150
35.00	30.50	4.50	1.147

Mean ratio of 2-in. by 1-in. bar, tested on 36-in. centres, to 1-in. by 1-in. bar, tested on 12-in. centres, equals 1.153 times the breaking load.

TABLE VII.—*Actual Relation between Cast-Iron Test-Bars 2 In. by 1 In. in Section, Tested on 36-In. Centres, and Test-Bars 1 In. by 1 In. in Section Tested on 12-In. Centres.*

Cast-iron test-bars cast to size 2-in. by 1-in. bar, and 1-in. by 1-in. bar cast out of same ladle in different boxes in each case.

Breaking Loads in Cwts.		Difference in Cwts.	Ratio of 2-In. by 1-In. Bars Tested on 36-In. Centres to 1-In. by 1-In. Bars Tested on 12-In. Centres.
2-In. by 1-in. Bars Tested on 36-in. Centres.	1-In. by 1-In. Bars Tested on 12-In. Centres.		
22.75	19.5	3.25	1.166
23.25	20.5	2.75	1.134
24.75	21.5	2.25	1.151
25.25	21.75	3.5	1.160
26.75	23.00	3.75	1.163
28.00	24.50	3.5	1.142
28.50	25.50	3.0	1.117
29.50	26.00	3.5	1.134
31.00	27.25	3.75	1.137
32.00	28.0	4.0	1.142
33.00	28.75	4.25	1.147
33.25	28.75	4.5	1.156
34.00	29.5	4.5	1.152
35.25	30.5	4.75	1.155
36.75	32.0	4.75	1.148

Mean ratio of 2-in. by 1-in. bar tested on 36-in. centres to 1-in. by 1-in. bar tested on 12-in. centres, equals 1.146 times the breaking load.

To ascertain whether the skin on the test-bar influenced this ratio the author cast another series of test-bars of various strengths, but to standard sizes. In each test two bars 2 in. by 1 in. section, to be tested on 36-in. centres, and two bars 1 in. by 1 in. section, were cast from the same ladle in immediate succession. After being fettled in the ordinary manner they were tested, the results being tabulated in Table VII.

It will be observed here that a good range of strengths has been obtained, also that the ratio between the 2-in. by 1-in. bar, tested on 36-in. centres, to the 1-in. by 1-in. bar, tested on 12-in. centres, only varies from 1.134 times to 1.166, the mean ratio being 1.146 times.

Conclusions.—The best standard cast-iron test-bar to give the most consistent and comparable results, both in breaking load and deflection, is the one cast as shown in Fig. 1, $2\frac{3}{8}$ in. by $1\frac{1}{2}$ in. in section, 42 in. long, machined down to 2 in. by 1 in. in section, and tested on 36-in. centres. The rate of testing should not exceed a load of 1 cwt. in less than 15 seconds (15 seconds being a very convenient rate). Instead of, as hitherto thought, the ratio of the 2-in. by 1-in. bar, tested on 36-in. centres, to the 1-in. by 1-in. bar, tested on 12-in. centres, being 1.333 times the breaking load, the experiments recorded in Table VI. on machined bars show the mean ratio to be 1.153; whilst in the bars tested with the skin on (see Table VII.), the mean ratio is 1.146 times the breaking load.

As there has been some little controversy during the last few years on the transverse testing of cast iron, the author thought the few observations made would be of interest, and may be of some help to those who are working at the standardisation of methods for testing cast iron.

THE BY-PRODUCT COKING INDUSTRY.

*The By-Product Coking Industry and its Relation to the Manufacture of Iron and Steel.**

By G. STANLEY COOPER, B.Sc. (Lond.), Sheffield.

THE standard of efficiency which has been reached in connection with iron and steel works at the present time is a result of the more economical application of existing resources rather than of anything entirely new. Perhaps the most striking development has been in connection with the fuel side of the industry, and it is to this question that the present paper is devoted. As is well known, until about the year 1880 the whole of the coke required for furnace-work was made in bee-hive ovens, and the wasteful character of this method of manufacture has already been exhaustively dealt with, and does not need reiteration here. In the present paper the author proposes to confine himself to the development which involves the production and use of coke-oven gas for metallurgical purposes. For a long time the waste-heat type of coke oven was predominant, but on account of the many disadvantages attending the operation of this type of oven, the regenerative coke-oven gradually came to the front, and at the present time comparatively few waste-heat ovens are built. The regenerative oven has the advantage that the surplus energy contained in the coal is produced in the form of a combustible gas which can be used anywhere and at any time without appreciable deterioration. It can be used for a variety of purposes, such as town-lighting, steam-raising, development of power by means of gas-engines, and also as a fuel for open-hearth furnaces. The author does not propose to go into very great detail concerning the use of coke-oven gas in iron and steel works, as much information has been presented to the Institute by those actually engaged in using coke-oven gas for these purposes. Until comparatively recent times, very little attention was paid to the surplus coke-oven gas, and although it was generally assumed that 50 per cent. of the total quantity of gas evolved from the coal was available over and above that required for heating the ovens, yet very little of this 50 per cent. was actually used. When it came to be realised that coke-oven gas could be used as a fuel for open-hearth and other furnaces, more attention was paid to the question of gas production in by-product coke-ovens, and consequently better efficiency was obtained from the ovens—at any rate, so far as gas-yield was concerned. In some cases the whole of the surplus coke-oven gas was diverted for use in the iron works, and efforts were made to increase the amount of available gas.

In this connection the regenerative type of oven was developed, and many improvements brought about. At the Allerdale Coal Company's colliery a battery of fifty Koppers' regenerative ovens was set to work in 1911, and the following figures, kindly supplied by Mr. F. D. Harper, the manager of the plant, serve to show what results may be expected using this type of oven. The coal used is compressed before carbonisation, and usually contains about 10 to 12 per cent. of added moisture:—

Coal carbonised per oven per annum (wet)	2574 tons
Coke produced	1704 ,,
Coke yield on dry coal	73.25 per cent.
Gas yield per ton of coal	10,600 cub. ft.
Surplus gas per ton of coal	6,996 ,,
Weight of wet coal (10 per cent. H_2O) per oven charge	9.5 tons
Time of carbonisation per charge	29.0 hours

Gas Analysis.	Before Extraction of Benzol.	After Extraction of Benzol.
CO_2	—	2.4
C_nH_m	—	2.8
O_2	—	0.2
CO	—	4.8
CH_4	—	31.5
H_2	—	55.2
N_2	—	3.1
Calorific value	560 British thermal units	511 British thermal units

* Paper submitted to the Iron and Steel Institute and now open for discussion by correspondence.

The natural consequence of the efforts to increase the suplus gas yield was the provision of other means for supplying the heat necessary to carbonise the coal in the coke-ovens, and thereby to allow the whole of the gas produced from the coal to be available for extraneous purposes. An exactly similar position, but one looked at from another point of view, had arisen in connection with the gas industry. It had been realised that chamber carbonisation had many advantages to offer as a means of gas production for town purposes. In such case, as the gas is the principal object, coke being only a secondary consideration, it was important to have the maximum possible quantity of available gas per ton of coal. With this in view, chamber carbonisation was adopted, and in order that the whole of the gas produced might be available for town consumption, producer-gas was resorted to for heating the chambers. As producer-gas has a calorific value of only about one-fourth to one-fifth that of coal-gas, various rearrangements were necessary in order to allow of the production of a sufficiently high temperature, and eventually it was found that by preheating the producer-gas, and supplying it with preheated air in the usual way, suitable temperatures could be obtained with economical consumption of the producer-gas.

Working on these lines, a battery of eighteen ovens was erected at the City Gas Works of Vienna. The ovens were heated by means of producer-gas generated in Kerpely producers. This experimental plant was a complete success from the first, and numerous other installations have since been erected working exactly on this principle. In order to make the development of this type of oven more clear, a detailed description of the Koppers regenerative coke-oven as installed at Allerdale, and also of the regenerative chamber-oven, of the type installed at Vienna, may be of interest.

The main points of difference between the several systems of coke-ovens now in use may be summarised as follow:—(1) The arrangement of the heating-flues; (2) the facilities for inspecting all the working parts of the ovens; (3) the method of regulating and controlling the heating of the ovens; (4) the preheating of the air required for combustion. The essential features of a good coke-oven may be generally stated thus. The heating of the ovens must be easy to regulate and control. The temperature should be the same throughout the whole length of the oven wall in order to produce a homogeneous coke. All working parts of the oven should be easily accessible for inspection and regulation, and without discomfort to the workmen. The amount of gas required for heating the ovens should be reduced to the minimum, and the largest possible amount of surplus energy should be produced without decreasing the output of by-products. The ovens should be simple in design, and great care should be bestowed upon the foundations. It is particularly necessary to study the nature of the foundations, and to take precautions against the possible effects of the heat of the oven structure on the subsoil.

The Koppers Regenerative Coke-Oven.—The Koppers regenerative coke-oven is of the vertical flued type, and possesses many special features, more particularly as regards the arrangements of the heating-flues and regenerators, and the facilities for inspection. Figs. 1 and 2, page 458, show sections through the oven chamber and the heating-flues. The oven is a chamber 10 metres long, 2 metres high and about 0.5 metre wide. The height and width vary somewhat according to the class of coal to be coked. Each oven is capable of taking a charge of about 8 to 10 tons of coal. The ovens are heated by the gas evolved from the coal during carbonisation, and the means adopted for distributing and regulating the supply of gas, together with the method adopted for preheating the air required for combustion, are special features. The gas and air for combustion are separately distributed on each side, and along the whole length of the oven, and combustion takes place in each vertical flue. Each oven-wall is formed of about thirty vertical flues, and there being a gas-jet in each flue, each oven is heated at about 60 points (Fig. 1). At the top of the oven, and over all the vertical flues, openings are provided for inspection and regulation. Very simple means are provided for the regulation of the combustion in each flue, which is such that it is easily possible for the walls of the oven to be absolutely uniformly heated from end to end. This uniformity not only results in the production of a homogeneous coke, but enables the charges of coal to be burnt off more quickly than is the case when such uniformity does not prevail; besides which it effects great economy in the consumption of the heating gas. The air for combustion is heated to a high degree in regenerators designed on Siemens' principle.

The distinguishing feature of the Koppers regenerative oven lies in the employment of separate regenerative chambers for each oven, so that every oven is entirely independent of its neighbour (Fig. 3). This construction permits of the air for combustion and the chimney draught being separately regulated. In the older type of regenerator oven there is a regulating damper over the passage leading from the regenerator chambers to the air-distributing channel. This damper has to be set to serve the dual purpose of regulating the admission of air when the ovens are burning in one direction, and of regulating the chimney draught when the ovens are burning in the reverse direction. It is not easy to effect a satisfactory regulation of both the air and the draught by means of one damper only.

Referring again to Figs. 1, 2, and to Fig. 3; the air for combustion flows along the passage-ways A, at the front and back of the oven, and passes thence into the regenerators through the inlets. In the regenerators the temperature of the air rises to 1000 deg. Cent. (1832 deg. Fahr.). The highly heated air passes out of the regenerators into the vertical heating flues through the openings

C. Part of the gas evolved from the coal is used for heating the ovens, and, after being purified, this gas is returned from the by-product plant to the ovens by mains D running along the whole length of the ovens on each side. Branch-supply pipes H conduct the gas into the gas-distributing channels E, which are situated directly beneath the oven-walls; thence it passes through the gas-nozzles F into each vertical flue, where it ignites with the hot air entering through the passages C previously referred to. A jet is therefore formed on a level with the oven-floor in each of the heating flues of the oven chamber. The gas is supplied to each oven by the branch-pipes, which are each provided with a regulating-cock, as well as with a second cock fitted with a lever. All the levers are attached to one of the wire ropes, which communicate with the automatic changing gear. The air is admitted to each oven cast-iron damper fitting into the chimney flue. At the base end of the cast-iron fittings there is a third slide, which can be set in any desired position to regulate the draught on each oven. It will therefore be seen that, by the new arrangement, the quantity of air for each oven, and the chimney draught on each oven, can be separately regulated, which is not possible with ovens working with the older form of regenerators. A very disadvantageous feature has thus been removed in the new system.

The automatic changing gear is a simple arrangement, and is placed at one end of the battery of ovens. It is operated electrically or by hand, and requires the least possible attention. It may be added that the gear is so designed that should anything fail to act an electric alarm is set in action, and does not stop until the gear is again at work.

Fig. 1. LONGITUDINAL SECTION THROUGH HEATING FLUES.
SCALE, 1 INCH = 10 FEET.

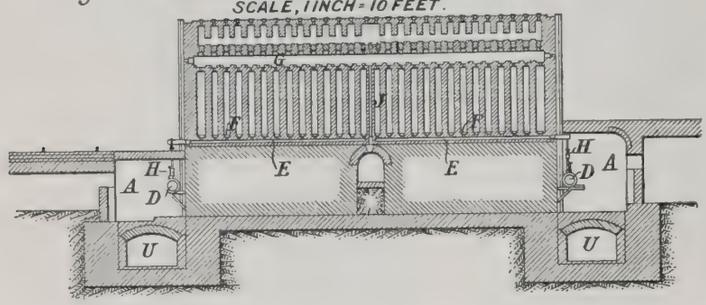


Fig. 2. LONGITUDINAL SECTION THROUGH THE OVEN CHAMBER.
SCALE, 1 INCH = 10 FEET.

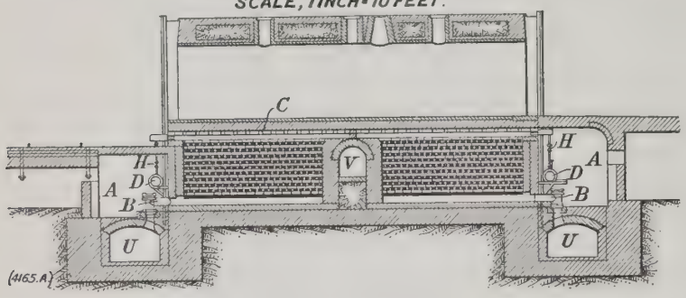


Fig. 3. CROSS-SECTION THROUGH OVENS.

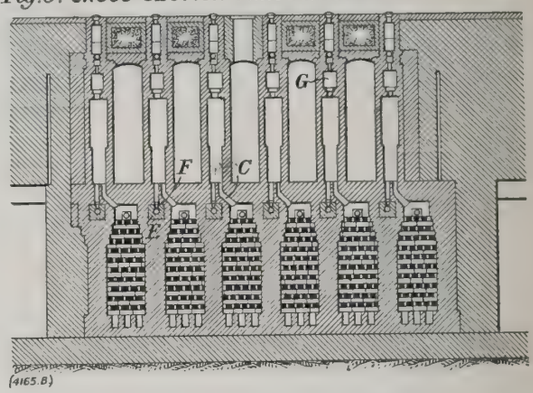


Fig. 4. OPENINGS AT TOP OF OVENS GIVING ACCESS TO SLIDING BRICKS.

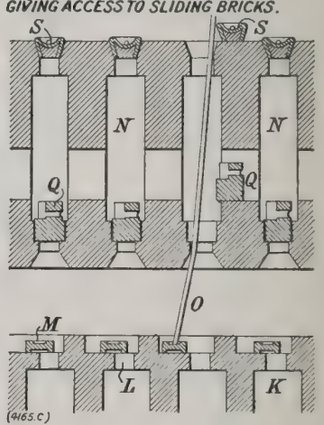
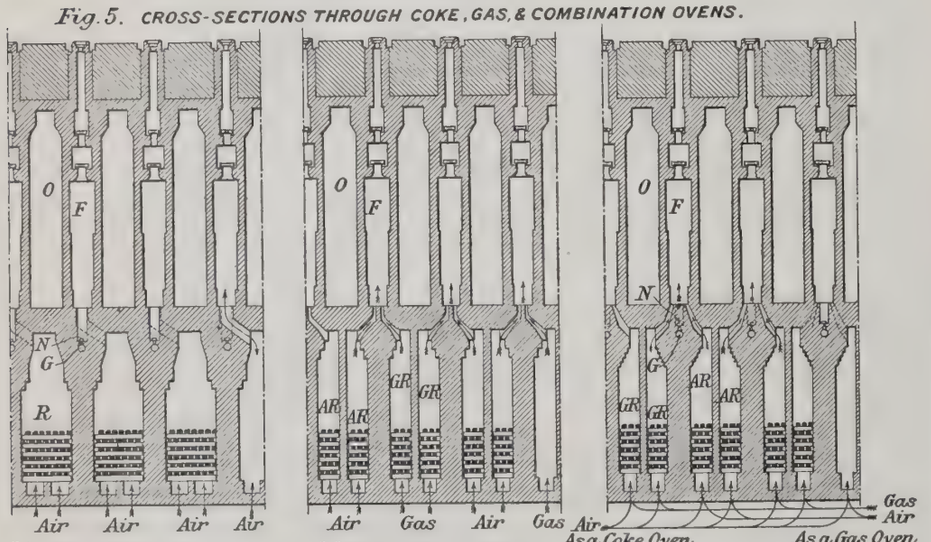


Fig. 5. CROSS-SECTIONS THROUGH COKE, GAS, & COMBINATION OVENS.



by means of the cast-iron damper fitting, which also serves to conduct the waste gases to the chimney flue. These dampers are each fitted at the top with a slide, connected, like the levers of the gas-cocks, with the second wire rope; and the whole arrangement is such that, when the automatic changing gear operates, the gas-cocks and damper-slides on one side of the battery are closed simultaneously with the opening of the corresponding parts on the other side of the battery. When the gas is burning on one side of the ovens the air-damper is open, and the air passes into the regenerator, the main chimney damper being closed. A little below the damper-slide there is a second slide, which can be set in any desired position, and serves to regulate the quantity of air required for each oven. When the gas is burning on the opposite side of the oven—that is, when the waste gases are passing to the chimney—the gas-cocks and air-dampers are closed, but the main chimney damper is open. The waste gases are therefore drawn through the

The employment of regenerators renders it necessary to reverse the heating process after a period of time, usually about thirty minutes, and the heating flues are divided into two sections, so that combustion can take place alternately in each half of the oven wall. When the gas is burning in one half of the wall, the products of combustion pass up the flues and enter the top horizontal flue G, whence they make their way down the flues in the other half of the oven wall, and enter the regenerator through the same passage C, by which the air is admitted to the flues when the direction of combustion is reversed. On issuing from the regenerator the waste gases pass into the flue leading to the chimney, after having given up their heat to the firebrick chequer-work. When the next half-hourly reversal is made, the heat is given up to the air entering for combustion.

Two of the principal features of this type of oven are the sliding bricks, and the openings in the top of the ovens which give access to them. The openings (Fig. 4) serve not only to provide means for regulating the dampers, but more particularly to give access to the gas-nozzles. The gas-nozzles are furnished with oval orifices to enable them to be taken out by a rod having a tee end. The orifices in the nozzles vary in size according to their position in the flues, and it will be readily obvious, even to those who have had no previous knowledge of the design and working of coke-ovens, that the means thus provided for controlling the admission of the gas to each flue at all points along the whole length of the oven must of necessity render it easily possible to heat the walls of the oven absolutely uniformly from end to end. This has been the great aim of all coke-oven builders. It may be added that the removal and replacement of a gas-nozzle can be effected in a few moments without the slightest trouble or discomfort.

The Koppers Regenerative Gas-Oven.—In coke works the principal aim is, of course, to produce the best possible quality of coke suitable for metallurgical purposes. The gas obtained is used principally for heating the coke-ovens, for boiler-firing, and for gas-engines. In gas works, on the other hand, the principal object is the production of the greatest possible amount of illuminating gas, and the coke obtained is regarded more or less as a by-product. By making slight alterations in design and practice the regenerator coke-oven has been adapted for use as a gas-oven, and as such is capable of producing a high yield of illuminating gas of good and even quality. At the same time the coke obtained does not deteriorate in quality, and is far superior to ordinary retort coke. The important point is to secure that the whole of the gas evolved from the charge should be available for illuminating purposes, and hence some other means has to be found for heating the ovens. This can best be done by installing a central producer-gas plant quite apart from the chamber ovens. The producer-gas is preheated before combustion, just as the air is preheated in the case of the regenerator coke-oven, and the design of the oven is altered to accommodate these new features. In the main, however, especially as regards the arrangement of the heating flues, it remains unaltered.

It was found necessary to ensure the thorough cleansing of the producer-gas from dust and tar before it was allowed to enter the heating flues, otherwise the tar is deposited in the valves, which eventually become clogged up, whilst the dust is carried forward into the heating-flues, and damage is caused there by fusion of the dust and slagging of the flue-bricks. The gas is first cooled in order to remove tar, and is then thoroughly washed with water by means of centrifugal sprays, the whole of the dust being thereby removed.

The Koppers Combination Oven Operated on Blast-Furnace Gas.—From the two foregoing types of ovens what is known as the Koppers combination oven was developed. As its name implies, this is an oven which can act either as an ordinary regenerative coke-oven or as a regenerative gas-oven. In the former case it is heated by means of a portion of the gas evolved from the coal carbonised, whilst in the latter case it is heated by some other gas, such as producer or blast-furnace gas. The arrangement of the oven is such that it can be

operated at will either as a coke-oven or as a gas oven. Blast-furnace gas resembles almost exactly producer-gas as far as its production and calorific value are concerned, and therefore what had been done with producer-gas it was naturally expected could also be done with blast-furnace gas. This idea of employing blast-furnace gas, as far as the writer is aware, was first mooted at the annual meeting of the Iron and Steel Institute, held in London in May, 1899, in a paper read by Mr. Enrique Disdier (Bilbao), on "The Use of Blast-Furnace and Coke-Oven Gases." This paper contains the following paragraph :—"Third Method: There is another new course open for consideration. In this the coke-ovens are heated by the blast-furnace gases, and the oven gases are used for driving gas-engines."

At a later date Mr. Adolph Wirtz, of the Friedrich Wilhelmshütte, Mülheim-Ruhr, Germany, suggested the employment of blast-furnace gas for heating coke-ovens at his works. At these works it had already been found that surplus coke-oven gas could be disposed of with great advantage. At the same time the whole of the blast-furnace gas was not being satisfactorily utilised. The suggestion was therefore carried into effect, with important resulting economies, for the Friedrich Wilhelmshütte no longer depended only on the surplus gas produced in their ordinary type of regenerator coke-ovens, but by the employment of blast-furnace gas for heating purposes they were able to command a much larger surplus, and at the same time, in the event of there being any shortage of blast-furnace gas, due to the stoppage of the furnaces, the ovens were not rendered idle, but could immediately be transformed into ordinary regenerative coke-ovens, the only difference being that the quantity of surplus coke-oven gas was reduced by about 50 per cent. As each oven is an entirely independent unit, the amount of coke-oven gas available could be regulated between very wide limits, either according to the demand for coke-oven gas in the iron works or the amount of blast-furnace gas available from the furnaces. The system also possesses a still further advantage. By the utilisation of the blast-furnace gas the time of carbonisation was actually reduced, thereby allowing of an increased output from the ovens. The plant of the Friedrich Wilhelmshütte consists of eighty Koppers combination ovens arranged in a single battery.

In order to understand fully the design and working of the combination oven, it is necessary to refer to the descriptions previously given of the regenerative coke-oven and the regenerative gas-oven. For the purpose of comparison, drawings are produced showing cross-sections through (A) the Koppers regenerative coke-oven, (B) the Koppers gas-oven, (C) the Koppers combination oven (Fig. 5).

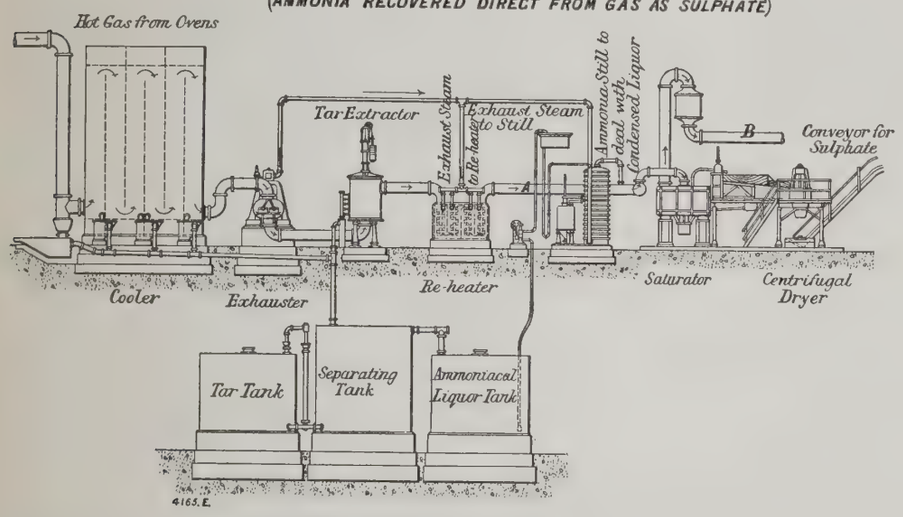
Coke-Oven A.—In this type of oven a portion of the gas evolved from the coal is used for heating the ovens, about 40 to 50 per cent. of the total quantity evolved being required. After passing through the by-product plant, the required portion of the gas is returned to the ovens through a series of distribution-pipes G, through nozzles N, into the vertical heating flues F. Here it meets air which has been preheated to a high degree in the regenerators R, and combustion takes place. In this way the charge of coal is carbonised, and all the gas not required for heating purposes is available for outside consumption. The operation of the oven has already been described in detail.

Gas-Oven B.—The Koppers gas-oven was designed for the production of the maximum quantity of illuminating gas, and hence none of the gas evolved from the coal is used for heating purposes. The ovens are heated by producer-gas generated in a central producer plant, and usually manufactured from inferior fuel. In this type of oven both the producer-gas and the air necessary for its combustion are preheated. For this purpose the generators are divided into two sections. The producer-gas is preheated by passing through the regenerators G R, and the air by passing through regenerators A R. The gas and air then meet in the vertical flues F, where combustion takes place as in the coke-oven.

Combination Oven C.—This oven is a combination of the coke-oven and the gas-oven, and can be used as either at will. The difference lies, of course, in the manner in which the oven is heated. If required as a coke-oven, it is heated by coke-oven gas; whilst if required as a gas-oven, it is heated by producer or blast-furnace gas. In the latter case the gas must be subjected to a cleaning process to free it from tar and dust. The process adopted is described elsewhere in the paper. It will be seen from the illustration that the combination oven is provided with divided regenerators similar to those adopted in the gas-oven. At the same time provision is made by means of the distribution-channel G for the utilisation of coke-oven gas for heating as in the coke-oven. If the oven is to be worked as a coke-oven, all the regenerators are used to preheat the air. The coke-oven gas, freed from its by-products, enters the distributing-flue G, and the oven works in exactly the same manner as described above for the working of the coke-oven. If the oven is to be worked as a gas-oven, one pair of regenerators are used for preheating the air, and the next pair for preheating the producer or blast-furnace gas. The heated gas and air meet in the vertical flues E, and combustion takes place, the oven now working in exactly the same manner as described above for the working of the coke-oven.

The temperature of the oven can be maintained just as easily in one case as in the other, and the change from a gas-oven to a coke-oven, and *vice versâ*, can be made almost instantaneously, and without interfering with its working in any way.

Fig. 6. DIAGRAMMATIC SKETCH OF KOPPERS' DIRECT-RECOVERY PROCESS FOR AMMONIA. (AMMONIA RECOVERED DIRECT FROM GAS AS SULPHATE)



The Carbonisation of Coal in Coke-Ovens.—As long as the primary object is the production of metallurgical coke, so must the selection of a suitable coal for use in the coke-ovens be of prime importance. Many investigations have been carried out with the object of determining what constitutes the coking property of coals, and what are the reasons for the varying behaviour of different classes of coal on carbonisation. Finality in the matter has by no means been reached, but it is possible, as a result of collected experiences, to lay down certain general rules concerning the relationship between the composition of coal and its coking capacity. Perhaps the most important of these is that as the oxygen content increases the coking power decreases, and it is generally assumed that a coal with more than 8 per cent. of oxygen on an ash-and-moisture-free basis is a non-coking, or at any rate a poor coking, coal. This view is further borne out by consideration of the results obtained in the distillation of various classes of coal. The oxygen in the original coal is distributed on distillation in the form of H_2O (ammoniacal liquor), CO_2, and CO. The following results were obtained by the author with different classes of coal, and it will be seen that, speaking generally, the figures for H_2O, CO_2, and CO are a good guide as to the coking property of the coal. The tests were all performed with dry coal under the same conditions.

Coal.	Coke.	H_2O.	CO_2.	CO.	Remarks.
	per cent	per cent	per cent	per cent	
Cumberland .	69.8	5.34	0.94	6.0	Good coke
Durham	76.5	4.11	1.02	4.6	,,
Warwick	62.0	12.98	3.60	10.6	Poor coke
Monmouth ..	80.0	3.37	0.51	3.2	Good coke
Stafford ..	71.0	7.53	1.08	4.9	,,
Yorks	70.0	6.66	1.28	7.8	,,
Lancashire ..	70.0	6.80	1.48	5.2	,,
Lanark	65.0	8.09	2.45	10 7	Fair coke
Fife	68.0	9.12	1.99	7.6	Good coke
Northumberland	67.0	8.55	2.46	7.8	Fair coke
Forest of Dean ..	68.0	6.73	1.58	7.5	,,
Brown coal, Australia	48.0	12.78	8.22	23.0	Poor coke
Leicester ..	63.0	10.52	2.74	12.4	,,
Lancashire cannel	63.0	6.19	0.56	5.6	,,

In a large number of tests carried out by the author, the general conclusion arrived at is that if the yield of H_2O from the dry coal on distillation is more than 7 or 8 per cent., the coke produced is of an inferior character. There are a few exceptions to this generalisation; but, on the whole, it is quite a satisfactory guide. The majority of Scotch coals behave in a very peculiar way. If the coal be ground up and carbonised immediately, a good coke is obtained. If, however, it be allowed to be exposed to the air for any length of time, and, particularly, if it be in a finely-divided and moist condition, its coking power deteriorates very considerably. Indeed, the author has found that a coal which produces a good coke when treated immediately after grinding will scarcely cohere on being carbonised after a day or two's exposure, the reason probably being that the coals absorb oxygen from the air on exposure, and this view is borne out by the fact that the yield of liquor on distillation is greater after exposure than before. Consequently, it is important with such coals to take precautions against the effect of atmospheric exposure, and to carbonise the coal as soon as possible after it comes from the mine.

Many attempts have been made to convert non-coking into coking coals, but as far as the author is aware these attempts have not been commercially successful. It is possible, by the admixture of a quantity of pitch, to produce a passable coke from a poor coking coal, but this method is expensive and could hardly be carried out on a large scale. The deleterious effect of weathering on the coking property of coals has already been mentioned, but the change from a coking to a non-coking coal may be brought about by other very simple means. If a coking coal in a fine state of division is exposed to a temperature of about 200 deg. Cent. for, say, two hours, it is found that the coking power has practically disappeared. Coal under such conditions gradually increases in weight up to a certain maximum—the percentage increase varying with the class of coal—and then begins to decrease again. When the maximum weight is reached, the coking property is generally completely destroyed. In the case of the best classes of coking coal, these still retain a little coking power even after long heating. For each coal also there appears to be a limit or critical temperature, and when heated above this temperature the coking property is seriously impaired. For the ordinary classes of coking coals, such as those of South Yorkshire, this temperature is about 150 deg. Cent., but the effect is much more pronounced at 209 deg. Cent. The size of the coal carbonised has also a marked effect on the quality of the coke produced, especially with those coals which possess only moderate coking properties. The author performed experiments with a Scotch coal, divided into four portions, one through a 90 mesh, one through a 60 mesh, one through a 30, and one below 30. The samples were arranged in order in a distillation tube, and separated by a thin cotton-wool plug. They were then carbonised in the usual way. The resulting coke was different in each case, and the larger grain coal produced the best coke, the quality of the others deteriorating as the sizes decreased. With such classes compression of the charge is necessary in order to produce a suitable coke; and with compression it is possible to treat many such coals in coke-ovens which otherwise could not be so utilised.

Different coals behave in different ways when carbonised under the same conditions, and consequently the method of treating the coal has to be adapted to the particular class of coal to be dealt with. The average Durham coal is charged into the ovens in a normal state—that is to say, containing about 2.5 per cent. of moisture, and crushed to a degree of fineness of about $\frac{3}{8}$ in. to 0 in. The coal is not compressed in any way, and a good, hard dense coke is produced. The coke is of about the same volume as that of the coal, and no difficulty is experienced in pushing the coke from the ovens. In South Wales the coal is charged into the ovens in a similar way, but has a tendency to swell on being carbonised. Unless care is taken, therefore, the oven-walls might be damaged, and difficulty will also be experienced in pushing the coke from the ovens. In Cumberland still another variation is met with. There the coals contain about 30 per cent. of volatile matter, as against about 25 per cent in Durham, and 15 to 20 per cent. in South Wales. If the coal is charged into the ovens as in Durham, the coke produced is soft and friable, and will not stand much handling. In order to produce a harder and denser coke, the coal is compressed into the form of a cake containing about 10 per cent. of added moisture, and so charged into the oven. The coke obtained by treating the coal in this manner is quite suitable for furnace work.

Preparation of the Coal for the Ovens.—Most of the coal used in Great Britain for coking purposes is subjected to a washing operation before being carbonised, so as materially to reduce the ash content of the coke by separating the shale, and also to eliminate some of the sulphur compounds which occur in the coal, such as pyrites. With a coal of only moderate coking power a high ash content is undesirable, apart from other considerations, because it helps to nullify the caking power. With a first-class coking coal the ash content does not have much effect, coals containing as much as 30 to 40 per cent. of ash yielding quite a good class of coke. Sulphur is an undesirable constituent in metallurgical coke, especially in that used for foundry purposes. Coal in certain districts contains an appreciable amount of salt, and this should be removed as far as possible, as the salt eventually produces a corrosive effect on the brick-work inside the oven, causing it to crumble, and thereby necessitating frequent repairs. After washing, the coal is crushed so that it ranges in size from about $\frac{3}{8}$ in. down to 0 in., and it is then deposited in a storage bunker, where the excess of water is allowed to drain off. Two methods of charging the crushed coal into the ovens are employed—namely (1), from above, the coal passing

through the holes in the roof of the oven; and (2) through the door, the coal being fed into the oven in the form of a compressed cake. In the former case the charge is levelled in the oven by means of a beam, which travels backwards and forwards through the oven. The method of charging adopted depends upon the nature of the coal. Generally speaking, a coal containing above 25 per cent. of volatile matter has to be compressed, whilst coal with less than 25 per cent. is charged in the normal state. These methods are adopted with all types of ovens, as the principles of coking involved are the same in all cases.

Recovery of the By-Products.—Until about the year 1903 the method adopted on coke-oven plants for the recovery of the by-products was similar to that which is still in existence in gas works. The gas, after leaving the ovens, was passed through coolers, and its temperature reduced to about that of the atmosphere, thereby removing the heavier tars and also the moisture contained in the gas. The moisture which was deposited dissolved out of the gas a proportion of the ammonia salts which it contained. The gas was then passed through scrubbers, and was well washed with water until the whole of the ammonia was eliminated and obtained in the form of ammoniacal liquor. In order to recover the ammonia from this liquor it had to be treated in a separate apparatus, and was distilled with milk of lime. The ammonia gas liberated from the liquor passed into the sulphuric acid when sulphate of ammonia was formed.

Obviously this process is a roundabout one, as the ammonia is first dissolved in water and then expelled therefrom. In the Journal of the Iron and Steel Institute for 1883 there is an abstract of a paper by R. Tervet, in which he predicted the ultimate abolition of this system, and forecast what is known throughout the world as the direct-recovery process. It was not until about 1905, however, that the direct-recovery process was satisfactorily operated on a commercial scale. In this process the gas is passed directly into sulphuric acid, thus obviating the necessity of washing out the ammonia by means of water. Several types of direct-recovery process are now in operation, and the first to meet with commercial success was that designed by Mr. Koppers. This process has since been largely adopted, and at the present time deals with the gas from upwards of 20,000,000 tons of coal per annum. Strange to say, in spite of the marked advantages which this process offers over the old system, and the fact that it has been largely adopted on coke-oven plants in Great Britain, not a single gas works of any size in this country has yet discarded the old system in favour of the new one. A start has, however, been made on the Continent, and at the new works of the city of Budapest the Koppers process is in operation, dealing with the make of 9,500,000 cub. ft. of gas per day.

The illustration (Fig. 6, page 459) shows a diagrammatic representation of the Koppers system. The hot gas direct from the ovens enters the coolers, where its temperature is reduced to about 25 deg. Cent. The gas is then drawn by an exhauster, by which it is delivered to the tar extractor. After having been freed from the tar, the gas is led into the reheater, where it becomes heated to a temperature of about 50 deg. to 60 deg. Cent. The heated gas is then conducted along the main, to the saturator, in which the ammonia gas is extracted by direct absorption in sulphuric acid, and is recovered in the form of sulphate.

The saturator is of the totally-enclosed type, and the sulphate is continuously removed therefrom by means of an ejector working either with steam or compressed air. The salt is delivered on to a collecting-table, and thence into a centrifugal dryer, where it is completely freed from mother-liquor.

The products of condensation which are extracted in the cooling and tar-eliminating operations are drawn off from the condensers, tar-extractors, &c., and are conveyed into a separating-tank, where the tar and ammoniacal liquor separate owing to their different densities. The tar flows into one storage-tank, and the liquor into the other tank. The liquor is pumped to the ammonia-still, where the ammonia is driven off by steam and lime in the usual way. The vapours of distillation are conducted from the still, and are delivered into the main, where they mix with the heated gas, and the whole then passes into the saturator.

It is important to note that no live steam is required in the process, either for distilling the liquor to liberate the ammonia, or to reheat the gas after cooling and tar-extracting. For both these purposes the exhaust steam from the engines driving the exhausters is more than sufficient. The gas passes out of the saturator by a main, by which it is conducted back to the ovens and other points where required. In cases where benzol is required to be recovered it is necessary for the gas to be cooled down after leaving the saturator, after which it is subjected to the scrubbing operation described below.

The sulphate produced by the above process is far superior to that obtained by the old system, and owing to the fact that the gas is thoroughly free from tar before entering the saturator a perfectly white salt is invariably produced. This portion of the paper would not, however, be complete without reference to the latest type of ammonia-recovery systems of Burkheiser and Feld. Crude coal-gas, as it leaves the ovens, contains sulphur in the form of sulphuretted hydrogen. Now sulphur is the basis of sulphuric acid, and the ideal process is therefore one which will utilise the sulphur in the gas to combine with the ammonia instead of having first to convert it into acid and then neutralise it by the ammonia to form sulphate of ammonia. It is this shortening of the process which is the object of both the Feld and Burkheiser systems. At present both these systems seem to be somewhat too complicated for general adoption, but the author believes that ultimately such a process will obtain.

The recovery of benzol has received much attention of late, owing to the fact that a large quantity of refined benzol is now being used in place of petrol as fuel for motor-engines. The majority of coke-oven plants now have benzol-recovery plants, but very few produce refined spirit, what is known as "crude" or "65 per cent." benzol being generally made.

The benzol can be extracted from the gas without affecting the amount of energy obtained from it when used for boiler-firing purposes, or for combustion in gas-engines, by more than about 5 to 10 per cent. The quantity of benzol obtainable differs, of course, according to the nature of the coal. In South Yorkshire, Derbyshire, the Midlands, and Cumberland the yield is about 2½ to 3 gallons of crude spirit per ton of coal; in Durham it is about 2 to 2½ gallons, whilst in South Wales it is usually only about 1 to 1½ gallons.

The recovery of benzol from coke-oven gas is now universally effected by means of absorption in creosote oil—a product obtained in the distillation of coal-tar—and the difference between the various systems on the market lies principally in the internal arrangement of the apparatus employed, and the temperature and steam-pressure at which the various parts are worked. In some cases rotary washers are substituted for the tower scrubbers mentioned in the following description.

The method employed for the recovery of benzol consists of the following stages:—After passing through the saturators the ammonia-free gas is conducted to final coolers, where the temperature is reduced to a degree required for the efficient extraction of benzol. The cooled gas then enters a series of tower scrubbers, inside of which are a number of boards, in order to ensure an even distribution of the scrubbing oil and complete extraction of the benzol. The oil is circulated by means of pumps, and is fed into the scrubbers at the top through sprays. The oil flows in counter-stream to the gas, and by the time the gas has passed through all the scrubbers the benzol is completely extracted from it. The enriched oil containing the benzol passes to a storage tank, whence it is pumped into a preliminary heater, where its temperature is raised to about 60 deg. Cent. It then goes to the superheater, where it is heated to a temperature of about 135 deg. Cent., after which it runs over into the still. By means of live steam the whole of the benzol is driven off, the debenzolised oil then flowing out at the bottom of the still. This weak oil is cooled, and used again for scrubbing purposes.

The benzol vapours, together with some water vapour, leave the still and enter a heat-exchanger. In this apparatus the heat contained in the vapours is transmitted to rich oil, and the vapours are thereby cooled down considerably, led into a final cooler, and condensed to the liquid form. The benzol and water thus obtained pass to a separator, where, by reason of the difference in specific gravity, the two are entirely dissociated. The benzol so obtained is known as crude spirit, and is usually of about 65 per cent. strength. When a refinery is available, the crude benzol is not produced higher than 50 to 60 per cent. Up to this point the process is continuous, and can proceed without interruption for any length of time, a little fresh scrubbing oil being added occasionally and some of the old oil removed.

If it is desired to produce a refined spirit, it is necessary to submit the crude benzol to processes of redistillation and purification. The crude spirit runs from the separator into a storage-tank, and from thence is pumped into a still of large capacity. This is heated by means of steam-coils. The benzol vapours pass into a dephlegmator, in which separation of the various constituents takes place owing to the different temperatures at which they boil. In order to produce the higher boiling homologues of benzol, further distillation under a partial vacuum by means of live steam is resorted to. The vapours leaving the dephlegmator are condensed and run into the various tanks. The products so obtained are benzol, toluol, xylol, &c., and each of these is now heated separately in order to produce a refined spirit. A pump delivers the spirit to an agitator, where it is washed with sulphuric acid. After allowing an interval for separation, the acid is run off, and the spirit is treated with caustic soda and finally with water. By finer dephlegmation and slower distillation in another still the washed spirit is fractionated, and the products known as 90 per cent. benzol, 90 per cent. toluol, solvent naphtha, &c., are obtained. In order to produce pure benzol, toluol, &c., for chemical purposes, further fractional distillation is necessary, but these products are seldom, if ever, manufactured in coke-oven plants.

In the stills from which the crude benzol is first redistilled a certain quantity of hydrocarbons, consisting mainly of naphthalene, settles out and is brought to a centrifugal machine and dried. The oily matter remaining is run back into the scrubbing oil and used for scrubbing purposes.

The sulphuric acid used for washing the crude spirit can, after a time, no longer be used for that purpose. It is run into lead-lined pots and heated by live steam, thereby being freed from hydrocarbons. The cleaned acid is then used in the saturator for the manufacture of sulphate of ammonia.

Fig. 7. TEMPERATURES AT THE REGENERATOR OUTLETS.

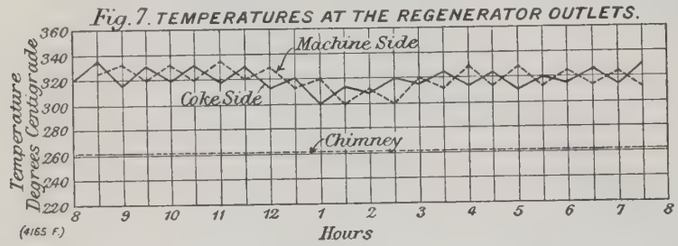


Fig. 8. TEMPERATURES IN THE REGENERATORS.

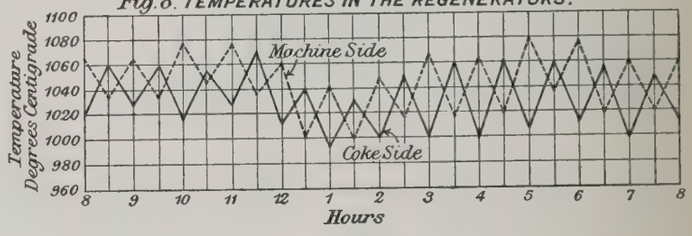
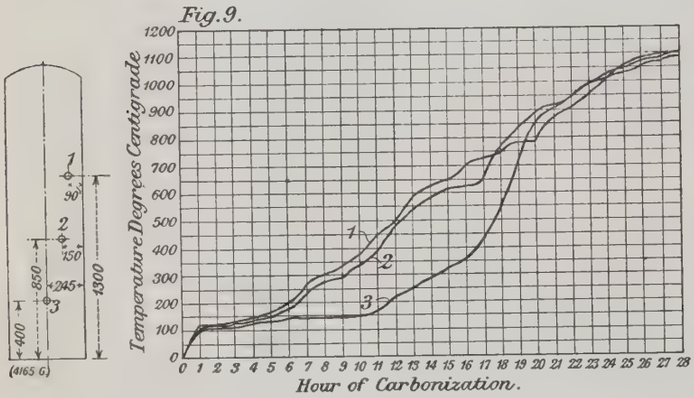
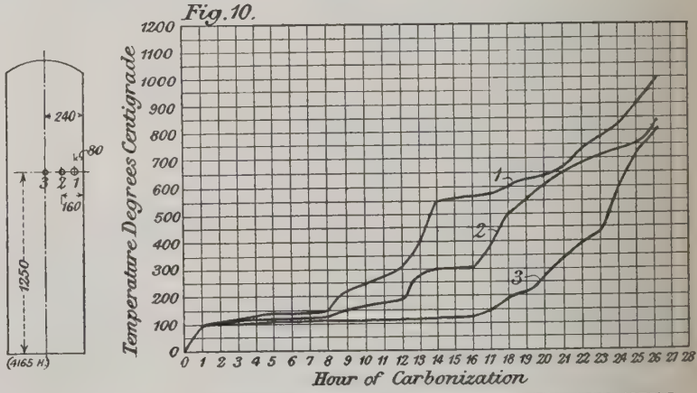


Fig. 9.



Temperature in Top Horizontal Flue 1130°C.
Moisture in Coal 12 per Cent.

Fig. 10.



Temperature in Top Horizontal Flue 1060-1070°C.
Moisture in Coal 15 per Cent.

Use of Coke-Oven Gas in Iron and Steel Works.—Coke-oven gas is now very largely used as a fuel in iron and steel works, but the author prefers to leave detailed statements with regard to the suitability of coke-oven gas for this purpose to those engaged in its employment. There is no doubt, however, that the use of coke-oven gas is increasing very rapidly indeed, and the tendency is becoming more and more pronounced for iron and steel works to manufacture their own coke and utilise their own coke-oven gas in the steel works.

Coke-oven gas has been used in open-hearth furnaces with great success, in some instances practically replacing the whole of the coal formerly used. At the Hubertushütte in Germany, figures quoted by Mr. Amende show that although the durability of bulkheads and roofs decreases 8 to 10 per cent. when using coke-oven gas, that of the chequers increases about 50 per cent. This is in general accord with the experience at other installations, and in an appendix to the paper reference is made to the effect of the coke-oven gas on the life of the furnace at Friedrich Wilhelmshütte. At the Hubertushütte 550 to 660 heats were run before it was necessary to repair the bulkheads and roofs, and as high as 1050 on the same chequers. The quality of the steel was not affected at all—a point which is particularly emphasised in the statement of the working results at Friedrich Wilhelmshütte. The consumption of coke-oven gas was about 2,000,000 cub. ft. per twenty-four hours, and the coal consumption per ton of steel was reduced from 31.8 to 14.9 per cent. by the use of coke-oven gas. In this instance the coking coal was only of poor quality, no more than 45 per cent. of surplus gas being available. According to another authority, coke-oven gas, with a calorific value of 500 British thermal units per cubic foot, will displace coal as a fuel for various furnaces in the following ratios:—In billet-heating furnaces 1000 cub. ft. of gas displace 64 lb. of coal used in gas-producers; in rod-mill heating furnaces 1000 cub. ft. of gas displace 58.9 lb. of coal used in gas-producers; in bolt-rod heating furnaces 1000 cub. ft. of gas displace 67 lb. of coal fired direct. In the foregoing ratios the coal displaced contained 8.5 per cent. of moisture, and evaporated 5.8 lb. of water per pound of coal when fired under boilers. In ingot-heating furnaces, 48 ft. long, no trouble has been experienced in obtaining a uniform temperature throughout the entire length of the hearth. The gas is introduced at each end of these furnaces, and the air is preheated by regenerators. An average temperature of 1425 deg. Cent. (2600 deg. Fahr.) is maintained with an average gas consumption of 1700 cub. ft. per ton of metal heated.

In a communication from the Dominion Iron and Steel Company, Limited, of Canada, the author is informed that the surplus gas from the coke-ovens of the company is used entirely in the steel department. One hundred tons of lime per day for use in basic Bessemer and open-hearth furnaces is burnt, and the mixer into which all the iron from the blast-furnaces is put before going to the steel plant is entirely heated by coke-oven gas. The dolomite for open-hearth and Bessemer work is calcined by coke-oven gas, and all ladle drying is done by the same means. Coke-oven gas is also used to a certain extent in reheating ingots before rolling, but this is not constant practice. Any surplus gas not required for the above purposes is used in the open-hearth furnaces for steel-melting. The calorific value of the gas is about 525 British thermal units per cubic foot, benzol not being extracted. The communication further states: "There is no question but that the greatest economy possible in steel works practice is through the general adoption of by-product coke-ovens, and not the least of these is in the proper utilisation of the large quantities of surplus gas." In this connection it will be remembered that the President of the Institute, Mr. Adolph Greiner, emphasised particularly, in his presidential address at the May meeting, the enormous economies possible through by-product coke-ovens and the great opportunities for the development of the by-product industry.

In conclusion, the writer hopes that he has succeeded in emphasising the importance of the by-product coking industry in connection with iron and steel works, and that the information contained in the paper will be of some little assistance to those who have under contemplation schemes for utilising their blast-furnace gas, and of linking up more closely the coke-oven industry with the manufacture of iron and steel.

APPENDIX I.

At the Friedrich Wilhelmshütte, Dr. Rudolph Biermann has carried out a number of experiments on a battery of combination ovens, part of which was being heated by coke-oven gas and part by blast-furnace gas. The capacity of the ovens is about 8.05 tons of dry coal; uncompressed coal is used, charged into the ovens from above, and it has been found that with coke-oven gas the time of carbonisation per charge is 29 hours, and with blast-furnace gas 27 hours. Dr. Biermann explains this in the following way: To produce 1000 calories, 0.24 cub. m. of coke-oven gas is required, or 1.007 cub. m. of blast-furnace gas; the volumes of the waste gases respectively produced are 1.28 and 1.88 times these volumes. The greater volume effects a better distribution of the heat, and therefore gives more even heating of the oven. Further, although producer-gas gives a greater amount of waste gas reckoned per 1000 calories, on account of its specific heat, 0.58 less heat is lost through the chimney than is the case with coke-oven gas with a specific heat of 1.75. A complete account of Dr. Biermann's investigation appeared in the *Gas World* (Coking Section), June 6, 1914, and the above tables are taken from this publication.

Various opinions have been expressed with regard to the effect of the coke-oven gas on the steel, but at Friedrich Wilhelmshütte no deleterious effect has been noticed. The life of the furnace, too, has been found to be increased by about one-third with coke-oven gas as compared with producer-gas, and the following is Dr. Biermann's recommendation of blast-furnace gas for heating coke-ovens:—

"In addition to the great economical advantage accompanying the use of blast-furnace gas, it is also to be preferred from the practical point of view. Stoppage of the gas-mains through naphthalene or tar is avoided. On account of the flameless combustion, choking of the jets, such as occurs easily with coal-gas, is impossible, and therefore the troublesome regular cleaning of these is not necessary. The formation of hot local flames, and thereby the disintegration of the fire-brick material, is avoided, and depositions of dust in the chambers and heating-flues has not occurred."

TABLE I.—*Comparison of Heating Gases.*

Composition.	Coke-Oven Gas. Volume.	Coke-Oven Gas. 1 Cub. M. Contains	Coke-Oven Gas. Weight.	Coke-Oven Gas. Calorific Value.	Blast-Furnace Gas. Volume.	Blast-Furnace Gas. 1 Cub. M. Contains	Blast-Furnace Gas. Weight.	Blast-Furnace Gas. Calorific Value.
	p.c.	grms.	p.c.		p.c.	grms.	p.c.	
H_2 ..	53.50	47.20	9.04	1637	1.00	0.89	0.007	30.6
CH_4 ..	23.50	166.85	31.95	2251	—	—	—	—
CO ..	4.60	57.50	11.05	141	29.60	370.20	28.79	905.76
$C_n H_m$	1.00	12.50	2.40	270	—	—	—	—
CO_2 ..	2.60	50.95	9.80	—	7.40	145.70	11.21	—
N_2 ..	14.80	185.00	35.76	—	62.00	775.50	60.00	—
Total..	100.00	520.00	100.00	4200	100.00	1291.79	100.00	936

TABLE II.—THEORETICAL COMPARISON OF THE WASTE GAS.

Composition.	1 Cub. M. Coke-Oven Gas + 25 per Cent. Excess Air = Waste Gas at Oven Temperature. Volume.	Grammes.	Volume	Weight	1 Cub. M. Furnace Gas + 25 per Cent. Excess Air = Waste Gas at Oven Temperature. Volume.	Grammes.	Volume.	Weight.
	per cent.		per cent.	per cent.	per cent.		per cent.	per cent.
CO_2	327.00	652.70	6.04	9.94	370.00	739.50	21.04	29.90
O_2	197.40	282.20	3.65	4.18	38.00	54.20	2.15	2.19
N_2	3860.50	4825.60	71.35	73.34	1340.90	1676.10	76.25	67.58
H_2O	1025.00	820.00	18.96	12.54	10.00	8.00	0.56	0.33
CO	—	—	—	—	—	—	—	—
Total	5409.90	6580.50	100.00	100.00	1758.90	2477.90	100.00	100.00

TABLE III.—*Comparison of the Waste Gas.*

Composition.	Coke-Oven Gas. Obtained Volume.	Coke-Oven Gas. Calculated Volume.	Blast-Furnace Gas. Obtained Volume.	Blast-Furnace Gas. Calculated Volume.
	per cent.	per cent.	per cent.	per cent.
CO_2	7.20	7.45	19.80	21.10
O_2	5.40	4.45	1.20	2.22
CO	—	—	—	—
N_2	87.40	88.10	78.00	76.68
—	100.00	100.00	100.00	100.00

TABLE IV.—*Draught Measured in Millimetres Water Gauge.*

Draught In	Coke-Oven Gas Heating. Coke Side.	Coke-Oven Gas Heating. Machine Side.	Blast-Furnace Heating. Coke Side.	Blast-Furnace Heating. Machine Side.
Regenerator	1½-2	2-2½	3½	4
Exit pipe ..	10-12	12-14	10-12	12-14
Chimney ..	56		52	

TABLE V.—*Temperature in the Heating Flues.*

Oven Number.	Blast-Furnace Gas Heating.	Coke-Oven Gas Heating.
51	1200	1170
52	1285	1180
53	1250	1220
54	1230	1220
55	1250	1230
56	1225	1180
57	1240	1250
58	1250	1230
59	1240	1180
60	1300	1210
61	1260	1200
62	1220	1175
63	1275	1220
64	1260	1210
Average ..	1253	1200

TABLE VI.—*Tabulated Comparison of the Values of Coke-Oven and Blast-Furnace Gas.*

—	Coke-Oven Gas.	Blast-Furnace Gas.
Gross calorific value of the gas ..	4200 calories	936 calories
Calorific value of 1 cub. m. gas and air mixture	880 ,,	541 ,,
Calorific value with 25 per cent. excess air	740 ,,	490 ,,
Specific heat of the waste gas ..	1.75 ,,	0.58 ,,
Air taken up by 1 volume of gas ..	3.76 volumes	0.73 volumes
Air taken up with 25 per cent. excess air	4.70 ,,	0.91 ,,
Volume of waste gas for 1 cub. m. gas	5.4 ,,	1.76 ,,
Heating gas per 1000 calories required	0.238 cub. m	1.067 cub. m.
Yield of waste gas per 1000 calories	1.28 volumes	1.88 volumes

APPENDIX II.

Detailed information concerning what goes on inside the coke-oven during the carbonisation of the charge of coal is naturally difficult to obtain. The writer has pleasure in reproducing two temperature charts embodying results obtained in a Koppers coke-oven plant. Pyrometers were inserted at different points in the charge of coal, numbered 1, 2, and 3 respectively (Figs. 9 and 10). Temperature measurements were taken every hour throughout the whole of the time of carbonisation, and the curves reproduced indicate the temperatures obtaining at different points during the period. The marked effect on the temperature of an increase of 3 per cent. in the moisture content of the coal will be noted.

MENDING MALLEABLE CASTINGS.—The *Iron Age* gives the following method of mending malleable castings. The fracture is chipped away in the form of a V-groove, and the part surrounding the fracture is then heated with an oxy-acetylene torch to a bright red and sprinkled with a bronze flux, followed by a few drops of Tobin bronze melted from the welding-rod. If the bronze remains in a little globule, the work is not hot enough; but if it spreads and adheres to the surface, the temperature is right, and the groove should be quickly filled, and at as low a temperature as possible.

TRANSACTIONS OF THE INSTITUTION OF NAVAL ARCHITECTS, 1914.—Mr. R. W. Dana, the Secretary of the Institution of Naval Architects and editor of the Transactions of the Institution, is to be congratulated, not only on the accuracy with which the Proceedings of the Institution have been prepared for publication, but also on the promptitude with which the volume of this year has been published. The Institution very properly prides itself on the quality of the work in the volume, and particularly in so far as it affects the reproduction of the extensive diagrams. This year there are thirty-one folding plates, and the volume itself extends to 394 printed pages. It is enhanced by a portrait of Dr. S. J. P. Thearle, one of the Vice-Presidents of the Institution, whose name is prominent in the obituary roll of the year. The proceedings of both the spring and summer meetings are included in this one volume, and it is a remarkable fact that many of the papers bear a very direct relation to the present crisis. For instance, there is much regarding the design of warships and the relationship of design to modern strategy and tactics. In the variety of the subjects dealt with the year's volume comes up to the best records, and we note that in many cases there are included written communications, in addition to the discussions which took place at the meetings. Such written communications are not obtainable except in the Transactions of the Institution.

BUSINESS LIFE.—One by one the various occupations are being systematised and organised by the professor, the last to be dealt with being that of buying and selling. Already, however, colleges exist solely for giving instruction in commercial matters, and universities even grant academic degrees testifying to the candidates' knowledge of the principles underlying finance and exchange. At Birmingham there is a course on business designed specially for engineers, a class who hitherto have had to trust to their native sense when they stepped outside their technical pursuits. On all hands the attempt is being made to put business on a more scientific footing, and to instruct the younger men in the principles by which efficiency can be attained. A book now before us is a modest contribution to the same end. It deals, however, more with the subject of character and behaviour than with methods, and would scarcely fall within the scope of our columns were it not that the position of its author, Mr. W. J. Parkins, as director and secretary of Tangyes, Limited, Birmingham, is a useful reminder that technical knowledge does not count for everything with the officials of a modern go-ahead firm. The book comprises five chapters, addressed respectively to the office-boy, to the clerk, to the departmental chief, to the secretary, to the chairman, the managing director, and the director, in addition to an introductory chapter and one on the principles of business. Each chapter is replete with common-sense and full of good advice, dealing largely with conduct and motives. The business world would be the better if this advice were taken to heart, not alone by the office-boy, but also by those above him, for the commercial magnate sometimes needs to be reminded that buying cheap and selling dear does not represent the whole duty of man. The book is published by Messrs. H. R. Allenson, Limited, of Racquet-court, Fleet-street, E.C., at the price of 1s. net.

CATALOGUES.

Wood-Working Machinery.—A small sectional catalogue of mortising and boring-machines, "drunken" saws, and saw-benches has been issued by the Carron Company, of Carron, Stirlingshire.

Bolts, Nuts, Studs, &c.—We have received from Messrs. James Wiley and Sons, Limited, of Eagle Works, Darlaston, a copy of their latest price-list of black and bright bolts, nuts, studs, washers, set-screws, spanners, &c. Useful tables showing the weight of bolts and nuts per gross and the number per hundredweight are also included.

Machine-Tools. — The Judson-Jackson Company, Limited, of 50, Marsham-street, Westminster, S.W., have sent us a copy of their monthly list of machine-tools in stock. The list includes lathes, milling-machines, drilling-machines, grinding-machines, cold saws, and other tools, as well as chucks, vices, &c. Prices are stated in all cases. The lists are issued in various languages for distribution abroad.

Steam-Hammers.—Messrs. Davy Brothers, Limited, of Park Iron Works, Sheffield, have sent us a copy of their latest catalogue of steam-hammers for smith-work, forging, and other purposes. Particulars are given of hammers of the overhung frame type, with and without slides, in sizes ranging from 2 cwt. to 40 cwt., and of double-arch frame hammers from 2½ cwt. to 40 cwt. The catalogue also deals with a special type of hammer for steel tilting, and illustrates examples of hammers with riveted steel standards, stamping-hammers, and tyre-becking hammers.

Electric Winches.—A very attractive catalogue containing specifications and prices of worm-geared and spur-geared electric winches has reached us from the London office of the Sunderland Forge and Engineering Company, Limited, 31, Budge-row, Cannon-street, E.C. The catalogue was accompanied by a list of ships on which these winches have been installed. We understand that a large number of these machines have been supplied to home and foreign dockyards for hauling purposes, and that they are also used for pile-driving.

Oil-Filters.—Messrs. A. C. Wells and Co., 102 to 104, Midland-road, St. Pancras, N.W., have sent us a new list of their filters for waste oil. The list illustrates and describes the principle of these filters, which are too well understood by engineers to require any explanation here. Prices and particulars are then given of six standard sizes capable of treating from 2 to 250 gallons of oil per week; much larger filters, with capacities up to 500 gallons a day, can, however, be supplied. Prices are also quoted for cylindrical and rectangular tanks and cabinets for storing lubricating oils.

Steam-Engines and Boilers.—Messrs. Marshall, Sons and Co., Limited, of Gainsborough, have sent us a copy of an attractive pamphlet they have issued to illustrate some of the special engines and boilers they have constructed for educational purposes. The illustrations show experimental engines they have supplied to the Heriot-Watt College, Edinburgh; the Municipal School of Technology, Manchester; the Polytechnic Institute, Regent-street, London; the Darlington Technical College; the Poona College, India; the University of Hong Kong; and several other important institutions. General particulars are given of all the installations, and the special features of each are pointed out.

Double-Helical Gearing.—Two small pamphlets issued by the Power Plant Company, Limited, of West Drayton, Middlesex, deal with the use of their double-helical gears in connection with machine-tools and motor-cars respectively. The first pamphlet deals generally with the application of the gears to machine-tool drives, and illustrates examples of lathes, boring-machines, milling-machines, and other tools on which they are employed. It also gives rules and data for determining the sizes of gears, dimensions of teeth, &c. The other pamphlet, relating to motor-car work, also gives the necessary data for determining the sizes of double-helical spur-gears; it also refers to the use of double-helical bevel-gears for back axles.

Hydraulic Machinery, Cranes, &c.—The Leeds Engineering and Hydraulic Company, Limited, of Oaklands Works, Rodley, near Leeds, have sent us an attractive loose-leaf catalogue of hydraulic machinery, cranes, &c., constructed by them. Illustrations and specifications are given of hydraulic-pressure pumps driven by belt pulleys, steam-engines, or electric motors, and also of hydraulic accumulators, intensifiers, stationary and portable riveting-machines, flanging and forging presses, bending-machines, wheel-presses, and other hydraulically operated machine-tools. Particulars are also given of hydraulic cranes, electric cranes and hoists, electric traversers, and electric winches and haulage gears.

Pumps.—Messrs. Dawson and Downie, of Elgin Works, Clydebank, Scotland, have recently issued a catalogue of marine pumps. The catalogue is divided into three sections, of which the first relates to Dawson direct-acting boiler-feed pumps, ballast-pumps, air-pumps, and combined air and circulating pumps. The next section deals with vertical and horizontal duplex pumps for boiler feeding, ash-ejector work, ballast-pumping, hydraulic service, and general purposes, while the last section includes vertical steam-driven fire and bilge-pumps, air-pumps, and combined air and circulating pumps of the crank type. The catalogue, which is nicely printed and well illustrated, gives full particulars of all the standard sizes made of each type of pump. It is also fully coded, to facilitate inquiries.

Engineers' Sundries. — Messrs. Wallach Brothers, Limited, Royal London House, Finsbury-square, E.C., have issued a new catalogue of goods made or sold by them. The articles included in this catalogue are so numerous, and of such a varied nature, that we cannot possibly mention them all, but in looking through its pages we noticed pressure-gauges, stop-valves, gauge-glasses and protectors, steam-traps, oil-filters, machine-tools and accessories, hoists, jacks, safety-helmets and face-masks, respirators, eye-protectors, fire-fittings and appliances, rubber goods, power-transmission accessories, small tools, forges, spraying-machines, pumps, and many other articles. The catalogue is very fully illustrated, and prices are stated for all the goods listed. It is also provided with a good general index, so that it will doubtless be found very useful to engineers and others.

Forging-Machines.—A catalogue of Ryder forging-machines has reached us from Messrs. Thomas Ryder and Son, Limited, of Turner Bridge Iron Works, Bolton. These machines are too well known to require a general description here, but we may, perhaps, remind our readers that they are of the type in which the upper swages are operated by a rapidly-rotating eccentric shaft, while the lower swages are raised as required by means of screws and wedges. A power elevating motion has recently been applied for the purpose of raising the bottom swages, and this device greatly increases the usefulness and efficiency of the machine. The catalogue illustrates and briefly describes the construction of the machines, and gives a general specification and instructions for working them. Full particulars of the different sizes made are also given, and some examples of work done are illustrated. Hot-sawing machines and coke-breaking machines are also dealt with in this catalogue.

Acid-Resisting Iron Vessels.—We have received from the Lennox Foundry Company, Limited, Tantiron Foundry, Glenville Grove, New Cross, S.E., a catalogue giving particulars of an acid-resisting alloy known as "Tantiron," and illustrating examples of vessels and apparatus made of this alloy. "Tantiron," it is stated, does not rust or oxidise, and is not attacked to any significant extent by any ordinary corrosive chemical. Its resistance to corrosion is said to be 1000 times greater than that of ordinary cast iron, so that, although "Tantiron" costs about four times as much as cast iron, a very great economy is effected by its use. "Tantiron" is lighter and not so strong as cast iron, but is some 60 per cent. harder, so that it offers considerably more resistance to erosion. With a few precautions, which are mentioned in the catalogue, it can be cast into any form, and can be machined with very little difficulty. The catalogue illustrates examples of nitric-acid plant, sulphuric-acid plant, nitrating vessels and other plant for the manufacture of explosives, as well as pumps, cocks, valves, pipes and pipe-fittings, pans, basins, dishes, and other vessels made of this very useful alloy.

Steam-Turbines.—Messrs. R. S. Price, Limited, 12, Norfolk-street, Strand, W.C., have sent us a catalogue illustrating and describing the construction of the "Iona" steam-turbines, and giving particulars of the various sizes made. These turbines are of the single-wheel impulse type, and the steam is first expanded in one or more divergent nozzles down to the pressure of the exhaust. After passing through the blades in an axial direction, the steam enters a U-shaped guide-passage, which directs it back again on to the wheel, so that it passes through the blades in the opposite direction. It then enters another guide-passage, which directs it on to the wheel for a third time, and it finally passes away to the exhaust. The number and type of nozzles used, of course, depend on the conditions under which the turbine is to run. They may be constructed so that the ratio of the areas of the throat and outlet can be varied, or they may be provided with a throttle-valve, for the purpose of varying the speed and output of the turbine. The sizes listed have outputs ranging from about 2 to 240 horse-power. They are suitable for direct coupling to centrifugal pumps, fans, blowers, electric generators, &c., as well as for driving machinery by belts.

Cascade Induction Motors.—From Messrs. Sandycroft, Limited, of Chester, we have received a catalogue giving prices and full particulars of their single-speed cascade induction motors. In these motors, which are made under Hunt's patents, the windings are equivalent to those of a pair of ordinary induction motors connected in cascade, so that the starting resistance can be connected to the stator windings instead of to the rotor. The use of slip-rings is thus avoided, and the motor has the high starting torque and speed-regulating properties of a slip-ring motor, combined with the simplicity and robustness of a motor of the squirrel-cage type. Cascade motors are thus especially suitable for rough work in dusty situations; they have been extensively adopted for mining work. Another important advantage is that, owing to the special type of winding adopted, cascade motors can be made for slow speeds much smaller in diameter than ordinary induction motors. The catalogue briefly describes the principles involved, and gives a general specification covering the construction of the machines. The remainder of the catalogue is occupied by tables of prices, weights, and other particulars of three-phase 50-cycle motors with 12, 18, 24, and 30 poles, and with capacities varying from 5 to 960 horse-power. Prices for bed-plates, slides, bolts, pulleys, flexible couplings, and liquid starters are also mentioned.

Steel Works Plant.—An interesting catalogue, illustrating and describing examples of fixed and tilting open-hearth furnaces, metal-mixers, and reheating furnaces recently constructed by Messrs. Wellman, Seaver and Head, Limited, of 47, Victoria-street, Westminster, S.W., has come to hand from this firm. The catalogue was practically completed before the outbreak of the war, and it is interesting to note that the plant illustrated has in several cases been supplied to works in places which have figured prominently in the war news. For instance, one furnace and charging-machine illustrated was supplied to Messrs. Japy Frères at La Fére, and an installation of rolling-furnaces at the Aciéries de Longwy is also shown. A metal-mixer supplied to the Espérance Company, Louvroil, near Maubeuge, is another instance of this kind. We also notice that the firm obtained orders for tilting-furnaces from German and Austrian works, including the Dortmunder Union and Messrs. Krupps, although those at the latter works were not completed at the time the war broke out. Among much other interesting matter, all of which is printed in both English and French, may be mentioned a brief article setting out the special advantages of tilting-furnaces. Among these advantages it is claimed that time is saved in making and breaking tap-holes, the furnace can be more fully charged and tilted backwards during the boil, fettling is done more quickly, there is less cooling of the furnace between charges, the excess of slag can be removed or changed if required, and the top metal, which is hottest, is poured first, so that there is less "skulling."

Drying-Machines.—A pamphlet illustrating and describing Ruggle's patent rotary drying-machines has been issued by the Drying Department of Electro-Metals, Limited, 9½, Union-court, Old Broad-street, E.C. These machines can be used for all kinds of materials, and several different types and patterns are made. They are, however, generally constructed on the following principles: Two concentric cylinders supported on friction-wheels, in a position slightly inclined to the horizontal, are made to rotate slowly about their longitudinal axis by means of gearing. The material to be dried is fed into the space between the two cylinders at the upper end, and during its passage through the machine it is picked up by pockets formed on the internal surface of the outer cylinder, and dropped several times on to the outer surface of the inner cylinder, which is also provided with pockets. The inner cylinder is connected at its upper end to a furnace, the hot gases from which are drawn through the machine by means of a fan. They first pass through the inner cylinder and then back again through the space between the inner and outer cylinders, so that on their return journey they come into direct contact with the material to be dried. The temperature of the gases is, of course, considerably reduced during their passage through the inner cylinder, but in order to cool them still further they are mixed with cold air, which is allowed to enter at the lower or outlet end of the machine. In this way the temperature of the gases is reduced to about 250 deg. Fahr. before they come into actual contact with the drying material, and their final exit temperature is only about 100 deg. Fahr. It is pointed out that with this construction the cold, wet material first comes into contact with the hottest part of the inner cylinder, so that the water is rapidly evaporated, and the vapour produced is quickly carried off. Also, radiation losses are very slight, because the temperature of the outer cylinder is low, and very little heat is carried off by the dried material, since the latter is cooled by the incoming cold air. It is claimed, in fact, that the actual over-all thermal efficiency of the machine is 75 per cent.; that is to say, 75 per cent. of the heat in the fuel supplied to the furnace is usefully employed. The pamphlet fully describes the construction of these dryers, and gives particulars of the different sizes made. It also illustrates portable and semi-portable drying-plants, and other types of drying-machines for use with materials, which would be injured if allowed to come into direct contact with the products of combustion. A steam-heated drying-machine for brewers' grains, cotton-seed, corn germs, and other organic materials is also dealt with.

Canal Finance.—The half-yearly meeting of the Leeds and Liverpool Canal Company was held at Liverpool on Friday, September 18, Mr. W. E. Willink presiding. The chairman said the results of the past half-year's working were not good. The losses in receipts—almost entirely in freights—in comparison with the corresponding period of last year, were 4655*l.* There had been, however, a saving in expenditure of 2454*l.*, the net decrease being thus 2201*l.* The company's old enemy, drought, had begun to make itself felt, and their traffic had been stopped over the summit, but heavy rain had fallen, and they had been able to resume their ordinary services. Mills and works were closed owing to the war, partly from financial difficulties, partly from want of men, and partly because of the difficulty of obtaining raw materials. The time before the company had, accordingly, much anxiety in store.

German and Austrian Exports of Firebricks, &c.—Germany exports firebricks, crucibles, &c., to the amount of about 644,000*l.* per annum, while Austria-Hungary's exports of this class amount to about 248,300*l.* Of these exports, goods to the value of over 30,000*l.* come to Great Britain, the principal class comprising Dinas, magnesite, bauxite, and graphite bricks, weighing up to 5 kilos. each. These represent nearly two-thirds of the total value of these imports from the two countries, the bulk coming from Austria-Hungary. In Colonial and neutral markets, Germany's trade in small and large firebricks is very considerable. Russia is her largest purchaser, buying to the value of about 150,000*l.* In some parts of Russia our trade is decreasing and Germany's increasing. Recent reports state that the attempt has been made by German firms to secure Russian trade by imitating the marks of well-known Scotch brands. France buys firebricks from Germany to the value of nearly 129,000*l.* per annum. Belgium is also a good market, taking to the value of about 79,000*l.* Austria's principal customers are Russia, France, and Italy.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

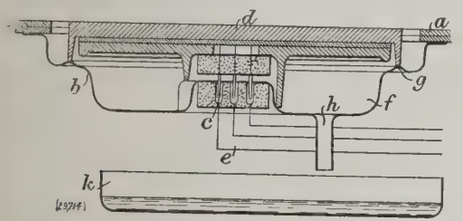
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

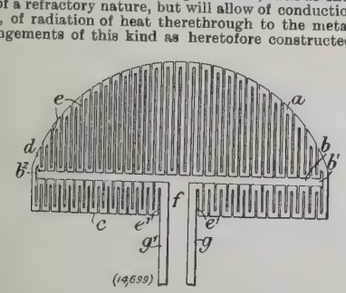
ELECTRICAL APPARATUS.

29,714/13. Firm Siemens-Schuckertwerke, G.m.b.H., Berlin, Germany. Electric Cooking-Stoves. [1 *Fig.*] December 28, 1912.—The heating-plates of cooking-stoves in certain cases are fixed, whilst in others they are removable. In the latter type of stove the heat losses are less than in the former, and further the heating elements are more easily repaired. Some cooking-stoves have removable heating-plates supported by the top plate, the provision of a channel for collecting any liquid which may boil over having been proposed in connection with such stoves. In the majority of cooking-stoves having removable heating-plates, these plates are not supported by the top plate, but by bridge-shaped carriers or supports arranged beneath the opening provided for the heating plate. In this case the current-supply leads must be specially protected against wet, dirt and mechanical damage caused by the dropping of articles through the apertures when the heating-plates have been removed. To reduce this possibility, the bridge-pieces have been so formed as to form covered conduits for the accommodation of the current-supply leads. The invention consists in an electric cooking-stove in which the removable hot plates, when in position, are each supported by an inset plate, preferably made from sheet-metal by pressing or stamping, the said inset plates being so formed that the current-carrying parts and the interior of the stove are entirely covered in. One method of carrying the invention into effect is shown by way of example in the drawing. *a* denotes the top plate of the stove or range, *b* the sheet-metal inset plate, *c* the socket for



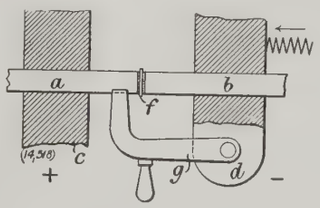
completing the circuit, which socket is attached to the inset plate *b*, *d* indicates the heating-plate in connection with the socket *c*, while *e* denotes the current-supply leads. These inset plates, besides possessing the advantages of the previously-known devices, also possess the advantage that they may be manufactured simply and cheaply on a large scale from sheet metal. Further, they have the advantage that it is possible to construct them in various forms—*i.e.*, to modify and develop them to a great extent. So, for instance, they may firstly be provided with a gutter for catching any liquid which may have boiled over or been splashed. Such a gutter is shown at *f* in the drawing. Further, wart-like projections *g* may be so arranged that the heating-plate *d*, after having been inserted in the socket *c*, finds a support on the said projections. By this means the liquid is permitted to escape into the gutter *f* even after the cooking-plate has been inserted, whilst the weight of the latter is supported by the inset plate. A further result of this particular method of supporting is that the escape of heat is only slight; further the efficiency of the heating apparatus is improved even when compared with stoves or ranges using bridge-shaped heating-plate supports or carriers. In order to increase the cleanliness of the stove or range, escape-openings *h* for the liquid may be provided on the gutters *f*. To these openings draining conduits of any suitable type may be attached, which lead to the waste-pipe of the kitchen, or to easily-accessible collecting vessels *k*, which are emptied from time to time, and which may be arranged inside or outside the cooking-stove or range. (*Accepted July* 1, 1914.)

14,699/13. A. F. Berry, Ealing. Electric Heating Apparatus. [9 *Figs.*] June 25, 1913.—This invention has reference to electric heating apparatus of the kind wherein the resistance conductor or heating element, in a crenellated, zig-zag, folded spiral or other shape, is held within a metal casing or container between layers of insulating material, such as sheet mica, that is of a refractory nature, but will allow of conduction and, it may be, of radiation of heat therethrough to the metal casing. In arrangements of this kind as heretofore constructed, when



the resistance conductor has been of crenellated, zig-zag or folded shape, and made from plain flat sheet or strip resistance material, as distinguished from wire of circular section, bent to shape, it has had sharp edges, usually produced by stamping the conductor out of a flat sheet or strip of resistance metal or alloy. Such sharp edges are, however, very objectionable in practice, because in the use of the apparatus embodying such a resistance conductor they are liable by continued use to weaken or cut through the layers of insulating material, which are necessarily thin, and short-circuit the conductor, or portions thereof, and make the metal casing or container alive. Now this invention has for its object to produce electric heating apparatus of the kind herein referred to, wherein the resistance conductor or heating element, formed of plain flat sheet or strip material, as distinguished from wire of circular shape, is so made that the slits or openings therein have rounded edges. A sheet *a* of resistance material is taken of approximately semi-circular shape, covered with bitumen and etching liquid applied thereto, so as to form therein, at parts thereof from which the bitumen has been scraped or otherwise removed, a comparatively wide slit or slot *b* parallel to the straight or diametrical side *c* of the sheet, and extending nearly to the curved edge *d* of the sheet at each side; and at each side of such wide slit and at right angles thereto a series of narrower slits *e* that terminate alternately at the wide slit *b* and at the curved periphery *d* of the sheet or straight diametrical side *c* thereof, according to the side of the wide slit at which they are situated, the centre slit *f* extending from the wide slit *b* to the straight edge of the sheet, being made much wider than the others, and the two next slits e^1 adjacent to and parallel with such wide slit *f*, being arranged sufficiently far from the wide slit as to form wide terminal portions *g*, g^1 that can be bent at right angles to the heating element thus formed. The arrangement is such that the sheet is formed into a long resistance conductor of crenellated or zig-zag shape that starts at one terminal *g* and extends, say, to the right, to one side of the curved periphery *d* of the element, then crosses over at one end b^1 of the wide slit *b*, then extends backward to the left-hand side of the element, then crosses over at the opposite side b^2 of the slit *b*, and continues to the right until the other terminal portion g^1 is reached. By this construction, parts of the conductor, between which there will be considerable difference in voltage when the element is in use, will be separated by an air-space of considerable width. Two resistance or heating elements *a* thus formed may be mounted between thin sheets of mica, and rigidly held within and between two metal cover-plates that entirely enclose them, and which will be heated thereby when current is passed through such heating elements, terminal portions *g*, g^1 of which, suitably insulated, extend through holes in one of such plates. The two resistance or heating elements *a* may be arranged to be connected up in series or parallel as described and in a manner well understood. (*Sealed September* 10, 1914).

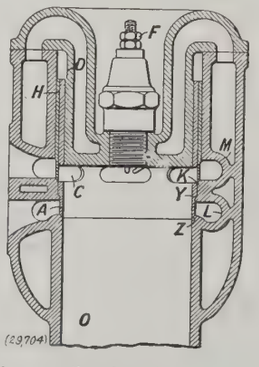
14,518/13. Allgemeine Elektricitats-Gesellschaft, Berlin, Germany. Electrical Soldering of Metals. [1 *Fig.*] June 21, 1912.—Hitherto it has been difficult electrically to solder metals by a process such as the resistance welding process. The difficulty arose from the presence of the soldering flux between the solder and the metal parts to be soldered, which did not permit of electrical contact being secured between the solder and the metal parts to be soldered. According to the present invention, the point of soldering, by means of an auxiliary electrode, is electrically heated by conduction to such a degree that the flux is affected, and contact is made between the solder and the parts to be soldered, and the soldering is then completed by the resistance heating which is thereupon set up at the soldering point. The drawing shows an apparatus for carrying out this



method. The metal parts to be soldered, *a* and *b*, are spread over at the joining faces with a soldering flux, and are clamped between the gripping electrodes *c* and *d*. A piece of solder *f* is then placed between *a* and *b*, and the latter are pressed together. A movable auxiliary electrode *g*, which is, for example, attached to the gripping electrode *d*, is then pressed against *a*, so that the flow of the current takes place from *a* to *g*, and heats the point of contact, and, by conduction of the heat, the point of soldering. As soon as the heat is sufficient, contact between the parts *a* and *b* is established at the soldering point, the auxiliary electrode *g* is removed, the solder *f* commences to flow, and soldering takes place by the pressing together of the parts *a* and *b*. (*Accepted July* 1, 1914.)

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

29,704/13. Crossley Motors, Limited, Manchester, and A. W. Reeves, Marple. Internal-Combustion Engines. [1 *Fig.*] December 24, 1913.—This invention relates to improvements in and in connection with the valves of internal-combustion engines, and particularly to the type used for the propulsion of motor vehicles; but which may also be used in the construction of light engines for marine, aerial and stationary purposes. An internal-combustion engine is, according to this invention, provided with a sliding, hollow cylindrical inlet-valve



having its seating or seatings formed within and upon the main cylinder-casting, and a sliding, hollow cylindrical exhaust-valve, within which the inlet-valve slides, such exhaust-valve having its seating also upon a bevelled face formed in and upon the main cylinder casting, both valves being concentric with a stationary cylinder-head carrying the ignition-plug fixed concentrically also in the power cylinder, and either the inner or the outer valve being capable of being used as the inlet-valve. The power cylinder O embodies at its upper end the arrangement of valves peculiar to this invention. A hollow cylindrical form of inlet-valve A, with ports C formed within or upon its circumferential shell, is employed. The inner surface of this valve A slides upon a fixed combustion-chamber head D, such head carrying the sparking-plug F for the ignition of the working charge. The valve A has formed upon it two bevelled seatings at Y and Z respectively, for which accommodating seatings are formed upon the main cylinder casting O, as shown. Sliding concentrically with, and outside, the inlet-valve A is a similar hollow cylindrical exhaust-valve H, having a bevelled seating K. A bevelled face is also formed upon the main cylinder casting O in the manner illustrated. For the admission of the explosive-fluid mixture, a circular passage L is cast in the main cylinder passage, as shown, such passage being in direct connection with the fluid-mixture supply. For the exit of the exhaust gases a circular passage M is similarly formed, such passage connecting with the atmosphere. (*Accepted July* 1, 1914.)

PUMPS.

5190/14. P. Rayner and G. H. T. Rayner, Sheffield. Air-Compressors. [10 *Figs.*] February 28, 1914.—The object of this invention is to provide an improved construction of inlet and outlet-valves for vertical air-compressors, whereby the friction in the valves is reduced and their efficiency for admission and exhaustion increased, whilst at the same time the manufacture of such machines may be simplified and rendered more economical than is the case in such machines as ordinarily designed. In the design to which this invention is applicable the admission-valve is situated in the top of the compression piston and opens to admit air on the downward stroke as soon as a very slight reduction of pressure occurs below that of the atmosphere. It closes by gravity when the piston finishes the down stroke. The discharge of the compressed air takes place as the piston nears the top of the cylinder, as soon as the pressure slightly exceeds that in the receiver or pressure main, and the discharge-valve is closed by springs when the discharging stroke of the piston is completed. The invention consists in the arrangement of inlet-valve apparatus, closing by gravity, consisting of concentric ring-plate valves formed without projections in any direction, each admitting

Fig. 1.

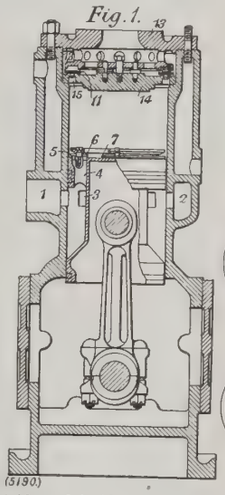
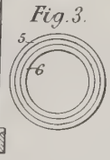


Fig. 2.

Fig. 3.



air past outside and inside peripheries mounted on the piston and moving with same, such valves being guided and spaced off from each other by renewable spring-washers or the like held in position by the screws securing the valve-guard plate to the piston. Atmospheric air passes into the cylinder at 1, and is admitted to the interior of the piston by annular recess 2, ports 3, all in the cylinder casting, and annular port 4 in the piston wall. The inlet-valves are formed as concentric rings 5 and 6, and admit air past their outside and inside peripheries, and past both the edges of the guard-ring 7, and also through the holes 9 in the same, thereby giving large area of inlet with minimum lift and free passage to the air. The guard-ring is held in position by screws locked by renewable spring-washers, which serve also as distance-pieces to keep the valves in their proper position, and also as guides ensuring correct rise and fall of the valves. The discharge-valve 11 discharges air past both inside and outside peripheries, and is closed by springs. The valve travel upwards is restricted by discharge-plate 13, formed in one piece with the cylinder-cover, and when closed the valve is seated on valve-guard plate 14, through which the air passes to the discharge-valves by port 15. (*Accepted June* 10, 1914.)

RAILWAYS AND TRAMWAYS.

9324/14. F. J. Talbot, Sheffield. Metal Keys for Rails. [16 *Figs.*] April 15, 1914.—This invention relates to that type of key for securing railway rails which is used in conjunction with an ordinary chair, and which is tightened up and adjusted so as to secure a tight, elastic fit with the rail and chair by means of a bolt and nut, the bolt being passed through apertures in the key and located parallel to the web of the rail. According to the present invention, the key has a central flat or approximately flat portion which rests against the inner vertical face of the chair. This central flat portion is connected

Fig. 1.

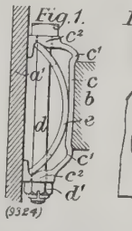
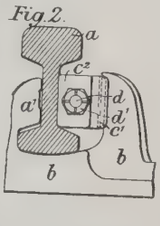


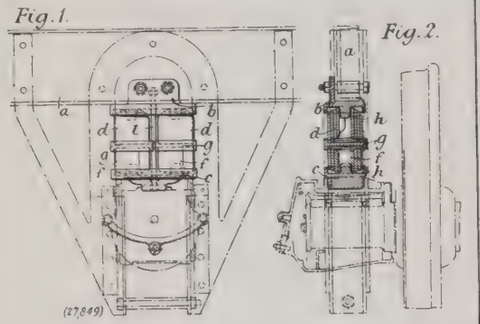
Fig. 2.



by curved parts with end parts which are approximately at right angles to the central flat portion, but are slightly splayed out at their ends, which come into contact with the web of the rail. The curved parts are located on each side of the jaws of the chair. These end parts are provided with feet which fit against the web of the rail, and they are formed with apertures to receive the bolt. Upon the nut being screwed on to the bolt, these end parts are bent towards each other until they are at right angles, or more nearly at right angles, to the web of the rail than in their original condition. These end parts thus act as compression

plates, the pressure being applied in the planes of the plates. a is the rail and b is a chair of ordinary construction. c is the central flat or approximately flat portion, which is located in contact with the inner face of the jaw of the chair b. At each end this central flat portion c has curved parts c^1, by which it is connected to the end parts c^2. These latter are thicker than the parts c and c^1, and act as feet at their ends, which are in contact with the web a^1 of the rail a. The curved parts c^1 prevent the key becoming displaced longitudinally, and by bending they act somewhat as pivots for the end parts c^2 and afford some amount of elasticity. As shown in Fig. 1, the end parts c^2 are at right angles to the web a^1 of the rail, but before the key is tightened by the bolt d and nut d^1 they are slightly splayed apart. With the key shown, an arched elastic stiffening-piece e, which is slotted to accommodate the bolt d, may be used. This arched piece bears against the centre of the flat or approximately flat part c, and its ends, as shown at Fig. 1, fit into recesses in the parts c^2. (*Sealed September* 10, 1914.)

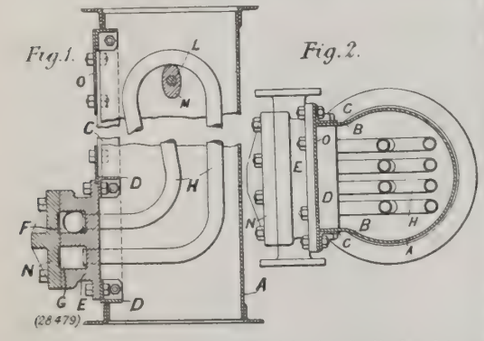
27,849/13. G. H. Sheffield and McKerrow and Co., Limited, London. Rolling-Stock. [5 *Figs.*] December 3, 1913.—This invention relates to improvements in bearing-springs for railways and like rolling-stock of the kind in which two coil springs, a lighter one and a heavier one, are employed in series, the light spring coming into action under light loads, and the heavier spring for heavier loads. Such an arrangement has been proposed in connection with the suspension of under-trucks for tramway vehicles, the springs being arranged above and below the side beam of the truck and at the sides of the axle-box. The invention consists in a bearing-spring system for railway and like rolling-stock, comprising one or more sets of superposed volute or other coil springs of different strengths, the springs being arranged between a casting or like fitting secured to the underframe of the vehicle and a similar fitting arranged wholly above and resting upon the axle-box, the superposed springs being separated by floating washers. A casting or like fitting b is secured to the sill a of the under-



frame of a wagon, and upon the crown of the axle-box a similar casting c is mounted, a certain amount of clearance being allowed between the base of the casting and the axle-box. Between the castings b and c are two sets of volute springs, the upper springs d of each set being more flexible than the lower springs f, while the washer g separates the springs of each set from one another. For the purpose of retaining the springs in position, each casting or like fitting may be formed or provided with a boss h, while each washer g is conveniently formed with a flanged edge, as shown, if this be found to be necessary, and for the purpose of holding the parts in position when the axle-box for any reason, is dropped, a bolt or the like may pass through the centre of the dividing-washer when a single washer is employed, or which may pass between the two washers, as shown in the example illustrated in the drawings, the bolt or the like being of sufficient length to allow of the necessary movement of the device while being of such a construction as to prevent the parts from falling out of place when the axle-box is dropped. (*Sealed August* 20, 1914.)

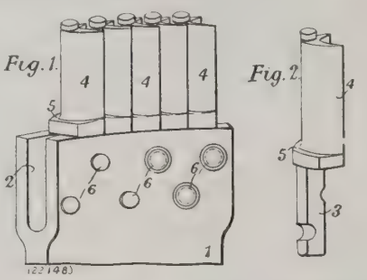
STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

28,479/13. T. Sugden, London. Steam Superheaters. [6 *Figs.*] December 10, 1913.—This invention relates to steam superheaters for vertical boilers. It is known to arrange in the uptake of a boiler a superheater of the type comprising bent tubes rising from a steam-box; also it is known to introduce such superheater through a door. According to this invention, the superheater-tubes, which extend to a considerable height in the uptake funnel or chimney (hereinafter referred to as the funnel), are arranged to be withdrawn through a longitudinal opening in the side of the funnel, which opening is closed partly by the steam-box and partly by a separate plate when the superheater is in position. An opening of suitable length is made in the side of the funnel A, and the edges of this opening are turned



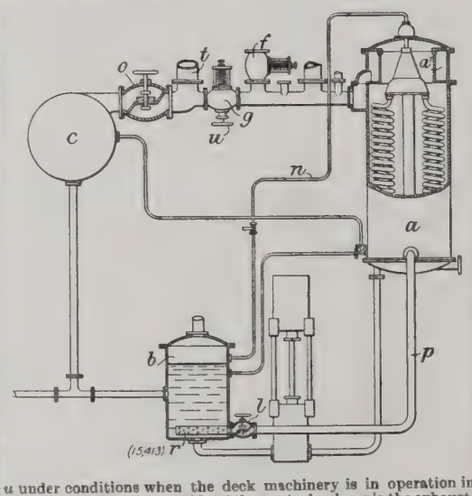
outward at B, B and strengthened by longitudinal and transverse angle-irons C, C, D, D, which form a framing to carry the superheater. The superheater comprises a box E having upper and lower chambers F, G with which the superheater-tubes H communicate, the ends of the tubes passing through holes in the back of the box and being secured by expanding in the usual manner. One end of each tube enters the upper chamber, and the other end enters the lower chamber. Steam entering one chamber of the box E from the steam-pipe passes through the superheater-tubes to the other chamber, and thence to the outlet-pipe. The chambers F, G are closed by a lid N at the front. The superheater-tubes are shaped as indicated, and extend some considerable distance up the funnel, and are supported at their upper end by a transverse bolt L passing across the funnel. This bolt is shown furnished with a sleeve M to protect it from wear. The upper part of the opening in the funnel above the superheater-box E is closed by a removable plate O bolted to the framing C, D. This plate can be removed to allow inspection of the superheater-tubes or to allow of the complete removal of the superheater, if desired. Should it be required to work the boiler while the superheater is removed this can be done. In such cases a second plate is bolted to the framing to cover the opening left by the removal of the box E. (*Sealed August* 20, 1914.)

22,148/13. H. Mensforth, Manchester. Steam-Turbines. [2 *Figs.*] October 1, 1913.—This invention relates to steam-turbines, and has for its object to provide an improved method of attaching the blades or vanes of such machines to the edge of a disc by which they are supported. According to this invention, the disc is provided with a groove having substantially parallel sides in which the ends or roots of the blades or vanes are received, radial movement of the blades or vanes being prevented by means of two rows of pins arranged in such a manner that each pin is adapted to engage with the roots of two adjacent blades or vanes, and each blade or vane is held in place by two pins, one on each side. Referring particularly to Fig. 1, the turbine disc or wheel 1 is provided with a groove 2 having substantially parallel sides, and adapted to receive the ends or roots 3 of



the blades or vanes 4. The roots are enlarged in the circumferential direction so that adjacent blades will be properly spaced apart. This enlargement is shown at 5 (see Fig. 2) as being on the convex side of the blade, this being preferable, but obviously the enlargement may occur on the concave side of the blade if desired, or it may be provided on both sides so as to secure central support. The blades are secured in position in the groove 2 by means of two rows of pins 6 which are arranged alternative so that each pin engages with the roots of two adjacent blades and each blade or vane is held in place by two pins, one on each side. The invention is limited in its application to cases in which the turbine-wheel carries one row of blades, as shown in Fig. 1, or in which at most two rows of blades are secured to the said wheel. (*Sealed August* 17, 1914.)

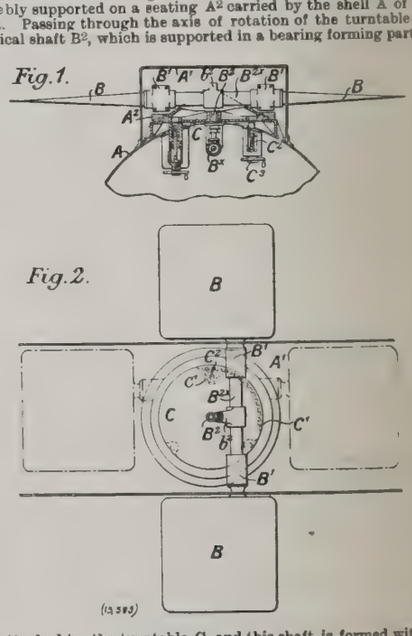
15,413/13. D. B. Morison, Hartlepool. Feed-Water Heaters. [2 *Figs.*] July 4, 1913.—The object of this invention is to provide improvements in or modifications of the apparatus described in Specification No. 3499, of 1912, for use on board ships. According to this invention, the heating-steam supply is connected to the primary heater and to a loaded valve, called the "control-valve," which is in communication with another loaded valve connected to the condenser, and called the "deflecting valve," a branch being provided between the valves for the reception of exhaust steam from deck machinery, and means for holding the control-valve open, whereby, when in port, a preferential supply of steam is deflected to the primary heater, the remainder passing through the deflecting valve to the condenser, and when at sea the closed control-valve acts as an escape at a predetermined pressure for the surplus steam into the condenser. The primary heater a is connected to a condenser c through a valve g, called the "control-valve," which controls the pressure at which the surplus exhaust steam from the auxiliaries passes to the condenser c when the main propelling engines are working at sea, and which may be maintained in an open position by the device



u under conditions when the deck machinery is in operation in port. On the condenser side of the control-valve g is the exhaust-pipe t from the deck machinery such as is used in port. Between this pipe and the condenser is a valve o, termed the "deflecting valve," and between the control-valve g and the primary heater a are the exhaust-pipes from the engine-room auxiliaries, the steering-engine, the water drainages and other exhausts which are available for feed-heating when the ship is at sea, together, it may be, with an escape-valve f to the atmosphere. The deflecting valve o may be of the deadweight, spring-loaded or other suitable type, so arranged that the valve may be held open or may be closed down by collars on the valve spindle, or it may act freely as a non-return valve. The lower portion of the heater a is connected by the pipe p and valve l to the secondary heater b, into which the surplus steam from the heater a may preferentially flow. Under normal conditions of working, as on a voyage, the control-valve g is loaded to the maximum pressure which it is desired to carry in the heating system, and all the available exhaust steam, such as exhausts from the feed, air and other pumps, evaporator, electric-light engine, refrigerating engine, steering-engine and the like, together, it may be, with a supplementary supply from one or more receivers of the main engines, and water drainages as from the receivers of the main engines, water-separators on steam-pipe lines, heating systems and the like are admitted to the pipe e between the control-valve g and the primary heater a, and pass into the primary heater, preferably through a steam cleanser, the drainage water in the primary heater, and, it may be, a portion of the steam passing into the secondary heater. Whenever the pressure in the heater a exceeds the predetermined limit, the control-valve g lift and steam passes through the deflecting-valve o into the condenser. When the deck machinery is at work in port, and the propelling engines are not in operation, the exhaust steam is many times greater than can be absorbed by the feed-water. Under these conditions the control-valve g is maintained in an open position, and the deflecting-valve o is so loaded as to cause a preferential supply of steam to the primary heater, the supply being slightly in excess of the condensing capacity of the primary heater, so that there is a free flow from the primary heater to the condenser or to the secondary heater b through the cock s^1, thereby preventing any accumulation of air in the primary heater. By the arrangement according to this invention, whereby a preferentially sufficient supply of exhaust steam is deflected to the primary heater, the lay-out of valves and pipes is simplified, and the size of the pipes and connections to the primary heater, and from the primary heater to the condenser, is minimised. The primary heater a shown is generally in accordance with that set forth in Specification No. 3499, of 1912, a^1 being the steam-cleanser, and n a discharge-pipe to the secondary heater b, or suitably elsewhere for the air separated from the feed-water. The connection between the primary and secondary heater is in this example formed by a pipe p and a controllable non-return valve l, both being of a size suitable for the discharge of the drainage-water together with the excess steam, the resistance to flow being determined by the head of water over the submerged nozzle r, together with the influence of the valve l. This resistance determines the working pressure in the primary heater, and therefore the maximum temperature of the heating steam, and when both heaters are in normal operation the constancy of this temperature favourably affects the heat-absorbing capacity of the heating system. (*Sealed September* 17, 1914.)

SHIPS AND NAUTICAL APPLIANCES.

15,583/13. Vickers Limited and James McKechnie, Barrow-in-Furness. Submersible Boats. [3 *Figs.*] July 5, 1913.—This invention relates to submersible boats, and has particular reference to the mechanism employed for operating their hydroplanes or horizontal rudders. These hydroplanes, which, as is well understood, project laterally from the sides of the boat, and are adapted to be adjusted to any desired angle to cause the boat during its propulsion to rise or descend, have heretofore been mounted in one or more horizontal bearings fixed to the shell or superstructure of the boat. According to this invention, the bearing or bearings of the hydroplanes are mounted upon a rotary member or turntable, which is capable of movement in a horizontal plane, and means are provided whereby the turntable can be angularly displaced to bring the hydroplanes from their operative lateral position to a position substantially parallel to the axis of the boat, and within the superstructure. Fig. 1 is a transverse section through the superstructure of a submersible boat, showing a constructional form of the improvements, and Fig. 2 is a plan. A is the shell of the boat, and A^1 the superstructure. B, B are the hydroplanes, and B^1, B^1 their bearings. C represents the rotary member or turntable. In the example shown, the turntable C is arranged within the superstructure A^1, and is suitably supported on a seating A^2 carried by the shell A of the boat. Passing through the axis of rotation of the turntable is a vertical shaft B^2, which is supported in a bearing forming part of,



or attached to, the turntable C, and this shaft is formed with or carries a worm which gears with a worm-wheel segment b^2, secured to the shaft B^2x of the hydroplanes B, B. The shaft B^2 in the example shown is connected, by means of bevel-wheels and a shaft Bx, to hand or power-operated mechanism arranged within the boat. By the actuation of the shaft Bx, the hydroplanes B, B are moved about their horizontal axis to the desired extent for causing the boat to dive or rise in the water in the usual manner. The turntable C is formed with the rack-teeth C^1, with which engages a pinion c^1, carried by a shaft C^2, extending through a bearing into the shell of the boat, where it is provided with a hand-wheel C^3 or other appropriate means for actuating it. The pinion c^1 is thus revolved, and causes the turntable C to be displaced, to bring the hydroplanes B, B into either the operative position or the housed position, as shown respectively by full and broken lines in Fig. 2. During the displacement of the turntable, to bring the hydroplanes from the operative to the housed position, or *vice versâ*, the hydroplanes will be moved about the axis of its shaft B^2x, but as the maximum travel of the turntable is only a quarter of a revolution, the hydroplanes will be moved about the axis of its shaft through an angle represented by a quarter of the pitch of the worm B^2, this movement of the hydroplanes being so small that no inconvenience will be found during the displacement of the turntable to place the hydroplanes in the housed or in the operative position. (*Accepted July* 8, 1914.)

CALCIUM CARBIDE AND NITROGEN PRODUCTS.

(*Concluded from page* 408.)

The Mechanical Appliances for Manufacturing Cyanamide.

We propose now to describe the mechanical appliances for preparing the calcium carbide for the absorption in electrical furnaces of the nitrogen recovered from the air, as described in our previous article. Not only have these been greatly increased in capacity, but important changes have been made in the mechanism for some of the processes since the factory was formerly described, and in this work the design and supervision are due in great measure to Mr. G. W. Sinclair, the general manager of the company; while Mr. A. E. Malpas, Wh.Sc., M.I.Mech.E., has acted as his chief engineering assistant, and Ingenieur Helmar Dishington prepared the designs and details of the building.

The process of manufacture of cyanamide at the works is illustrated by the diagram, Fig. 50, while in sacks weighing 2 cwt. gross, or in steel drums of approximately the same gross weight, the nitrogen content being guaranteed 18 per cent. For the German market two qualities are supplied—namely, 15 to 16 per cent. nitrogen and 17 to 20 per cent. nitrogen. In both cases the supply is made in double sacks of 100 kg. gross. The works since we last described them have been rearranged, and many new mechanical features introduced, and to these we propose to devote special attention.

The cooled ingots of carbide are transported by means of travelling-cranes from the Alby Company's cooling-house (Fig. 52) on heavy iron trays and dropped from a considerable height into a large storage-bin of massive steel construction, having an inclined floor. The lower part of the floor is fitted with discharge-gates arranged at a convenient height for filling the carbide into wagons. In cooling the carbide blocks become intersected with cracks which cause them to break into pieces of convenient size when they are dropped into the storage-bin. On the floor immediately below the discharge-gates a operation is controlled by a chain-gear placed convenient to the winch-operator. The load discharged from the wagons is delivered by means of inclined chutes to the breakers. This is an entirely new arrangement of delivery at the Odda Works.

The carbide-breaking machinery consists of two independent units, each designed to crush at a maximum rate of 16 tons per hour, so that each unit is capable of dealing with the full production, the other meanwhile standing in reserve. Each unit consists of a large steel-frame jaw crusher, supplied by Messrs. Edgar Allen and Co., Limited, Sheffield, a second crusher by Messrs. Marsdens, Limited, Leeds, and a heavy roller-mill by Messrs. Broadbents, Limited, Stalybridge. The crushing machinery (see Fig. 53, page 478) is erected on a massive concrete foundation strengthened by steel beams on the floor-level. The broken carbide is transferred from one machine to the other by special elevators, from which it is conveyed into the fine-grinding department. This arrangement of crushers and elevators has the advantage that

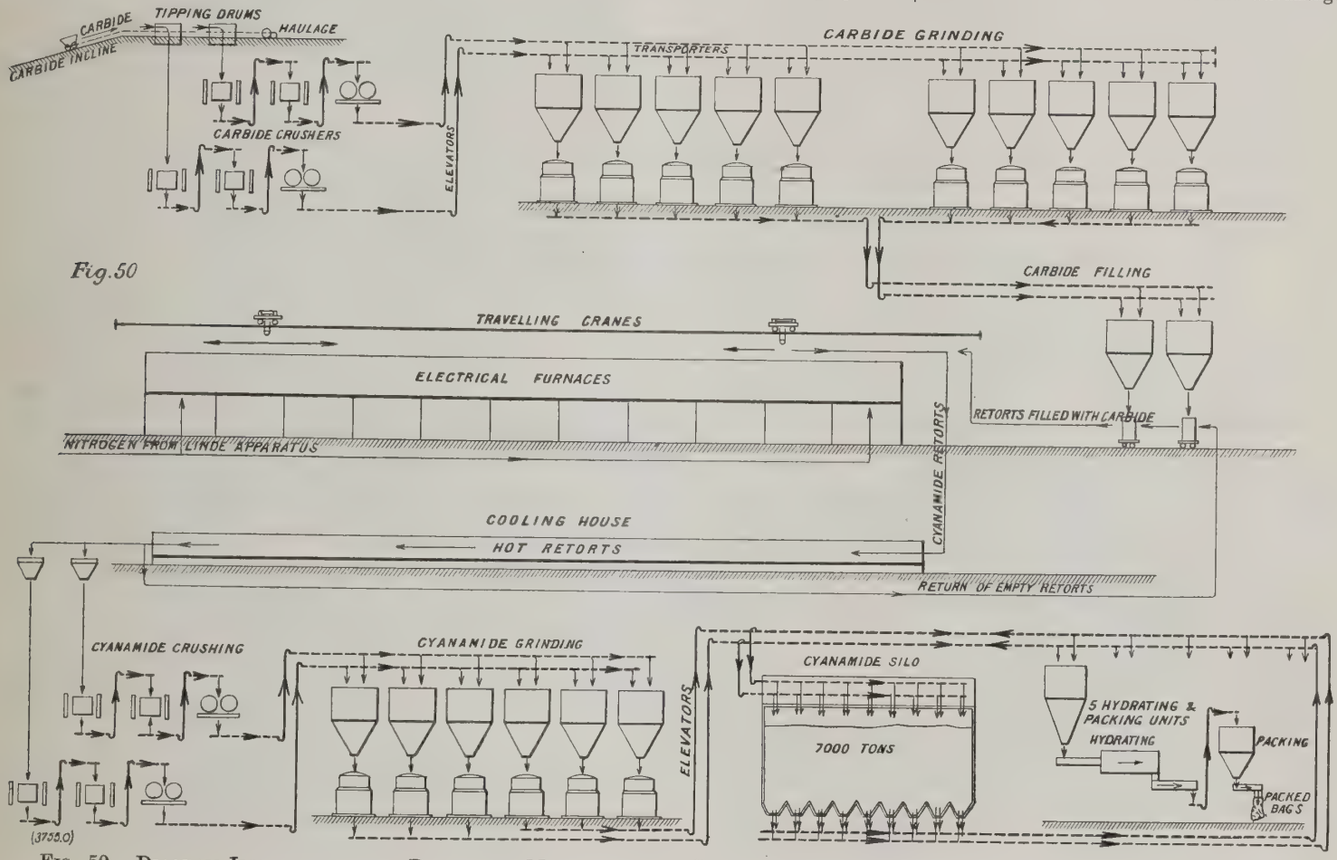


Fig. 50

Fig. 50. Diagram Illustrating the Process of Manufacturing Cyanamide at the Odda Works, Norway, of the Nitrogen Products and Carbide Company, Limited.

Fig. 51, page 466, gives a general view of the factory. Calcium carbide in rough pieces is delivered from the cooling-house of the Alby United Carbide Factories, Limited, to wagons on an inclined railway. Fig. 52, on page 478, shows the cooling-house in the carbide factory, as described in a previous article (page 353 *ante*). At the foot of the railway (Fig. 50) the wagons and content are weighed, and samples taken periodically for analysis. The wagons are then hauled by electric winches to the top of the incline and tipped into chutes communicating with the crushing machinery. In the crushers and subsequent grinding-mills the carbide is reduced to a fine powder. In this state it is filled into the electrical furnaces, where it is subjected to electrical heating in the presence of nitrogen. The chemical reaction which takes place in the furnaces changes the brown powdered carbide into a hard, grey-black stone-like mass—calcium cyanamide. This substance, after cooling, is crushed and ground to a fine powder, and in this state is treated with water to remove the last traces of calcium carbide, and is subsequently mixed with a small proportion of mineral oil, in order to prevent the formation of fine dust. The product is packed in double sacks, of which the inner is lined with paper. For the English and colonial markets the product is delivered system of lines and turntables is arranged to accommodate the wagons for the transport of the carbide to the crushing department of the cyanamide works. From the filling-floor the carbide wagons, containing a normal load of 1000 kgs. each, are hauled on an inclined plane, to the tipping-platforms. The inclined plane is provided with two lines, each with independent haulage. At the foot of each incline is a tram-bridge weighing-machine, supplied by Messrs. Averys, Birmingham. The loaded wagons are hauled up the incline of 1 to 6 by electric winches at the rate of 300 ft. per minute. The winches are furnished with an automatic switch, which stops the wagons in a rotating tipping-cage.

On reaching the level at the top of the incline, a catch on the side of the wagon automatically engages with a hook attached to a counterweight, which is drawn up as the wagon enters the tipping-cage and serves to draw it out of the cage after tipping and to start it upon the return journey down the incline. The hauling and counter-balance ropes remain attached to the wagon during tipping, and the operator manœuvres the wagon entirely by means of the controller on the electric hauling-winch. The rotary tipping-cages are operated by means of independent electric motors, which are coupled through friction mechanism and cause the cages to make one complete revolution. This the heavy machines are all carried on solid foundations instead of being supported upon a more or less flexible structure, as is usually the case when they are arranged in series one above the other. Further, all parts are accessible to the travelling-crane, and repairs can be effected more expeditiously and without interference to the other machines. Each of the crusher units above described is served by an independent system of shafting driven by belt by an electric motor. The fine dust arising from the crushing is collected by a system of piping and conveyed to a large dust-filter working in conjunction with an exhaust-fan.

The crushed carbide, reduced to pieces approximately of $\frac{1}{2}$ in. cube, is conveyed from the elevators in the crushing department to a system of ten hoppers. This is effected by two independent transporters constructed upon a novel principle, the features of which will be clearly seen from the drawings reproduced in Figs. 56 and 57, on page 467. The transporters consist of steel troughs hung by means of links from a framework provided with wheels. These wheels run upon rails, which form part of the structure of the storage hoppers already mentioned, and permit of a longitudinal movement of the framework and trough. By means of a crank and connecting-rod, driven by an independent motor, the framework receives a longitudinal movement of

approximately 8 in., at the rate of fifty double strokes per minute. As the framework moves to and fro it imparts a corresponding but increased movement to the trough, which is suspended from it by means of the links above mentioned, giving the trough a total movement of approximately 18 in. Between the frame and the trough a pneumatic buffer-cylinder is fitted, and so arranged that the trough moves forward with a slow and returns with a sharp movement, thereby causing its contents to progress from one end to the other. These transporters, which have been supplied by Messrs. Amme, Giesecke and Konegen A.-G., Brunswick, present many advantages over screw conveyors where gritty material is to be handled. The conveyor-troughs are fitted with valves corresponding to each of the ten storage-hoppers.

The storage-hoppers, each of approximately 2 tons capacity, are placed at a level above the fine-grinding mills, and connected to the latter by means of automatic feeding mechanism, which is so arranged that it can be swung clear of the grinding-mills in order to permit the travelling-crane to operate freely. The fine-grinding mills are of the vertical ball type, known as "Roulette" mills, and supplied by Messrs. Amme, Giesecke and Konegen, Brunswick. They consist of a vertical driver carrying six large steel balls, which are rotated within a heavy steel ring. The outer casing of the mill is provided with fine and coarse sieves and the driver with fan-blades, by means of which the finely-ground material is projected, first against the coarse sieve, and finally through the fine sieves. The rapidly-rotating driver promotes a circulation in the interior of the mill, which brings the coarser stuff continually in contact with the balls, and drives the fine particles through the sieves.

In order to avoid danger from explosion through the evolution of acetylene from the finely-ground carbide, the mills are completely closed and kept filled with nitrogen supplied through a gas-meter with which each mill is provided. The finely-ground carbide is collected in closed screw conveyors under the mills, and delivered to a duplicate system of elevators and screws, which transport it to the retort-filling machines situated in the furnace-house.

Each motor is of 50 horse-power, of the vertical three-phase induction A.E.G. type, and runs at 960 revolutions per minute (Fig. 54, page 478). The windings are enclosed, but ventilated. The driving-pulley is supported in two vertical bearings in a separate housing, which forms a substantial base for the motor proper, and the pulley shaft is connected to the rotor spindle through a flexible leather band coupling. The weight of the motor is taken on a special thrust-bearing arranged in the top of the frame. The drive with these vertical motors gives no trouble whatever when a suitable tension is preserved, but with a heavy load an insufficient tension there is a tendency for the belt to slip down. To obviate this, the motors are slightly inclined towards the mill.

The retorts are constructed in the form of cylindrical baskets from flat iron strips, and hold about 450 kg. of ground carbide. Before filling they are lined with corrugated paper. The two filling-machines consist each of a large rectangular steel hopper mounted upon a framework. To the mouth of each hopper a feed-screw of fine pitch is fitted, to transfer the ground carbide to a distributor, which delivers it evenly through eight vertical tubes into the retorts placed below. In this manner a perfectly uniform and level filling of the retorts is secured.

The furnace-house is divided into three sections, containing in all 604 furnaces. One of these houses is illustrated by Fig. 55, on page 478. The furnaces are mounted upon steel framework, so as to provide head-room underneath for the furnace operators. On the top of the framework a continuous platform is provided a few inches below the furnace tops. The furnaces consist of cylindrical steel shells lined with firebrick, and provided with external heat insulation. The removable covers, which are of sheet-iron lined with firebrick, rest in a sand lute. Each furnace is provided with an independent nitrogen connection and an electric circuit communicating with a switchboard placed under the platforms above mentioned.

The retorts, after being filled, are placed in the furnaces and the covers secured. A carbon electrode is then fitted through a vertical hole left for the purpose in the centre of the powdered carbide, and is secured in terminal clamps on the furnace cover and bottom respectively. The electrode, which is connected to an alternating-current circuit of 70 volts, quickly heats up the carbide in the immediate neighbourhood of the hole to the temperature necessary for the chemical reaction to take place, and nitrogen being at the same time supplied, the heat rapidly rises until the whole mass becomes incandescent. The reaction, which is strongly exothermic—namely,

$$Ca\,C_2 + N_2 = Ca\,CN_2 + C,$$

results in an average temperature of 1100 deg. to 1200 deg. Cent. being reached, and, for a mass of 450 kg. of carbide, requires some 30 hours for completion. After a short period of cooling the retorts are removed at a dull-red heat to the cooling-house. The operations of filling and discharging the furnaces are performed with the aid of electric travelling-cranes, of which there are two in each furnace-house. On removal from the furnaces the retorts are placed upon small wagons.

Fig. 51. General View of the Cyanamide Factory at Odda of the Nitrogen Products and Carbide Company, Limited.

The cooling-house consists of a long alleyway running parallel with the furnace-houses, and is fitted with five lines of rails—four for the accommodation of hot retorts, and one for the return of empty retorts to the filling-machines. On each line some ninety hot retorts can be placed. The wagons upon which the retorts rest are coupled together with short-link couplings, and the trains are pulled forward periodically by means of wire ropes attached to electric winches. In order to assist the cooling of the retorts, two powerful fans are fitted about midway at the side of the cooling-house, and, while serving to cool the retorts, provide an adequate ventilation for the furnace-houses. At the end of the cooling-house the retorts and wagons are weighed, and the former lifted by means of an automatic device and the contents discharged into a hopper communicating with the mouth of a powerful breaker. The retort is then returned to the wagon and the tare is weighed.

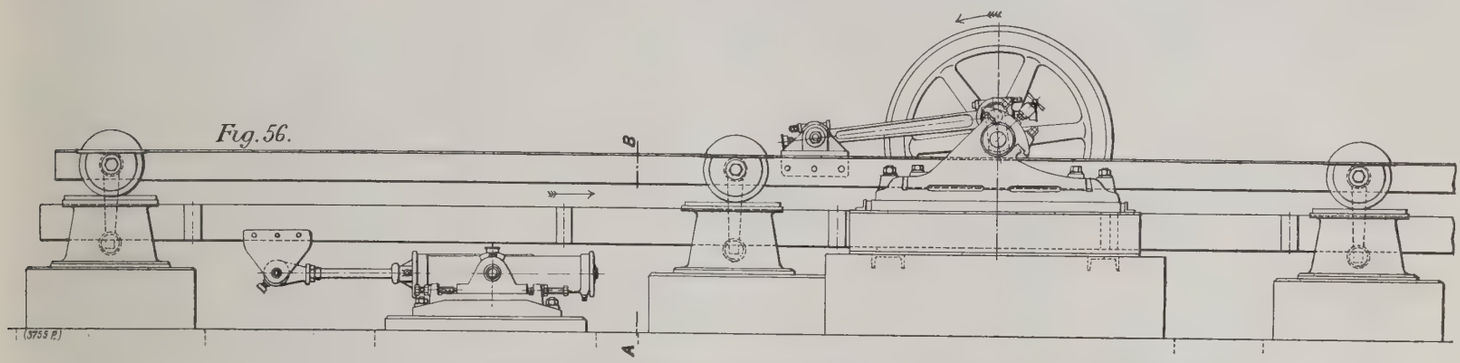
The cyanamide-crushing machinery is of exactly the same construction and arrangement as that for the carbide-crushing, but has a slightly greater capacity. After crushing, the cyanamide is transferred to the fine grinding department, by means of elevators and screw conveyors. For the grinding four roulette mills are employed, but in this

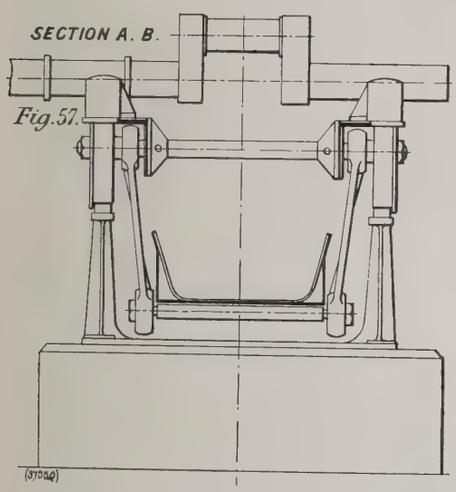
department the machines are driven from two independent shafts instead of by vertical motors. Two extra foundations and hoppers are provided for extra roulette mills with vertical motors.

From the roulette mills the cyanamide is delivered into duplicate elevators, and transport screws provided with reversing gear, so that the cyanamide may be transported in either direction. At one end of this system of screw conveyors is a large elevator reaching to the top floor of the storage silo, and arranged to deliver into a duplicate system of transport screws, by means of which an even distribution of the cyanamide in the silo is secured. The floor of the storage chamber is provided with hopper openings communicating with a system of discharge screws delivering into an elevator. The duplicate system of transport screws into which the roulette mills deliver, besides being connected to the silo elevator, is also connected to the hoppers of the hydrating machines to be described, and to the elevator communicating with the discharge screws under the silo. By this arrangement cyanamide may be ground in the roulette mills, and delivered either to the silo or to hydrating machines as desired, or to both simultaneously. At the same time cyanamide may be transported from the silo to the hydrating machines. The arrangement is best seen in the diagrammatic arrangement of the factory machinery (Fig. 50), where the reversible screws ars indicated by double arrow-heads.

As the whole of the carbide is not transformed by the chemical reaction to cyanamide, it is necessary to eliminate the small proportion which remains. This is effected by adding water. The machines in which this operation is carried out, and of which there are five sets, consist of a large hopper, with a feeding device of special construction placed in the discharge opening. This feeder delivers the cyanamide powder in a measured stream to a mixing-machine, in which it comes in contact with a water spray. The water immediately decomposes the greater part of the carbide, and acetylene is evolved, which latter is burnt. The decomposition of the carbide and the reaction of the water on the free calcium oxide of the cyanamide raises the temperature of the mass. From the mixing-machine the hydrated cyanamide passes to a large rotating drum, where it is cooled to a temperature of about 60 deg. Cent. From this drum it is discharged to a second mixing-machine, where, as already stated, a certain proportion of mineral oil is added, to render the product dustless. From this mixer the finished cyanamide is raised to a storage-hopper, connected to an automatic packing-machine, by means of which the sacks are automatically filled with the weight desired.

The entire production of the factory is packed in double sacks, the outer of strong jute, and the inner of a thinner and looser material lined with paper. This method of packing has the advantage of protecting the cyanamide against damp, and at the same time prevents loss of the finely-ground powder from the sack. The transport of the packed cyanamide from the warehouses to the export quays is at present effected by means of an electric railway, but the installation of an automatic transport system is contemplated, and will no doubt be adopted at an early date.





Figs 56 and 57. Transporters for Cyanamide; Amme, Giesecke and Konegen A.-G., Brunswick.

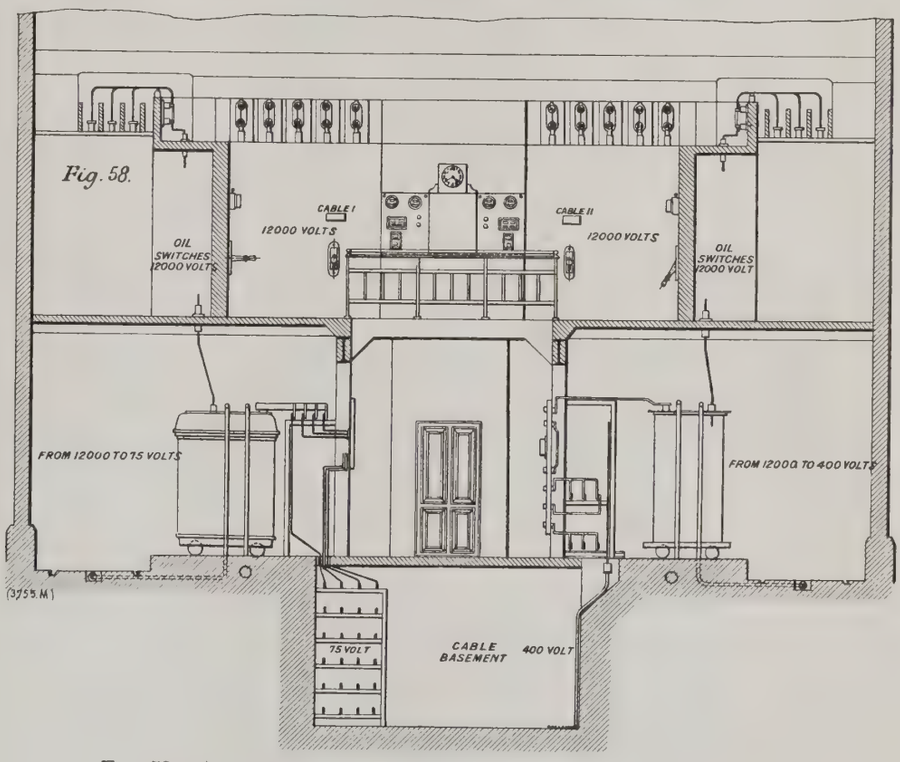


Fig. 58. Arrangement of Electric Station at Cyanamide Factory.

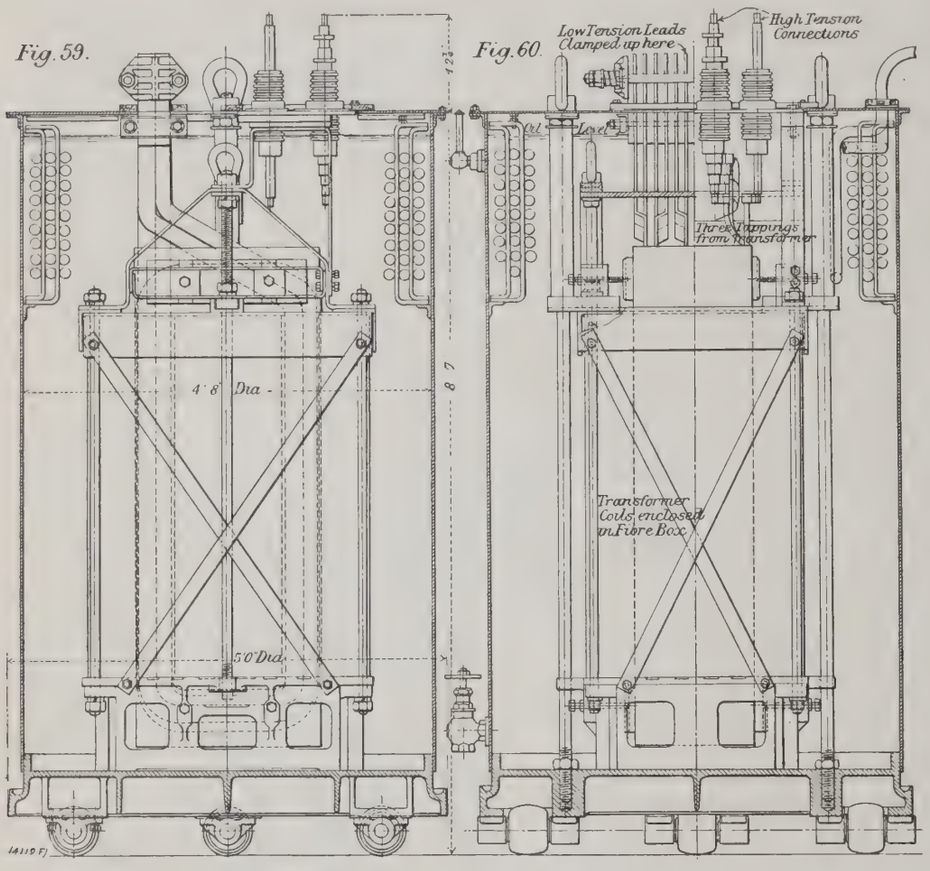
The Electrical Arrangements.

The electrical installation, the arrangement of which is illustrated diagrammatically in Fig. 58, is designed for a full-load capacity of 6000 horse-power, delivered on two cables direct connected to the generating-station at Tysse. The current is three phase, 12,000 volts, and 25 periods. For the motor circuits the current is transformed from three-phase 12,000 volts to 400 volts, and for this purpose six transformers are used, each of 600 k.v.a. capacity. For the furnace circuits there are four 400-k.v.a. and four 200-k.v.a. single-phase transformers. Three of each size are coupled to the bus-bars, the fourth in each case standing as reserve. One pole of each of the furnace transformers is coupled to a common bus-bar, so that the two sets of three work as three-phase transformers. For the furnaces the ratio is 12,000 volts to 75 volts, but the high-tension windings are arranged with tappings so that the secondary voltage may be varied within a considerable range. All transformers are of the oil type, with internal water-cooling.

One of the furnace transformers is shown in Figs. 59 and 60, page 468. It is of the shell type, a form of construction which has been adopted rather from mechanical than electrical considerations. Large numbers of heavy-current furnace transformers of the core type are in satisfactory operation, but the British Westinghouse Electric and Manufacturing Company, Limited, Manchester, on the whole prefer the shell construction, owing to the way it lends itself to simple, solid, and well-supported and braced windings. A very large number of transformers of the type are in use. The general lines of the transformers will be seen from the figures, which clearly show the oil-tank and cooling-coils. Attention may be drawn to the low-tension terminals, which are arranged so that the outgoing leads may be interleaved with them. This gives an excellent joint, and reduces the impedance of the leads and increases the power-factor and efficiency of the connection.

The current from Tysse is delivered on two paper-insulated lead-covered and armoured cables of 120 sq. mm. cross-section, each cable being capable of taking the full load of 6000 horse-power continuously, the other standing as reserve. The receiving ends of the cables are connected to lightning-arresters of the oil-resistance type, with horn spark-gaps. The cable-heads, as also the lightning-arresters, are built in separate compartments of ferro-concrete, and so arranged that all

parts can be cut out for repairs. From the cable-heads connections are made to separate compartments, in which are placed the ammeter and voltmeter transformers and the choking-coils. These compartments are placed on the ground floor of the station. From each of the compartments above mentioned connections are made to a three-phase oil-switch built in a cell on the floor immediately above. These oil-switches are of large capacity and capable of breaking 50,000 horse-power. Each switch is fitted with overload and reverse-current relays. From the main high-tension switches the current is led through porcelain insulators in the roof of the cells to a ring system of bus-bars, which is carried entirely round the transformer building. The bus-bars are mounted upon large vertical porcelain insulators, supported upon transverse iron frames, and separated from each other by means of ferro-concrete partitions. The ring system of bus-bars is provided with six



Figs. 59 and 60. Electrical Transformers; 12,000 Volts to 75 Volts.

sets of section switches, so that both of the main oil-switches and the groups of transformers can be cut out, if desired, without interrupting the service. The coupling of the main oil-switches to the bus-bars, as also the bus-bars to the transformer groups, is made through section switches, placed above the cells, so that the oil-switches and all connections can be cut out in case of repair. The connections from the bus-bars to the transformers are made through quick-break oil-switches of large capacity, each switch being fitted with overload relays, and in the case of the switches to the furnace circuits the relays are coupled so as to operate simultaneously on each set of three switches. The whole arrangement of the high-tension apparatus has been carried out with a view to reliability from the electrical point of view, and, at the same time, to afford perfect protection to the operators.

The current from the transformers, reduced to 400-volt three-phase, is carried on solid-copper bars to the terminals of three-phase circuit-breakers, placed upon a switchboard on the ground floor of the transformer-house. On the same switchboard panels are arranged for the outgoing circuits. The interconnecting bus-bars are placed at the back of the board, and are partly in duplicate. Each transformer panel is fitted with an automatic circuit-breaker, three-phase switch, ammeter, and reverse-current relay. The outgoing motor circuits are connected to panels of the same type as those used for the transformers, but have no reverse-current relays.

In the case of the furnace circuits the transformers are connected directly to a system of bus-bars with a neutral common to each set of three transformers. From these bus-bars three-phase feeders are taken to panels mounted on the ground floor. On each of the eight feeders an automatic circuit-breaker with overload trip is provided.

The three-phase current for motors at 400 volts is distributed by means of lead-covered and armoured cables carried in a large tunnel, which forms a basement to the transformer-house, and traverses the full width of the factory. The bare copper conductors to the furnace-houses are also carried through the same tunnel on porcelain insulators mounted in iron frames.

In addition to the switchboards already described, a separate system has been arranged for feeding the lighting system of the works. The current is supplied from a motor-generator mounted on the ground floor, consisting of a three-phase induction motor wound for 400 volts, and a direct-current generator for 220 volts.

In order to facilitate repair, a workshop has been arranged at the north end of the transformer house.

The transformers, which are mounted on wheels, are easily removed from their places to a traverser, of which there is one provided in each transformer-alley. By means of the traversers the transformers can be transported into the workshop, and there dismounted. For this purpose a 10-ton hand-crane is provided. In the floor of the workshop two large oil-tanks have been fitted. One of these contains fresh transformer oil, and the other will be held in reserve to take the oil from transformers under repair. In connection with the oil-tanks, a filter and electrical boiler apparatus has been fitted, so that both new and used oil can be treated.

Workmen's Houses.

The town of Odda is lighted by electricity supplied from the factories, and has derived great benefit indirectly from the presence of such an important industry. The workmen's houses have been greatly increased in number, and further blocks of dwellings on the most modern lines are in progress of erection. Hitherto the houses have been rented from the company on easy terms, but the intention is to encourage the workers to purchase their dwellings and the ground upon which they stand, as it is thought that this will be greatly appreciated by the men.

A STUDY OF SOME AUSTRIAN LOCOMOTIVE TESTS.

By Lawford H. Fry.

(*Concluded from page* 439.)

Engine Performance.

The engine—that is, the steam-cylinders—is considered independently of the boiler, attention being directed to the power developed and to the steam consumption per horse-power-hour at various cut-offs and speeds.

The relation between the power developed, as measured by the mean effective pressure, and the speed and cut-off is shown by Dr. Sanzin's figures, which are reproduced in Table III. and Fig. 6, page 689. The percentage of the boiler pressure, which Table III. shows to be available as mean effective pressure, is extremely high, and can only have been obtained by reducing to a minimum the various losses by friction in the steam-pipes and steam-passages and by back pressure and by imperfections in the valve motion. In fact, it is difficult to consider these figures as a safe guide for practical work. Before leaving them it may, however, be of interest to note Dr. Sanzin's figures for the drop in pressure between boiler and steam-chest, and for the drop during admission from the time of admission to the point of cut-off. These two pressure drops are determined by the design of the locomotive and play a large part in determining the value of the mean effective pressure for a given boiler pressure.

The percentage of the boiler pressure lost between boiler and steam-chest when running with a cut-off of 30 per cent. and the throttle in the normal running position, with an area of 48 sq. cm. (7.45 sq. in.) for the passage of the steam, is :—

Revolutions per second ..	1	2	3	4	5
	p.c.	p.c.	p.c.	p.c.	p.c.
Drop in pressure between boiler and steam-chest as a percentage of the boiler pressures ..	0.5	2.5	6.0	10.5	17.5

The drop in pressure between admission and cut-off, expressed as a percentage of the admission pressure, is shown in Table IV.

Another phase of the cylinder action which has a most important effect on the efficiency of the engine is the back pressure during exhaust. The locomotive on which the experiments were made is fitted with an exhaust-nozzle in which the outlet can be varied from 160 sq. cm. (25 sq. in.) to 75 sq. cm. (11.6 sq. in.). With the exhaust-nozzle opened to its widest, the following pressures were measured during the exhaust stroke, with cut-off of 30 per cent. :—

Revolutions of the Driving Axle per Second, n.	Steam Pressure at the Beginning of the Return Stroke, P_z.	Least Back Pressure During Exhaust, P_t.	Steam Pressure at the End of the Return Stroke, P_a.
	lb. per sq. in.	lb. per sq. in.	lb. per sq. in.
1	0.9	0.6	2.0
2	3.4	1.1	4.5
3	7.1	2.8	7.7
4	11.6	5.1	11.9
5	18.2	8.5	14.8

The least back pressure is practically the pressure at which the steam is exhausted to the stack, and as such plays an important part in inducing the boiler draught.

The mean back pressure, acting as it does against the piston throughout the whole of the return stroke, absorbs a very considerable amount of energy, and this is greatly increased if the area of the blast-nozzle is reduced.

The table in the next column shows the horse-power absorbed by the back pressure for the maximum and minimum openings of the exhaust-nozzle, 25 sq. in. and 11.6 sq. in. area respectively, when the cut-off is 30 per cent.

From this it appears that at the higher speeds the power absorbed by the back pressure, even with the largest nozzle area, is from 25 to 30 per cent. of the available power developed by the cylinders, while with the minimum area this percentage rises as high as 70 per cent. These figures emphasise the necessity of designing the front end and the exhaust-nozzle with the greatest care, so

that the necessary draught may be produced with the least possible back pressure.

Revolutions per Second	Speed in Miles per Hour.	Mean Back Pressure. Nozzle Area, 25 sq. in.	Mean Back Pressure. Nozzle Area, 11.6 sq. in.	Net Indicated Horse-Power Available in the Cylinders.	Horse-Power Absorbed by Back Pressure. When Nozzle Area is 25 sq. in.	Horse-Power Absorbed by Back Pressure. When Nozzle Area is 11.6 sq. in.	Horse-Power Absorbed by Back Pressure. Difference between Horse-Power with 25 sq. in. and 11.6 sq. in.
		lb. per sq. in.	lb. per sq. in.				
1	11.9	8.5	11.4	303	14.4	19.2	4.8
2	23.9	12.1	19.2	595	79.2	112.8	43.6
3	35.8	15.6	27.0	815	143.5	248.0	104.5
4	48.4	19.9	34.8	975	246.0	431.5	185.5
5	59.6	25.6	45.5	835	391.0	695.3	304.3

In a few of the tests it was found possible to run at a nearly constant speed and cut-off, so as to determine the effect of these variables on the amount of steam used. The weight of steam found to be consumed per indicated horse-power hour was as follows :—

Steam per Indicated Horse-Power Hour.

Cut-Off.	Revolutions Per Second. 2	3	4	5
per cent.	lb.	lb.	lb.	lb.
45	29.3	—	—	—
40	29.0	27.9	27.8	—
35	28.6	27.4	27.0	27.2
30	27.9	26.8	26.3	26.8
25	27.0	26.2	25.7	26.4
20	25.9	25.6	25.1	25.2

Dr. Sanzin makes some examination of the difference between the steam shown by the indicator and that actually consumed with a view to determining the loss by condensation in the cylinders. As he points out, however, it is practically impossible to carry out experiments on the road under conditions sufficiently constant to give really definite information on this point. It is only on a locomotive - testing plant that data sufficiently accurate to have any practical value can be obtained.

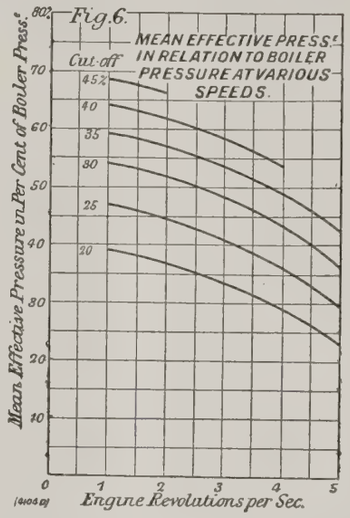
Locomotive Performance.

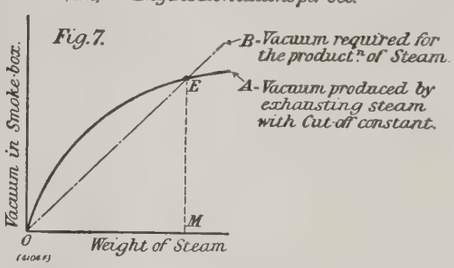
Having examined separately the power and efficiency of the boiler in producing, and of the engine in consuming, steam, it remains to consider the locomotive as a whole, and to study the relation between steam production and steam consumption. These two processes are doubly linked, for while the steam consumed by the engine is produced by the boiler, the production of the steam is dependent on the exhaust from the engine.

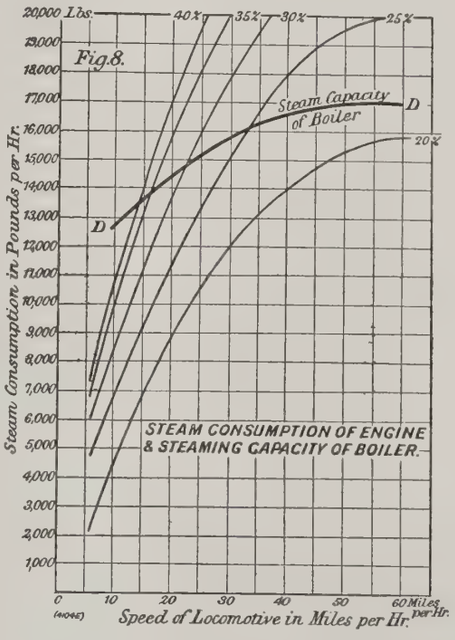
Dr. Sanzin points out that with a given quality of coal the steam-producing power of a given boiler is dependent almost exclusively on the vacuum in the smoke-box, and this vacuum, he says, depends on the weight of steam exhausted, and on the conditions of speed and cut-off. To show how these relations interact to set a limit to the power of a locomotive, he gives a diagram from which Fig. 7 is adapted. If, with the engine running at a given cut-off, the speed be increased, the weight of steam consumed and exhausted is increased, and consequently the amount of vacuum in the smoke-box is increased. The relation between the weight of steam exhausted and the vacuum produced under these conditions is represented by the line O A.

Now to produce a given weight of steam a certain smoke-box vacuum is required, the relation being indicated by the line O B. The line O A represents the vacuum available, and the line O B the vacuum required, and their point of intersection marks the maximum rate at which the locomotive can be worked at the given cut-off. In this way can be found for each cut-off the maximum speed at which the locomotive can work, and the corresponding rate of steam consumption. The result of this is shown in the line D D in Fig. 8. This diagram shows the steam consumption of the cylinders for the various cut-offs and speeds, while the line D D shows the limit imposed by the capacity of the boiler. It is obvious that if the speed be increased, the cut-off being kept constant, the steam consumption will increase as shown by the line in Fig. 8 corresponding to the given cut-off; and the increase in speed can be maintained until this steam consumption line cuts the steam production line D D. Then, if a higher speed is to be attained, the cut-off must be shortened. Having found, as in Fig. 8, the maximum speed available at each cut-off, the horse-power, the tractive effort, and the steam and coal consumption can be determined from the data already examined. This has been done, and the results as given by Dr. Sanzin are collected in Table V.

This table shows the conditions of operation when the locomotive works at its maximum power at various speeds, and it will be seen that the greatest efficiency is obtained at speeds of about 40 to 50 miles per hour. The maximum indicated horse-







power is 700 at about 50 to 55 miles per hour. As the heating surface, measured, as is usual in English-speaking countries, on the water side of the tubes and on the fire side of the fire-box, is 1400 sq. ft., the locomotive gives 1 indicated horse-power for each 2 sq. ft. of heating surface, which is a very satisfactory figure indeed for a single-expansion engine working with saturated steam. The coal consumption of $4\frac{1}{4}$ lb. per horse-power hour is also good when the quality of the fuel is considered.

The figures given so far enable the operation of the locomotive to be studied from the point of view of the designer—that is, the action of boiler and of engine can be criticised separately, with a view to seeing where changes are possible or desirable. When this has been done the locomotive must be considered as a whole—as a machine for moving trains in the process of manufacturing transportation. This Dr. Sanzin does by determining from his tests the weight of train which the locomotive can haul on various grades at different speeds. He thus obtains tables and curves which would enable the operating department of a railroad to determine the proper loading for the locomotive in any service.

Table III.—*Mean Effective Pressure as a Percentage of the Boiler Pressure at Various Speeds and Cut-Offs.**

Cut-Off in Per Cent.	Mean Effective Pressure as a Percentage of the Boiler Pressure. Engine Revolutions per Second. 1	2	3	4	5
	per cent.	per cent.	per cent.	per cent.	per cent.
45	68.5	66.5	—	—	—
40	64.0	62.0	58.5	54.0	—
35	59.0	57.5	54.0	49.0	42.5
30	54.0	52.0	48.5	43.6	36.0
25	46.5	45.0	41.5	36.0	29.5
20	39.0	37.0	33.5	29.0	23.0

* *Cf.* "Locomotive Characteristics," by Lawford H. Fry. See Engineering, vol. xci., page 571.

Table IV.—*Drop of Pressure Between Admission and Cut-Off.*

Revolutions per Second.	Cut-Off. 20 Per Cent.	30 per Cent.	40 Per Cent.	50 Per Cent.
	Difference Between Admission and Cut-Off Pressures, as Per Cent. of Admission Pressure.			
	per cent.	per cent.	per cent.	per cent.
1	–	—	4.0	3.0
2	13.0	10.0	8.0	6.0
3	18.5	14.0	11.0	9.0
4	26.0	19.0	15.0	12.0
5	34.5	25 5	—	—

Table V.—*Maximum Power Conditions at Different Speeds.*

Speed per Hour.		Indicated Tractive Force.	Indicated Horse-Power.	Steam Consumption. Per Hour.	Steam Consumption. Per Indicated Horse-Power Hour.	Steam Consumption. Per Square Foot of Heating Surface per Hour.	Coal Consumption. Per Hour.	Coal Consumption. Per Indicated Horse-Power Hour.	Coal Consumption. Per Square Foot of Grate per Hour.	Cut-Off in per Cent.	Vacuum in Smoke-Box in Inches of Water.
km.	miles	lb.		lb.	lb.	lb.	lb.	lb.	lb.	p.c.	
30	18.6	10,100	500	14,200	28.4	11.2	2250	4.50	90	34.0	4.10
40	24.9	8,640	574	15,130	26.3	11.8	2460	4.28	99	29.0	4.96
50	31.1	7,490	621	15,800	25.5	12.4	2660	4.28	106	25.5	5.67
60	37.3	6,670	665	16,280	24.5	12.7	2800	4.21	112	23.5	6.35
70	43.5	5,900	685	16,600	24 2	13.0	2900	4.24	116	22.5	6.77
80	49.7	5,700	700	16,820	24.0	13.1	2960	4 24	118	22.0	7.05
90	55.9	4,660	700	17,000	24.3	13.3	3010	4.30	120	21.5	7.28
100	62.1	3,920	650	17,100	24.4	13.4	3040	4.68	121	21.5	7.45

Table VI.—*Maximum Train-Loads.*

Speed per Hour.		Train-Load in Metric Tons behind Tender on Various Grades. Grade in Per Cent. 0.0	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
km.	miles											
30	18.6	1556	749	476	337	254	198	159	129	107	87	72
40	24.9	1120	582	364	259	195	156	123	98	79	64	51
50	31.1	779	431	284	202	150	115	88	69	53	40	—
60	37.3	552	322	215	152	112	84	62	46	—	—	—
70	43.5	384	231	155	109	77	55	—	—	—	—	—
80	49.7	263	162	107	73	48		—	—	—	—	—
90	55.9	173	106	68	—	—	—	—	—	—	—	—

Table VI., above, gives the train-loads measured in metric tons which the locomotive can pull on grades from a level to $2\frac{1}{2}$ per cent., at speeds from 18 to 56 miles per hour. At the higher speeds the train-load is determined by the limit which the boiler capacity sets to the horse-power available, but at the speed of 30 km. (18.6 miles) per hour, and for any lower speed, the train-load is limited by the "adhesion" of the driving-wheels; that is to say, at a speed of 40 km. (24.9 miles) per hour the hauling capacity can be increased by lengthening the cut-off until a point is reached where the rate at which the steam is consumed by the cylinders is just the maximum rate at which the steam can be produced by the boiler. At a speed of 30 km. (18.6 miles) per hour the hauling capacity can be increased by lengthening the cut-off; but before the maximum steaming capacity of

THE QUADRUPLE-SCREW LINER "LUTETIA;" THE ENGINE-ROOM.

CONSTRUCTED BY THE SOCIÉTÉ ANONYME DES CHANTIER ET ATELIERS DE ST. NAZAIRE, ENGINEERS, ST. NAZAIRE.

(*For Description, see opposite Page.*)

Fig. 15.

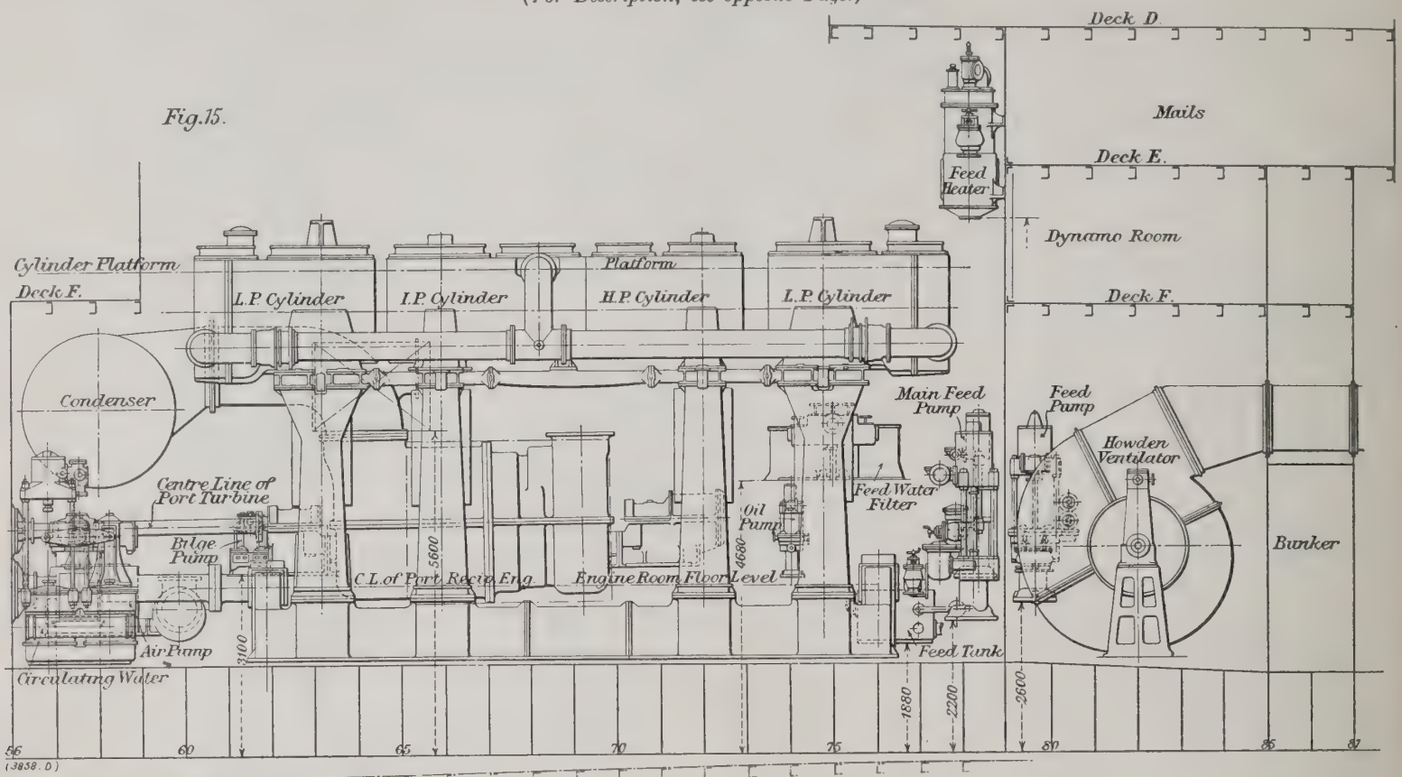
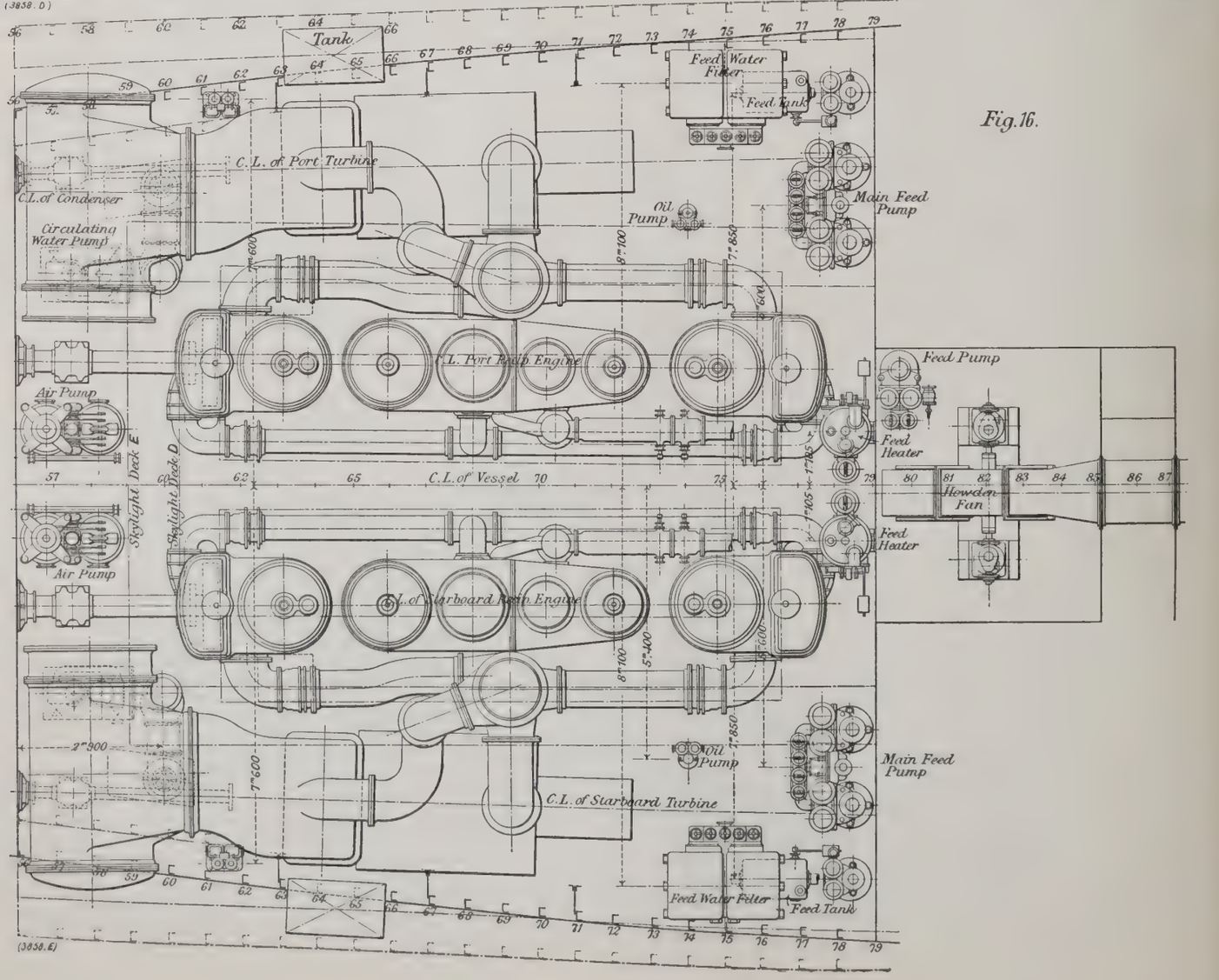


Fig. 16.



THE QUADRUPLE-SCREW LINER "LUTETIA," OF THE COMPA

CONSTRUCTED BY THE SOCIÉTÉ ANONYME DES CHA

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Fig. 19.

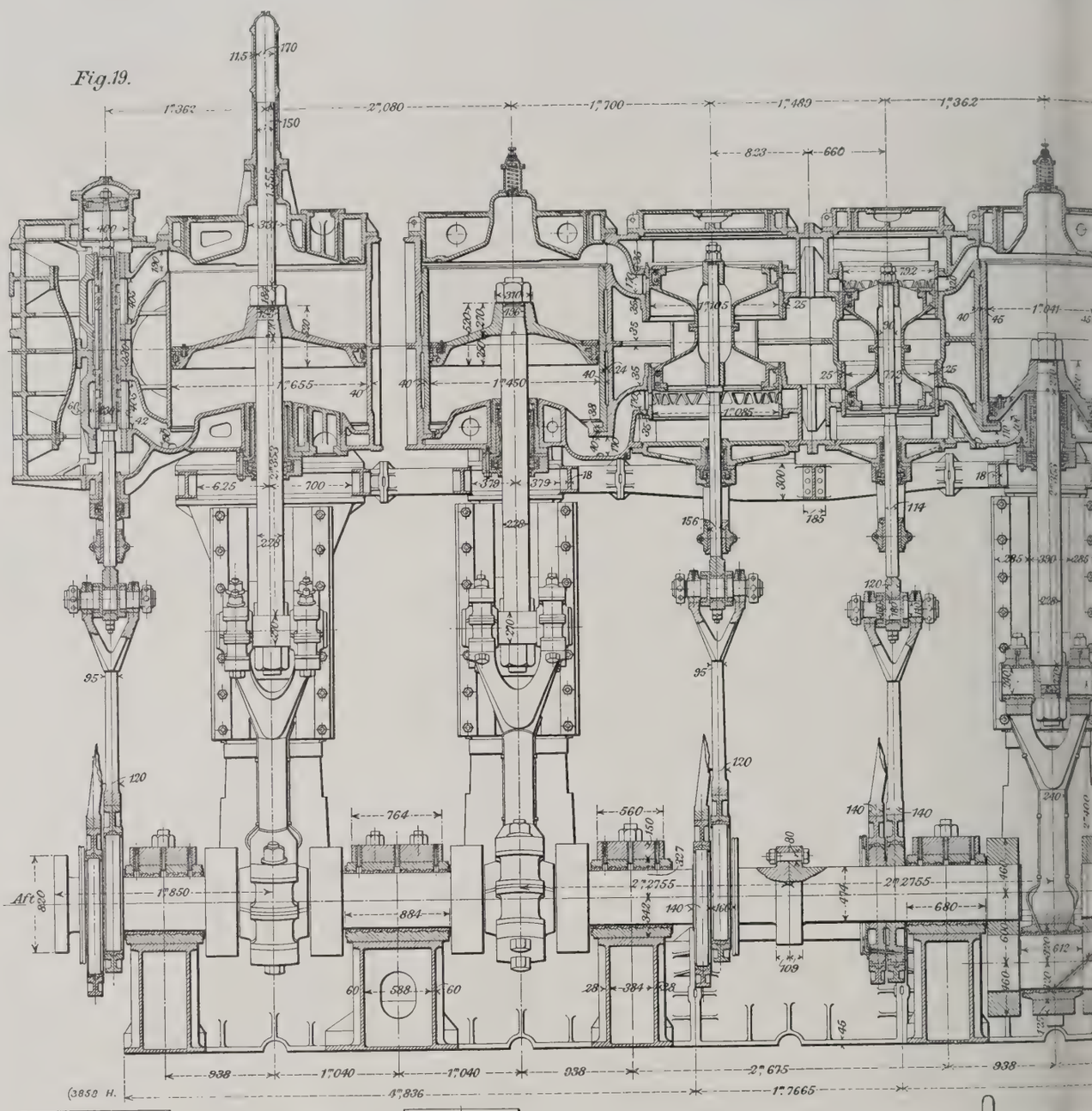


Fig. 21.

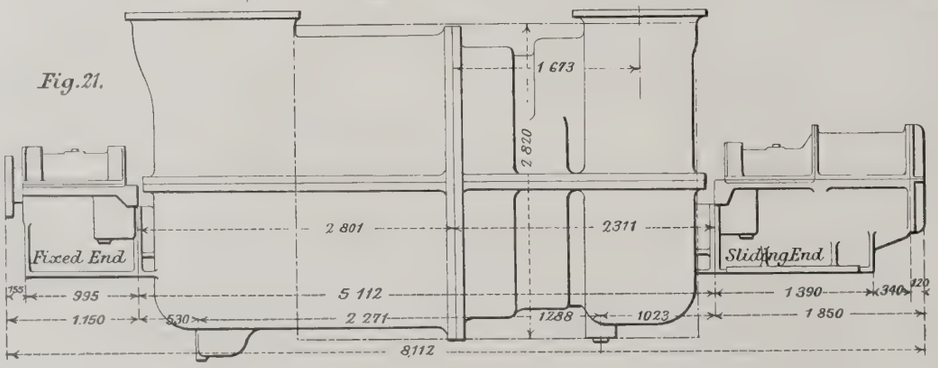


Fig. 24.

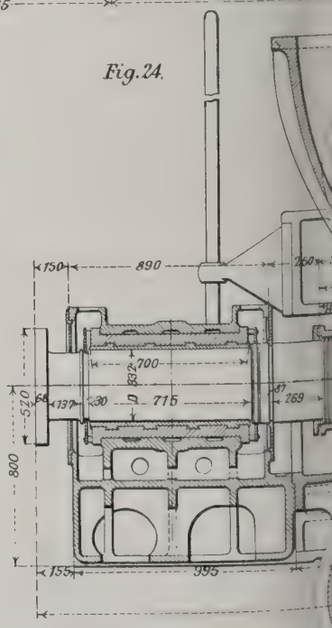


Fig. 22.

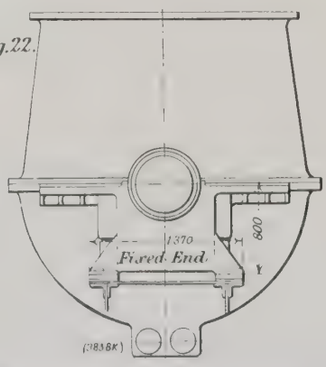
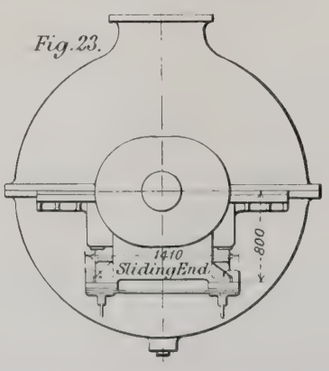


Fig. 23.



É NAVIGATION SUD-ATLANTIQUE; ENGINES AND TURBINES.

ELIERS DE ST. NAZAIRE, ENGINEERS, ST. NAZAIRE.

e 471).

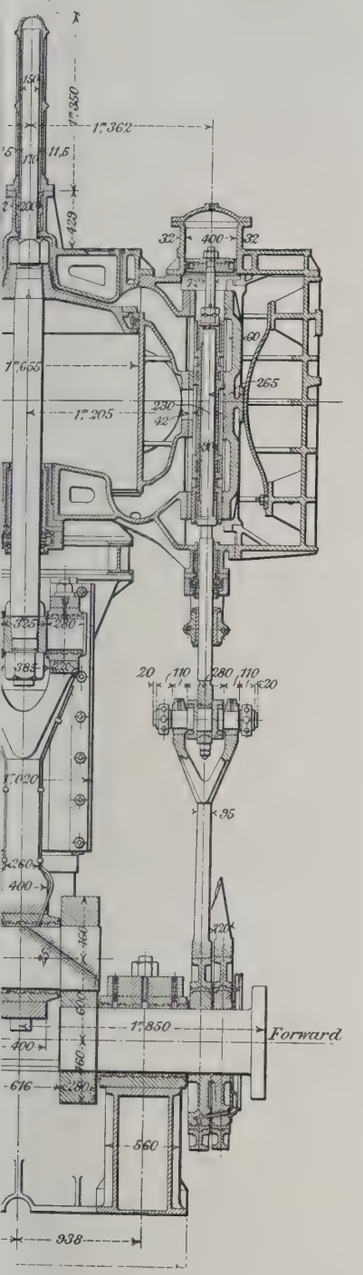
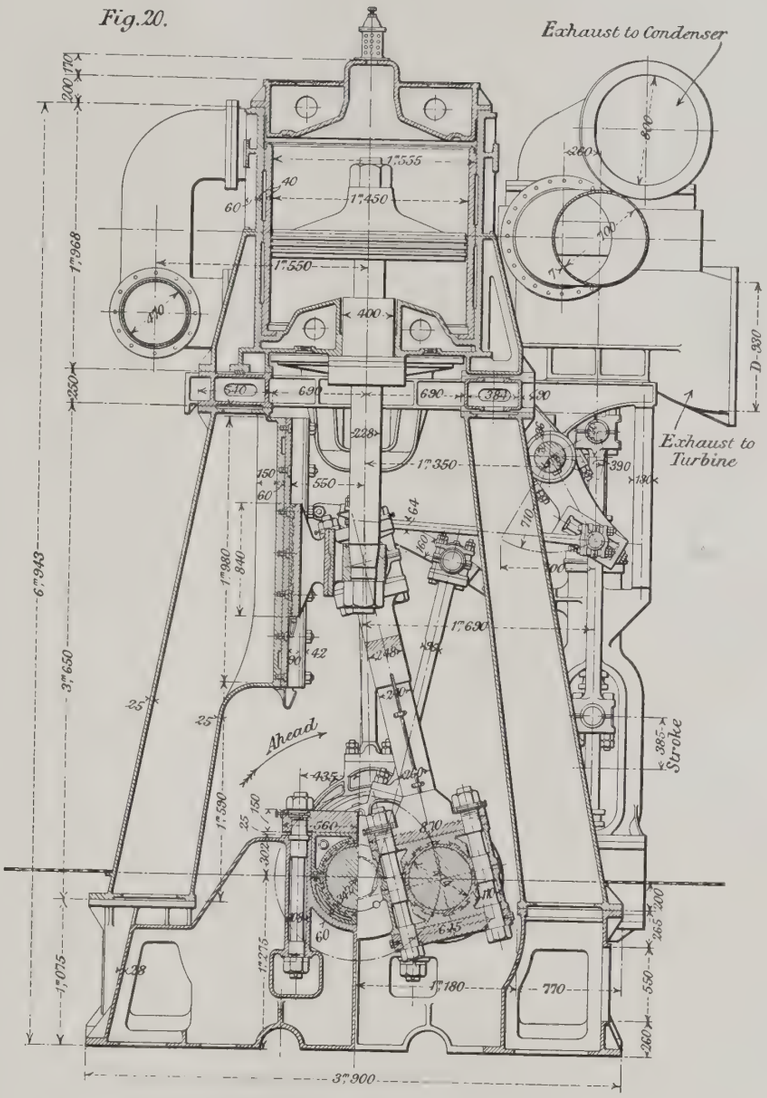
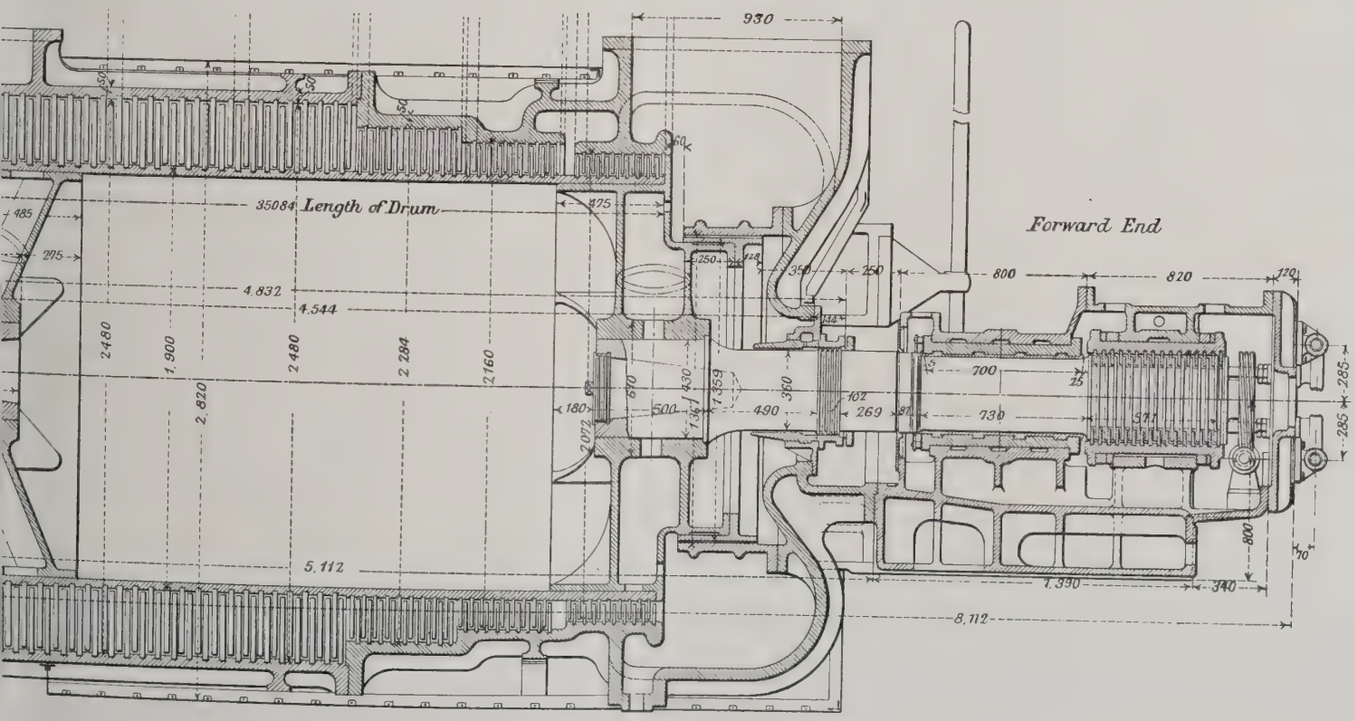


Fig. 20.





THE QUADRUPLE-SCREW LINER "LUTETIA;" THE ENGINE-ROOM.

CONSTRUCTED BY THE SOCIÉTÉ ANONYME DES CHANTIER ET ATELIERS DE ST. NAZAIRE, ENGINEERS, ST. NAZAIRE.

Fig. 17. SECTION AT FRAME 79.

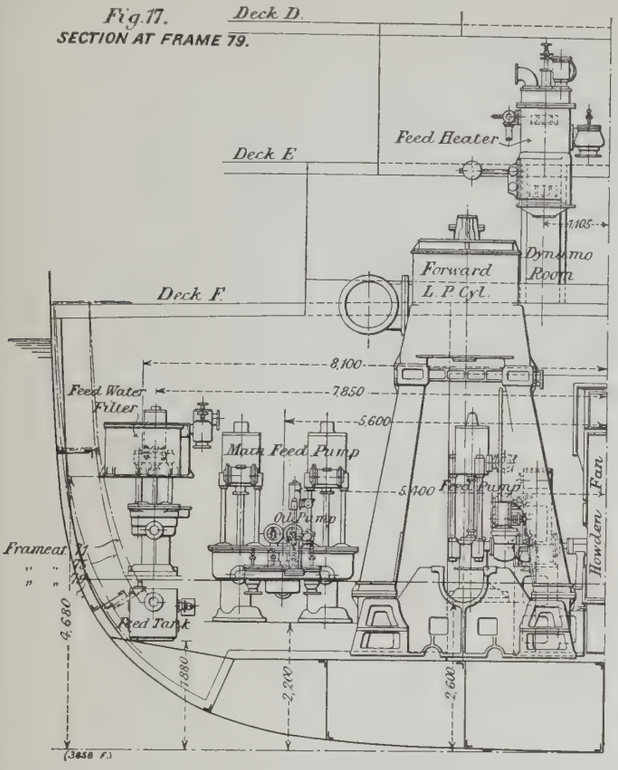
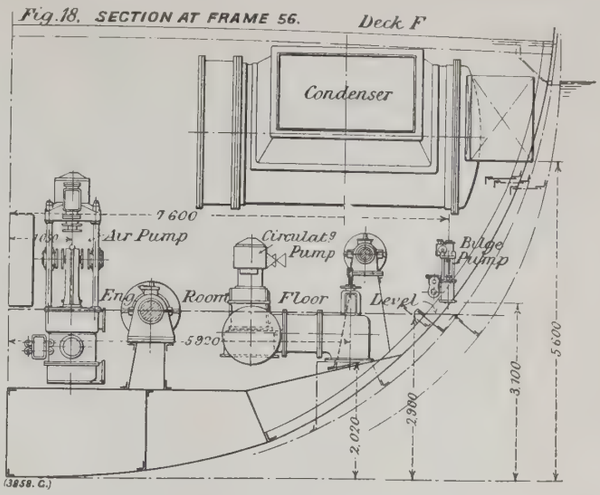


Fig. 18. SECTION AT FRAME 56.



The reciprocating engines are of the following principal dimensions :—

Diameter of high-pressure cylinder	1.041 m. (40.984 in.)
Diameter of intermediate-pressure cylinder	1.450 m. (57.086 in.)
Diameter of low-pressure cylinders	1.655 m. (65.157 in.)
Stroke	1.200 m. (47.244 in.)

The low-pressure cylinders are at each end of the engine. Steam is distributed to the high and intermediate-pressure cylinders by piston-valves in valve-chests which are located as shown in Fig. 19, on Plate XXXV.; the steam distribution to the low-pressure cylinders is by Martin Andrew slide-valves, in valve-chests at the extreme ends of the engine. The whole of the valves are operated by eccentrics and link motion. The crank-shaft, of forged steel, is 474 mm. (18.661 in.) in diameter, in two parts, coupled together in the centre, between the valve-chests of the high and intermediate-pressure cylinders. It is supported, as shown in Fig. 19, on six bearings.

Each reciprocating engine exhausts into an adjoining steam-turbine; the two turbines, which are illustrated in Figs. 21 to 24, drive the wing shafts. They are of the standard Parsons type, each having a drum 1.900 m. (74.803 in.) in diameter, carrying fifty rows of moving blades. There are three groups of standard blades at the high-pressure end of the turbine, having each nine rows of moving blades with heights respectively of 86 mm., 136 mm. and 192 mm. (3.385 in., 5.354 in. and 7.559 in.). At the low-pressure end, as is usual, the blade height is constant, but the requisite steam-way needed to provide for the constantly augmenting volume of the steam is secured by the use of semi-wing and wing-blades. The common blade height here is 290 mm. (11.417 in.), and there are twenty-three moving rows. The exhaust steam from the reciprocating engine enters the turbine by a branch 930 mm. (36.614 in.) in diameter, shown on the right-hand top corner of the turbine section, Fig. 24. It flows thence to the left, through the blading. The forward end of the drum is a hollow casting, to the interior of which steam is admitted through the openings shown. By this means the rotor and casing expand equally, and the arrangement allows of finer dummy clearances. The dummy is to the right of the drum, Fig. 24, and is substantially smaller in diameter; there is thus an unbalanced thrust from left to right which is added to the thrust of the steam on the moving blades. The sum of these thrusts is approximately equal to the propeller thrust in the opposite direction. The glands are of the ordinary Parsons marine type; the labyrinth is of the axial-flow pattern. Through them, the steam is wire-drawn down to the pressure of the exhaust, any back-flow into the engine-room being prevented by four Ramsbottom rings to each gland. The exhaust steam received from the reciprocating engines is at about atmospheric pressure, so the supply to the glands is taken from an independent pipe, and is wire-drawn down to a pound or two above atmospheric pressure before it is allowed to enter the glands. The Ramsbottom rings, therefore, are subjected to a very moderate pressure only. The forward bearing and thrust-block are in accordance with the Parsons standard practice. The brasses are 332 mm. (13.070 in.) in diameter by 700 mm. (27.559 in.) in length. A wiper-ring and oil-baffle, shown to the left, Fig. 24, prevent the oil from creeping to the gland, from which it might pass into the turbine, and thence to the condenser. The upper and lower halves of the thrust-block are independently adjustable by means of screws and worm-gear. After each has been adjusted to give the desired clearances at the dummy and between the thrust-rings, both are locked against motion forward or aft by means of the packing rings shown in Fig. 24. The governor and oil-pumps are driven by screw-gearing from a worm secured to the main turbine spindle. The turbines not being used for manœuvring purposes, there are no reverse turbines.

The arrangement of the main engines, as will be seen from the above, is very similar to that of the engines of the liner Rochambeau, also built by the St. Nazaire Company, and which we described in former issues (see ENGINEERING, vol. xciv., pages 704 and 742).

The engines and turbines develop together a total of approximately 20,000 shaft horse-power. The reciprocating engines are supplied with steam from 18 boilers 5 m. (16 ft. 5 in.) in diameter, having in all 54 furnaces, the total grate area of which is 111.60 sq. m. (1201.30 sq. ft.). The boilers work on Howden's forced-draught system, the installation comprising three fans, having each a capacity of 80,000 cub. m. (2,825,600 cub. ft.) of free air per hour. With a mean consumption of 120 kg. of coal per square metre of grate area (24.6 lb. per sq. ft.) the coal consumption per day would be 320 tons, but the boilers have been most carefully designed, and the normal speed in service can be obtained with a much lower fuel consumption and without the necessity of using the whole of the boilers, this allowing several of the boilers to remain free for an emergency, and also allowing them all to be maintained in perfect working order. Transverse and lateral coal-bunkers have been fitted in close proximity to the stokeholds; they can contain 3300 tons of coal. The ship can take over 1200 tons of fresh water. Evaporators have been provided for distilling sea-water.

From the bridge—the real centre of the ship—orders are transmitted by telegraphs and loud-speaking telephones to the engine-rooms and to all manœuvring quarters. The whole power of the reciprocating engines can be utilised for running astern, this ensuring perfect safety in all manœuvring in harbours. Recording instruments in the wheel-house enable the captain to follow the working of the main engines and of the steering-gear.

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he boiler is reached, the tractive effort exerted by the cylinders becomes sufficient to cause the driving-wheels to slip on the rail. This slippage occurs when the indicated tractive effort is only about 15 per cent. of the weight carried on the two pairs of driving-wheels, which is an extremely low factor of adhesion—that is, a low ratio of tractive force to adhesion weight. In any locomotive the factor of adhesion varies with the condition of the track, and with the cut-off, speed, and design of the engine. At slow speeds and long cut-offs it is unusual for slippage to occur with a tractive effort of less than 22 per cent. of the adhesive weight, so that Dr. Sanzin's engine shows a considerable deficiency in the starting power available.

Conclusions.

From what has been said it will be seen that Dr. Sanzin's *brochure* presents a very comprehensive study of the operation of a steam-locomotive. In their original form the tables and diagrams are so set out and are so related to each other that they offer a logical and enlightening account of the various processes involved. To a beginner approaching the study of the locomotive the work should have the highest value, while to the practical or practising locomotive engineer it may be offered as a most excellent model of the best form in which to present the results of any study of a given type of locomotive. Unfortunately, however, the curves and tables represent only Dr. Sanzin's conclusions, and the original observations, on which these conclusions were based, are not given. This is a serious disadvantage, as without these it is practically impossible to carry out any further analysis of the operation of the locomotive, or to use the present results directly in practical work. The form and the results of Dr. Sanzin's work are interesting and instructive, but there are several of his conclusions that one would have liked to test by an examination of the data from which they are derived.

THE FRENCH QUADRUPLE-SCREW LINER "LUTETIA."

(*Concluded from page* 426.)

As will be seen by our illustrations, Figs. 15 to 18, annexed, the Lutetia has four propellers, an arrangement which the builders have always advocated in reference to the fitting of three propellers only. The two inner shafts are each driven by a four-cylinder triple-expansion reciprocating engine, both engines being supplied with steam from eighteen cylindrical boilers of the mercantile marine type.

Our Rails Abroad.—September was a better month for our export rail trade, the shipments having amounted to 39,185 tons, as compared with 26,283 tons in September, 1913, and 43,917 tons in September, 1912. The aggregate shipments for the nine months ended September, this year, were 365,939 tons, as compared with 379,105 tons and 305,952 tons in the corresponding periods of 1913 and 1912 respectively. Argentina took 24,927 tons of British rails to September 30, as compared with 39,797 tons and 40,386 tons.

World's Record in Pontoon-Bridge Building.—The history of the establishment of the Canadian military camp at Valcartier, Quebec, is a record of remarkable engineering achievements. News comes now to hand of a further record in bridge-building, made by the men of the Royal Canadian Engineers, under the direction of Major W. Bethune Lindsay, of Winnipeg. The Jacques Cartier River separates the main camp from the artillery practice grounds at the base of Mounts Ileene and Irene. Across this 350 ft. of waterway the Royal Canadian Engineers built, within four hours, a barrel-pier pontoon bridge, capable of carrying heavy batteries.

BOILER EXPLOSION AT SOUTHSEA.

A formal investigation by the Board of Trade, under the Boiler Explosions Act, 1882, has been held at the Town Hall, Portsmouth, with regard to a boiler explosion which occurred in the basement of the South Parade Pier, Southsea, the property of the Portsmouth Corporation. By the explosion a boiler attendant was so severely scalded that he died the following day.

The Commissioners were Mr. F. Sims Williams, LL.B., K.C., barrister-at-law, who presided, and Mr. A. J. Maginnis, M. Inst. C.E., consulting engineer. Mr. Hamar Greenwood appeared on behalf of the Board of Trade, and Mr. Radcliffe represented the Corporation.

In opening the proceedings, Mr. Greenwood stated that when the pier was completed, in 1908, the Atmospheric Steam Heating Company, Limited, Westminster, were employed by the Corporation to arrange for the necessary heating of buildings on the pier. The specifications stated that the boiler to be used for the purpose should be of the "Ideal" type, as supplied by the National Radiator Company, London, and it was the explosion of this "Ideal" boiler that formed the subject of that inquiry. The boiler was of cast iron, 6 ft. 8 in. in length, 5 ft. 8 in. in breadth, and 6 ft. 10 in. in height, including the foundation forming the ash-pit. It consisted of sixteen separate castings forming eight sections. The boiler was originally provided with the following mountings :—

One safety-valve, 1½ in. in diameter, loaded by means of a lever and weight, to 10 lb. per sq. in.

One bellows-valve (or automatic damper regulator) with lever for regulating the opening of the damper in the ash-pit door.

One set of water-gauge valves with glass, and three test-valves on a cast-iron column.

One steam-pressure gauge, graduated to 30 lb. per sq. in.

One drain-cock.

One feed-check valve.

All these were supplied by the National Radiator Company, Limited.

In addition, on the main steam range was a steam stop-valve of the sluice type, and also a steam-reducing valve, adjusted for a pressure of 1 lb. per sq. in.

The boiler was made by the American Radiator Company, of Chicago and Buffalo, U.S.A., in January, 1908, and installed on the pier in November of the same year, so that it was about five years old at the time of the explosion.

On February 20, 1913, the boiler exploded, the flat portion at the back of the seventh casting being blown out, breaking two of the stays, which were cast solid with the flat portion, tearing one of them out by the root. The boiler-house was badly shaken, the main walls being cracked and the floor overhead partly blown out, together with the various windows, while an attendant, who was the only person near at the time, was, as already stated, fatally scalded.

The explosion was caused by excessive steam pressure, due, firstly, to the absence of the automatic control of the damper; secondly, to the steam not getting away freely to the radiators; and, thirdly, to the area of the safety-valve being wholly insufficient to relieve the undue pressure.

A number of witnesses were called by the Board of Trade, the first being Mr. Watson, manager of the Atmospheric Steam-Heating Company, who stated that a 2-in. safety-valve was specified for, but when he tested the boiler in November, 1908, he did not notice that a smaller one had been supplied. He examined the boiler the day after the explosion, and was of the opinion that the latter was due to the accumulation of flue-gas. The safety-valve was in perfect order. Possibly the boiler had been in work for a longer time than usual, and when the attendant opened the door to stir the fire up, all the gas which had collected above the fire exploded.

In examination by Mr. Greenwood, the witness stated that the ventilation of the boiler-room was bad, and he thought that the safety of the apparatus depended entirely upon the use, at occasional periods of the day, of the induced draught, and keeping the doors open. He gave these instructions when the boiler was first taken over, but only did so verbally.

After other evidence had been given, Mr. C. J. Farnie, superintendent engineer to Messrs. Moorwoods, Limited, stated that he agreed with the opinion that the explosion was due to flue-gas, and gave his reasons for so thinking. He was present when the boiler was tested in 1908, and did not notice that the safety-valve was 1½ in. in diameter instead of 2 in.

Mr. C. E. Smith, the Corporation's architect for the erection of the pier, gave evidence in connection with the ventilation of the boiler-room, and explained what had been done in connection therewith.

Mr. W. J. Coward, the head boiler attendant, stated that his assistant, Helan, who had been killed, was perfectly competent to look after the boiler in his absence. When he took over the job he had no instructions, either written or verbal, as to the working of the heating apparatus. He never used the induced draught or fan except when he was starting firing, and he had never found an insufficiency of air or draught. He did not consider the conditions of the boiler-room would induce an accumulation of gas in the boiler, and the doors were always open; he held the view that the explosion was due to the shortness of the water supply. He had known the water in the gauge-glass to drop from 7 in. to 4 in. in consequence of the strap of the feed-pump coming off or being broken, and when that occurred the water would cease going into the boiler. He had never found the air or draught to be insufficient, and there had never been an explosion of flue-gas.

Further evidence was given by various witnesses, including Mr. Tarrant, engineer-surveyor to the Board of Trade, who reported the result of his examination of the exploded boiler, and his views as to the cause of the explosion. After Mr. Greenwood, on behalf of the Board of Trade, had submitted a long list of questions on which he desired the judgment of the Court, the presiding Commissioner delivered judgment at great length. He carefully reviewed the evidence which had been given, and stated that with the exception of the area of the safety-valve, which was wholly insufficient, the Commissioners considered that the boiler was originally fitted with proper and adequate mountings. They thought that Coward, the boiler attendant, and Helan, his assistant, were both competent persons to have charge of the boiler; but the former, although stated to have been employed in the dockyard for thirty-six years, four of which he was employed on steam-launches, first as a stoker and then as driver, did not, in the opinion of the Court, thoroughly understand all details; while, further, no competent person had been employed to instruct him. If the boiler had been examined by a properly qualified person any existing defects would have been ascertained and made good, while the insufficiency of the safety-valve would have been pointed out, and a valve of sufficient area would have been put in its place, so that the pressure of steam would not have been exceeded. Boiler explosions were, in nearly every case, preventable, and the present one was certainly not an unavoidable accident, but could have been avoided had ordinary care been taken in the installation, inspection, and supervision of the boiler.

With regard to the theory that the explosion was caused, not by steam pressure, but by flue-gas, the Commissioners, after a careful examination of the exploded boiler and débris, had come to the conclusion that the theory was unsound. In their opinion there was no doubt that the explosion was caused solely by excessive steam pressure, due to the absence of the automatic control of the damper, to the steam not being able to get away immediately to the radiators, and to the safety-valve being wholly insufficient to relieve the undue pressure. They were of the opinion that proper measures were not taken by the owners to ensure the safe working of the boiler. With regard to the question by the Board of Trade as to who was to blame for the explosion, the decision of the Commissioners was that the National Radiator Company, Limited, Mr. Robson (manager of the pier), and Mr. W. J. Coward (boiler attendant), were not to blame, but that the Atmospheric Steam-Heating Company and the Portsmouth Corporation (owners of the pier) were to blame. The Atmospheric Steam-Heating Company were blamable for allowing the boiler to be fitted with an insufficient safety-valve, and the Corporation for the same reason, and because there had been no supervision or inspection of the boiler.

The presiding Commissioner ordered the Corporation to pay the sum of 75*l.* and the Atmospheric Steam-Heating Company 25*l.* towards the costs of the inquiry, which had lasted three days. It was stated that the total costs would amount to about 150*l.*

THE THEORY OF HARDENING AND THE CONSTITUTION OF STEEL.*

By Edward D. Campbell (Ann Arbor, Michigan).

Several of the papers read of late at meetings of the Iron and Steel Institute would seem to indicate a general *rapprochement* amongst metallurgical chemists in regard to their conceptions of the constitution of steel and the changes which take place in hardening. It is therefore to be hoped that before long a theory of steel broad enough to include a reasonable explanation of all the known facts concerning the behaviour of steel and not contrary to any known fact may be worked out.

In studying the paper read by Professors Edwards and Carpenter at the May meeting, one cannot but be impressed with the fairness with which they have discussed the whole subject, even though one may not be in full accord with all their interpretations, and may feel that they have omitted some features in the problem which may seem to one important.

Mr. M'Cance, too, is to be congratulated on the skill with which his experimental work was carried on, and particularly on the accuracy of measurement of the temperatures from which samples were quenched and the determinations of the Brinell hardness numbers, specific volumes, and electrical resistance of heat-treated specimens. It would be interesting to know the maximum temperature to which his specimens had been heated during their annealing, and the rate of cooling from the maximum temperature to the Ar 1 point, and from the Ar 1 point to ordinary temperature. It is well known that the size of the grain will depend largely on the maximum temperature reached during annealing, and the size of the individual carbide masses in hypereutectoid steel or of ferrite and carbide areas in hypoeutectoid steel will depend on the rate of cooling from the maximum temperature to the Ar 1 point. Experience in the present author's laboratory goes to indicate that with a steel containing 0.32 per cent. carbon cooled from 1060 deg. to 700 deg. in about seven hours, the carbide areas will be sharply separated, and will be from 0.2 mm. to 0.3 mm. in size, embedded in a nearly pure ferrite, the distance between individual carbide areas being somewhat greater than the diameters of the latter. While much work remains to be done before accurate quantitative data can be accumulated on the rate of diffusion in solid solution and the time required to secure chemical equilibrium at a given temperature, results obtained in this laboratory on steel annealed as above described point to the probability that at least an hour at 1000 deg. Cent. is required for precipitated carbides to redissolve and diffuse so that a strictly homogeneous solid solution in chemical equilibrium is obtained.

It might be well to ask whether what Mr. M'Cance calls "interstrain" is not a different name for what was called "internal tension" by Metcalf in his joint article with Langley.* That "interstrain" or "internal tension" is one of the contributing causes of hardness can be but little doubted, but that it is the only cause or even the most important factor may be seriously questioned. If interstrain were the only cause of hardness, should not the hardness of a given piece of steel be directly proportional to the temperature from which the sample is quenched, provided the temperature of the quenching liquid is kept below 20 deg. Cent., as it would seem that the amount of interstrain produced in a given steel would depend on the difference in temperature of the outside and the centre of the piece during cooling? Mr. M'Cance's figures indicate that eutectoid and hypereutectoid steels quenched from about 1000 deg. may be softer than when quenched from 770 deg., and yet would not one expect the interstrain in the former to be greater than in the latter case?

Professors Edwards and Carpenter, while apparently leaning toward the idea that crystal twinning produced by sudden cooling with the probable formation of an intensely hard amorphous form of iron at the contact surfaces of the twinned crystals is the cause of hardness, point out that the chemical constitution of the mass must be of great importance, since by proper heat treatment a 0.20 per cent. carbon steel may be converted into a mass of twin crystals without having great hardness, while some special steels may be made intensely hard without showing indication of crystal twinning.

It seems a little difficult to conceive any reason why amorphous vitreous iron produced at the surfaces of twinned crystals slipping over each other (this slipping being caused by internal pressure due to sudden cooling) should differ from amorphous vitreous iron resulting from cold hammering of annealed metal. Very thorough cold hammering of annealed metal would be expected to produce a larger proportion of amorphous vitreous iron than could be expected from quenching. By very careful annealing the Brinell hardness number of pure iron may be brought down to about 78 or 80, but we have not been able to raise this number by repeated hammering to more than about 240. It is well known that many chemical elements may be made to combine at ordinary temperature by submitting them to high pressure, and that the solubility of many substances, particularly gases, in water is dependent on pressure. It is easy to conceive, then, how cold-hammering of steel might have a marked influence on the hardness, not only by its effect on the amount of amorphous iron produced, but by influencing the amount of substances in solution in the iron, even though the solutes might not have been in solution at the beginning of the operation.

In order that any real progress can be made in any scientific work, such as research work on the constitution of steel and the relation of the constitution to the mechanical properties, it is necessary, after acquiring as much knowledge as possible of preceding work on the subject, to formulate a fairly clear working hypothesis to serve as a basis for systematic experimentation to prove or disprove the correctness of the working hypothesis. If at any time the hypothesis is found too narrow to include all known facts, it is desirable to attempt to widen it, but if at any time it is found to be contrary to any known fact the hypothesis must be modified so as to avoid such inconsistency.

To anyone who has paid much attention to the historical development of research work on steel it must be evident that any theory of steel sufficiently comprehensive to include all the known facts concerning the behaviour of steel, and to serve as a basis for future experimental work, must be a composite conception representing the accumulated experiences and ideas of a large number of research workers who have been engaged for nearly one hundred years on this subject. It was with these ideas in mind that the working hypothesis at present serving as a basis for experimental work in the chemical laboratory of the University of Michigan has been gradually developed.

A bit of history suggesting the evolution of ideas at the University of Michigan may not be out of place. In 1875 Professor John W. Langley, previously consulting chemist for the steel firm of Miller, Metcalf and Parkin, at Pittsburg, came to the University of Michigan as professor of general chemistry, and was soon placed in charge of metallurgy. In 1876† he published an article on the change in density in steel caused through change in composition and temperature of quenching. In 1880, Byron W. Cheever was appointed acting professor of metallurgy, which position he held up to the time of his death in 1888. Professor Langley remained in the university as professor of general chemistry, but continued his research work in connection with his outside professional practice as consulting metallurgist. In 1888-9, Professor Langley's title was changed to that of professor of chemistry and metallurgy, but he was on leave of absence, doing experimental work in Pittsburg. The author was a student in the university from 1881 to 1886, specialising in chemistry and serving as assistant under Professor Cheever in the year 1885-6, during which time he assisted Professor Cheever in his research work on steel. In 1890 the author returned to the university

* Paper contributed to the Iron and Steel Institute and now open for discussion by correspondence.

* Transactions of the American Society of Civil Engineers, vol. xxvii., page 682.

† Proceedings of the American Association for the Advancement of Science, page 124.

as assistant professor of metallurgy, and has remained in charge of the work in metallurgy and applied chemistry up to the present time. It will thus be seen that the chemical constitution of steel and the relation between the chemical constitution and the mechanical properties have constituted a line of research work carried on at the University of Michigan almost continuously for nearly forty years.

The working hypothesis which has served the purpose of training students, and as a basis for systematic experimental work in this laboratory for upwards of twenty years, but for which comparatively little originality is claimed, is a composite conception including as many of the ideas of previous experimenters as seemed necessary to furnish a reasonable explanation of the known facts concerning the behaviour of steel. This hypothesis assumes that the chemical constitution of steel is the most important single factor in determining the mechanical properties, since the nature and extent of the changes in the mechanical properties induced by different rates of cooling from different temperatures will fundamentally rest on the chemical constitution of the mass at the instant of quenching.

The chemical constitution of steel is regarded as a study in solubilities, the perfect parallelism between the solution of substances in iron as a solvent and that of ordinary substances in aqueous solution, so clearly pointed out by Langley,* being recognised. Langley considered the iron as a solvent, but did not include the allotropy of iron or the molecular constitution of carbides in his conceptions.

The hypothesis now, of course, assumes that iron is capable of existing in at least two allotropic forms, α and γ, differing somewhat in mechanical properties, but most markedly in solvent power, the γ iron possessing a much greater solvent and dissociating power than iron in the α form. There seems to be no necessity for assuming the existence of an intermediate β form of iron, and the most recent work seems to indicate that no such form exists. We have no knowledge of the molecular weight or molecular constitution of iron in the solid condition, so that we have no positive knowledge of the reason for the differences in properties of α and γ iron; but it is reasonable to assume that these differences are connected with the changes in molecular weight or atomic arrangement within the molecule, or both.

It is well known that in certain isomorphous crystals, such as magnesium sulphate and ferrous sulphate, we may have iron apparently replacing the magnesium atomically in any proportion up to a certain percentage, the crystals retaining the form of the crystals of pure magnesium sulphate, but the other properties being modified by the substitution of iron for magnesium. In a similar way we have assumed that certain elements, such as nickel and manganese, when added to iron, may atomically replace the iron in a complex molecule, thus modifying the physical properties, especially its solvent and dissociating power and its magnetic properties. On what molecular constitution ferro-magnetism depends we are unable to say, but so far as we know there is no instance on record in which iron has been rendered non-magnetic at ordinary temperatures without the addition of some other element which might atomically replace part of the iron, and in this way modify the molecular constitution as compared with that which would exist in strictly pure iron. In this sense it is a proper question to ask whether there is any evidence to show that strictly pure γ iron would be non-magnetic.

If, then, iron be regarded as a solvent capable of existing in two allotropic forms possessed of marked differences in solvent and dissociating power, and capable of being replaced atomically by other elements, this atomic substitution often profoundly modifying the properties of the solvent, the next natural thing to consider would be the chemical constitution of the solutes.

Although the carbon compounds in steel are by far the most important of the solutes, yet the general conception of steel as a study in solubilities would apply just as much to compounds of other elements with iron as to the carbon compounds. It has been known for nearly a century that when steel is dissolved in acids various compounds of carbon and hydrogen are evolved, and at least fifty years ago research work in both Germany and France seemed to demonstrate the existence of a good many different carbides of iron. In 1877 Cloëz† undertook some extensive work in the way of studying hydrocarbons obtained by dissolving manganiferous iron, but apparently drew no conclusions from his results. It was in 1885 that Sir F. Abel‡ described the recovery of a pure carbide of iron from annealed steel and assigned to it the formula Fe_3C, this formula being based wholly on the percentage of carbon and iron. No effort was made to determine whether this was a purely empirical formula, or whether it represented the chemical constitution of the carbide. Because of the apparent simplicity of this formula, metallurgical chemists immediately adopted it, and all efforts to determine the chemical constitution of the carbides of iron from a study of the products of solution were apparently abandoned for the time in favour of what seemed to be such a simple formula as the one given by Abel. Had the work of investigators who were studying the products of solution of steel up to the time of Abel's discovery been continued, it is very probable that the complex constitution of carbides would have been worked out, and the necessity of recognising this complexity in any theory of steel would have been conclusively shown 30 years ago. As it is impossible for a chemist to account for all the products of solution of the carbides of iron if so simple a formula as Fe_3C is employed to represent these, the writer undertook research work on a study of the products of solution of steel, about 1891, to see whether any relations existed between the carbon concentration and heat treatment of steel and the products of solution. In the development of this work it has been shown* that in annealed steel the mean molecular weight of the hydrocarbons evolved, hence, presumably, of the carbides from which the hydrocarbons are derived, decreases as the percentage of carbon increases—that is, the carbides existing in hypereutectoid steel have a lower molecular weight than in hypoeutectoid metal. Second, that with a given steel the mean molecular weight of the hydrocarbon evolved from hardened steel is lower than that of hydrocarbons from the same steel annealed—that is, the molecular weight of the carbides decreases when the metal is hardened. More recently,† in another paper, it has been shown, by a study of the dinitro-derivatives derived from the carbides in steel that the carbides of lower molecular weight are more readily soluble in iron than those of higher molecular weight, and have a greater hardening effect, but that they tend to dissociate with rising temperature, probably a dissociation analogous to ionic dissociation in liquid solutions. It was also shown that carbides of high molecular weight with rising temperature tend to split up into compounds of lower molecular weight and undergo more or less ionic dissociation.

In order to acount for differences in the products of solution of steels with varying carbon contents and heat treatment, the simplest hypothesis which we have been able to formulate which would satisfactorily account for the products of solution, is that the carbides of iron should be regarded simply as metallic substitution products of the hydrocarbons. It is well known that a part of the hydrogen in hydrocarbons may be easily replaced by a metal, as in zinc methyl, Zn $(CH_3)_2$, and there is no reason why all the hydrogen in hydrocarbons might not be completely replaced by a metal, in which case we would have simply a carbide of the metal. It seems to us more reasonable to assume that all the hydrogen in the hydrocarbons might be completely replaced by a metal, thus giving rise to a number of carbides of different molecular weights and molecular constitutions, than that the element carbon, whose most striking property is that of forming complex molecules in which carbon is linked to carbon, as in organic compounds, should lose its most striking property because it has combined with iron. The simple assumption that the carbides in steel are to be regarded as metallic substitution products of the hydrocarbons, whose molecular weights and molecular constitutions will depend upon the carbon concentration and heat treatment, offers a reasonable explanation for all the products of solution, and opens up an almost unlimited field for research on the constitution of these carbides.

The acceptance of the conception of the chemical constitution of carbides, above outlined, would offer a reasonable explanation for a number of known facts for which we have no satisfactory explanations by most of the hypotheses at present held. No hypothesis which assumes a single carbon atom molecule, Fe_3C, will satisfactorily explain the products of solution in hydrochloric, sulphuric, or nitric acid. If the increase in specific volume of hardened steel compared with that of annealed metal be largely due to the osmotic pressure of the dissolved carbides, then it would seem, if a single carbide, Fe_3C, only were present, that the increase in specific volume should be directly proportional to the increase in percentage of carbon. The very accurate determinations reported by M'Cance clearly show that the specific volume increases in a greater ratio than the percentage of carbon.

This is reasonably accounted for if the molecular weight of the carbide is recognised, for as the percentage of carbon increases the molecular weight of the carbides decreases; hence the number of carbide molecules per unit volume, and consequently the osmotic pressure at a given temperature, would increase more rapidly than the percentage of carbon.

It may be assumed that the increase in electrical resistance is due to substances in true solid solution in a manner analogous, but in opposite direction, to conductivity in aqueous solutions. Strictly pure water is supposed to be a non-conductor, while strictly pure metals at or near the absolute zero are supposed to be without electrical resistance. We assume that the increase in electrical resistance is dependent on the concentration of substances in solid solution, and that undissolved solutes, such as carbides, even if in a finely divided state analogous to colloidal suspension, do not influence the electrical conductivity to a very marked degree. The work of M'Cance confirms that of other experimenters in showing that the specific resistance of annealed steel in which most of the carbides are precipitated, only that portion soluble in α iron remaining in solid solution, is but slightly modified by the carbon content, and is probably more modified by the phosphides and possibly the silicides or sulphides remaining in solid solution than by the presence of variable amounts of more or less finely-divided precipitated carbides.

The author would suggest that austenite, produced by quenching high-carbon steel from temperatures of about 1050 deg., and having a different structure from martensite, being also distinctly softer, is a solid solution in which the carbides have undergone almost complete ionic dissociation, carbon ions or carbon in a state corresponding to ions in aqueous solution, not having the same hardening effect or the same effect on electrical resistance as that exerted by carbon in the form of undissociated carbide molecules.

The ionic dissociation of carbides of low molecular weight with rising temperature would account for the falling-off in the Brinell hardness of hypereutectoid steel when the temperature is raised much above that at which the carbides are completely dissolved, since the maximum hardness would be expected in such metal when complete solution was effected, but when ionic dissociation was at a minimum.

Under the above outlined conception of steel the study of the influence of a third element will necessitate the determination of the chemical relations of that element to both the iron and the carbon. Experiments may be systematically planned to determine whether a given element enters wholly into the constitution of the solvent or into the solute, or whether it is partly in one and partly in the other, thus bringing the law of mass action, which has been of such importance in the chemistry of aqueous solutions, into play. Some elements, such as nickel, seem to enter almost wholly into the solvent, while others, such as vanadium, as has been shown by some recent brilliant work by Arnold, have a much stronger affinity for carbon than has iron, and tend to go almost wholly into the solute. Manganese enters into both solvent and solute, as does chromium, although the greater part of the chromium, even when the percentage of the latter is low, is found to be combined with carbon in the form of double carbides—that is, in the solute. Other instances could be cited, but the above merely serve to suggest the possibilities which are open for systematic research if the general conception is held that the study of steel becomes a study of the influence of solutes in solid solution on the physical properties of the solvent.

* Proceedings of the American Society of Civil Engineers, vol. xxvii., page 682.

† *Comptes Rendus*, vol. lxxxv., page 1003.

‡ Proceedings of the Institution of Mechanical Engineers, page 30.

* Journal of the Iron and Steel Institute, 1899, No. 2, page 223.

† *Ibid.*, 1913, No. 2, page 367.

The New Army.—Messrs. Bruce Peebles and Co., Limited, of Edinburgh, announce that, since the outbreak of hostilities, well over one hundred members of their staff and works have joined the forces.

Competition with Germany and Austria-Hungary.—In connection with the campaign undertaken by the Board of Trade, on the advice of their Advisory Committee on Commercial Intelligence, to assist British manufacturers and merchants to secure trade formerly in the hands of German or Austro-Hungarian firms, the Board have received a very large number of inquiries for names of sellers or buyers of articles of which the sources of supply or markets have been interfered with by the war. Special arrangements have been made in the Commercial Intelligence Branch of the Board of Trade for dealing with the inquiries, and lists are being prepared and circulated of articles which inquirers desire (*a*) to purchase and (*b*) to sell. The first and second lists were published on August 29 and September 18 respectively; the third list, in which the first and second lists are incorporated, is now ready, and may be obtained on application to the Commercial Intelligence Branch. Firms interested in any of the goods mentioned, either as buyers or sellers, should communicate with the Director of the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

The Manchester Association of Engineers.—One of the first of our technical institutions to embark upon the winter session has been the Manchester Association of Engineers, whose President, Mr. E. G. Hillier, delivered his address on Saturday, October 10. With so many of our normal arrangements upset, it is natural that Mr. Hillier should have touched on the effect of the war. It is, in fact, referred to both at the opening and close of his address. Although engineers are intimately concerned with all the modern science of warfare, it is peaceful development which is of the greatest service to the world. At the present time, as our columns have abundantly testified recently, there are opportunities in all directions for expansion of our trade. Mr. Hillier rightly reminds us that this diversion may only be temporary, unless our progress in production and distribution is such as to enable us to retain this business. When Germany re-enters the field she will naturally make great efforts to regain the business formerly in her hands. If she finds herself in such a condition that it will be comparatively useless for her to concentrate her attention on military and naval equipment, her devotion to commerce will be intense. Mr. Hillier is therefore of the opinion that the opportunities now presented to us are of rather temporary advantage. His address, however, seems to admit that, properly followed up, the present openings may be secured in a more permanent manner. Whether as a nation we are able to rise to the occasion and manage to hold what we now merely have to reach out the hand to secure, remains to be seen. There is no doubt that the motto of "Business as usual," to which Mr. Hillier refers, is, in present circumstances, best not only for the institutions, but for the whole country, in so far as it is practical. Anything tending to further departure than is absolutely necessary from the normal, is to be deprecated. The bulk of Mr. Hillier's address was concerned with the discussion of engineering as a calling. It pointed out that the engineer seldom accumulated wealth, but derived some compensation from the satisfaction of introducing improvements, and that not until engineering became manufacturing did large profits accrue. Finally, Mr. Hillier spoke of the relation of technical societies to their members, and to other societies, and suggested that if some scheme could be devised for affiliating the Manchester Association of Engineers with the central Institution of Mechanical Engineers, it would be to the benefit of both bodies.

GAS-FIRED LEAD-MELTING FURNACE.

CONSTRUCTED BY THE MONOMETER MANUFACTURING COMPANY, LIMITED, ENGINEERS, BIRMINGHAM.

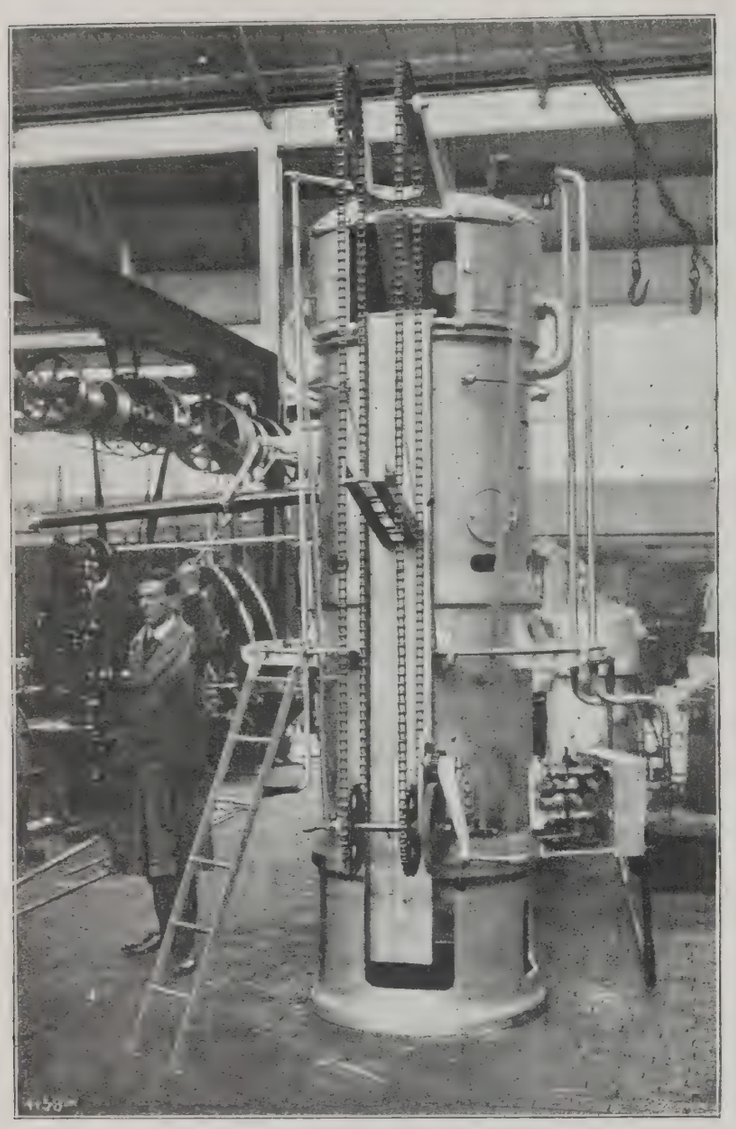
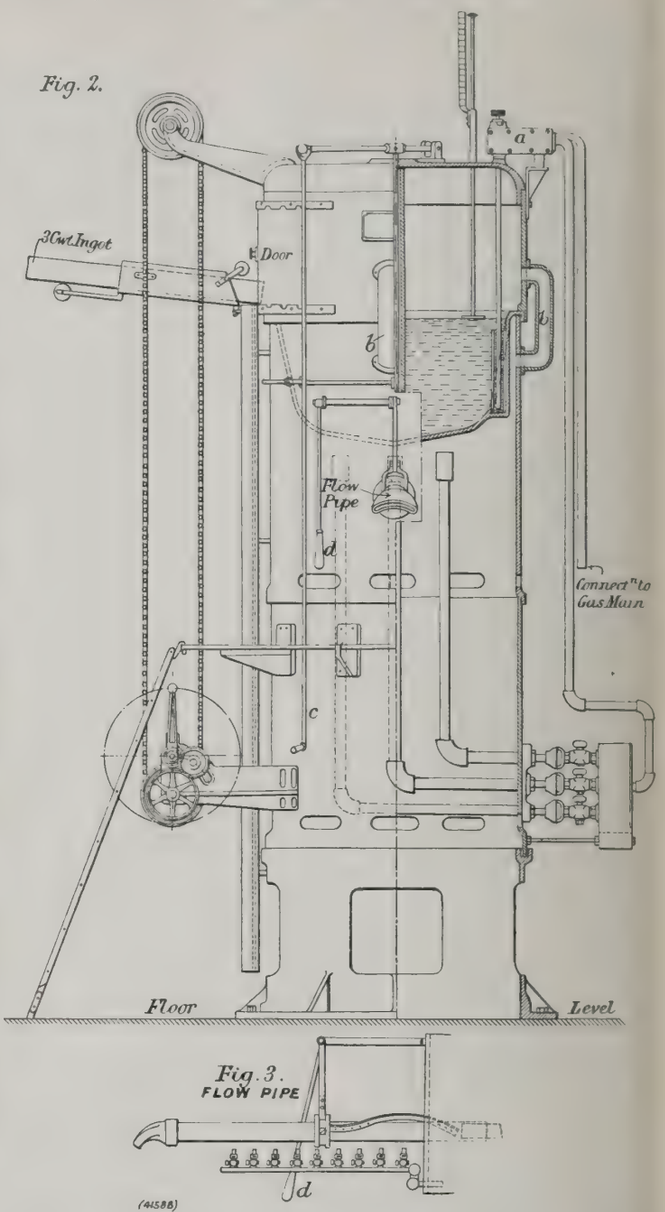


Fig. 1.



In our issue of April 17 last, on page 536, we illustrated a gas-fired furnace used for melting the large quantities of type metal required in a modern newspaper office. The most important feature of this furnace was the automatic temperature-regulating device, which was illustrated separately, but could not be fully described owing to the fact that certain patents were not completed.

We now illustrate, on the present page, another furnace employing this device and used for melting the lead required for covering cables in a large cable-making works. The same objection to the publication of a complete description of the means employed to regulate the temperature still applies, so that we must content ourselves by saying that the gas-valve is regulated so as to maintain a constant temperature by the expansion and contraction of a material contained in a tube which dips into the metal. Fig. 1 is a general view of the furnace, reproduced from a photograph, and Fig. 2 is partly an outside elevation and partly a longitudinal section through the axis. In this furnace the heating is effected by means of six Bunsen burners connected to the low-pressure town mains through the regulating device marked *a* in Fig. 2. The hot gases, after travelling round the bottom and sides of the melting-pot, pass through bent tubes *b* into the upper part of the pot, which, it will be seen, is completely covered in. By this means further heat is extracted from the gases before they finally pass away to the chimney, and the atmosphere is prevented from coming into contact with the molten metal. Loss of metal due to oxidation is thus very greatly reduced, and no noxious fumes are allowed to escape into the atmosphere. The furnace is charged through sliding-doors in the wall of the space above the melting-pot, the doors being opened and closed from the ground level by means of the long hand-levers shown in Fig. 1. The lead ingots are placed in an inclined tray attached to two endless roller-chains which pass round sprocket-wheels at the top and near the bottom of the furnace. By turning a handle connected to the lower pair of sprocket-wheels by spur-gearing, the tray carrying the ingot is raised until the charging-door is reached, when the ingot slides into the melting-pot. Fig. 1 shows the arrangement most clearly, and it will be seen that no labour other than that required to turn the handle is involved in the process of charging.

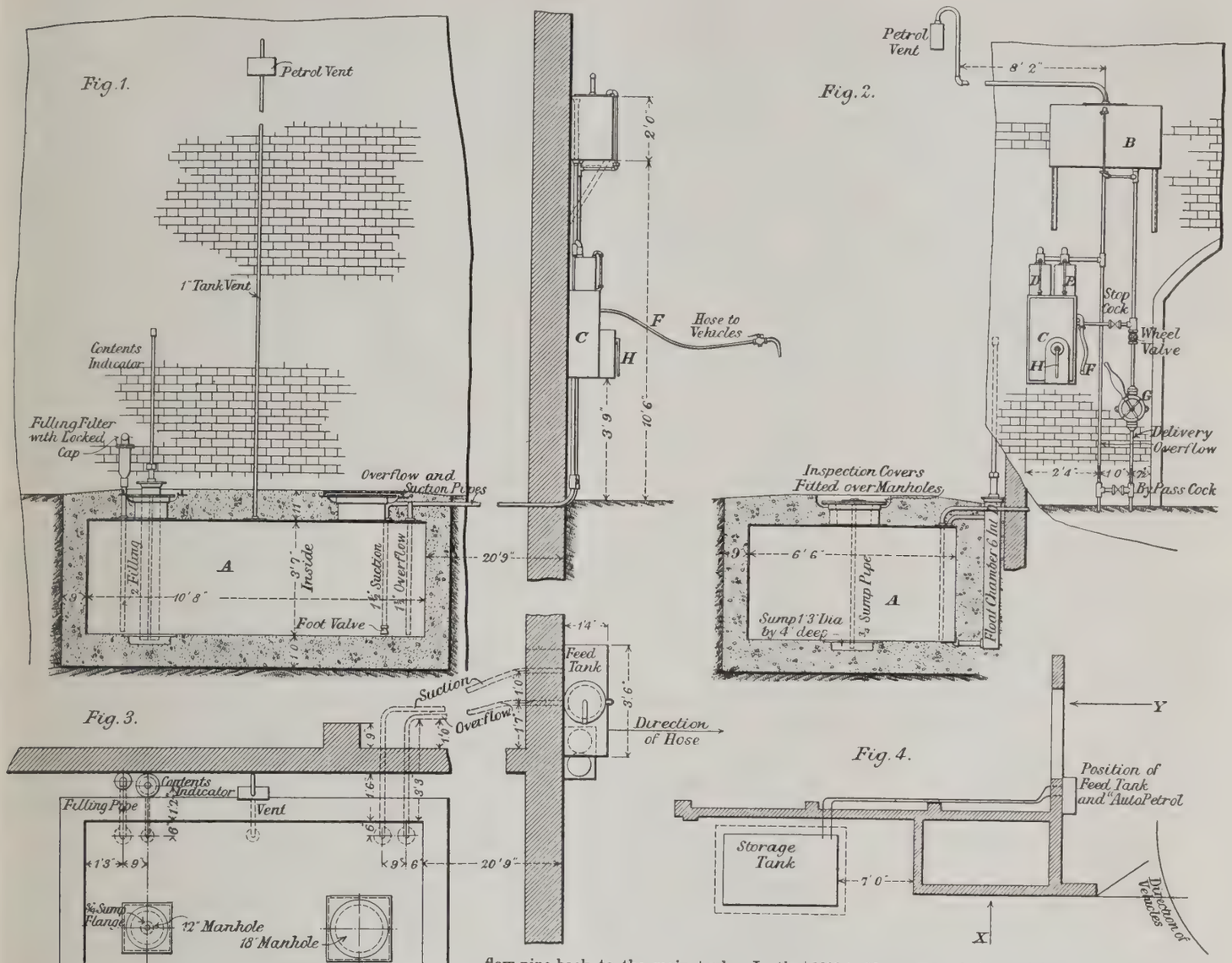
Another interesting detail of the furnace is the telescopic outlet-pipe, by means of which the molten metal is conducted into the receiver of the hydraulic press used for covering the cables. The pipe, which is fitted with a suitably shaped nozzle, is shown in position in Figs. 1 and 2, while Fig. 3 illustrates it separately. The flow of metal is controlled by a valve in the centre of the melting-pot, operated by a hand-lever *c*, in Fig. 2. When the metal is to be run out of the furnace the outlet-pipe is first pulled out by means of the hand-lever *d*, so that the nozzle comes over the receiver of the press, and the valve is then opened by the lever *c*. After sufficient metal has passed, the valve is closed and the pipe pushed back close up to the furnace. Gas-burners, visible in Figs. 1 and 3, are provided to prevent the metal from cooling in the pipe.

The melting-pot has a capacity of 30 cwt., and this quantity of metal is melted in about an hour. In order to indicate how much metal the pot contains, a float and scale, shown in the upper part of Fig. 2, are provided. The furnace, which was made by the Monometer Manufacturing Company, Limited, of Whitehouse-street, Aston, Birmingham, is claimed to be very economical in gas consumption, since the automatic regulating device entirely prevents waste of gas. It is also obviously very convenient to operate.

Birmingham Small Arms.—The directors of the Birmingham Small Arms Company report that in the rifle department the company has had a fairly good business year. It has been moderately engaged without a break on Government work, and its business in sporting and small-bore rifles has been well maintained. Immediately on the outbreak of the present war the company placed its rifle factory at the disposal of the Government, and it has received sufficient orders at ordinary contract prices to keep its works running day and night. Further, at the desire of the War Office the company is rapidly pushing forward large extensions which will enable it to considerably increase its output. Owing to the fact that every recruit in the new armies which have been raised has not been supplied with a rifle, some anxiety has arisen in the public mind as to the number of rifles available. The new armies far exceed in number anything before attempted by Great Britain; but the Government possesses large stocks of rifles, and these stocks, with the output of the company and sundry Government factories, will prove sufficient for arming the new troops before their services are required in the field. The directors add that the Lewis machine-gun has given satisfaction, and is now actually in service. The company is engaged in the manufacture of this arm for the Government, and the extensions of the works now in hand will enable it to supply practically any number required.

PETROL STORAGE AND DELIVERY APPARATUS.

CONSTRUCTED BY MESSRS. F. BRABY AND CO., LIMITED, ENGINEERS, DEPTFORD, S.E.



We illustrate herewith an arrangement for the delivery of petrol in predetermined small quantities. The arrangement, which is known as the "Auto-petrol," is particularly applicable to taxi-cab and other garages where payment for petrol is made by the driver. The device renders it impossible for the driver to obtain more spirit than he is entitled to by tallies served out to him. The apparatus also serves as a meter, the number of times it has been operated being registered by a continuous recorder in terms of gallons of spirit delivered.

The apparatus consists of a main storage tank A, to which, as will be seen in the illustration, is attached a float arrangement for indicating the quantity of spirit; this tank for preference is set in concrete under the floor. The spirit is pumped from this tank to a feed-tank B by means of a semi-rotary pump G.

The tank has a vent-pipe, attached to which is a valve-box containing two valves so arranged that the vent-pipe is normally closed to the atmosphere, but automatically allows of the inlet and egress of air when petrol is being drawn from, or run into, the tank. The arrangement also prevents evaporation and acts as an additional safeguard against fire.

From the main storage-tank B the spirit flows to two measuring-tanks D and E, the capacity of each being 2 gallons. These measuring-tanks are fitted with float-actuated valves, and arranged so that should the valves leak, the excess of petrol flows down an over-flow-pipe back to the main tank. In the casing C are two three-way cocks which are actuated by a cam when the handle H is turned. In working, a tally is inserted in a slot above handle H, and the handle then given a half turn. This causes the cam to open one of the cocks, so that the petrol from one measure is allowed to flow down the armoured outlet-pipe F, which is fitted with a spring-valve, as seen in the illustration. The other cock is turned so that the petrol from the feed-tank flows by gravity to the other measures. By inserting another tally, and giving the handle another half turn, the operation is reversed.

The apparatus, which is manufactured by Messrs. F. Braby and Co., Limited, Ida Works, Deptford, S.E., should remain perfectly accurate after long service, as there are no packings to cause leakage.

German Export Trade in Boilers, &c.—A Board of Trade bulletin, issued a few days ago, points out that the export trade of Germany in boilers of steel and iron, tanks, drums, &c., is valued at about 1,157,150*l.* per annum. Of this sum goods to the value of 44,650*l.* come to this country, consisting chiefly of gas and other reservoirs and drums, and mooring-buoys, which we import to the value of over 33,000*l.* per annum. Our imports from Germany in the form of boilers proper are comparatively small, but that country's exports to France, Argentina and Russia are appreciable, especially to the last-named country, which imports steam boilers to the value of 93,000*l.* Germany also exports mooring-buoys, gas-drums, &c., in large quantities to France (44,200*l.*), Russia (33,300*l.*), the Netherlands (26,450*l.*), Argentina (24,400*l.*), Japan (20,600*l.*), and so on, her total exports in this line amounting to 372,050*l.* It is interesting to note that in Japan Germany's trade in steam boilers and parts, expanded from 2 per cent. of the total imports in 1911 to 16 per cent. of the total imports two years later, while our own trade from being 87 per cent. of the total imports fell in the same two years to 68 per cent. of the total. At the same time the total imports fell off by about 40 per cent.

The Junior Institution of Engineers.—At a meeting of this Institution on Monday, October 12, an interesting paper on "Cotton-Spinning" was read by Mr. William Scott Taggart, M.I. Mech. E., of Manchester. The lecture dealt in a general way with the main features of cotton-spinning machinery—*i.e.*, the machinery used for the transformation of the raw cotton from the plant to the finished product in the form of yarn. To show the importance of the subject, a few words were devoted to the interest of cotton-fields in various parts of the world, the production of raw cotton, and the character of the fibres. The separation of the cotton fibres from the seeds to which they are attached was described and illustrated, and samples shown. The baling of cotton was briefly mentioned, and the entrance of the bale to the Lancashire cotton-mill was made the starting-point for an extended description, fully illustrated, of the various processes through which the cotton passed to the yarn stage, and the machinery employed in these operations. Some of the most important mechanical features of these machines were emphasised. The lecture was designed to give the impression that whilst the textile industry is probably the most important in England (agriculture excepted), the engineering aspect is also one equal to it in prominence. The engineering and mechanical problems that have been, and are being, solved have raised cotton-spinning to the highest plane of mechanical science; and the huge engineering establishments that devote their attention to the supply of textile machinery are in the front rank among the industries of the country. A large number of drawings accompanied the lecture, practically all of which were line sketches illustrative of the action of the machines. Examples from seed-cotton to the finished yarn were also shown.

THE WORKING OF THE BOILER EXPLOSIONS ACTS.

The annual report for the year ending June 30, 1913, on the working of the Boiler Explosions Acts, 1882 and 1890, has just been issued by the Board of Trade. During the period named, 66 preliminary inquiries and 14 formal investigations were held under the provisions of the Acts. The 80 explosions thus dealt with caused the death of 31 persons and injury to 42 others. The 31 deaths were caused by 20 explosions, of which 11 occurred on land and nine on ships. The number of persons killed is above the average (26.5) for the 31 years since the Act came into force, but the number of injured is considerably below the average. It is satisfactory also to be able to record a drop in the number of explosions which occurred during the year, though this is still slightly above the average (72.9).

On analysis of Appendix A, which gives a very complete summary of the explosions for the year, it appears that 22 boilers, &c., were under boiler insurance or accident insurance companies; 12 were under the Board of Trade or Lloyd's Survey; 5 were under mutual marine insurance companies, &c.; 3 were under the inspection of the makers; while in the remaining 38 cases the boilers, &c., were apparently under no system of periodical inspection.

Appendix B describes the 80 explosions as having arisen from the following boilers or vessels, &c.:—

13 horizontal multitubular boilers.
5 vertical boilers.
3 Lancashire or Cornish boilers.
3 locomotive boilers.
8 water-tube boilers.
9 tubes in steam-ovens.
4 heating apparatus.
18 steam-pipes, stop-valve chests, &c.
3 hot plates, &c.
6 calenders, drying-cylinders, &c.
3 economisers.
1 steam-jacketed pan.
4 miscellaneous.

The causes of the 80 explosions were as follow:—

24 deterioration or corrosion.
13 defective design or undue working pressure.
11 water-hammer action.
16 defective workmanship, material, or construction.
7 Ignorance or neglect of attendants.
9 miscellaneous.

Appendix C states that the number of explosions respecting which formal investigations were held during the year ending June 30, 1913, was 14. They related to:—

2 vertical boilers.
2 water-tube boilers.
1 stop-valve chest.
2 heating apparatus (rectangular and "Ideal").
1 marine boiler.
1 drying-cylinder.
2 steam-pipes.
1 separator (cylindrical).
1 feed-check valve-chest.
1 economiser.

These explosions resulted in the death of 20 persons and injuries to 10 others. The report states that the causes of these explosions have been clearly ascertained, and in two of the cases the explosions have been attributed to accidents—viz., in the case of an explosion on board a vessel the Commissioners found that it was due to water-hammer in the pipe, brought about by the accidental opening of a drain-cock. In the case of an explosion of an oil-separator the Commissioners found that it was brought about by an accident to one of the workmen.

The findings of the Commissioners in the fourteen formal investigations referred to were as follow:—

In one case the owner was found to blame. In one case the owner and a boiler insurance company were found to blame.

In one case the owner of the boiler was found to have contributed to the explosion by reason of negligence.

In one case a superintending engineer was found to blame.

In one case the owners were found to blame and a firm of contractors also partly to blame.

In one case the makers, the works manager, works engineer, a foreman, and a chargeman were all found more or less to blame.

In one case a superintending engineer was found guilty of an oversight and error of judgment.

In one case the owners and a contracting company were found to blame.

In one case a foreman and a chargeman were found to blame.

In five cases no one was found to blame.

The following amounts were ordered to be paid towards the costs and expenses of the investigations:—

In one case an owner was ordered to pay 10*l.*
In one case the owners were ordered to pay 25*l.*
In one case the owners were ordered to pay 35*l.*
In one case the owners were ordered to pay 75*l.*
In one case a boiler insurance company was ordered to pay 50*l.*
In one case the owner of the boiler was ordered to pay 20*l.*
In one case a superintending engineer was ordered to pay 50*l.*
In one case a firm of contractors was ordered to pay 15*l.*
In one case a contracting company was ordered to pay 25*l.*
In one case a foreman was ordered to pay 7*l.* and a chargeman 5*l.*

The total sum ordered to be paid amounted to 317*l.*

Appendix D gives the total number of explosions dealt with since the passing of the Acts, the number of lives lost, and of persons injured:—

Year.	Number of Explosions.	Personal Injuries.		
		Number of Lives Lost.	Number of Persons Injured.	Total.
1882-83	45	35	33	68
1883-84	41	18	62	80
1884-85	43	40	62	102
1885-86	57	33	79	112
1886-87	37	24	44	68
1887-88	61	31	52	83
1888-89	67	33	79	112
1889-90	77	21	76	97
1890-91	72	32	61	93
1891-92	88	23	82	105
1892-93	72	20	37	57
1893-94	104	24	54	78
1894-95	114	43	85	128
1895-96	79	25	48	73
1896-97	80	27	75	102
1897-98	84	37	46	83
1898-99	68	36	67	103
1899-1900	59	24	65	89
1900-1	72	33	60	93
1901-2	68	30	55	85
1902-3	69	22	67	89
1903-4	60	19	45	64
1904-5	57	14	40	54
1905-6	54	25	21	46
1906-7	77	28	65	93
1907-8	73	23	50	73
1908-9	93	12	53	65
1909-10	103	14	62	76
1910-11	100	13	61	74
1911-12	106	30	75	105
1912-13	80	31	42	73
Totals	2260	820	1803	2623
Average of 31 years	72.9	26.5	58.2	84.6

The report further states that in the investigations of some of the explosions during the past year important recommendations were made by the Commissioners. In one case they recommended that the attention of the users of small boilers should be called to the neglect of periodic "thorough" examination of their boilers. In two others they made recommendations dealing with the construction and management of the boilers of heating apparatus and cylinders of drying machines respectively. In a fourth case the Commissioners recommended that all owners of steam-trawlers should be warned of the danger attending the use of loose-fitting valve-seatings unless they are under the control of a master-valve interposed between the check-valve and the boiler.

It may be pointed out that many of the explosions reported upon were of a comparatively trivial character, such as those due to the failure of tubes in steam-ovens, &c., but inasmuch as such occurrences endanger life, it is important that they should be investigated by the Board of Trade in the hope that by the spread of information on the subject greater care will be taken both by those who make and those who use any vessel liable to give rise to an explosion of a more or less serious nature.

The Institution of Mechanical Engineers: Local Meeting in Manchester.—In response to requests from members in the Manchester district, arrangements have been made for a meeting of the Institution of Mechanical Engineers to be held in the Main Room of the Portico Library, Mosley-street, Manchester, at 8 p.m. on Tuesday, the 20th inst., for the presentation and discussion of the Report of the Refrigeration Research Committee. Mr. George Hughes, Member of Council, will preside.

The Institution of Municipal Engineers and the War.—Captain Arthur J. Martin, M. Inst. C.E., is forming a 2nd London Sanitary Corps, which has volunteered for service abroad. The chief duty of the new company will be to supervise the water supply and camps and billets, reporting defects and instructing the squads of the combatant units. The company will be a branch of the R.A.M.C.T.F., and the men whom Captain Martin is now enrolling are drawn from the various professions and trades connected with sanitation; mostly engineers, surveyors, architects, sanitary inspectors, and a sprinkling of men from the building trades. Applications should be made to Captain Martin direct at the Duke of York's headquarters, Chelsea, S.W., or to Lieutenant Cave, or to the Orderly Serjeant.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was very flat, and Cleveland warrants showed a decline. The turnover was limited to 1000 tons at 50s. 1½d. cash and 50s. 11d. three months, and closing sellers named 50s. 2d. cash, 50s. 6d. one month, and 51s. three months. In the afternoon there was little doing, and business was confined to 500 tons of Cleveland warrants at 50s. 10½d. three months. The closing quotations showed little change. On Friday morning the market was a little easier, and only one lot of Cleveland warrants was put through at 50s. 1d. cash, with sellers over at that figure, and at 50s. 4½d. one month and 51s. three months. A steady tone prevailed in the afternoon, when 1500 tons of Cleveland warrants were done at 50s. 0½d. cash, and sellers' prices at the close were called 50s. 1d. cash, 50s. 5d. one month, and 51s. three months. On Monday morning the market was dead idle, and Cleveland warrants were weaker, with sellers at 49s. 11d. cash, 50s. 2½d. one month, and 50s. 9d. three months. In the afternoon the tone was again weaker, and 1000 tons of Cleveland warrants changed hands at 49s. 11d. and 49s. 10d. one month. Closing sellers quoted 49s. 7d. cash and 49s. 10d. one month, but there were no quotations for the three months position. The downward trend of Cleveland warrants continued on Tuesday morning, when 1000 tons were dealt in at 49s. cash, and at the close sellers named 49s. 1½d. cash and 49s. 5d. one month. The afternoon session was also weak and idle, and the closing prices were called 49s. cash and 49s. 3d. one month. When the market opened to-day (Wednesday) Cleveland warrants eased off a little more, and 1000 tons changed hands at 49s. 3d. three months. Sellers' closing prices were 48s. 7½d. cash, 48s. 10½d. one month, and 49s. 6d. three months. In the afternoon there was little change in the state of the market, and no dealings were recorded. Sellers of Cleveland warrants quoted 48s. 9d. cash, 49s. one month, and 49s. 6d. three months.

Sulphate of Ammonia.—The demand for sulphate of ammonia is not very heavy at the present time, and the price shows almost no change.

Scotch Steel Trade.—During the past week there has been very little change in the state of the Scotch steel trade, and rolling-mills generally are not fully employed. The dearth of new shipbuilding orders has caused a much smaller demand for plates, but as the stocks of foreign ship-plates are getting smaller, the local consumers are passing better orders, although the quantities are on the small side. Black sheet makers, while still doing well in heavy qualities, are in receipt of few specifications for the lighter gauges, and for galvanised sheets the demand is rather poor. Export orders do not bulk very heavily at present, and, except for one or two spots, the shipping trade is quiet. Taken all over, the steel trade might be said to be "marking time," and in daily expectation of an improvement.

Malleable-Iron Trade.—The malleable-iron makers in the West of Scotland are still rather quiet, and report a poor demand. Business is difficult to secure, and they are finding it very hard to obtain enough to keep their plant running. Prices are unchanged.

Scotch Pig-Iron Trade.—The Scotch pig-iron makers have struck a dull seam at the moment, and not only has the home demand fallen off, but there is also a much smaller inquiry for export lots. Prices show an easier tendency, due, it is said, to the threatened import of American pigs, but most likely to induce fresh orders. The following are the market quotations for makers' (No. 1) iron:—Clyde, 68s. 6d.; Calder, Gartsherrie, and Summerlee, 69s.; and Langloan, 72s. (all shipped at Glasgow); Eglinton, 63s.; and Glengarnock, 70s. (both at Ardrossan); Shotts (at Leith), 69s.; and Carron (at Grangemouth), 69s. 6d.

Queensland Coal.—The quantity of coal raised in Queensland in 1912 was 902,166 tons. The corresponding output in 1911 was 891,568 tons. The average value of the coal produced in 1912 was 7s. 6d. per ton, as compared with 7s. 3d. per ton in 1911. There were thirty-four collieries working in the Ipswich district in 1912, seven on Darling Downs, and seven in the central district, or, altogether, forty-eight. In the Ipswich district several new shafts have been sunk on various coal properties to the Aberdare and other seams, and a development of special significance in this part of the State has been a verification of the existence to the south of Ipswich of the coal-bearing series carrying the Aberdare seam.

The Association of Engineers-in-Charge.—On Wednesday last, at St. Bride's Institute, E.C., the President for the ensuing session of the Association of Engineers-in-Charge, Mr. F. Bailey, M. Inst. C.E., delivered his inaugural address. Naturally, considerable reference was made to the war, a large part of the address being occupied with the expenditure on armaments and the commercial opportunities now offered to our manufacturers. German and British exports in a number of branches of the engineering trades were compared, and it was pointed out how large Germany's foreign business was compared with ours, although we had actually done the pioneer work in many of the most remarkable developments of this era. Mr. Bailey's object elsewhere in his address was the stimulation among members of the Association of a progressive state of mind such as would enable them to partake in, and take advantage of, the developments which are bound to come and, if we may judge by recent years, to do so at an ever-increasing pace.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Quietness prevails in the pig-iron trade, and the situation is not encouraging. This week Messrs. Palmer and Co. are restarting three blast-furnaces at their Jarrow works, almost the whole of the output of which the firm will consume themselves. This increases the number of furnaces in operation on the North-East Coast from 68 to 71, of which 35 are producing Cleveland pig, 25 are making hematite, and 11 are manufacturing special kinds of iron. The furnaces running on Cleveland pig are not blowing at full pressure, but they are still turning out more iron than is required, with the result that stocks are steadily accumulating, and as Cleveland pig prices have now dropped considerably below cost of make, the blowing-out of furnaces would cause no surprise. Not since December, 1911, has Cleveland pig been obtainable at such low rates as now rule. No. 3 g.m.b. is 49s. 3d. f.o.b.; No. 1 is 51s. 6d.; No. 4 foundry, 49s.; No. 4 forge, 48s. 6d.; and mottled and white iron, each 48s. 3d., all for early delivery. East Coast hematite pig is weak, but prices are still relatively a good deal better than those of Cleveland pig. Mixed numbers of the former used to be 8s. to 10s. above the price of No. 3 Cleveland, whereas the difference at present is 14s. 9d. Nos. 1, 2, and 3 hematite stand at 64s. Values of foreign ore tend downward, but in the absence of transactions, fixing quotations is not easy. Several sellers continue to base market rates on 17s. 6d. ex-ship Tees for Rubio of 50 per cent. quality, but it is understood that less would be accepted, and probably contracts could be made on a basis of about 17s. Freights Bilbao-Middlesbrough are firm at 4s. 6d.; Middlesbrough pig-iron warrants to-day closed 48s. 3d. cash buyers, the lowest quotation since December 8, 1911, when they were down to 48s. 2d. cash buyers. Sellers of coke are very reluctant to reduce quotations, and some of them hold out for as much as 17s. 9d. for Durham bee-hive average blast-furnace kinds delivered at Tees-side works. Inferior Durham and Yorkshire coke, however, is obtainable at a good deal below that figure. Local consumers are holding off buying.

Stocks and Shipments.—The stock of Cleveland pig-iron in the public warrant stores now stands at 106,703 tons. Since the beginning of the month the stock has been increased by 3737 tons. Shipments of pig-iron from the Tees are on only a moderate scale. To date this month they average 2237 tons per working day, the total despatches being returned at 26,845 tons, 22,425 tons of which have gone from Middlesbrough, and 4420 tons from Skinningrove. To the same date last month the loadings were given at 21,464 tons, or a daily average of 1788 tons, and for the corresponding part of October, a year ago, the clearances reached 37,765 tons, or an average of 3147 tons per working day.

Manufactured Iron and Steel.—Producers of all descriptions of manufactured iron and steel keep busy. Specifications for constructional steel are coming in well, but there is little demand for deliveries of plates and angles for shipbuilding, owing to the shortage of labour in the shipyards. In the rail trade Messrs. Bolckow, Vaughan and Co. have, in spite of keen American competition, secured an order for 6000 tons of steel rails for South Africa. Principal market quotations stand:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 10s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 8*l.*; iron ship-rivets, 9*l.*; iron girder-plates, 7*l.* 5s.; steel bars (basic), 6*l.* 15s.; steel bars (Siemens), 6*l.* 15s.; steel ship-plates, 7*l.* 5s.; steel ship-angles, 7*l.*; steel boiler-plates, 8*l.* 5s.; steel joists, 7*l.* 2s. 6d. to 7*l.* 5s.; steel strip, 6*l.* 10s.; steel hoops, 6*l.* 15s.—all less the customary 2½ per cent. discount; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 15s.; steel railway sleepers, 7*l.* 15s.—all net at works.

Cleveland Miners' Wages.—The question of wages to be paid to miners during the ensuing three months was considered at a meeting held at Middlesbrough this week, between the representatives of the Cleveland Ironstone Mine Owners and the Cleveland Miners' Association. It was agreed that wages should be advanced 0.25 (a quarter of one) per cent., the same increase as has been conceded to the Cleveland blastfurnacemen. The advance takes effect from the 26th inst.

Wagon Order.—It is reported that the Blake Boiler, Wagon and Engineering Company, Limited, of Darlington, have secured an order for 178 all-steel bogie, covered wagons, each of 23 tons carrying capacity, required for the metre-gauge lines of the South Indian Railway.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—Though the coal traffic through Hull continues to be seriously affected by the war, the returns for September show that many of the leading South Yorkshire pits have managed to retain the bulk of their export business. The total sent to the port—418,096 tons—was 211,938 tons less than during the corresponding month of 1913. For the nine months, January to September (inclusive), 4,532,315 tons were handled, against 6,081,058 tons for the corresponding period of last year—a decline of 1,548,743 tons. During the month foreign exports declined to 176,733 tons, compared with 393,026 tons in September of last year, a deficit of 216,293 tons. The tonnage sent to home ports was 118,000 tons less than in September, 1913. The collapse of foreign trade is easily explained. A year ago Germany took nearly 70,000 tons compared with no exports last month, while only 7036 tons were sent to the Baltic ports, as against 132,335 tons a year ago. During the month South America took 12,000 tons less, Egypt 11,000 tons less, and France 8000 tons less. Trade with Holland was normal. On the other hand, Italy took 13,000 tons more, and Sweden 30,000 tons more.

South Yorkshire Coal Trade.—The dangers attending shipping and the difficulties of foreign exchange have jointly brought about another decline in the already shrunken export trade. Fortunately the home demand is good, the extra requirements of firms dealing with Government work compensating for lighter deliveries in other branches of industry. The demand for house coal has slackened, but a better inquiry is expected with the advent of colder weather. Pits are limiting their output in accordance with the current demand, so as to make supplies of props last as long as possible. Gas fuels are a steady market. A fair tonnage is being sent inland, and shipments, though well below the normal, are as large as can be expected. An abundance of slacks is available at cheap rates, the paralysis of the Lancashire cotton industry having thrown a big tonnage on the open market. In order to prevent the further increase of large stocks at the pits, fewer days are being worked. Coke is quiet. Quotations:—Best branch hand-picked, 16s. to 16s. 6d.; Barnsley best Silkstone, 12s. 6d. to 13s. 6d.; Derbyshire best brights, 12s. 6d. to 13s. 6d.; Derbyshire house, 11s. to 12s.; best large nuts, 11s. to 11s. 9d.; small nuts, 9s. 3d. to 10s. 3d.; Yorkshire hards, 11s. to 12s.; Derbyshire hards, 9s. 9d. to 10s. 9d.; best slacks, 7s. to 8s.; seconds, 4s. 6d. to 5s. 6d.; smalls, 1s. 9d. to 2s. 9d.

Iron and Steel.—Pig-iron sellers have experienced another quiet week. Buying has largely been of a hand-to-mouth character, very little attention having been paid to covering some of the large orders that have been booked for finished goods; but the output is nicely restricted and for the most part prices are firmly held. Derbyshire foundry sorts are offered at 57s. delivered, and Derbyshire forge at 55s. 6d. to 56s. Lincolnshire official prices are unaltered, but sales of large quantities are being booked at slight reductions. There has been a steady, though by no means a strong, inquiry for mixed numbers in hematites. The bulk of the orders booked have gone to East Coast makers, who, as usual, have a price advantage over West Coast producers. East Coast mixed numbers are quoted at 73s. 6d., delivered locally, a decrease of 1s. 6d. as compared with a month ago. More favourable reports are to hand regarding the condition of the finished-iron trade. The outlook is stated to have improved, there being an increase in general business as apart from Government orders and diverted German trade, and the South Yorkshire Makers' Association has accordingly decided not to lower its standing basis price of 8*l.* 5s. for crown bars. The quotation in competing districts is as much as 1*l.* 5s. lower, but the facilities provided in those districts for cheap production are enabling makers to secure a far bigger share of diverted German trade than is coming into South Yorkshire. There has been quite a slump in the buying of scrap. Heavy-iron scrap is now quoted at 55s. 6d. to 57s., and good ordinary steel scrap about 44s. 6d. Billets are dull, and good orders scarce, but prices are steady. Bessemer acid is quoted at 7*l.* 15s. to 8*l.*, Siemens acid at 8*l.* 5s. to 8*l.* 10s., hard basic billets at 6*l.* 10s., and soft basic billets at 6*l.* Uneven conditions prevail at the forges and rolling-mills. Some are working full time, but others have difficulty to keep running four days a week. The armament factories are as busy as possible. Orders are being executed for France and Russia, in addition to the heavy work on hand for the British Government. Shipbuilders are making big demands upon heavy-steel makers. South Yorkshire railway material is in much greater request, to fill the gap in production created by the suspension of Germany's wide activities in this direction. Special orders are being completed for motor-wagons and camp-kitchens. Some good contracts have been booked for engineers' tools, though this branch of trade has been adversely affected by the necessary restrictions placed by the British Government on exports to the Continent. The War Office is making inquiries with a view to placing further large orders in South Yorkshire for military implements. In this connection, mention is made of upwards of half a million trenching tools, designed to form a combined pick and shovel.

BRITISH LOCOMOTIVE EXPORTS.—Notwithstanding the war, our locomotive shipments exhibit, upon the whole, satisfactory results for the nine months ended September 30, the value of the engines exported to that date having been 2,929,502*l.*, as compared with 2,067,316*l.* in the corresponding period of 1913, and 1,430,977*l.* in the corresponding period of 1912. Argentina took British locomotives in the first nine months of this year to the value of 603,766*l.*, as compared with 499,254*l.* and 313,432*l.* This result must be regarded as favourable in view of the current disorganisation of the Argentine railway interest. It is, however, in British India that the greatest progress in the demand is observable, the value of our Colonial imports having been as follows to September 30, this year, as compared with the corresponding periods of 1913 and 1912:—

Colonial Group.	1914.	1913.	1912.
	£	£	£
British South Africa..	64,099	96,831	148,442
British India	1,322,082	711,910	298,996
Australia	430,950	338,861	237,919

It will be seen that purchases of our locomotives upon Australian account have been good this year. The war may exert an unfavourable influence upon Australian development, but thus far it has not had much effect.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has remained steady at about former rates, Admiralty qualities, especially the better descriptions, being booked well forward. Lower-class steam-coal has been comparatively plentiful. Th general output has continued comparatively limited, in consequence of a heavy recruiting of miners for service in the war. Small steam-coal has been steady all round. House coal, patent fuel, and coke have shown little change. The best Admiralty large steam-coal has made 20s. to 21s.; best secondary descriptions have realised 18s. 6d. to 19s. 6d.; other secondary qualities, 17s. 6d. to 18s.; best bunker smalls, 8s. 3d. to 8s. 6d.; and cargo smalls, 5s. to 7s. per ton. The best household coal has brought 19s. to 20s.; good households have made 17s. to 18s.; No. 2 Rhondda large has been quoted at 13s. to 14s.; and No. 2 smalls have realised 6s. 6d. to 7s. 6d. per ton. Patent fuel has ranged between 17s. to 18s. per ton. Special foundry coke has brought 27s. to 30s.; good foundry coke, 20s. to 24s.; and furnace coke, 17s. 6d. to 18s. 6d. per ton. As regards iron ore, Rubio has made 17s. 9d. to 18s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

The Tin-Plate Trade.—Exports of tin-plates showed a considerable contraction in September, having fallen to 23,440 tons, as compared with 36,572 tons in September, 1913. The absence in September of any deliveries to Germany, Belgium, and Roumania accounted to some extent for the decrease. There was, however, also a contraction in the shipments to Russia, Holland, France, Italy, China, Japan, and Argentina. On the other hand, there was some increase in the shipments to Norway, the United States, British India, and Australia. The aggregate exports to September 30 this year were 347,351 tons, as compared with 371,031 tons in the corresponding period 1913. Until the war broke out matters were moving on pretty well, but a great change has since been observable.

Bristol Widening Works.—The sanitary committee of the Bristol City Council proposes to widen Avonmouth-road between West Town-road and Cook-street, and Filton-road between Horfield Barracks and the city boundaries. In the first case, the improvement will increase the carriage-way from a width of 18 ft. to one of 22 ft.; and the second proposal would increase an average width of 21 ft. to an actual width of 50 ft.

Newport.—Monmouthshire steam coal has shown scarcely any change. The best Newport black vein large has been quoted at 16s. 9d. to 17s. per ton. Western Valleys have made 16s. to 16s. 6d., and Eastern Valleys, 15s. 6d. to 16s per ton.

Dowlais.—The Goat Mill has completed some orders for tin bar and cogging steel, while some tons of steel rails and steel sleepers have been despatched. The Big Mill has been occupied with steel props, curves, &c., for underground working, as well as with sole-plates, fish-plates, and tram-rails.

Pembroke Dock.—The fortress commander has issued an order by which all passenger traffic across the ferry from Hobbs' Point to Neyland is to cease at sunset. The ferry connects roads on opposite sides to Milford Haven, and a great deal of traffic passes over it, especially in the evenings. Many objections have been raised to the order, as it is contended that it will interfere unduly with railway and general traffic.

CONTRACT.—The Underfeed Stoker Company, Limited, has recently booked orders for forty-nine of their stokers for this country, the Continent, and the British Colonies.

GERMAN AND AUSTRIAN CEMENT.—The exports of German cements are valued at about 1,724,000*l.* per annum, and those of Austria-Hungary at about 216,000*l.* Compared with these, our exports figured at 1,273,000*l.* in 1913. Our principal markets are India, South Africa, Argentina, and Brazil, which all take our cement to a value of between 110,000*l.* and 241,800*l.* Germany sends to Brazil cement to the value of 281,300*l.*, compared with our 203,500*l.*; but in the other countries named, in which our trade is large, Germany's is small. For instance, we send cement to India to the value of 241,800*l.*, to South Africa 110,400*l.*, and West Africa 66,700*l.* Germany sends to these countries cement to the value of 19,800*l.*, 6000*l.*, and 6400*l.* respectively. The bulk of the Argentine trade is in our hands, Germany's business being worth only 51,600*l.*, compared with our 164,000*l.* On the other hand, to Australia, Germany in 1912 shipped cement to the value of 133,800*l.*, while our shipments recently were only worth 48,200*l.* per annum. The Netherlands naturally take large quantities of German cement; in fact, their imports of 249,700*l.* show that country to be Germany's second best customer. Russia is another large importer from Germany, while Chile takes 142,300*l.* worth of German cement as opposed to only 45,500*l.* worth of the British product. Other important markets for Germany in this trade are France, Dutch East Indies, Turkey, Philippines, Belgium, and so on. Austria's exports do not amount to 20,000*l.* to any single country, but her trade with Bulgaria, Argentina, Brazil, Turkey and Russia is in all cases between that figure and 10,000*l.* As a competitor of British cement products, Austria does not appear dangerous, though in neighbouring countries she is in an advantageous position. On the other hand, although the British products are usually recognised as unexcelled, a good deal of trade goes to Germany on account of low freights, the German steamship lines being prepared to make favourable terms for regular shipments. It is stated that this is the primary cause of the large hold Germany has on the Australian market. The above figures are taken from a recently issued Board of Trade bulletin.

MAKING CYANAMIDE AT THE ODDA FACTORIES OF THE NITROGEN PRODUCTS AND CARBIDE CO., LTD.

(*For Description, see Page* 465.)

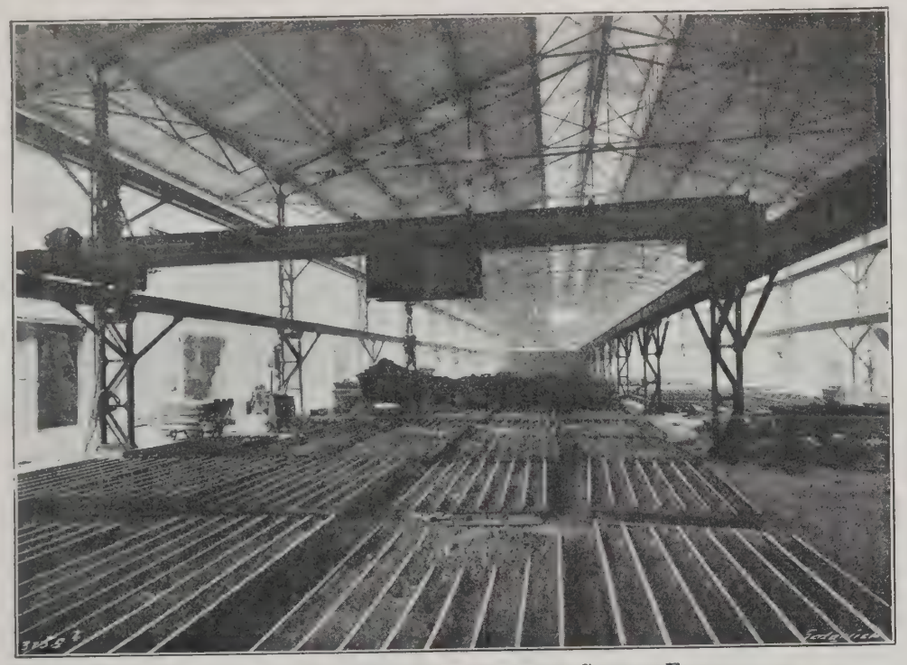


FIG. 52. THE CARBIDE-COOLING HOUSE AT THE CARBIDE FACTORY.

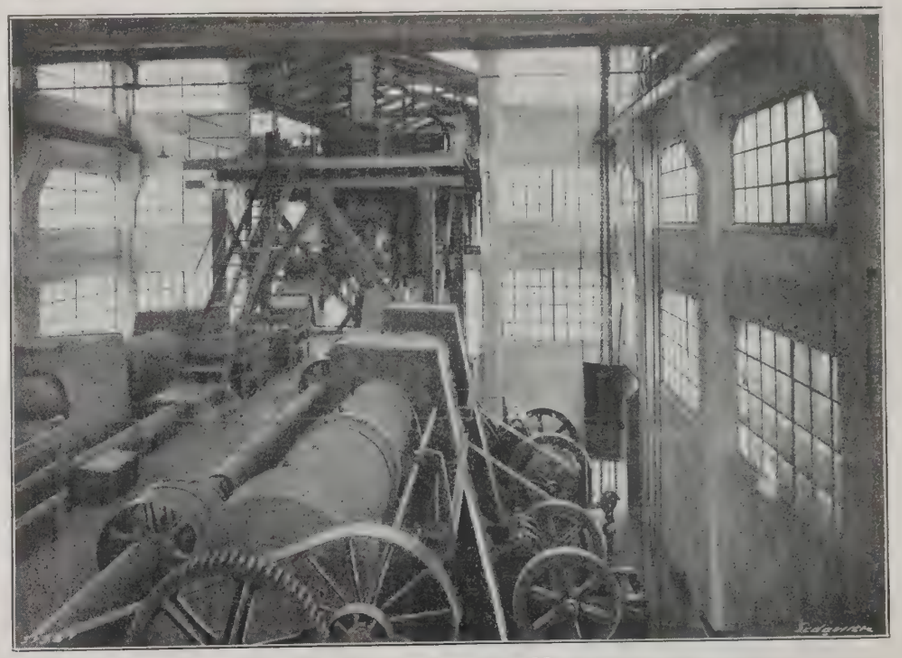


FIG. 53. CARBIDE-BREAKING MACHINERY.

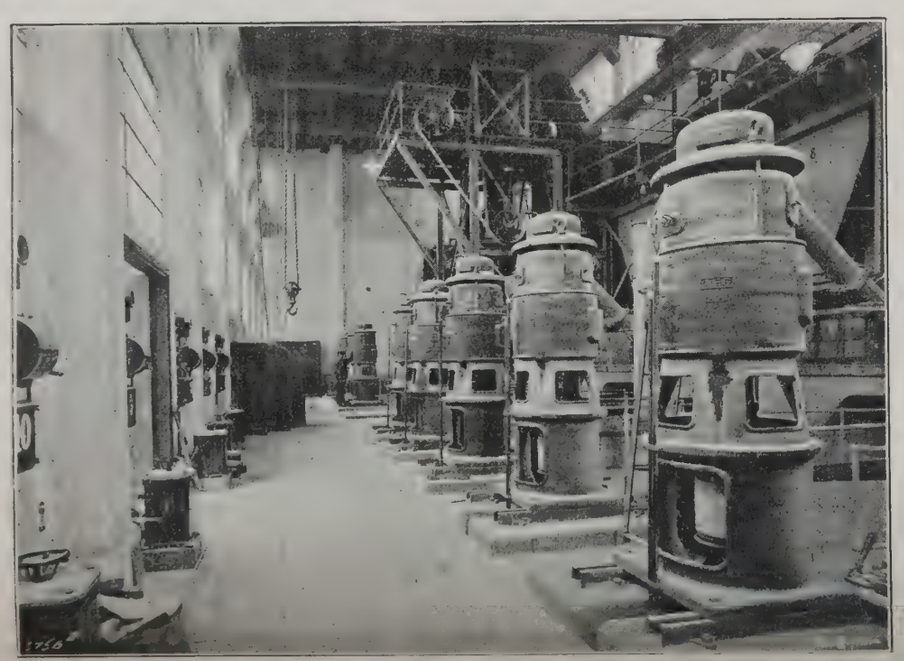


FIG. 54. 50-H.-P. VERTICAL THREE-PHASE INDUCTION MOTORS, DRIVING FINE-GRINDING MILLS.

FIG. 55. THE CYANAMIDE ELECTRIC FURNACES.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
AUSTRIA-HUNGARY, Vienna: Lehmann and Wentzel, Kartnerstrasse.
BELGIUM: E. F. Satchell 45, Avenue de Terneuzen, Brussels.
CANADA, Toronto, Ont.: Wm. Dawson and Sons, Manning Chambers. Montreal: Sells, Limited, 302 Shaugnessy Building, McGill-street.
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NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 16, at 8 p.m., at the Institution, Storey's Gate, Westminster. Paper, "Report of the Refrigeration Research Committee," by Sir J. Alfred Ewing, K.C.B., LL.D., F.R.S., Chairman.

THE INSTITUTE OF MARINE ENGINEERS.—Monday, October 19, at 8 p.m., at 58, Romford-road, Stratford. Paper on "Terrestrial Magnetism," by Mr. A. N. Somerscales (Member).

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS: LONDON CENTRE.—Monday, October 19, at 6 p.m., at the Institution of Electrical Engineers, Victoria Embankment. A paper will be read by Mr. A. S. Renshaw, on "Ethics of Supervision."

THE PHYSICAL SOCIETY OF LONDON.—Friday, October 23, at 8 p.m., at the Imperial College of Science, South Kensington, Sir J. J. Thomson, O.M., F.R.S., will deliver his presidential address. The subject of the address will be "Ionisation."

NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to some Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, OCTOBER 16, 1914.

GERMAN SCIENCE.

MUCH has been written and much spoken during the last few weeks on the subject of German *Kultur*, and although, most unhappily and most emphatically, it has been demonstrated that "Kultur" in German is by no means synonymous with culture in English, yet in some quarters, not, of course, the best informed, there has been observable a tendency to admit the German claim to pre-eminence so far as pure and applied science is concerned. The matter in debate is in essentials the same as is involved in the question as to whether the palm in oratory is to be awarded to the man who has delivered the greatest speech or to him who makes the greatest number of good speeches. So far as quantity is concerned, the output of German science is probably in excess of that of any other country, but the average quality is by no means unduly high. In fact, Germany has been distinguished, even in pure science, rather by her contributions to scientific data than to scientific thought. In but one of the great generalisations on which modern science is based can she lay claim to a share, and this but a subordinate one. Good work in establishing the doctrine of the conservation of energy was undoubtedly contributed by Helmholtz and Clausius, but practically the whole of the original work of the latter was anticipated by Thomson and Rankine; and in the great names associated with the pioneering in the field of thermodynamics the Germans make a poor show in comparison with Carnot, Joule, Thomson, Rankine, and Willard Gibbs. It would, of course, be extravagant to maintain that Germany's contribution to scientific thought bore the same relation to her contribution to scientific data that the poor half-pennyworth of bread did to the intolerable deal of sack in Falstaff's famous reckoning; but it is hardly disputable that Germany's achievements, both in pure and applied science, have in the main been parasitic on the thought of other countries. In mathematics, against Liebnitz, who devised the exceedingly convenient and valuable notation of the differential calculus, must be set such names as Napier, Newton, the Bernouillis, and Euler; whilst Gauss and Bessel are more than offset by Fourier, Laplace, Lagrange, and Legendre, to say nothing of Green. In all cases it is notable that the German strength has been mainly in the development of fields opened up by others, the national genius being that of the settler rather than of the pioneer. To this general rule, which holds pretty generally throughout the whole field covered by the word "Kultur," music is presumably an exception, as we believe those authorised to speak do admit a claim to Germany's primacy in this art.

In surgery Germany has done excellent work, but the two great triumphs of modern surgery—viz., the use of anæsthetics and the introduction of antiseptics and asepsis—are attributable to other nationalities, and America has led the way in a large proportion of other advances in operative surgery, whilst the germ theory of disease is also of non-Teutonic origin. In biology no German name ranks besides that of Darwin, whilst Mendl, whose work on heredity has attracted so much attention of late years, was an Austrian. In bacteriology Pasteur has no Teutonic compeer, and what is probably the most important discovery in this department of late years—viz., the connection between certain insects and the spread of certain diseases—is the work of Patrick Manson. Of course, in all these departments of scientific achievement excellent and highly valuable work has been accomplished in Germany, but with few exceptions the great basic ideas originated elsewhere. This is true even in respect to chemistry—a science in certain respects well suited to the particular national traits of the Teuton; but here, as elsewhere, most of the fundamental conceptions were brought forth in other countries. Thus it was Lavoisier who overthrew the phlogiston theory and founded modern chemistry; Dalton gave us the atomic theory, to which Italy made an extremely important contribution in Avogadro's hypothesis. The doctrine of valency was originated by Frankland, whilst Germany's principal contribution to chemical theory is associated with the eminently non-Teutonic name of Kekulé. In this connection, indeed, it is noteworthy that both Helmholtz and Kant were of mixed ancestry, furnishing fresh instances of the generally-accepted doctrine that crosses between two not too dissimilar races often yield an astonishingly able progeny.

In electrical work the same condition holds as elsewhere; the great names are Volta, Ampere, Faraday, and Clerk-Maxwell, who are without peers amongst their Teutonic rivals. The same state of affairs is met with in the applied sciences. In electrical engineering, Germany, ably as she has developed their conceptions, cannot show any such record of pioneering work as is attributable to Thomson, Gramme, Hopkinson, Edison, or Swan, and the seeds from which her great chemical industries have sprung were gathered from England. Everywhere the German is much more notable for intelligent industry than for creative genius. Even the internal-combustion engine originated in France, to whom also is due the credit for the first invention of the so-called Otto cycle, and France was also the pioneer in the production of the large gas-engine, which, with the Diesel engine, has since become a typical product of the Fatherland. Germans are credited with a remarkable aptitude for linguistic studies; but the key to the hieroglyphics was found by Champollion, and to Sir Henry Rawlinson belongs most of the credit for the deciphering of the cuneiform inscriptions.

Where Germany excels most other nations is, however, is her respect for scientific attainments, and it is this which induces her capitalists to finance expensive experiments, a form of enterprise from which the nation has deservedly reaped a marvellous harvest in the past, and which, it is to be feared, cannot be emulated here until our authorities reform on a more rational basis the present system on which the average boy is educated. As matters stand, the English boy leaves school with little Latin, less Greek, and a most complete ignorance of the principles of that science which is transforming the whole face of civilisation. It is only the exceptional youth that acquires any knowledge whatever of these, and it is probable to this cause must be attributed the high average standard of British scientific achievement. To the fundamentals of science we have contributed probably a larger proportion of basic principles than have any of our rivals.

Most of the comparisons made in the foregoing, between German claims and German achievement, are, no doubt, matters of ancient history; but a comparison of the pioneering work done within the last few years will show that, in spite of the enormous sums devoted to pure physics and chemistry, but a small proportion of the really notable discoveries of recent years have been made within the limits of the German Empire. A complete list of these would include the discovery of the inert gases of the atmosphere, of the corpuscle or electron, of radioactivity, of the Zeeman effect, and of the Röntgen rays; and of these the last-named only is attributable to Germany. Of matters still under discussion, such as Planck's atomisation of energy, the time has not yet come to speak definitely; but if this view does turn out to be more than a provisional hypothesis affording a temporary bridge over the difficult gap detected by Lord Rayleigh in the kinetic theory, it must undoubtedly be regarded as an important pioneering contribution.

No country has concentrated so much industry as Germany on the improvement of armaments,

yet here again history repeats itself; and it is ideas borrowed from other nations that in the main constitute the basis of the remarkable developments made. It is true that the military breech-loader is a Teutonic conception, but practically every other important improvement is of alien origin. France gave us the armour-plate and America the machine-gun and magazine rifle. It was France, again, which introduced the high-explosive shell, the quick-firing field-gun, military smokeless powder, and the modern submarine; whilst she shares with America the credit for the aeroplane, which is unquestionably a much more original development than Germany's sole important contribution to aeronautics—viz., the Zeppelin. America, again, introduced the cemented armour-plate, of which Krupp improved the resisting qualities by his heat treatment.

Even in the matter of organisation, in which the possession of a remarkably docile population is no inconsiderable asset, Germany must yield the palm to the United States. Here not only have we such practical exemplifications of the science as is afforded by, say, the Ford motor-car works, but America has done much to lay down and formulate principles which have since been adopted elsewhere. Much has been written in criticism of American "efficiency experts," but whilst their methods may not be applicable to all conditions, the remarkable increase in output effected in suitable cases, and without overstrain to the workmen, is too well established to be denied. The importance of an efficient workshop organisation was forced on America by the high price of labour, and it is, of course, also to the United States that we largely owe the extended application of the principle of interchangeability which has effected such an astonishing reduction in the cost of repetition work generally. Again, it is to America, not to Germany, that commissions of inquiry into the organisation of the telephone industry are naturally directed, her superiority being unquestioned.

To sum up, whilst Germany may fairly claim a high position in both pure and applied science, no claim to primacy in either department will bear the test of investigation. With but few exceptions, she follows; others lead.

MOTOR ENGINEERING.

Among the trades concerning which the Board of Trade has been putting statistics before the public in a series of White Books is that of motor engineering. Naturally, as shown in an article on this subject in our issue of October 2, the Board of Trade deals mainly with figures, and leaves the application of them to the reader. Many persons, on seeing these figures, have jumped to the conclusion that all our manufacturers have to do is to imitate the ancient Israelites, and attack the markets of the world by persistent trumpet-blowing. That our cars are equal to any is undoubted, and that the output of German machines must practically cease during the war, and for some time afterwards, is also clear; but it by no means follows that we can at once obtain an accession of trade equal to that of the German exports. The war alone will account for a great falling-off in what are called "pleasure cars," not only in the combatant countries, but in all others. In spite of moderate bank rates, and still more moderate discount rates, money is "tight." Even in South America, in the States, and in Canada, expenditure is being restricted to what is necessary, and luxuries are being cut off. The motor-car trade must necessarily experience a great falling-off in demand, and the fact that German exports of an annual value of 4,113,350*l.* have practically ceased will not alone retrieve the situation.

If the motor trade of this country were self-contained, the question of obtaining greater influence in the markets of the world would be one of business methods solely. It would turn upon credit and commercial organisation and a general adaptability to new conditions. It would devolve on the non-technical departments of the works to take it in hand, and the engineer would be left free to execute the orders when they were obtained. But unfortunately the case is far otherwise. We have it on the authority of Mr. L. H. Pomeroy, who discussed the effect of the war on motor engineering before the Institute of Automobile Engineers last Wednesday evening, that quite 50 per cent. of the material composing a motor-car is supplied, wholly or partly finished, by firms who specialise in the various lines of manufacture concerned. If these parts were entirely produced in this country, the matter would present no difficulty, but unfortunately a great many of them come from Germany and Austria, and very often they have merits which are absent from similar articles made here. In 1912 we imported 90,000*l.* worth of motor-car parts, and although this is a trifling percentage of the total annual value of the motor-cars turned out, it must be remembered that only 50 per cent. of the selling value of a car is represented by material and labour, and that the absence of any one essential part renders a car useless.

Foreign buyers who really want cars will no doubt now buy what they can get, and as all Continental builders, except Italy, are hampered by the war, we should obtain the bulk of the orders. They will be very welcome, but trade of this kind is not of any great value unless it ends in a permanent connection. If the cars we send do not prove to be efficient in every respect, they will not gain us a reputation. The war is not going to last for ever, and once it is over business will again be conducted on commercial principles. The combat will be transferred from the battlefield to the market place, and will be waged by means of price and quality instead of sword and rifle. Questions of infringement of international law, and of high-handed dealings with non-combatants, will soon recede into the background, and orders will go to those who can offer the best terms. It therefore behoves not only the motor trade itself, but also all those who supply it with accessories, to take advantage of the fact that we are temporarily obliged to fill all our needs ourselves, to improve their plant and processes to such an extent that they can no longer be excelled or undersold by German manufacturers.

The list of fittings and accessories which are ordinarily bought by motor-car firms is long and various. It includes pressed-steel frames, radiators, wheels, springs, carburettors, ball-bearings, tyres, magnetos, sparking-plugs, bevel and worm-gears, and detail fittings, such as instruments, grease-cups, unions. In some cases engines, gear-boxes, and axles are among the finished parts bought ready-made, but that is only by small firms. On the other hand, there are concerns who produce most of the items included in the above list, but there is probably none that is quite self-sufficient. The constituent of a motor-car which everyone knows to be of foreign origin is the Bosch magneto. We understand that it is now made to some extent in this country, but the bulk of the supplies have come from abroad, and have practically gained a monopoly by their reliability. There are certainly magnetos of British make, and there is no reason why they should not attain to the same reliability if the makers will devote themselves—in the words of Mr. Pomeroy—to the patient training of labour and the constant aim at perfection of a whole works organised on scientific lines. This sentence might be called the text of Mr. Pomeroy's paper. He does not aver that any part of a motor-car cannot be produced in this country, but he insists that in many cases it can be got better, or cheaper, or both better and cheaper, abroad. This condition of affairs he attributes to the greater effort expended by German and Austrian manufacturers towards attaining the ideal demanded by their customers. When there is a demand they set themselves to meet it, and are not hasty to say that it is impossible of attainment. Every engineer knows that if he wants thin steel castings he must go to the Continent for them. Motor-omnibus wheels are now cast in steel in Austria of a thinness which is unobtainable here, and no doubt they are sold at a profit. It is inconceivable that they could not be made in England if sufficient study were given to the subject. It is one of the penalties of falling behind in the commercial race that every-day it becomes more difficult to overtake one's competitors. Their preliminary outlay has been written off from the early profits they made when competition was slack, and they have fixed prices at a point which leaves no margin for experiment or failure to those who attempt to follow them. They have "a whole works organised on scientific lines."

Another item that figures large in car construction is stampings. There are many capable stampers in this country, and they are subject to constant pressure from their customers to increase the accuracy and uniformity of their products. Often what is demanded of them is manifestly impossible to one who understands the art, and such demands are apt to generate a spirit of obstinacy which refuses to consider the question of progress at all. When the Institute of Automobile Engineers paid a visit to Belgium this summer, they were impressed, says Mr. Pomeroy, with the scientific methods seen there, and, further, "with the unremitting care with which the product is checked, the elaborate research work which has directed the choice of the material used for various purposes, its heat treatment, and the investigation of its physical and chemical characteristics." Mr. Pomeroy continues that the chief complaints against British stampers are, first, a lack of knowledge of the physical characteristics of the material they are stamping; second, the tendency to dispense with preliminary hand forging of parts like connecting-rods, and to overheat the metal to obtain easy working and quick production; third, a lack of appreciation of how closely to its desired shape a stamping can be made, and consequent non-uniformity of product; and, fourth, a complete disregard, in all but a very few firms, of the manifest advantage of heat treatment after stamping in all cases, and its absolute necessity in many.

This is a fairly severe indictment, but it is certainly true in many cases. Stamping is a business which must be conducted on a wholesale scale to make it remunerative, and the heads of firms are apt to pay scant attention to small orders. This is natural, and, indeed, often cannot be avoided, but it is a practice that needs to be carefully scrutinised, especially when the orders come from a new and growing industry. A spirit of content is the worst frame of mind in a manufacturing establishment, for it assumes that matters can be relied upon to remain as they are, and experience shows that they cannot. If we were all well off and happy, we might rely on freedom from change; but there are always people in the world who are far from satisfied, and who are ready to spend time and labour in improving their position at the expense of others. During recent years there have been many such on the Continent, and wherever they have found dissatisfied buyers they have exerted themselves to the utmost to meet their requirements. They have often succeeded in creating a trade where there was none before, or in diverting customers from British firms by lower prices or better goods. For the time such manufacturers are out of the running; but they will certainly return to the contest, and will regain their lost ground if they find us as we were.

The newspapers are full of articles on the necessity of capturing German trade, and by this is meant Germany's customers. Unfortunately, in this case a customer is a free agent, and cannot be made a permanent captive. He may find himself faced with Hobson's choice of taking our goods or going unserved until the close of the war, but in a year or two he will recover his freedom, and will satisfy his needs in the way that pleases him best. What we really want to do is to capture so much of German methods as are capable of combination with British practice, and then we may expect to retain each customer we gain. And we do not need to make long journeys to foreign countries to find out in what respects we have to learn.

Very many manufacturers may find the information in their own works if they will seek out the articles "made in Germany," and then inquire why they were bought. If the information is not to be found in a particular works, it can certainly be got next door. It would be very interesting to turn a gathering at some technical institution into an "experience meeting," at which each member would explain how much of his finished and half-finished material he got from Germany, and why he did so. Such a consensus would be more instructive than any paper ever read, and if the building could be converted by magic agency into a Palace of Truth, in which every one was unconsciously obliged to utter his thoughts with perfect candour, it would be both surprising and enlightening.

To-day we stand on the threshold of an opportunity such as this generation has not seen. On all hands there are demands, not alone in motor engineering, that must be fulfilled if we are to maintain our manufacturing supremacy. Goods are required that only few manufacturers can turn out, and prices are obtainable that will permit of experiment and research. It is not that the impossible is demanded. Already such goods are in existence

as commercial products, and if they can be made in some countries, it is clear that they can also be produced here in many shops, if only sufficient trouble and thought be given to them. Possibly they will not yield a large profit at first, and it is a great temptation to refuse to shoulder all the worry when easier jobs are offering. But the question is not one of an immediate profit; rather it is one of building an enduring trade which will continue for years, and secure that most valuable of assets—a good connection. It is a matter of experience that Continental firms will take endless pains to secure even a small order from a new customer in the expectation that it will lead to better results in the future, and that in this way they have undermined many an old British business. As stated in another article in this issue, the Germans have not shone in original work demanding scientific imagination. But nevertheless they have distanced us in the application of scientific discoveries, and by the constant exercise of thought, by the tireless collection of data, and by endless experiments conducted in the light of scientific knowledge, they have got ahead of us in not a few industries in which we originally showed them the way. All this is somewhat foreign to the British character, which exhibits an inherent objection to change, and will only accept it under compulsion. Fortunately, though difficult to move, we are not incapable of imbibing foreign ideas and of improving on them. We have seen many inroads into our home markets finally repelled. The American bicycle, the American machine-tool, and the American boot, in succession, came in like a flood and threatened to submerge us; but each spent its force and flowed back, and now under better conditions we ought to be able to render ourselves free of all extraneous aid in the construction of motor-cars. Although the demand for pleasure vehicles has fallen off, there is no slackening in the trade for commercial cars, but, on the contrary, the war has filled the order-books of the makers to the point of embarrassment, so that they are seeking aid from engineers engaged in other lines. Makers of accessories who are prepared to study and experiment need not fear they are wasting their efforts.

HEAT TRANSFER AND SKIN FRICTION.

In the report of the Advisory Committee on Aeronautics for the year 1912-13, Mr. W. F. Lanchester gives an interesting discussion of the close relationship between surface-cooling and skin friction. He observes that when a fluid passes an obstacle the actual form of the turbulent motion set up is of the nature of a series of vortex filaments, geared together and to the solid surface where they originate, by the viscosity of the fluid. The same engagement between the molecules which resists shear, and thereby imparts viscosity to the fluid, is that by which heat is transferred from the one portion of the fluid to the other, so that the viscosity and conductivity of the fluid may be considered as virtually a single physical property. Hence to whatever extent the encounter between two molecules transfers momentum from one part of a stream to another, it will, to the same extent, transfer heat if the temperature of the moving fluid differs from one region to another. Thus if a fin of a radiator is above the temperature of the air through which it moves, heat and momentum are communicated to this air simultaneously, and by identically the same mechanism. The drag between the fin and the fluid is the "skin friction," and is approximately proportional to V^2, where V is the velocity of the moving fin. Mr. Lanchester suggests that this law holds because the depth of the layer of air acted on by the fin is directly proportional to the velocity, whilst the velocity this layer acquires is also proportional to the velocity of the motion. Hence the total effect varies as V^2. Thus the virtual mass of the layer acted on per square foot per second may be taken as equal to

$$\frac{\xi C \rho V}{2},$$

where ξ is the double surface coefficient of skin friction, C the normal plane resistance coefficient, and ρ the density of the air. If t be the temperature difference, and 0.24 be taken as the specific heat of air, the heat disposed of by 1 sq. ft. of surface will be

$$\frac{0.24\,\xi\,C\rho\,V\,t}{2}.$$

Applying this to the case of a motor-car radiator for which $C = 0.6$, $\xi = 0.008$, and $\rho = 0.078$, then, at a velocity of 50 ft. per second, and a temperature difference of 120 deg. Fahr., the heat disposed of will be

$$\frac{0.24 \times 0.008 \times 0.6 \times 0.078 \times 50 \times 120}{2} = 0.27 \text{ B.Th.U.}$$

per square foot per second,

an energy expenditure which is equivalent to about 0.4 horse-power. As the jacket loss in a petrol motor is about equal to the useful work done, some $2\frac{1}{2}$ sq. ft. of surface are needed in the radiator for each horse-power developed when the speed is 34 miles per hour, a figure which agrees well with practice. It follows from the foregoing that the cooling surface required will vary inversely as the velocity, but the horse-power absorbed in producing the necessary current increases as the cube of the velocity. In the foregoing example the resistance due to skin friction is

$$\frac{\xi\,c\,\rho\,V^2}{2g} \text{ lb.} = \frac{0.008 \times 0.6 \times 0.078 \times 50^2}{2g} = 0.0145 \text{ lb.},$$

and the horse-power thus absorbed per square foot of cooling surface is 0.00134 horse-power per square foot of surface, or 0.0033 horse-power per brake horse-power developed. This, Mr. Lanchester points out, is a minimum value, as the radiator surfaces may give rise to other resistances as well as to skin friction. If the current is produced by a fan, the above figure must be divided by the efficiency of this fan in order to get the power absorbed. Mr. Lanchester concludes from the foregoing course of reasoning that very high power losses are inherent in air-cooled motors. Thus, in the case of the "Gnome" engine of 50 horse-power, the windage loss is 6 horse-power with the engine run on a test-bed. Of this total two-thirds is directly attributable to the gilled portions of the cylinder. Under flight conditions the loss is still higher, so that the power absorbed in the cooling may be as much as 8 horse-power. In an appendix to Mr. Lanchester's note, Dr. Stanton gives Osborne Reynolds's view of the same connection between surface friction and heat transfer. Conceive a tube traversed by a fluid. Then this fluid has a certain momentum which the surface friction tends to destroy. Also, if there be a temperature difference between the wall and the fluid, this temperature difference also tends to be destroyed. Then, according to Osborne Reynolds, the ratio of the momentum destroyed to the total momentum of the fluid is equal to the ratio of the actual destruction of temperature difference to the total temperature difference. Thus, if $d\,p$ be the fall of pressure between two sections, $d\,x$ apart, $d\,t$ the rise of temperature in the same distance, W the weight passing per second, v the mean velocity of the fluid, r the radius of the pipe, and t the mean temperature between two sections, then $d\,p\,\pi\,r^2$ is the difference in pressure between opposite ends of the section considered, and is thus equivalent to a loss of momentum. The actual momentum passing per second is $\frac{W}{g}\,v$. Hence, according to Osborne Reynolds,

$$\frac{d\,p\,\pi\,r^2}{\frac{W}{g}\,v} = \frac{d\,t}{T_s - t},$$

where T_s denotes the temperature of the surface of the pipe.

The Institution of Electrical Engineers.—The opening meeting of the Institution session will be held on Thursday, October 29, at 8 p.m., when the president, Sir John Snell, will deliver his inaugural address. At this meeting a marble bust of Michael Faraday will be presented to the Institution by Mr. Llewellyn Preece, on behalf of the family of the late Sir William Preece, K.C.B., F.R.S., past-president.

Personal.—Messrs. Ronald Trist and Co., Limited, of Coronation House, 4, Lloyd's-avenue, London, advise us that they have retained the services, as manager of their machinery export department, of Mr. George A. Goodwin, M. Inst. C.E., Past-President of the Society of Engineers. Mr. Goodwin has transferred his practice to the firm.—The Cambridge Scientific Instrument Company, Limited, Cambridge, state that they have taken over the business connection of the Leskole Company, Limited, Palace Works, Enfield, who have gone into liquidation, also that Mr. F. Wakeham, the assistant manager of the Leskole Company, has joined their staff.—Mr. John Hammersley, inspecting and supervising engineer, has been appointed resident engineer in Manchester for Messrs. Home Morton, Ker and Gibson, of Glasgow, Birmingham and London, the well-known consulting engineers and industrial works designer.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. VII.

By Frederick William Lanchester, M. Inst. C.E.

Attack by Aeroplane on Aeroplane.

In the present war the services of the Flying Corps have, in the main, been confined to scouting and reconnaissance in its various forms, the amount of work that has been done in this direction being very great; according to present reports, a mileage equivalent to many circuits of the globe has already been covered. So far the casualties have been slight, and the actual risk and danger are considered less than in the other combatant branches of the Service. The meaning of this evidently is that the methods of attack on aircraft have not kept pace with the development of the craft themselves. Considering the importance, from the enemy's point of view, of interfering with the operations of our aircraft (for from a modern standpoint to annihilate the aircraft of an enemy is virtually to deprive him of his power of vision), it is quite certain that the present conditions cannot last, and means will assuredly be found before the next great war, if not during the continuance of the present war, by which the attack of aeroplane on aeroplane will be rendered far more deadly than at present, and the air forces of both combatants will be more highly organised than is the case to-day. It has already been remarked that attack on so swift and, in effect, on so small a moving target as an aeroplane is by no means an easy problem. We have already discussed the difficulties of attack from the ground, and it now remains to examine the problem of attack by air—*i. e.*, attack by aeroplane on aeroplane.

At one time the writer was disposed to be somewhat sceptical as to the possibility, or rather the general feasibility, of such a mode of attack. It seemed as though aeronauts might spend hours manœuvring and firing, and between them blow away hundreds of pounds weight of ammunition without any decisive result. On closer consideration, however, it would appear that, provided one machine can, either by greater speed, or power of manœuvre, force the other to close quarters, there are conditions, as when both machines are moving in the same direction, under which gun-fire (especially machine-gun fire) could be brought to bear with conclusive effect. We have already been regaled from time to time by the Press with florid descriptions of aeroplane fights in which pilots or observers were said to blaze away at each other with automatic pistols, and in which the enemy has been said to have been brought down by this means. After careful inquiries in quarters believed to be well informed the writer is disposed to discredit these stories; they probably emanate from some back office in Fleet-street. Doubtless attempts have been made by one pilot, or aeronaut, on another by rifle and pistol fire, but there is not, so far as the writer has been able to ascertain, any definite record of casualties resulting.

The Fighting Machine as a Separate Type.

It is uncertain as yet whether the scouting or reconnaissance machine will itself in the future be called upon to fight; the view has already been expressed in these articles that the long-distance machine or strategic scout should not in any sense be considered as a fighter, its speed and power of rapidly putting on altitude alone form its natural and most appropriate means of defence. The tactical scout is not in the same position; its duties are of such a character that if it be driven by hostile aircraft away from its place of operation, it has for the time being ceased to fulfil its mission, and so either it must always operate with a protective force of fighting machines within call, or it must itself be armed, and be rendered capable of putting up a fight. In any case the tactical scout or machine for local reconnaissance will require to be furnished to some extent at least with both offensive and defensive armament. But it is by no means clear that it will require to be armed more heavily than may be sufficient to hold its own with the aircraft of the enemy engaged on similar duty, or more than is required to enable it to perform the minor acts of aggression against the enemy's land forces that fall to its lot.

Evidently it can be only a matter of time before the specialised fighting-machine is called into being. We may admit that the first and more immediate

step will be to render the tactical reconnaissance type capable of taking the offensive, so that it may establish its ascendency over the similar craft of the enemy. But the struggle for supremacy in the air which must then ensue will call imperatively for something more powerful and efficient, a specialised and heavily-armed fighting-machine in fact. It is this type, the fighting machine of the future, that the writer proposes to make the present subject of study, discussing primarily the factors upon which its armament and its usage, or tactical employment, depend. It may be taken that for the period during which the tactical scout is playing the double *rôle* of reconnaissance-machine and fighting-machine the main general considerations will apply.

The Question of Armament; Treaty Restrictions.

In the specification of a fighting type of aeroplane the first and foremost consideration is its means of attack. These fall into two broadly distinct categories: fire-arms, chief amongst which for the purpose in question is the machine-gun or mitrailleuse; and gravitational weapons, including bombs, hand-grenades, steel darts, &c. These latter are in the main only suitable for employment in attacking a terrestrial objective, and, except where the object of attack is a dirigible or airship, ill suited to attack on other aircraft. Light artillery may certainly be mounted on an aeroplane, but only the very smallest calibre — namely, the "1-pounder" — can be considered suitable for machines such as are built at the present day; even the mounting of a gun of this size is a matter of great difficulty. The only advantage obtained by the employment of a weapon of this character is in the fact that it is permissible to throw shell, high-explosive or otherwise, the use of which for smaller sizes of projectiles is prohibited by treaty obligation. Any explosive projectile of less than 1 lb. weight (more exactly, 400 grammes, or 14 oz., about) is banned by the Declaration of St. Petersburg,* of 1868; the paragraph with which we are concerned reads:—"The contracting parties engage mutually to renounce in case of war amongst themselves the employment by their military or naval troops of any projectile of a weight below 400 grammes which is either explosive or charged with fulminating or inflammable substances." This is reaffirmed in the text of an abortive declaration of the Brussels Conference of 1874, Article 13 (*e*): "The use of arms, projectiles, or material which may cause unnecessary suffering, as well as the use of the projectiles prohibited by the Declaration of St. Petersburg in 1868." In the Hague Conference of 1899, Article 23 (*e*), it is prohibited "To employ arms, projectiles, or material of a nature to cause superfluous injury." Also Article 60, Declaration ii.:—"The contracting parties agree to abstain from the use of bullets that expand or flatten easily in the human body, such as bullets with a hard envelope which does not entirely cover the core, or is pierced with incisions." In view of the fact that the Brussels Conference of 1874 was sterile, and that the Hague Declaration ii., Article 60, was not subscribed to by the British representative, the Declaration of St. Petersburg with its 14 oz. minimum for explosive projectiles is the only *definite* statement by which we are bound. However, the restriction as to the employment of dum-dum or expanding bullets appears to have received our tacit acquiescence, at least in so far as concerns warfare with other civilised States. There is also the rather indefinite statement of the Hague Conference of 1899, to which we have subscribed, to the effect that we shall not employ arms, projectiles, or material of a nature to cause superfluous injury. The subject of these restrictions shall be returned to in a later article; it is here sufficient to point to their existence, and to the fact that they considerably hamper and restrict the development of aircraft and counter-aircraft armament. There seems to be no proper reason why we should be compelled to use some hundreds of unsuitable projectiles, specially designed to afford the least possible injury to the struts, spars, &c., that they pass through, when a comparatively few expanding or explosive bullets would do vastly more injury, and result in a machine being incapacitated both in less time and at less expense. It cannot be supposed that if one of the nations at present at war were to inaugurate the practice of utilising, against aircraft, projectiles infringing the Declaration of St. Petersburg there would be any great wave of indignation created in the world at large. If, for example, we were to find our aircraft being knocked about by such means, we need not imagine that we should receive much compensation in the way of international sympathy. The writer is not for a moment suggesting that we should initiate any departure from the accepted usage of warfare in this respect; he is rather questioning the ethics of a procedure by which a country, whose obligations and responsibilities are as wide and great as those of Great Britain, and whose traditions and the force of public opinion make solemn contracts binding, should become a signatory to agreements which are always liable to be (and sometimes are) signed by the other party with his tongue in his cheek. At the best the signing of restrictive agreements relating to the conduct of war may at some time after turn out to be no more or less than the drawing of a cheque on another's banking account—a cheque that may have to be honoured in another man's blood.

* The signatories to this Declaration include representatives of the following:—Great Britain, Austria and Hungary, Belgium, Denmark, France, Greece, Italy, Netherlands, Persia, Portugal, Russia, Sweden and Norway, Switzerland, and Turkey. The German Confederation and semi-independent States were also signatories; but in view of the doctrines of modern Germany as touching the value of international treaties, her signature cannot be taken as meaning anything.

The One-Pounder as an Aeroplane Gun.

For the present we will take the restrictions imposed by international agreement as though they were restrictions imposed by Nature, and accept the fact that for the throwing of explosive or inflammable projectiles the "one-pounder" is the smallest gun available. At present this offers considerable difficulty in the case of an aeroplane. In order to throw a 14-oz projectile with a muzzle velocity of 1700 ft.-sec., the weight of gun and its mountings, including suitable recoil mechanism, could not be much less than 1 cwt., and with 100 rounds of ammunition the total would be about 2½ cwt. Now this weight alone cannot be considered in any sense prohibitive; in fact, it is no more than most of the existing machines in service would be able to carry. But the difficulties of design are not confined to the weight problem; the gun would have a length from muzzle to breach of 4 ft. or 5 ft., in addition to about 1 ft. representing its movement on recoil, as permitted by the buffer mechanism. To accommodate such a weapon, with reasonable freedom in elevation and traverse, would almost require that the gun be designed first, and that the aeroplane be *designed round it*. The difficulties can only be properly appreciated by taking a drawing-board and paper and endeavouring to find a practicable solution. Beyond the initial difficulties of the problem, it is very doubtful whether it will be found to pay to attack a hostile aeroplane with so large a shell as required by the 14-oz. limit. If a thoroughly sensitive fuse were available, so that the shell would explode on impact with canvas, matters would wear a different aspect, for the wing spread of an aeroplane presents a target of respectable size. However, as things stand, with a total of only about 100 rounds at command, and so small and elusive a target, it is doubtful whether, save under very exceptional circumstances, it would pay to throw away ammunition in pursuit. If the problem be that of attacking a dirigible, it may be considered more hopeful; there is actually more to hit, besides the fact that the aeroplane, in the matter of speed, has the balloon always at a disadvantage; here again the importance of a sensitive impact fuse is paramount.

The necessity for being sparing in the use of ammunition must not be taken to mean (as sometimes represented) that there is no advantage in rapidity of fire, but rather the contrary, and any aeroplane armament gun must be essentially a quick-firer, if not actually automatic or semi-automatic; it is of vital importance that when the opportunity does occur, the utmost use should be made of it. When an aeroplane is within decisive range of its prey, it must be presumed that it is itself also under fire, and all the conditions discussed in the foregoing articles apply. If a machine, type A, has four times the rate of fire of another machine, type B, the machine A, *so long as its ammunition holds out*, is worth as much as two machines of the type B. In the case of the one-pounder now under discussion, this condition of the exhaustion of the ammunition is just the weak point that renders it doubtful whether under existing circumstances it is worth while seriously considering the mounting of such a weapon. It is doubtful, also, whether a fully automatic gun of this calibre is admissible with aeroplanes of present-day dimensions, on account of the mean recoil reaction. This is approximately 1 lb. per shot per minute, or at a rate of 100 per minute, 100 lb.; a quantity that would still further hamper the designer in the arrangement of his gun position.

The Machine-Gun; Importance of Rapid Fire.

For the time being there is no doubt that the ordinary machine-gun is the most serviceable and effective weapon available. Taking, for example, the Lewis gun with its self-contained magazine, the weight of the weapon mounted in place is under 30 lb., and the service ammunition runs 17 to the pound. Assuming, as before, 2½ cwt. as the available total, and taking 4 lb. as the weight of a magazine of 47 rounds, it will be possible to carry some sixty magazines representing nearly 3000 rounds. The usual manner of employing such a weapon on a moving target, as presented by an aeroplane in flight, is to fire by "bursts," each burst being sighted afresh and commonly consisting of some six or eight shots, so that the speed of fire never averages as high as that of which the gun is capable; thus the supply of ammunition above given would be sufficient for a continuous and hot engagement of about a quarter of an hour's duration. From the point of view of recoil the machine-gun is quite harmless; the mean recoil of the Lewis gun firing Mark VII. ammunition amounts to slightly less than 3 lb. per shot per second, or at 480 per minute the recoil reaction is about 23 lb.

In view of the advantages of rapid fire, it would seem desirable to increase the speed of fire of the machine-gun to the maximum extent possible. When, on land, the obvious thing to do under similar circumstances would be to bring two guns into action, a similar course is not possible on a flying-machine, owing to the weight of the additional gunner. An extra man must either mean the sacrifice of a couple of thousand rounds of ammunition or a couple of hours' petrol supply, neither of which alternatives can be entertained. The conditions indicate the mounting of machine-guns in pairs, or the design of double or triple-barrel guns, the breech actions of which would be independent, but so arranged that they could be fired one, two, or three at a time; by this means a "burst" of twenty-five or thirty bullets could be got off in less than one second. It may be found that a gun designed to take the 0.45 service revolver or automatic-pistol ammunition will be better suited to the conditions than the present weapon, in which the service rifle (Mark VII.) ammunition is employed. Such a gun would be far more handy, owing to the shortness of the cartridge, and would be furnished with a comparatively short barrel; also the magazine could be made of more compact form better to permit of the multiple-barrel design. Beyond the above, the shattering effect of the round-nose pistol bullet is known to be far greater than that of the 0.303 spitzer, so that greater injury will be inflicted on any spars or other structural members that may be hit. Incidentally, also, the stopping effect on pilot or gunner will be greater in the event of a shot getting home. In addition to the advantages enumerated, the 0.450 pistol ammunition weighs 21 to the pound, against the service rifle 17, which gives an addition of 25 per cent. to the number of rounds. When drawing on a limited supply of ammunition it is clearly necessary to select whatever is best suited to the work in hand.

London Electricity Supply.—The report prepared by the Special Committee on London Electricity Supply was brought up at the meeting of the London County Council on the 13th inst., and permission was given to the committee to take the necessary steps to present definite proposals to the Council on November 10 next, with a view to the promotion of a Parliamentary Bill. The report was originally intended to be considered at the meeting on July 28 last, but, owing to the large amount of other business, was not dealt with. We summarised the report in a note in our issue of July 31, and no purpose would be served by dealing with it again at this stage, especially as it is distinctly stated that the scheme outlined is preliminary only. When the final proposals are made in November the question may well be considered fully. In the meantime it is a matter for congratulation that another definite attempt is to be made to reduce the chaos of London electricity supply to some sort of order.

NOTES.

The Expansion of Steel Bridges.

Some interesting observations on the expansion of steel bridges were recorded in *Engineering News* some time since by Mr. H. A. Loser. The bridges in question had all been erected on the New York, New Haven, and Hartford Railroad within the ten years previous to the observations. Of the forty-five bridges examined, ten had pin-connected trusses, the spans ranging from 182 ft. to 217 ft. Eleven of the bridges had riveted "through" trusses, varying in span from 70 ft. up to 145 ft., and the remaining eighteen were plate-girder deck-spans, from 70 ft. to 111½ ft. in length. The winter temperatures recorded during the observations ranged between + 15 deg. Fahr. and + 56 deg. Fahr., and the summer temperatures from + 46 deg. Fahr. up to + 86 deg. Fahr. The greatest range recorded during a single set of observations was 54 deg. Fahr. Mr. Loser observes that in all tests the whole of the extension took place at the rollers; there was no sliding in any case. Moreover, the motion occurred in successive steps, each accompanied by a loud noise. The temperature of the bridge was assumed to be that of the surrounding air. The coefficient of expansion observed appeared to be a little less for the pin-connected trusses than for the other types of bridge, as the following figures indicate:—

Number of Observations.	Type of Bridge.	Average Range of Temperature.	Coefficient of Expansion.
		deg. F.	
16	Pin-connected	39	0.000,005,3
11	Riveted	39	0.000,006,4
18	Plate-girder	44	0.000,006,3

Mr. Loser concludes that the coefficient of expansion of actual structures is the same as for a solid bar of the same material. The whole of the expansion can be effectively taken up by rollers 5 in. to 7 in. in diameter rolling between planed steel surfaces. From other observations, however, he believes that rollers of under 2½ in. diameter, such as used under light steel highway bridges, do not remain effective for any length of time.

A New Ejector Air-Pump.

An interesting type of ejector air-pump, constructed to the designs of M. Delaporte by the Maison Bréguet, Paris, is described by M. Aimé Witz in a recent issue of *La Technique Moderne*. The pump tested by M. Witz was fitted to a jet condenser, and proved to be capable of extracting very large quantities of air with but a moderate consumption of steam. In the Delaporte system two ejectors are used, arranged in series, with an auxiliary condenser of the jet type interpolated between the two. The first ejector draws air from the main condenser, and compresses it into the auxiliary condenser, from which it is drawn off and discharged into the atmosphere by the second ejector. From this auxiliary condenser a long U-pipe connects with the main condenser. Through this pipe the condensate and the condensing water from the auxiliary condenser enters the main condenser, whence it is abstracted with the main condensate by means of a water-pump. The Delaporte ejector is therefore analogous to a dry air-pump, since, being connected to the condenser near the top, it draws off air and vapour only, and not water. To the top of the auxiliary condenser is connected the second of the two ejectors, by which the air is finally discharged into the atmosphere. It is in the construction of this second ejector that M. Delaporte claims great advantages over previous air-extractors of the same type. The difficulty which has arisen in previous attempts to make efficient ejector air-pumps has, he claims, arisen from the great variations which are liable to occur in the amount of air to be abstracted. As the second ejector which discharges to the atmosphere has the most work to do, and thus requires the most steam, it is important that it should work under economical conditions, and to that end that there shall not be great variations in the work it is asked to accomplish. This is secured by providing a spring-loaded air-inlet valve to the top of the auxiliary condenser so as to maintain within the latter a constant air pressure. It is claimed that this admission of additional air actually reduces the amount of steam that would be necessary to secure the desired vacuum should the air to be abstracted fall much below its normal value. M. Delaporte remarks that an ejector is essentially a convergent-divergent nozzle working backwards. In such an ejector the pressure at the throat should therefore be 0.58 of the discharge pressure, and the speed of flow equal to that of sound. If the supply of gas is, however, insufficient to fill the throat at this pressure and at this velocity, serious losses will arise by eddying, which can only be eliminated by making good the deficiency in the amount passing, by a further supply either of air or of steam. The latter has generally been the alternative adopted, but M. Delaporte claims that the former is by far the more economical plan. The results obtained in one series of trials are tabulated below. The ejector steam was supplied at a pressure of 9 atmospheres; the total consumption of the two being 105 lb. per hour, which M. Witz takes as equivalent to that of an engine developing 5.3 horse-power. The weight of air removed per hour at different vacua in four sets of experiments was as follows, the condenser being of size sufficient for a turbine developing 250 kw. at normal load, and taking some 5800 lb. of steam per hour:—

Air Abstracted per Hour.	Vacuum per Cent. Test No. 1. Low Load, Auxiliary Condenser out of Action.	Test No. 2. Low Load, Auxiliary Condenser in Action.	Test No. 3. Full Load, Auxiliary Condenser out of Action.	Test No. 4. Full Load, Auxiliary Condenser in Action.
lb.				
3.31	99.50	99.86	99.37	99.93
6.61	98.76	99.59	98.68	99.77
9.92	97.53	98.57	97.72	99.43
13.23	96.31	97.40	96.51	99.13
16.53	93.28	93.94	93.97	96.53
19.84	89.70	90.39	91.06	93.14
26.45	84.70	85.25	86.48	
33.07	79.60	—	81.40	
46.30	63.80	—	65.70	

The Impermeability of Concrete.

In a paper recently read before the Western Society of Engineers, Professor M. O. Withey described the results of a series of tests on the permeability of concrete, which have been made at the University of Wisconsin. The materials used were Portland cement, sand ranging in weight from 104.5 lb. to 112.2 lb. per cub. ft., and gravel weighing from 107.3 lb. to 109.3 lb. per cub. ft. Eighty-eight of the test-pieces were made with a 1 : 1½ : 3 mixture by volume, and sixty-seven with a 1 : 2 : 4 mixture, and there were ninety-eight specimens proportioned with 1 part by weight of concrete to 9 parts by weight of aggregate. None of the concretes proved absolutely water-tight in the sense that they would not absorb water, but most were so impervious that there was no visible evidence of flow. The signs of dampness on the bottom of the specimens increased with increasing humidity of the atmosphere. With mixture of 1 part of cement to 7 parts of aggregate the average rate of flow during a period of fifty hours was under 0.001 gallon per sq. ft. per hour, when the pressure was 40 lb. per sq. in. With the 1 to 9 mixtures, practically water-tight concrete could, it was found, be obtained by suitably grading the sand and gravel. Richer mixtures, such as the 1 : 1½ : 3, proved very impervious, but Professor Withey remarks that such rich mixtures show considerable volume changes when alternately wetted and dried. To secure impermeability great care is needed in mixing the concrete, especially when the proportion of cement is small. If mixed too dry, the concrete cannot be properly compacted. The best results were obtained by mixing the materials dry for ¼ to ½ minute, and then continuing the process after adding the water for 1½ to 2 minutes with 1 to 9 concrete, or for 1 minute with the rich 1 : 1½ : 3 mixture. Proper curing of the concrete greatly adds to its impermeability. Premature drying destroys the imperviousness of the lean mixture, seriously impairs that of the 1 : 2 : 4 mixture, and appreciably diminishes the water-tightness of the rich mixture. Thus, thin sections of 6 in. to 8 in. in thickness should be, he concludes, kept damp for one month for lean mixtures, or two weeks for a rich one.

South Africa.—The Board of Trade reports that H.M. Trade Commissioner at Cape Town states that it is essential that British manufacturers desirous of competing successfully in the South African market should realise the need for both the manufacture of cheap lines and their universal distribution throughout the Union. The better-class articles meet the needs of urban communities alone, and are beyond the means of the rural population.

LITERATURE.

The Tin-Plate Industry; with Special Reference to its Relations with the Iron and Steel Industries: A Study in Economic Organisation. By J. H. Jones, M.A. London: P. S. King and Son. [Price 7s. 6d. net.]

The history of an industry constitutes necessarily an important chapter in the tale of a nation's social progress, and one that deserves careful consideration. On the most superficial outlook, such a history involves the examination of the circumstances under which that industry has grown, the conditions that have fostered its development or impeded its advance, the labour organisations to which it has given rise, its relation to other activities, and its influence on the health and character of the community. It should interest and instruct the politician and the economist, the capitalist and the operative, the philosopher and the patriot. Mr. Jones should have a large audience, and we conceive that he will give the greatest satisfaction to those who study him the most keenly. He is as happy in his subject as in his treatment of it. He has selected a specially localised industry, completely of modern development, one in which the method of production has remained essentially the same throughout the entire period; but notwithstanding the small number of variable influences, one that has undergone many vicissitudes necessitating changes of policy on the part of its controllers, whether operatives or manufacturers.

We may pass over the processes of manufacture into which the author has thought it necessary to enter in order to explain the effect of the technicalities of the trade on industrial organisation and labour disputes. The details are neither many nor important. The interest centres rather upon the policy pursued in times of crisis, and the mistakes that have resulted from a failure to grasp the true nature of the underlying issues. In the early days under review, about 1870, the British manufacturers enjoyed the complete monopoly of nearly all foreign markets. They were halcyon times, when competition was absent and wide variations in price were possible without much resultant change in demand, ensuring enormous profits to the producing class. This happy state of things no longer exists. The manufacturers made the inevitable mistake of over-investment of capital. Next we find the workman, dissatisfied with the general conditions of labour, endeavouring to force the hands of employers by the use of the strike. It failed, injuring both parties to the dispute, mainly because the workmen chose an unfortunate time to press their claims. They fought during a period of depression due to over-production. The leaders were earnest but inexperienced men, who had failed to follow the movements of the trade with sufficient closeness, and did not understand the nature of the economical depression. Later we find the masters, conscious of some loss and inconvenience, striving to right matters by restricting the output—that is, each desired his neighbour to curtail, while keeping his own machinery at full pressure. Having again mistaken the true source of trouble, matters grew worse, and a disastrous strike followed, in which the masters were worsted. They misread the signs of the times and demanded a reduction of wages when the trade was emerging from a period of depression, and to take advantage of an improving market they had to withdraw their demands, else they could not share in the returning prosperity. The key of the situation is frequently not seen till after the issue has been decided, but the study of the determining factors, unheeded in the blind strategy of partisan conflict, is highly instructive.

We are invited to consider the tin-plate trade in another aspect. It depends for its market mainly upon foreign demand, and until the McKinley Act came into force, more than 70 per cent. of the annual production was exported to the United States. We should therefore be able to trace the effect of the imposition of a high tariff on a particular industry, and doubtless the advocates and opponents of Free Trade and Protection alike can derive arguments to support their respective views. But though the facts are given, and, as we believe, impartially and accurately, it is very difficult to draw a satisfactory conclusion as to the bearing of that fiscal operation, either here or in the States. This is what one would expect. If the problem could be easily solved, if the effects were limited to small areas, and the interests of producers and consumers identical, the rivalry which exists in the

respective camps could not exist. It is easy to point to statistics to show that, up to 1891, the export of tin-plates gradually increased till it reached about 450,000 tons, and from that date declined to the end of the century, when the total export fell to about 250,000 tons. In the same space of time, the last decade of the nineteenth century, the American manufacture of the finished article rose from practically nil to about 360,000 tons. It is not so easy, however, to draw a conclusion as to the relative merits of opposing fiscal policies, though, on a superficial view, it is patent that these figures represent so much trade lost to South Wales. If Protectionists are to get any support from this isolated example, it is for them to prove that the success which has crowned American enterprise could not have been secured without imposing a duty on imported tin-plate. Such an inference is hardly warranted on a close examination of the facts. It is by no means certain that the trade could not have been built up as rapidly, and at less cost to the consumer, if no hostile tariff had been imposed. Doubtless protective measures gave a stimulus, and attracted attention to a possible line of attack on British trade; but other causes contributed to start and maintain the abnormal activity. In the front rank must be placed the enormously reduced cost of production, and if this decrease is due to protective duties, and could not have have been effected without them, the case for Protection would stand; but without satisfactory proof it is impossible to justify the policy. The fall in the price of steel, coupled with improved methods of manufacture, and the substitution of machinery for hand-labour, have been the main cause of the American successful competition. The point is complicated by many side-issues; but it may at least be demonstrated with equal plausibility, that if protective duties were abolished in the United States, the Welsh tin-plate trade would be very seriously injured. The prosperity—one may say the existence—of the Welsh industry depends upon the continuance of the Protectionist policy in the States. Taken generally, if in the future the financial policy of America should tend towards the Free Trade system, our manufacturers will be compelled to face a new and unpleasant situation.

It may, and will, be argued that if Protection in America has injured the industry, the unwavering adherence to a Free Trade policy in this country has exercised a no less mischievous influence by permitting and facilitating the dumping of steel bars from Germany and America. To trace the effect of overloading the market with foreign steel bars it would be necessary to consider the technical details of the manufacture with some care, as well as the relations between the steel and the tin-plate industry. Into this we cannot enter, but it may be said that the dumping has not been so disastrous as represented. Doubtless the Welsh steel manufacturers, a powerful body who could make their grievances known, had to abate some of the advantages of their privileged position, and the smaller tin-plate manufacturers had to suffer, not from the actual dumping so much as from the manner in which they had conducted their business. The destruction of the bar monopoly was not an unmixed evil, nor was it one that had no remedy. It had the effect of hastening the amalgamation of the steel and tin-plate industries, constituting them practically one industry with united interests; for the easiest way out of the difficulty caused by dumping was to secure preferential treatment and a market for the bar by acquiring financial interests in tin-plate factories. Large firms, controlling both stages of production, are able to eliminate one form of competition. They can sell tin-plate at a very small profit and also erect new tin-plate mills in order to secure a market for the steel-bar. The extension of the manufactory means more economical methods of management. It is true that in its turn this policy leads to over-production with its inevitable consequences. The cycle of alternate inflation and depression proceeds unchecked.

Rapid fluctuations in trade will be productive of disputes and much friction between capital and labour. The student of industrial democracy will find here an instructive lesson on combination and collective bargaining. The employers of labour are seen to have their jealousies as well as the men. Different sections of operatives would find themselves in conflict, the tinmen and millmen having divergent interests. Tales have been told of enormous wages earned by skilled workmen in this trade, but there is no evidence here to support those assertions. Wages among rollers and the better class of workmen are certainly good, and the labour market does not seem overstocked. Great diversity in wages would probably prove fatal to universal combination, and it is important to notice that whatever difficulties stood in the way—and at times these were so great as to appear well-nigh insuperable—the tin-plate workers are now thoroughly well organised, 99 per cent. of them, it is said, belonging to six unions. Unions have been formed and have died from inanition; attempts to coalesce with other trades have been made and failed. The happiest outcome of various changes has been the formation of a conciliation board, upon which the different unions and masters' associations are fully represented. This board is not inelastic; it can be modified to meet contingencies as they arise, and has accomplished admirable results. The history of this organisation deserves to be written, for it provides an excellent example of perseverance in well-doing and of steady determination to remove hindrances to progress. Mr. Jones has proved himself a competent and impartial historian.

Alternating Currents and Alternating-Current Machinery. Revised and enlarged. By D. C. and J. P. Jackson. London: Macmillan and Co. [Price 23s. net.]

Whilst in this volume the authors aim primarily at the production of a text-book for students taking a regular course in electrical engineering, and one which will assist lecturers in their teaching, the book should also prove an aid to engineers as a ready reference to the principles involved in, and their application to, the solution of the problems met with in the everyday practice of electrical engineering.

As is usual in text-books dealing with alternating currents, the volume under consideration first treats of vectors and Fourier's series; their application to the resolution of the wave-form into its fundamental and harmonic components is then exemplified. The second, a very short chapter, is given to a few brief statements about transformers and measuring instruments, whilst in the third we have armature and field windings for alternators, and materials of construction discussed; many winding diagrams are given in circular and developed formations, which show clearly how windings differ from one another. The carefully-drawn perspective drawings of stators and rotors should also prove helpful to the student uninitiated in practical work. The separate, self, compound, and composite methods of excitation of generators are described by the aid of diagrams, and the disadvantages of the rectifying commutator, which is necessary in all but the first type, are pointed out. The next chapter (the fourth) is devoted to a somewhat lengthy treatment of self-induction, capacity, reactance, and impedance. Besides the usual articles on the establishment and termination of current in circuits containing induction and capacity, the effects of transient states of electrical circuits are treated generally, and these are applied to the explanation of the distortion of wave-form during switching operations. The fifth chapter is devoted to "The Use of Complex Quantities," and their proper mathematical manipulation is carefully explained.

The application of graphical and analytical methods to the solution of circuits containing inductance and capacity, singly or together, in series and in parallel, is explained in the sixth chapter, whilst the seventh brings in "power factor," and the various details—*e.g.*, power loops and momentary oscillation of energy—are dealt with. Closely allied to this is the measurement of power in polyphase circuits, which is covered by the eighth chapter, where the usual methods are given, with their corresponding vector and circuit diagrams. Continuing, the authors deal with hysteresis and eddy-current losses, to which a fair amount of space is allotted. The Ewing, Holden, and step-by-step methods of determining the hysteresis loss in iron specimens are described, and the graphic method for determining the wave form of exciting current for a given specimen is explained. The next (tenth) chapter, on "Mutual Induction and Transformers," is one of the longest in the volume. After mutual induction, variation of reluctance of iron, exciting current, &c., are considered, circular diagrams are given for the various load conditions of transformers, and the constant current transformer is also given a place.

The eleventh chapter, being 186 pages, is allotted to "Synchronous Machines." Power factor and armature reaction, machine characteristics, oscillographs, voltage-regulation methods, the operation of generators in parallel, syncroscopes, high-tension switch-gear and converters all find a place. The limitations of converters are discussed, incidentally involving split poles and equaliser rings. Asynchronous motors and generators form the subject of the twelfth, which is also a long chapter; the general principles of the induction motor and the relations of current, torque, impedance, and magnetic leakage are explained. Vector relations and formulæ for torque and slip are deduced, and the induction motor as an asynchronous generator is briefly discussed, showing vectorially the difference of the conditions when motoring and when generating; features of construction and other branches are included. The modified induction, repulsion, and series motors are described and treated analytically and vectorially. The concluding chapter is on self-induction, mutual inductance, and electrostatic capacity of parallel wires and skin effect, which should prove attractive in these days of increasing overhead transmissions, not to mention the importance of these factors in telegraphy and telephony.

The authors have treated their subjects with characteristic American directness; and whilst the proper use of their book would entail a knowledge of trigonometry and the calculus, the numerous vectorial and wave-form diagrams will be instructive to many of those practical engineers whose mathematical knowledge is not great, or has suffered from want of use.

Technical Mechanics: Statics and Dynamics. By Professor Edward R. Maurer, of the University of Wisconsin. Third edition, re-written. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 10s. 6d. net.]

The publication of a third edition of a work is a distinct proof of its merit, and, moreover, indicates that its later arrangement has been directed by a maturer experience and its methods of presentation improved by ample criticism. Mechanics deals mainly with subjects that are permanent in character, and by methods that are insusceptible of change. Since Newton's day no essentially new truth has been stated. We may attach other meanings to certain terms as "mass," &c., but the behaviour of force and its effects under given conditions remain unchanged. The scope for originality of treatment is therefore limited; the judicious arrangement of facts, the choice of illustration, the variety and width of outlook, are the only directions in which those who are dissatisfied with existing manuals can hope to effect improvement. In the author's own words, all that is now possible is "a deductive, formal, and mathematical development on the bases of Newton's laws." We may improve our notation, effect some useful generalisations, coin new words to express old ideas, but demonstrated truth remains immutable, and one may well wonder at the frequent issue of elementary text-books to teach the same principles and practically by the same means.

The author, however, has found some unoccupied ground which he fills profitably. He describes his treatise, intended for students of engineering, as a work on "technical mechanics," implying thereby an intermediate position between theoretical and applied mechanics as generally understood. It departs in essential particulars, and usually advantageously, from the ordinary academic methods; and, on the other hand, it differs from manuals on applied mechanics by omitting such subjects as the strength of materials, hydraulics, &c. Put in another way, the student needs no profound acquaintance with the higher branches of pure mathematics, while the problems and examples discussed are such as may occur in actual engineering experience. For instance, the weightless pulleys and frictionless surfaces that figure in so many problems find no place here. It is early impressed upon the student that in even simple mechanical devices the various parts are more or less intimately connected, and that their parts, or some of them, exert forces upon each other that cannot be neglected if a practical and useful result is to be obtained from machines in actual use. Or it may be we are taught to find the centre of gravity of an irregular body by the methods of suspension and balancing, dispensing with all mathematical aid save the underlying principle. But lest we should be misunderstood and convey the notion that the

theoretical side is too little in evidence, we hasten to say that there are very useful discussions of centroids both of surfaces and solids, in which a close approach is made to the so-called theoretical mechanics, and, indeed, throughout we have a happy combination of theory and practice.

The book is divided into the two sections of statics and dynamics. In the latter section there is adequate treatment of rectilinear and curvilinear motion, with a good article on simple harmonic motion. Work, energy, and power, the last defined as the rate at which work is done, form the subject of another section. In the remarks on gyrostats, a rather fuller treatment might have been bestowed on the Anschütz gyro-compass, if it were necessary to discuss such special applications at all. The Schlick gyro-stabiliser, whose future is very doubtful, obtains mention, an abbreviated account being taken from the pages of this journal. The last two chapters deal with two and three-dimensional motion respectively. A number of practical examples, selected to elucidate general principles, are given and solved. Teachers and students alike, to whom the concrete and practical side of mechanics appeals, will appreciate this carefully-constructed manual, in which it is evident that experience has maintained its early freshness, and routine has not brought carelessness nor dulled an energetic purpose. As a rule, it is difficult to approve of books that are written to meet the special needs of a class of students who have to show proficiency up to a certain point in a certain time. But the author is quite aware of the objectionable features in books of that kind, and though this is intended to supply an adequate course of instruction for pupils in one semester, "five times per week," Professor Maurer has avoided the obvious disadvantages frequently encountered. He regrets that it has been found necessary to sacrifice the logical order of arrangement to some extent; but, though this may be evident to the trained teacher, it will prove no disadvantage to the student, or to those who consult the book for information on special points.

BOOKS RECEIVED.

Transactions of the Barrow and District Association of Engineers. Vol. VI., Session 1913-14. Barrow-in-Furness: The Association, the Technical School.

United States Geological Survey: Department of the Interior. Water-Supply Papers. No. 309. *Surface Water-Supply of the United States*, 1911. Part IX. *Colorado River Basin.* By Robert Follansbee, W. B. Freeman, and G. Clyde Baldwin. No. 322. *Surface Water-Supply of the United States*, 1912. Part II. *South Atlantic Coast and Eastern Gulf of Mexico Basins.* By W. E. Hall and C. H. Pierce. No. 324. *Surface Water-supply of the United States*, 1912. Part IV. *St. Lawrence River Basin.* By G. C. Covert, A. H. Horton, and W. G. Hoyt. No. 340-A. *Stream-Gaging Stations and Publications Relating to Water Resources*, 1885-1913. Part I. *North Atlantic Coast Drainage Basins.* By B. D. Wood. No. 345-A. *Preliminary Report on Ground Water for Irrigation in the Vicinity of Wichita, Kansas.* By O. E. Meinzer. No. 345-B. *Ground Water for Irrigation in the Vicinity of Enid, Oklahoma.* By A. T. Schwennesen. *With a Note on Ground Water for Irrigation in the Great Plains.* By O. E. Meinzer. No. 345-C. *Underground Water of Lima County, New Mexico.* By N. H. Darton. *With Results of Pumping Tests.* By A. T. Schwennesen. No. 345-D. *Ground Water for Irrigation in the Valley of North Fork of Canadian River near Oklahoma City, Oklahoma.* By A. T. Schwennesen. Washington: Government Printing Office.

Transactions of the Institution of Naval Architects. Vol. LVI. Edited by R. W. Dana, M.A., M. Inst. C.E., Secretary of the Institution. London: The Institution, 9, Adelphi-terrace, and Henry Sotheran and Co.

An Introduction to Machine Drawing and Design. By David Allan Low, Wh.Sc., M.I. Mech. E. New edition, re-written, re-illustrated, and enlarged. London: Longmans, Green and Co. [Price 2s. 6d.]

Text-Book on Wireless Telegraphy. By Rupert Stanley, B.A., M.I.E.E. London: Longmans, Green and Co. [Price 7s. 6d. net.]

Every Briton's War-Book, with Maps of Europe, the North Sea, and Paris as London. London: The Motherland League, 4, Johnson's-court, Fleet-street, E.C. [Price 6d.]

What Every Private Soldier Ought to Know on Active Service. By Lieut.-Colonel Sir Frederick Ponsonby, K.C.V.O. London: Polsue, Limited, Gough-square, Fleet-street, E.C. [Price 2d.]

Some Considerations Regarding Cast-Iron and Steel Pipes. By John Sharp, Wh.Sc., M.I. Mech. E. London, New York, Bombay, Calcutta, and Madras: Longmans, Green and Co. [Price 4s. 6d. net.]

Trading with the Enemy: The Effect of War on Contracts. By Leslie Scott, K.C., M.P. Second Edition. London: Stevens and Sons, Limited, 119, Chancery-lane, E.C. [Price 2s. 6d. net.]

INDUSTRIAL NOTES.

We read in the last monthly report issued by the Amalgamated Society of Engineers that during September the engineering trade greatly improved, the number of unemployed members falling from 9133 to 5425, out of a total membership of 172,170. The question of minimising unemployment arising out of the war has been discussed.

Special consideration has been given to the adoption of a three-shift system in districts busily engaged on work required for the Government. Schemes prepared by the Manchester, Sheffield, Birmingham and Tyne districts have been presented; there was, however, a consensus of opinion that no one scheme would be suitable for all districts, and, where necessary, district committees have been asked to formulate a scheme to meet their requirements and thus minimise unemployment as far as lies in their power.

On Thursday, the 8th inst., a meeting of the Parliamentary Committee of the Trade Unions Congress was held, when a letter was read from Belgian trade unions making a pathetic appeal for financial assistance. They stated that on account of their country being overrun by Germans thousands of workpeople had been thrown out of employment, and, trade being at a standstill, the union funds were unable to provide benefits to keep the members. The Committee decided to make an appeal to British trade unionists for financial assistance which would be sent across to Belgium as received. The Committee further postponed consideration of the question of the Congress meeting this year.

The Leather-Workers' Union announce that the Walsall firms engaged in leather manufacture have agreed to terms of settlement, in regard to wages, which will represent concessions amounting to an average of about 25 per cent. It is anticipated that these will be generally paid in the town. The price-list agreed upon is the following:—Table hands and curriers, 8d. an hour; piecework curriers' rates as per Curriers' Society list; stainers and nishers, 7d. an hour; rollers, buffers, scourers, and setters, 6½d an hour; warehousemen, packers, drummers, and compo men, 6d. an hour; shaving-machine hands, 8d. an hour; and unskilled labourers, 23s. a week. Time and a quarter will be paid for overtime, and time and a half for Sundays.

Following upon the statement we gave on page 393 *ante*, we take the following paragraph from a recent issue of the *Sheffield Daily Telegraph*:—

"The effect of the war on employment in Germany is shown by the *Vorwärts* of October 2, which publishes an article on the strength of the returns supplied by 34 trade-union organisations, which count over 1½ million members. Only 1,269,000 members, however, responded to the inquiry, and of these, no fewer than 268,459 were workless, and 2254 were travelling in search of work on August 29. This makes over 21 per cent. unemployed of the total number of members reported.

"It is certain that the remaining 18 trade unions, which did not supply the necessary returns on the census day, were affected by the war still more deeply. Thus the Wood-Workers' Union counted on September 19 no fewer than 39,457 members, or 24 per cent. of its total membership, unemployed.

"The percentage of 21 is, of course, the average figure. The hat-makers show over 62 per cent. of their members unemployed, the lithographers nearly 55, the pottery workers 54, the boot-makers 35, the textile workers 28, and even the metal-workers over 21 per cent.

"A remarkable feature of these figures is that the women workers seem to be more severely affected by the war than the men. The number of unemployed women workers is over 48,000, or nearly 32 per cent. of the total female membership of the unions making returns.

"There is no means of discovering the amount of unemployment among the unorganised workers, but it must be still higher.

"In the United Kingdom the percentage of unemployment in the trades compulsorily insured against unemployment is 5.1, as compared with 6.3 a month ago."

The fustian workshops and mills at Hebden Bridge are now working full time on Government army contracts. Orders are in hand for two million khaki suits, one million heavy serge coats, 250,000 cotton bed-ticks and pillow-cases, and half-a-million haversacks for the French army. The contracting firms have distributed the work amongst other local firms in order that the contracts may be rapidly carried out. The execution of the contracts in question will keep the firms busy for over six months.

The following remarks are taken from the quarterly report of the Executive of the Amalgamated Association of Card and Blowing-Room operatives:—

"We have for years lived in an atmosphere of expectancy, and almost fear, of war between our country and Germany, but that feeling has often been relieved by the expressions of greetings given by the German delegates who have attended our Trade Union Congresses, and who repeatedly have affirmed that they and the whole of the united workers of Germany worked for the solidarity of the workers of the world, the uplifting of struggling humanity, the breaking down of the power of those who alone benefited by wars, the giving of full power of government into the hands of the masses, and destroying the power of the classes. We admit they have obtained to a large extent privileges they had not twenty years ago. They do to a limited extent participate in the governing of their country, by having a number of working-class representatives in the German Reichstag; but their professed love for the solidarity of the workers of the world vanished like vapour in the air when war against France was spoken of in their Houses of Parliament. They forgot their expressions of love for all mankind, and, in spite of their expressions to the contrary, they are fighting for German Imperialism."

At a recent meeting of the Kidderminster and Stourport Carpet Weavers' Association the president stated that they had remitted contributions of members to the extent of 145*l.*, and had voted 100*l.* to aid their members owing to trade having been so badly affected by the war. They might jeopardise the future of the society by too hasty an expenditure at the present time. He, however, asked authority for the committee to apply money voted for emigration purposes to meet the special circumstances caused by the shortness of work. Some of the weavers were anxious, since there was no employment for them, to go away to other work temporarily, and forty or fifty were probably going to Hereford to make cider. The meeting acceded to the suggestion of the committee.

The following is an abstract from a letter written recently by Mr. Casimir Berger, Treasurer of the International Cotton Committee and member for France, to the International Federation of Master Cotton-Spinners' and Manufacturers' Associations:—

". . . Our districts of the North and the Vosges are occupied, and the entire work of all industrial establishments there is at present suspended. Heaven knows when they will be able to resume work under normal conditions. Here in Normandy we are in a somewhat better situation, as we are able to obtain a cotton supply through the Seine, and to forward our yarn and cloth by way of the canals to the interior of France. Under these conditions, our weaving-sheds have been able to execute very important orders for the supply of the army. Business in the spinning section will to some extent revive when the weaving-sheds have exhausted their stocks of yarn, and will be obliged to give out new contracts to the spinners. At present the spinning industry of Normandy works short time, which may be estimated at about 50 per cent. of the normal production. Just as Lancashire spinners, so are we very much concerned as regards the position of the raw-cotton market . . ."

The spinning and weaving-mills in the Midlands are extremely busy on khaki and hosiery goods. Employment is good, and is likely to continue so for some time to come. It is a felicitous circumstance that the mills are now practically all engaged in the manufacture of khaki, since this shade can be obtained without the use of aniline dyes. On the other hand, as was stated at a recent meeting of the Leeds Chamber of Commerce, the stoppage of the supplies of aniline dyes from Germany is being seriously felt in the West Riding textile trade. It is not, however, anticipated that this will cause the dye works of the district to come to a standstill. There are dyes available which, while admittedly not as good, will serve their purpose until such time as aniline dyes are manufactured in quantity in this country, as everybody hopes they will be in the near future.

In their October report, dealing with the situation for September, the Amalgamated Toolmakers make the following statement:—

"It is very gratifying, at a time like the present, to be able to report that we have but a small percentage of unemployed members, and the figures would be still better but for the trouble at Keighley. On the other hand, we are sorry to have to report that a considerable number of members are working short time, and the Council is taking steps to ease the position for the brethren so situated.

"With a view to securing the co-operation of employers in getting work spread out as much as possible, we have met them in conferences, central and local, and generally they have shown themselves sympathetic with our object, and to some extent have met our wishes. These conferences have been held in London, Birmingham, Coventry, Manchester, Sheffield, &c.

"Seeing that it is of vital importance to the interest of the country that our soldiers and sailors should be

supplied with all necessary equipment with the least possible delay, we have agreed to the regulations limiting overtime lying in abeyance, at the same time urging that care should be taken to employ as many men as possible."

The following statement is also made:—

	Sept., 1914.	Sept., 1913.	Increase.
Members ...	14,544	10,379	4165
Unemployed ...	187	151	36
	£	£	£
Reserve funds...	44,250	37,750	6500

We are informed that Mr. John Syz, vice-president of the International Cotton Committee, and member for Switzerland on the International Committee, has recently written to Sir C. W. Macara, President of the International Federation of Master Cotton-Spinners and Manufacturers' Associations, stating that "the question how to get the new supplies of Egyptian and American cotton is now the order of the day. Our Government has forbidden the export of cotton, so that Germany and Austria cannot get it by way of Switzerland. In doing so, the objection to letting Switzerland have a new supply should be removed, and no obstacle put in the way of ships bringing cotton to French or neutral ports for our country. Switzerland is an importer of considerable quantities of English yarns, and now none are coming in, as the German ports are closed, and the English shippers seem to be afraid to ship by way of Rotterdam. It seems to me that it would be in the interest of the English export trade to organise a regular service with the Continent, and perhaps your Government could be interested in it. After having lost such a big trade with the war-stricken countries, it seems to be of increased value to keep up the trade with the neutral States, even if it were only to provide work for the people in the cotton industry."

Our Coal Abroad.—The outbreak of war with Germany and Austria, as well as continued trouble in the region vaguely known as "the Balkans," and the general shattering of Belgium, has had the effect of materially reducing our coal exports. They have also been reduced by the collapse of general business, which has now extended nearly all over Europe. Even business with Chili, Brazil, Uruguay, and Argentina has suffered from European depression. The aggregate exports of coal from the United Kingdom in the nine months ended September 30, this year, were 48,116,347 tons, as compared with 54.517,788 tons in the corresponding period of 1913 and 45,750,423 tons in the corresponding period of 1912. When shipments of coke and patent fuel are taken into account, the totals for the three years are increased to the following amounts:—1914, 50,372,512 tons; 1913, 56,898,208 tons; and 1912, 47,546,767 tons. Still further, coal shipped for the use of steamers engaged in foreign trade carries the aggregate to September 30, this year, to 64,954,479 tons, as compared with 72,443,825 tons and 60,749,058 tons.

Scientific Instruments.—According to a Board of Trade bulletin just issued, the exports of the United Kingdom of scientific instruments are valued at about 1,833,200*l*. Unfortunately, there is no detailed information on the various classes contributing to this total. On the other hand, comparatively detailed particulars are available of the German and Austrian trades of this description. Germany's total export trade is valued at 2,285,300*l*. per annum, and Austria's at 198,350*l*. As would be expected from their wide repute, among the most important exports of Germany are field and opera-glasses, telescopes, &c., which are sent abroad to the value of 355,200*l*. per annum. The class of exports next in importance comprises pedometers, automatic measuring and recording apparatus, speed-indicators, automatic balances, &c., which are exported to the value of 350,600*l*. Next come surgical instruments, in which Germany's export trade amounts to 344,600*l*. Her exports of apparatus and instruments of glass are valued at 293,200*l*., and of microscopes, optical glass, ground and unground, to 230,000*l*. Compared with these figures, Austria's exports are small. Germany takes these goods from us to the value of 133,000*l*., and Austria to about 45,000*l*. The most important German markets for telescopes, field-glasses, &c., are: Russia, taking 84,300*l*. worth; Italy (26,700*l*.); Switzerland (24,700*l*.); and France (18,600*l*.). In speedometers and automatic measuring devices Germany's best sales are again to Russia (46,700*l*.); France stands second on the list (39,600*l*.); other purchasers of importance being again Switzerland and Italy. In surgical instruments, again, Russia (55,600*l*.), France (24,600*l*.), and Italy (25,000*l*.) head the list of customers, to them being added the United States, who purchase from Germany to the value of 60,300*l*. The United States constitute Germany's best customer for mathematical instruments (33,500*l*.), and also for apparatus of glass (50,400*l*.); in the latter category Russia is down for purchases valued at 48,300*l*. In microscopes, lenses, &c., Germany's best sales are to Russia and the United States, though to Japan she sends goods valued at nearly 22,000*l*., and is said to have practically a monopoly so far as microscopes are concerned. In all the countries named, and in others, our makers now do a considerable business, and they should therefore be in a position to know the market requirements, and so take prompt advantage of the opportunity for expansion now offering.

BRITISH EXPORT TRADE.

To the Editor of Engineering.

Sir,—As I see from the papers that considerable attention is now being paid to the furtherance of the British export trade, I should be glad, with your permission, to mention a few facts which are worth the attention of exporters.

Packing for Shipment.—So far as my experience goes, there is very little to complain of with regard to the packing of British machinery for export; at any rate, where experienced firms are concerned. Shippers, however, would be well advised to stencil the name and address of the consignee in bold letters on at least two sides of every large case. Otherwise the goods may lie for weeks or months in some railway warehouse, their arrival being strenuously denied by the local agent of the railway company. The usual diamond mark, with initials of shipper and consignee, is inadequate.

British (and other) packers rarely seem to realise that unloading machinery from railway-cars will almost invariably have to be done by the consignee without the use of a crane of any sort. All large packing-cases containing heavy goods should therefore have stout wooden skids, with bevelled ends, firmly nailed lengthways to the underside of each case. While these skids do not interfere with slinging, they make it easy to move the case on rollers. The battens usually found on packing-cases prohibit the use of rollers, unless the case is first jacked up, and planks laid across the battens. One well-known firm of British engine-builders always uses cases fitted with skids such as I have advocated.

The consignee should receive, in duplicate, a full and complete list of every piece of apparatus packed in each particular case.

Sending Out Quotations.—Manufacturers should invariably quote prices in the currency of the country of destination, as any other course is liable to be offensive to the customer, even if the latter is of British birth, as his accounts and ideas will all be in terms of local currency. The very small percentage which might have to be added to cover exchange fluctuations will be insignificant compared with the other doubtful items of a quotation.

It is also particularly desirable to quote prices f.o.b. cars at the customer's station, including freight and duty. The British manufacturer may rest assured that if he will not take this trouble, other people will, and will often carry off orders which they otherwise would not have got. Nothing is more irritating to a customer at the other side of the world than to receive quotations "f.o.b. Liverpool or equal," with possibly the added insult of "packing extra." Such a customer often has no possible means of calculating freight and duty for himself, while the information can be got without any difficulty by the shipper. Every purchaser likes to know exactly what he will be called upon to pay for his goods, and he will give the preference to the manufacturer who will take the trouble to tell him.

Agents Abroad.—British firms cannot possibly be too careful whom they appoint as their agents abroad, for many a highly reputable firm has suffered seriously by the conduct of its representatives. Manufacturers will often place their interests and reputation in the hands of people abroad whom they would not trust with a 5*l*. note at home. Faults to be guarded against in agents are:—(1) Utter ignorance in regard to what they are selling; (2) representation of rival firms simultaneously; (3) desire to make sales at all cost, regardless of whether the goods are suitable for any particular conditions; (4) neglect of the interests of the manufacturer, either through incompetence or laxness. The faults of the manufacturer with respect to agents are:—(1) Placing confidence in utterly unreliable parties; (2) placing too little confidence in responsible agents; (3) putting prohibitive minimum prices on goods, which disheartens an agent who is trying to introduce them; (4) disappointing agents with regard to promises of delivery, and thus discrediting them in the customer's eyes; (5) giving agents either too much or too little territory to cover; (6) not trusting agents with a standard price-list, and thus preventing them from quoting without referring to the home firm.

An advantage of a foreign agency which is often overlooked is the fact that the manufacturer can invoice the goods to the agent at the shop cost. The agent then only pays duty on this value, whereas the manufacturer, in invoicing direct to the consumer, often has to pay duty on a far higher value than would otherwise be necessary. Furthermore the agent will look after the changing of sterling quotations into local currency, and by his (presumed) knowledge of freight rates and classification can probably save money in this direction.

Erection.—Manufacturers of heavy machinery, or of any apparatus of which the use may not be thoroughly understood by the buyer, should always arrange, if possible, to do the erection themselves, even if they have to do this at cost price. The erector should be an energetic, good-tempered, and thoroughly practical mechanic who has been for some years in the workshops of the firm, and who can take charge of all unloading and other heavy work. There is no single man who can do so much to make or mar a firm's reputation as an erector, and the utmost care should be taken in selecting a man who is thoroughly "on to" his job. The erector should have a knowledge of foundation work, and be more or less conversant with all things likely to affect his own particular duties. There are two bad types of erector, the one who gets drunk and the college-trained man. Of these, the former is the lesser evil, as he can do his work part of the time. An erector must, above all things, know how to do a job, not merely have learnt how it is done. The value of a good erector is "far above rubies," and this fact should be recognised in the treatment he receives. If he advises his firm to modify their machinery or their business methods in some detail, his advice should be taken, and not argued about.

Quoting to Specifications.—When specifications are sent out for any particular piece of machinery, it frequently happens that the specified requirements are not exactly in line with the manufacturer's standard practice. The proper course to pursue is to quote exactly to specification, and to add an alternative quotation for goods such as the manufacturer would recommend for the purpose. By quoting to specification the maker prevents his tender being rejected for formal reasons; while if, as in nine cases out of ten, the customer is quite ready to waive any detail in the specification, or even neglect the latter altogether, if he sees a better alternative, the maker's standard product will have a good chance of being accepted.

Yours truly,

Canuck.

THE INEFFICIENCY OF THE PRESS.

To the Editor of Engineering.

Sir,—I am writing to ask if you are in a position to give any further information about the turbines of the R.M.S. Aquitania. I asked Messrs. John Brown and Co. for particulars of the Curtis turbine, of which I am advised they hold the licence in this country, for marine purposes. They referred me to your issues in which the machinery of the R.M.S. Aquitania was described. The issue of May 8, in which the turbines are described, gives very little information indeed. In fact, I believe I am voicing the complaint of a good many engineers who study the development of different branches of engineering when I say that your journal appears to have the monopoly of description of certain engineering developments, particularly with reference to shipbuilding on the Clyde, and the monopoly appears to be used to give very little information. In the case of the description of the steam-turbines on board the R.M.S. Aquitania, for instance, it is not stated whether they are impulse or reaction, and there is absolutely no information about their construction, except a few figures as to their sizes; and the following:—

"There are four stages of expansion; the blades—on the Rosary system—vary from 3⅜ in. to 7 in. long."

What is the "Rosary" system as applied to turbine blades; and if the turbines are of the Curtis type, is it correct to describe the operating portions as blades? Are the turbines of the reaction type, and is it desired to keep the matter secret?

I shall be much obliged for any information that you can kindly give me on the subject. I am preparing some correspondence lessons in connection with a college on marine engineering, and I am anxious to give as full information as possible upon the Curtis turbine. One can obtain information in heaps about the Curtis turbine on land; but as to the Curtis turbine on board ship, information appears to be held up on the old school-boy lines of "Oh! that's tellings."

Yours very truly,

Sydney F. Walker.

Bloomfield-crescent, Bath, October 6, 1914.

[At this time it is surely not too much to expect an engineer to distinguish from such exceptionally complete drawings as we published of the Aquitania's turbines, whether these turbines were of the Curtis or of the Parsons type, and this should be the less necessary when the engineer in question has himself published a treatise on the steam-turbine. No other technical journal, so far as we are aware, has published anything like such complete discussions, both of the theory and of the actual construction of steam-turbines and their details, as ourselves. It is, however, impossible to repeat on every occasion elementary matter as to the special characteristics of the various types. That is now more suitable for the text-book than for the technical Press. If, however, Mr. Walker wishes to learn something about the distinction between the Curtis and Parsons type of turbine, he will find in our issue of August 18, 1911, a very detailed description of the Curtis marine type, whilst in our issue of March 22, 1912, an equally complete account of the Parsons marine turbine was published. After perusing these he may, perhaps, be able to see for himself to which type the turbines of the Aquitania belong. If still in difficulty, we shall be happy to help him; but he will not then, we think, find any difficulty in understanding the drawings of the Aquitania's turbines. As for the "Rosary" system of assembling turbine blades, it is one which has been in use for many years, and we should have expected it to be familiar to all engineers engaged in turbine construction. Mr. Walker will find it fully illustrated on page 311 of Mr. H. M. Martin's book on "The Steam-Turbine."—Ed. E.]

The Recent Accident on the South-Eastern and Chatham Railway near London Bridge.—It will be remembered that on September 5 an accident occurred near London Bridge Station on the South-Eastern Railway, in which a train standing at a home signal against it was run into by a following train. The evidence shows that the latter overran a home signal against it. This is proved by evidence of the signalmen, and has been admitted by the driver, who, in explanation, stated that he was new to the train which he was detailed to work, and passed the home signal while consulting the weekly notice giving information concerning it. The man had an excellent character, and it is to be regretted that so experienced an employee should have selected so inopportune a moment for this act. The Inspector, Lieut.-Colonel P. G. Von Donop, states that as a result of the recommendations made in connection with the Cannon-street accident of June last, the railway is experimenting with a form of train-stop for installation on this congested part of their system.

THE CHANGE OF THE MODULUS OF ELASTICITY AND OF OTHER PROPERTIES OF METALS WITH TEMPERATURE.*

By Professor F. C. Lea, D.Sc., A.M. Inst. C.E., and O. H. Crowther, M.Sc.

The use of materials in heat engines and other machines subject to temperatures considerably higher than normal temperatures make it desirable that the properties of these materials shall be investigated at temperatures at least as high as those to which they are subjected.

During the last nine months the authors of this paper have carried out a large number of experiments on the breaking strength of mild steel aluminium alloys, and the alloys of copper at temperatures varying from 15 deg. Cent. to 650 deg. Cent. A considerable amount of work in this direction has been done by other investigators, but very little attempt appears to have been made to determine the effect of temperatures on properties other than the breaking strength, and especially is this so in regard to the effect of temperature on the elastic properties of metals. The difficulties inherent in the experiments, no doubt, account for this to a considerable extent.

The object of the following short paper is to give a preliminary account of an attempt the authors have made to determine the variation of the modulus of elasticity with temperatures, and, incidentally, the variation of other properties will be referred to. The work has not yet proceeded sufficiently far to make it possible to state very general conclusions, but a description of the apparatus used and of some of the results obtained may prove of interest.

In an investigation of this nature it will be apparent that two serious difficulties have to be overcome.

1. To maintain the specimen at a constant known temperature for a sufficient length of time.

2. To determine the elongations of the heated specimen under given loads with the necessary degree of accuracy.

The specimens experimented upon were heated by an electrically-heated furnace while held in a horizontal testing-machine, as shown in Fig. 1. The furnace was 24 in. long, and consisted essentially of a porcelain tube, $2\frac{1}{2}$ in. in diameter, on the outside of which was wound platinum foil in such a manner as to prevent the production of a magnetic field within the furnace. Surrounding the foil is a thick layer of asbestos. By suitable resistances in series with the coil, a fairly uniform temperature, as high as 1200 deg. Cent., can be maintained in the central part of the furnace. Iron-constantin thermo-couples, calibrated, were used to measure the temperatures.

The distribution of temperatures in the interior of the furnace was investigated under varying conditions, and the authors are of opinion that the results, as far as the temperature measurements are concerned, are reasonably reliable. For example, a thick iron tube was fixed in the grips of the testing-machine, and passed through the furnace, as in Fig. 2. Thermo-couples were placed inside and outside the tube, and when a steady condition of temperature was obtained, the thermo-couples showed that the temperature differed by less than 5 deg. Cent.; and also when the thermo-couples were moved a distance greater than half the length of the specimen from the centre of the furnace, a variation of temperature not greater than 5 deg. Cent. was obtained. The curves of variation of properties show that such variations of temperature cannot materially affect the results.

The determinations of the elastic extensions of the specimens under load were more difficult than the determinations of temperature, but the degree of accuracy finally obtained is no doubt greater than in the determination of temperatures.

The necessities of the case demand that the apparatus shall be simple in form, reliable, and easy to manage. The moving portion of the extensometer consisted of a small rocker, as shown in Fig. 3. Into a small slab of brass were inserted three hard-steel points *a*, *b*, and *c*, while a long pointer P made of aluminium tube was attached to the slab, and the whole carefully balanced by the balance-piece B. The pointer moved over a glass scale, shown in Fig. 4, in which figure the extensometer is shown connected to a steel specimen with the furnace removed.

The rocker, which is shown in Fig. 3, rested on the lower bar, shown above the specimen in Fig. 4, and the upper bar of this figure rested on the top point of the rocker. There is thus three-point contact. The extensometer was fixed to the specimen by means of hard-steel screws passing through steel rings. To one of the rings the lower bar was rigidly fixed, and to the other ring the upper bar was attached by means of a thin piece of spring steel to give a degree of freedom in a vertical plane.

The apparatus was very sensitive in showing when a uniform temperature had been obtained in the furnace. To test the extensometer, it was put in series on a cold specimen with a Ewing extensometer, and it was found to give perfectly reliable results. It will be seen from the curves, to be shown later, that the up and down readings of the elastic stress-strain curves obtained with the extensometer agree remarkably well.

For the elastic-extension experiments on mild steel, long specimens, of the form shown in Fig. 4, and having a length of about 7 in., turned down in the centre, were used. For breaking-strength experiments of all materials and for the elastic experiments on alloys, specimens having screwed ends and a parallel length of about $\frac{3}{4}$ in. diameter, 7 in. long, were used. The screwed ends of these specimens were attached to screwed sleeves, which in turn were attached to long steel bars, which were screwed into the shackles of the testing-machine.

Elastic Constant of Mild Steel at Varying Temperatures.—Fig. 5 shows elastic stress-strain lines for the mild-steel specimen at various temperatures. It will be seen that the slopes of the lines diminish as the temperature increases, but in all cases a straight-line law is obtained within certain limits of stress.

Fig. 6, page 488, shows the variations of the modulus of elasticity with the temperature. It will be seen that the points lie very well about the curve. The variation of the other properties of this particular quality of mild steel with temperature are shown in Fig. 7.

It will be seen that the maximum breaking stress per

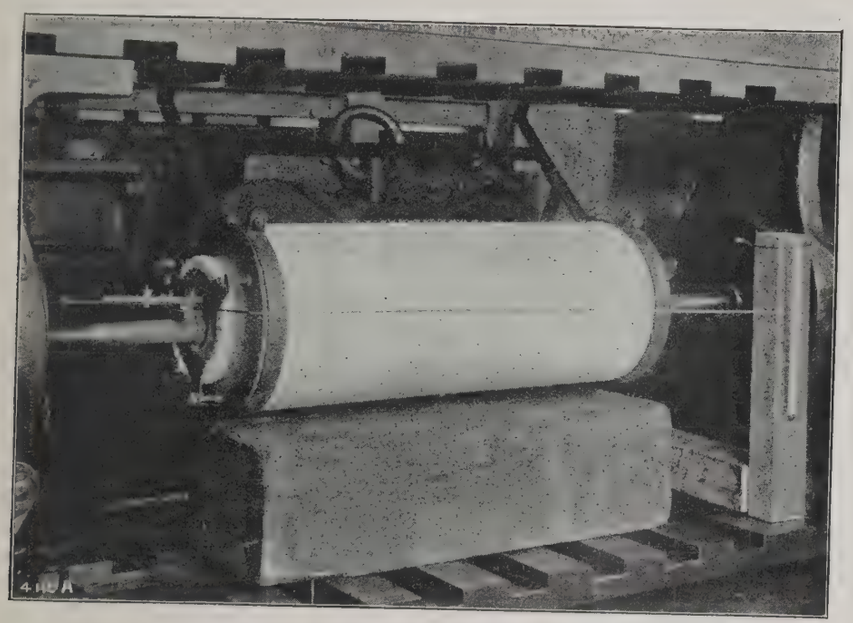


Fig. 1.

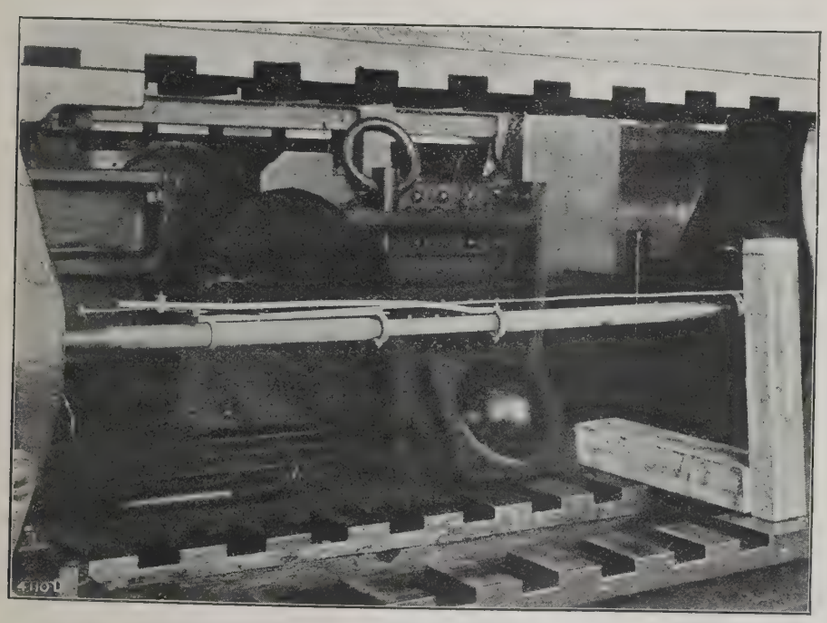
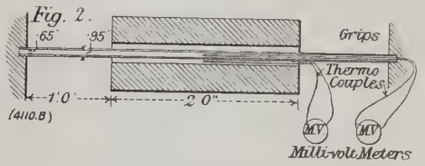
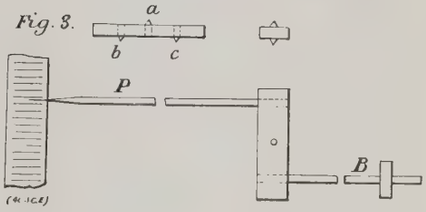
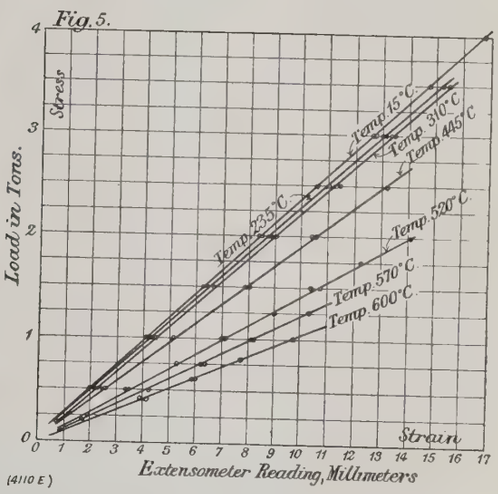


Fig. 4.







* Paper read before Section G of the British Association in Australia.

square inch occurs at a temperature of 250 deg. Cent., and this is the temperature at which the reduction of area is a minimum; the calculated stress per square inch, obtained by dividing the breaking load by the reduced area was 67.5 tons per sq. in.; at 550 deg. the stress obtained in this way was 82 tons per sq. in. When the stress obtained by dividing the breaking load by the original area is greatest, the stress on the actual fractured area is least. It is, of course, difficult to determine the value of the fractured area with any degree of precision, and these figures are therefore somewhat approximate. The yield-point in these cases was only obtained by noting the drop of the lever of the machine, and is therefore also only approximate.

Fig. 6.

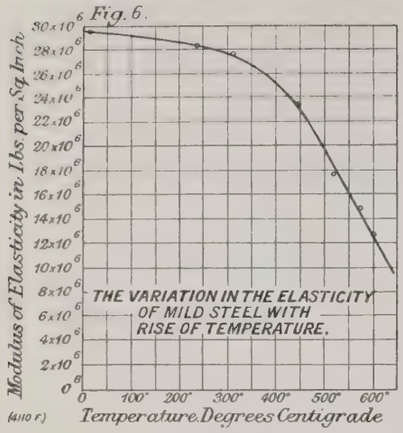

Modulus of Elasticity in Lbs per Sq. Inch
THE VARIATION IN THE ELASTICITY OF MILD STEEL WITH RISE OF TEMPERATURE.
Temperature Degrees Centigrade
(4110 F.)

Fig. 8.

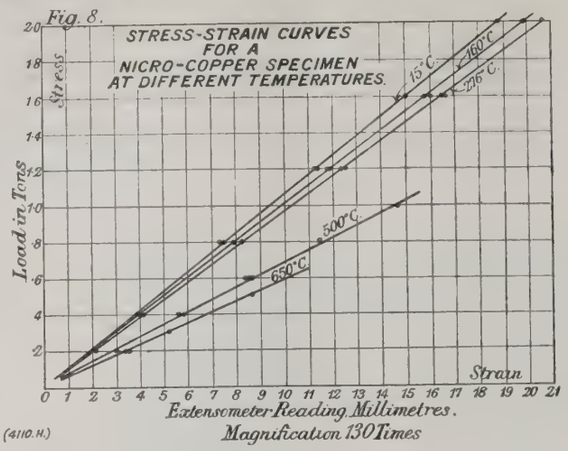


Fig. 9. EFFECT OF TEMPERATURE ON THE MODULUS OF ELASTICITY OF NICRO-COPPER.

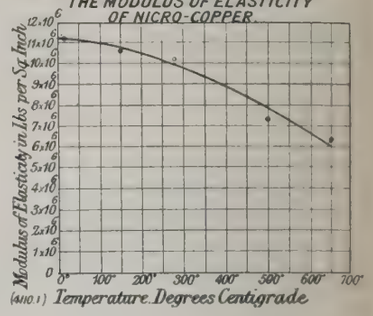


Fig. 7.

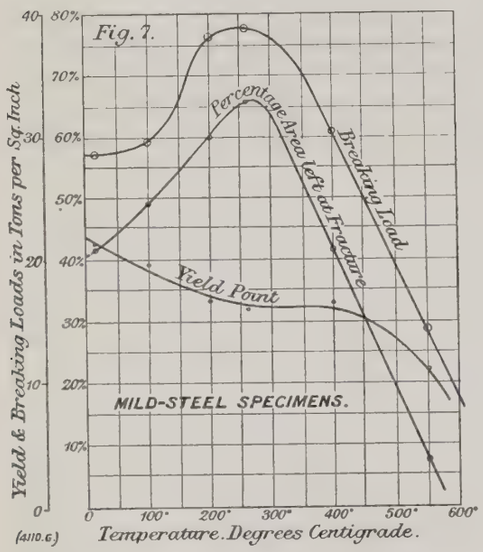


Fig. 10. CURVES SHOWING THE EFFECT OF TEMPERATURE ON THE STRENGTH OF NICRO-COPPER.

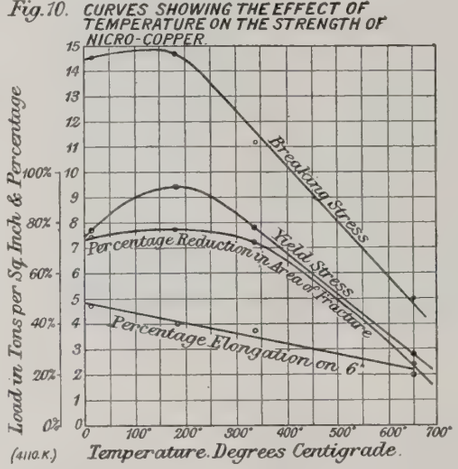
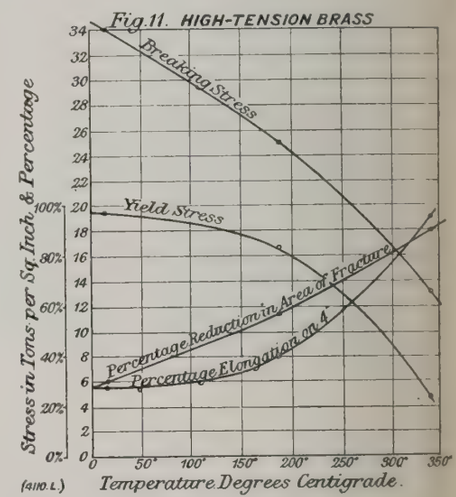


Fig. 11. HIGH-TENSION BRASS



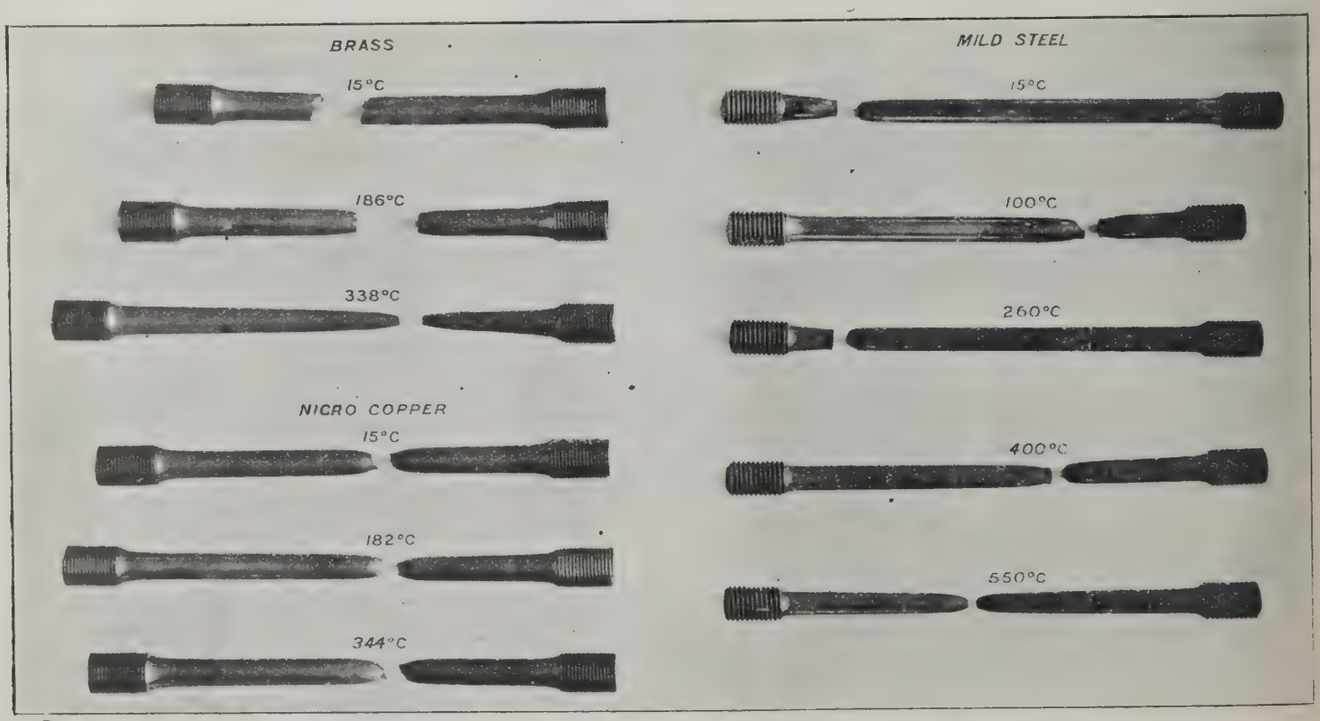


Fig. 12.

Fig. 8 shows the stress-strain curves for a nicro-copper finished cold-drawn and annealed. The curves are straight lines within the shown limits of stress. The slopes of the lines indicate the values of the modulus of elasticity.

Fig. 9 shows the variation of the modulus with temperature. The change is much more gradual than in the case of steel. The changes in other properties of the materials with temperature are shown in Fig. 10. At normal temperatures the breaking stress of the material is 14.5 tons per sq. in.; the maximum breaking stress is less than 15 tons per sq. in., and occurs at 150 deg. Cent. On this figure reduction of area per cent. is plotted instead of area left at fracture. It is interesting to see that at high temperatures the reduction of area is small—*i.e.*, the material breaks off short. The reduction in area at 650 deg. Cent. is 24 per cent.; at 180 deg it is 77 per

cent. The total elongation on a 6-in length at 650 deg. Cent. is 22 per cent., and 41 per cent. at 180 deg. Cent. There is thus at high temperatures a more uniform pulling out of the whole specimen than at the temperatures at which the stress is a maximum.

The curves shown in Fig. 11 for high-tension brass show that the rate of change of breaking stress with temperature is considerable. The variation of the elastic constants with temperature for this material have not yet been obtained.

Photographs of the fractured specimens are shown in Fig. 12.

The authors have been supplied with material by a number of firms, and in the near future it is hoped that the work which has been begun will be completed for many varieties of alloys and due acknowledgments made. It is proposed to continue the investigations by changing the sizes of specimens, and to use hollow specimens, so that a thermo-couple can be placed inside and outside of the specimens under test.

CONTRIBUTIONS TO THE HISTORY OF CORROSION.

In our issue of September 11 we published, on pages 342 to 345, a paper entitled "Contributions to the History of Corrosion," submitted by Mr. Arnold Philip, B Sc., F.I.C., A.M.I.E.E., Assoc. R.S.M. (Admiralty Chemist), to the Institute of Metals, and open to discussion by correspondence. We have received from the Institute the following communication which has been sent them, as part of the discussion invited :—

Communications.

Dr. G. D. Bengough and Mr. R. M. Jones (Liverpool) wrote that Mr. Philip's paper might be divided into two parts. The first, which consisted of some ten pages, was devoted to a criticism of certain experiments and views put forward by them. The second, which consisted of some twelve pages, described some new experimental work carried out by the author, and suggested certain deductions.

In dealing with the first part they would begin by discussing the general grounds, mentioned on page 5, upon which Mr. Philip considered that "very damaging criticism" might be directed against their views.

Taking them in order, No. 1 must be held to be quite inadmissible, since the fact that the writers had been obliged to change their views as the result of certain experimental work could not possibly be regarded as evidence that their original views were correct.

With regard to No. 2, they would remark that to invoke a mere "general belief" to decide upon the differences between the results of two sets of experiments was not sound—unless indeed the belief was based on definite experimental work. So far as they have been able to ascertain by inquiry, this general belief was based merely upon the admitted plausibility of Mr. Philip's position and upon nothing more. As an instance of the fallibility of "general belief" they would quote the view widely held by engineers that the coppery areas which occurred in badly dezincified tubes were due to bad mixing of the copper and zinc in the manufacture of the tubes. Anyone who was familar with the details of tube manufacture was aware that such a view was quite inadmissible, yet it was widely held by engineers and extremely difficult to eradicate. Regarding the "experience of users and manufacturers," they had yet to meet one who could point to definite and satisfactory experimental evidence in support of his so-called "experience," and they had made many inquiries on the subject.

The second part of 2 and the whole of 3 and 4 might be taken together. In brief they amounted to the statement that "almost all scientific investigators," as well as ordinarily accepted theory, together with the fact that iron and other metals might be used for electro-chemical protection, negatived the writers' view that carbon did not set up electrolytic corrosion in sea-water.

The reply to these objections was obvious. The ordinarily accepted theory of the electrolytic action of carbon on brass did not take any account of the electrical contact resistance between the carbon and the brass. This resistance, due to the loose and variable contact over a limited area, would be high even at the beginning of the action, if any, and would rise rapidly with the action, if any, by the interposition of layers of loosely-packed basic salts, and the layer of oxide formed on the brass. Oxides were notoriously bad conductors of electricity, and the total resistance thus interposed into the circuit might very probably be sufficient to stop any current from flowing under the action of the electromotive force set up by the carbon-seawater-brass circuit. Thus electrolytic theory (which they freely accepted), as well as scientific investigators who supported it, of whom they have questioned many leading authorities, conveyed no indication as to the possibility or otherwise of the action of carbon on brass corrosion till these contact resistances had been determined—a matter of very great experimental difficulty. Theory neither supported nor disputed the author's views. It was absolutely silent on the point at issue, which must be left to direct experiment.

In No. 4 Mr. Philip stated that the fact that the writers believed in electro-chemical protection by iron, &c., was contrary to, or incompatible with, their disbelief in the electro-chemical action of carbon. This was not so. When iron or zinc was used for protective purposes great care was, and must be, taken to secure good electrical contact between clean surfaces of these metals and the brass. If this contact were broken by layers of oxide, or in other ways, protection at once ceased, as was well known to those who used this method of protection. Obviously it was much easier to secure a good metal-to-metal contact by means of bolts and screws than a good carbon-to-metal contact by mere touch under the action of gravity. In the latter case also oxide layers were easily and quickly formed over the limited contact areas between the carbon and the brass; in the former case they would be formed and spread very slowly and gradually over the large areas of contact. Thus any possible initial electro-chemical action between the carbon and brass would be quickly stopped, whereas it would continue for long periods in the case of iron-brass contacts. Further than this, layers of calcium carbonate scale played an important part in electro-chemical protection, which latter was effective even when no current was passing. Scale formation would also prevent the attack of carbon on brass, owing to its high electrical resistance.

With regard to objection No. 5 very little need be said. The strength of a negative case must always be proportional to the strength of the corresponding positive case. As far as the writers could discover there was no definite *experimental* positive case extant at the time of their paper, hence they were content with a comparatively small amount of negative evidence. Had the evidence *now* presented by Mr. Philip been *then* available, additional experiments would have been carried out.

The only really important objection in the whole list was No. 6 (to which No. 7 was an appendix). This would be discussed in full detail later.

Objection No. 8 was a remarkable example of the use of purely circumstantial evidence to support a case. The writers would point out that corrosion usually occurred along the bottom of the tubes in the corrosion committee's experimental condenser (Second Report).* In this case there was no evidence whatever of the presence of coke or carbon particles lying on the bottom of the tubes. On the other hand, the scale, which consisted of ferric oxide, calcium carbonate, &c., and copper and zinc basic salts, was thickest on the bottom of the tubes. As far as any direct evidence went, the increased attack on the bottom of the tube might equally well be attributed to secondary reactions by any of these substances.

With the exception of No. 6 all the "damaging" criticisms given on pages 6 and 7 had now been discussed. Mr. Philip next devoted pages 7, 8, and 9 mainly to working out No. 6, which was his principal criticism, with great industry and detail. On this account it was deserving of a more elaborate reply than the matters already discussed.

In the last paragraph of page 9 Mr. Philip made a statement to which he evidently attached much importance, since it was largely in italics. This statement was :—"Firstly, *the corrosion loss on the piece of tube corroded in contact with coke for thirty days in experiment No.* 16 *—namely,* 0.25 *per cent.—is greater than the loss observed by the investigators on any other sample of* 70 : 30 *brass (with one exception) which was corroded under similar conditions*—namely, in stagnant sea-water of normal composition at atmospheric temperatures for thirty days; and the results of no less than nine such experiments are recorded—Nos. 1, 2, 4, 5, 6, 7, 19, 20, and 21; and yet it is upon the result of this single quantitative test on the action of coke that the investigators base their conclusion that no action takes place."

In the first place, this statement was incorrect as regarded *four* of the nine experiments quoted—namely, Nos. 1, 2, 5, and 21. These experiments were *not* conducted under similar conditions to the coke experiments, since they were made with the tube specimen hung vertically instead of horizontally, and all the experiments so carried out showed smaller losses than with horizontal tubes, as stated on page 34 of the Second Report. There were left, therefore, for comparative purposes, experiments Nos. 4, 6, 7, 19, and 20. The losses of weight recorded in these experiments were as follow (expressed in percentages) :—

	Per Cent.
4	0.24
6	0.21
7	0.22
19	0.24
20	0.22

i.e., an average of 0.23.

The loss of weight in the coke experiment was 0.25 per cent.

It was clear from these figures that the coke could not have had any important influence on the rate of corrosion of its tube. A difference of 0.02 per cent. represented in the actual experiment a difference in weight of about 5 milligrams—an amount that might easily be lost or gained in the process of cleaning the tubes previous to weighing. In any case, an increased loss of weight of 0.02 per cent. during thirty days, even if real, was too small to be of any importance in the practical problem. It might here be remarked that, in the writers' opinion, the practice adopted by Mr. Philip of stating results in "equivalent loss of weight in grains per square foot per 100 days," calculated to four significant figures, was objectionable, since it clearly amounted to an apparent and large, though quite unreal, magnification of accuracy, and hampered correct comparison.

Page 10 of the paper was devoted to a criticism of specimen No. 15 in Table I., which showed a loss of 0.54 per cent.

In view of the fact that the loss of weight of the specimen with coke approached so nearly to the average of five other tests carried out under similar conditions, it was really unnecessary for the writers to defend this result; but since Mr. Philip suggested that a clerical error had crept in here the writers desire to state that this was not so. This result was seen to be unusually high at the time of the experiment, and the percentage loss was not only recalculated, but the specimen was independently reweighed and the loss calculated *de novo;* an identical result was, however, obtained. It was thought at the time that some of the usual oxide layer had been removed inadvertently by the ordinary treatment with a rubber-tipped glass rod, such oxide being for some reason less adherent than usual. The matter was not considered important, since the loss in weight in the coke experiment was so close to the losses in weight of other tubes.

At the top of page 11, and in other places throughout the paper, Mr. Philip emphasised the fact that only one quantitative experiment was quoted in the report regarding the effect of coke on corrosion. Apparently Mr. Philip considered that loss of weight was by far the best, if not the only, test that should be made in studying corrosion. The writers, on the other hand, considered that loss-of-weight tests were of quite minor importance in studying the practical problem. In practice it was comparatively seldom that tubes failed by thinning and more or less uniform loss of substance. The ordinary cause of failure was local dezincification, and when once dezincification had been started loss of weight measurements were useless. The action was quite *local* and *irregular*, and the white-zinc salt formed was strongly adherent and usually could not be removed without injury to the underlying oxide layer. The apparent loss in weight was then too low, and no strict quantitative comparisons could be made. Mr. Philip found difficulty in detecting dezincification. The only measure of the progress of dezincification at present available, as far as the writers knew, was by visual and microscopic observation, especially of sections cut at right angles to the supposed dezincified spot. The latter was the best test known to the writers for dezincification. Unfortunately, it involved the destruction of the specimen. The next best test was a hardness or feeling test carried out by rubbing with a blunt steel needle, the dezincified area being, of course, softer than the unchanged brass. In addition, the eye could be trained to detect the action fairly readily *in the fresh specimen* even in the earlier stages of the process; in old specimens the copper became oxidised, and it was sometimes impossible to distinguish it from the ordinary oxide layer.

For the reasons above stated, and because more than 90 per cent. of tubes failed by dezincification, the writers had abandoned loss-of-weight tests save for exceptional purposes. To quote from the Second Report, page 58 : —"It is, however, quite evident that loss-of-weight experiments conducted at the ordinary temperature for periods of a few months only, give no clue whatever to the behaviour of the alloys at 40 deg. Cent. as regards dezincification." It might be pointed out that before the publication of the Second Report, the action of carbon and other particles was supposed to be the only means by which dezincification could be produced in sea-water. It was shown clearly in the Second Report that dezincification could be readily brought about without the intervention of any particles whatever—a point of very great significance.

Mr. Philip ignored altogether the *qualitative* tests regarding the effect of carbon on dezincification published in the Second Report. In this connection it must again be emphasised that after dezincification had once set in, qualitative tests were the only tests admissible. These tests might be summarised as follow :—

1. At the ordinary temperature in stagnant sea-water. Coke and graphite used with 70 : 30 and Admiralty tubes. Time, 30 days. Micrometer measurements made to ascertain whether increased action took place in neighbourhood of particles. Result negative. No dezincification observable. No sign of "copper-ring" formation which would be expected if electrolytic action took place.

Number of separate experiments, four; page 42, Second Report.

2. At the ordinary temperature in running sea-water. Pieces of coke tied on to 6-in. lengths of 70 : 30, 70 : 29 : 1, lead-brass, and Muntz metal. Water circulated inside the half section tubes. Time, 30 days. Results negative.

Number of separate experiments, four; pages 45 and 46, Second Report.

3. At a temperature of 40 deg. Cent. Stagnant sea-water. Fine graphite used, 70 : 30 and 70 : 29 : 1 tubes. Time, 28 days.

Results: In case of 70 : 30 tubes, dezincification which showed no definite relation to graphite, and which also occurred on check-tubes containing no graphite, placed in same beaker.

In case of Admiralty tubes, no dezincification.

In neither case could any increase in general corrosion be detected beneath or around graphite-covered areas either by eye or micrometer.

Two experiments; page 55, Second Report.

4. At 50 deg. Cent. Aerated sea-water. Coal and graphite used. Time, six weeks. Tubes, 70 : 30 and Admiralty. Results: 70 : 30, dezincification as in case of check-tube, but not in any definite relation to position of coal. Admiralty tube, no dezincification. No increased total corrosion observable near coal.

Four experiments; pages 62 and 63, Second Report.

Thus, in the Second Report there were described twelve qualitative experiments, supported by micrometer measurements, and one quantitative experiment—*i.e.*, thirteen in all, in *not one of which* could any special action in or around the neighbourhood of the carbon be observed.

All these experiments were made under the direct observation of both of the writers, both of whom expected different results. It seemed to them that it was at least *extremely improbable* that they could have been so entirely deceived as to overlook the action they sought for in every single case. It was only fair to assume, therefore,

* Journal of the Institute of Metals, No. 2, 1913, vol. x., page 77. ENGINEERING, Aug. 29 and Sept. 5, 1913.

that no action took place under the conditions of these experiments.

Mr. Arnold Philip had suggested in a number of passages in his writings that dezincification took place in practice by the settling of particles of coke, &c., along the bottom of tubes when the condenser was out of work —*i.e.*, when it contained stagnant sea-water In the first set of experiments described above those conditions had been accurately observed, since actual condenser-tubes were used in contact with coke and graphite. No *quantitative* experiment described by Mr. Philip *observed these conditions*, even approximately. The only evidence he adduced, in spite of his insistence on quantitative work, was purely qualitative, and was contained in paragraph 2, on page 20. He stated: "In every case accelerated corrosion has been caused, and *what appears to be* dezincification has been observable within two days, even in tests carried out with sea-water at the ordinary temperatures, but the action, as might be expected, is accelerated at higher temperatures."

According to Mr. Philip, then, dezincification should take place in a few hours at a temperature of 50 deg. The statement was, of course, weakened by the use of the expression, "what appears to be dezincification;" but if it was to be taken as it stood, the writers could only say that it was entirely contrary to the evidence of their own observations. The shortest time in which dezincification had been observed at 50 deg. Cent. was seven days, either with or without the presence of coke. The shortest time at the ordinary temperature was seven months, either with or without coke.

There was here clearly a direct conflict of evidence, but Mr. Philip's evidence was no more quantitative than the writers', and had not apparently been supported by micrometer tests regarding general corrosion. The writers suggested that Mr. Philip had mistaken areas of red cuprous oxide for copper areas, especially as he admitted that he had difficulty in distinguishing between the two in the earlier stages.

It should perhaps be remarked that the term dezincification in the above passage referred to the action by which areas of metallic copper were formed and penetrated progressively through the tube, and not to the purely initial and superficial removal of zinc which resulted in the formation of a more or less continuous film of *cuprous oxide* over the surface of the tube.

On page 20 (near bottom) Mr. Philip made the following statement: — "Whether dezincification takes place or not is a *side issue* in the present case, and does not affect the important main conclusion, which cannot be doubted—namely, that the contact of coke with Admiralty condenser-tube material in sea-water accelerates corrosion at all temperatures, and not only accelerates it, but accelerates it far more markedly than any of the other causes of acceleration which have been pointed out in the Second Report to the Corrosion Committee."

In reply to this the writers desired to point out some of the reasons why the main conclusion *might* be doubted, and also to remark that if coke did not produce dezincification, but merely accelerated general corrosion, then its action was merely a side issue, and its bearing upon the practical problem of corrosion was of secondary importance only, since over 90 per cent. of the premature failures of tubes were due to dezincification, and not to general thinning.

Moreover, the quotation cited above was in marked contrast to previous writings of the author, in which he had always emphasised the purely electro-chemical action of coke—*i.e.*, its purely dezincifying action. Indeed, apart from such action, it was difficult to understand why coke should directly accelerate general corrosion. It was significant, therefore, that no mention of marked dezincification was recorded in connection with the results obtained with coke. But granting for a moment a certain dezincifying action to be exerted by coke, was it not reasonable to claim that the independent type of dezincification—not requiring the presence of particles—whose existence was clearly established in the Second Report, must constitute a much greater source of trouble?

Turning now to the experimental work described by Mr. Philip, it was found that the conditions of his experiments were widely different from those of the writers. On page 11, paragraph 3, a description of the material used was given. Pieces of condenser-tube were annealed at a low red heat, rolled flat, cleaned by means of emery, and filed to the same size. The purpose of this treatment was, apparently, to save subsequent calculation. Its effect, however, was unfortunate. An important factor in connection with corrosion phenomena was surface condition, as had been shown by a number of experiments that had recently been made at Liverpool and elsewhere. The nature of the surface of Mr. Philip's specimens could not be regarded as typical of condenser-tube material, neither was their shape, though both these factors probably influenced the adhesion or removal of basic salts which set up secondary reactions in the tubes. The mechanical condition was also different. In the writers' opinion, condenser-tube material should, except for special purposes, receive no treatment previous to experiment other than washing with benzene and alcohol to remove grease. For these reasons the writers did not consider that Mr. Philip's experiments could be considered to apply directly or quantitatively to condenser-tubes under conditions of practice, though, of course, they did not invalidate Mr. Philip's general conclusion that coke accelerated the corrosion of brass.

An interesting point of difference between the writers' experiments and Mr. Philip's was to be found in the nature of the sea-water samples. All the samples of natural sea-water used by the writers had been found to be quite neutral. Mr. Philip's sample was stated to have been alkaline. One of the writers had lately been experimenting with natural sea-water, to which sufficient sodium bicarbonate had been added to make it distinctly alkaline, and had found such sea-water to be distinctly more active in producing dezincification than neutral sea-water. If Mr. Philip used alkaline sea-water for his qualitative as well as for his quantitative tests, there was qualitative explanation of some of the differences here, *possibly*, an explanation of some of the differences between the two sets of results regarding dezincification.

The writers gathered from the wording of the paper and the photographs that *no pronounced dezincification* had occurred with these specimens. If that were so, then the alkalinity of the water could not be considered the cause of the divergence between Mr. Philip's and the writers' results, and Mr. Philip's results must be considered as having little bearing on the practical problem, though interesting and important in themselves and from a theoretical standpoint. If Mr. Philip's results and view were accepted, then it must be supposed that coke and graphite very rarely entered tubes, or at any rate remained in tubes in practice for times sufficiently long to set up dangerous general thinning of the tubes, and the causes of dezincification must be sought elsewhere.

Turning to the photographs exhibited in Plate I. [Fig. 4], specimens in row A were extremely uniform in appearance, more so, indeed, than was usually the case with untreated condenser-tubes corroded for thirty days. The very different appearance of row B might perhaps be accounted for on the grounds that the close packing of the coke around the specimen prevented the corrosion products from falling away from the alloy, but enabled them to stick on to the tube. The photographs in Plate II. [Fig. 5] were more interesting. Again, specimens in row A were extremely uniform in appearance, and that might perhaps be due to the heat treatment adopted. Specimens in row B showed distinct pits and curious longitudinal furrows which did not appear in any of the other specimens. The writers assumed that that appearance corresponded to something real in the actual specimens, though it was possible that it might be due to some purely photographic effect. If those furrows were real, it was curious that Mr. Philip did not refer to them.* They appeared to be most strongly marked about the middle portions of four out of the five specimens. The definite pits, on the other hand, seemed to be most strongly marked near the lettered end of each specimen, though they occurred over the whole of the surfaces to some extent. Mr. Philip stated that only the lower half of the specimens were packed in coke, and it was difficult to see how the pits on the top parts of the specimens could have been produced by the coke unless, of course, certain pieces floated up and touched the specimens higher up. In these circumstances it seemed to the writers improbable that such loose and variable contact could have allowed any electro-chemical action to be set up, and it would seem that some direct chemical or mechanical action must have been set up. But Mr. Philip washed and prepared his coke carefully, and it was difficult to suggest any probable direct chemical action. Some mechanical action seemed more likely, especially in view of the striated appearance to which reference had already been made, and for which it was difficult to account on electro-chemical lines. They would like to ask Mr. Philip whether his coke was packed so tightly in the tubes that no movement could take place under the action of the flow of water, and whether erosion was not an important factor in his experiments with rough coke?

They were prepared to admit that they were much surprised at the results of Mr. Philip's experiments, which were directly at variance with their own experimental experience. But they were not yet prepared to admit that coke had any electro-chemical action on condenser-tubes in sea-water. The conditions of Mr. Philip's experiments were so different from those of their own that it was as yet impossible to say which of those conditions had affected the result. They need hardly add that a further experimental investigation of the problem would be made.

* Inspection of the specimens showed them to be really covered with a large number of fine grooves running along the specimens in the direction of their length.

THE OXYGEN CONTENT OF OPEN-HEARTH STEEL.†

By J. Allen Pickard, B.Sc., A.R.C.Sc., and F. M. Potter, B.Sc., A.R.C.Sc.

The following work was undertaken as part of a systematic examination of the oxygen content of commercial steels with a view to collecting trustworthy evidence as to the amount of oxygen normally to be expected in good-class material, and the limits within which it is desirable to restrict this element.

The method of estimation previously communicated to the institute by one of us,‡ which consists in heating the steel in a confined volume of hydrogen with a weighed boat containing phosphorus pentoxide and measuring the increase in weight of the boat, has been used throughout and has fully confirmed the opinion arrived at as to its convenience and reliability.§ The importance of adhering strictly to certain details of procedure, chiefly in the precautions necessary in the insertion and removal of the weighed boat of phosphoric oxide, has, however, been clearly shown, and for the convenience of others using the method it will be well to state these precautions here. Care must be taken that the boat is removed from the weighing-tube and inserted in the mouth of the combustion-tube as quickly as possible and the cap placed in position at once, contamination by moisture from the breath being, of course, carefully avoided. It is also necessary to have the boat ready close to the combustion-tube before removing it from its containing vessel, so that the distance of transport through the free air is as short as possible. The total time occupied in inserting and removing it should not exceed 6 seconds, and may be less. In these circumstances a blank of 0.0010 to 0.0013 gramme is obtained, but defects in manipulation may cause the blank to run as high as 0.0035 gramme, which is too large a proportion of the total increase in weight obtained to allow of a proper feeling of certainty of the final result. In weighing the boat the usual precautions in polishing the weighing-tube must be observed, and the sensitiveness of the balance must be adjusted to weigh with exactness to one-tenth of a milligramme. If drillings are clean and bright, no error in the estimation will be introduced by surface oxidation or condensation of air. An amount of oxygen equal to 0.020 per cent. would represent 0.090 per cent. of ferrous oxide, or 0.022 gramme on a 25-gramme sample. If in the form of rust containing hygroscopic moisture and carbon dioxide, the weight might easily be 0.035 gramme, which would produce a sheet 0.1 millimetre thick and 1 square centimetre in area, and would easily be detected by inspection. The condensation of air on the surface has been dealt with in the former paper, and has been shown to have no influence.

The determinations were in most cases carried out in duplicate by the two authors independently. The weights of steel used in each estimation were from 20 grammes to 30 grammes or more, and the furnace was heated to a temperature estimated at 1000 deg. Cent. No increase in the percentages found was observed on employing higher temperatures or longer times of heating, 30 minutes being quite sufficient. The blank remained unchanged when longer periods of heating were given; indeed, the blank obtained if the heating be omitted altogether is practically identical with that when the whole experiment is carried through in the ordinary way. This fact is important as showing that the walls of the tube are totally impervious, and that no oxygen from the air leaks through during the course of the experiment.

The majority of samples examined in this work were courteously supplied to the authors by Messrs. S. Fox and Co., Limited, of Sheffield, and the Cargo Fleet Iron and Steel Company, Limited, of Middlesbrough. All the steels were made by either the acid or the basic open-hearth process, and, as far as can be judged from their analyses, they were generally of excellent quality. In the following tables the samples are arranged in order of carbon content. The actual figures obtained for oxygen in duplicate analyses are given in the last two columns, and show the amount of agreement ordinarily obtained when using this method. Six of the results are reprinted from the former paper, and are included here for ease in reference.

Table I.—*Acid Open-Hearth Steel.*

Sample.	Carbon.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Oxygen, per Cent.		—
	p.c.	p.c.	p.c.	p.c.	p.c.	i.	ii.	
1	0.67	0.73	0.95	0.035	0.027	0.004	0.004	Mean: Carbon, 0.87 Oxygen, 0.011
2	0.79	0.65	0.210	0.030	0.050	0.020	0.021	
3	0.93	0.68	0.035	0.031	0.027	0.007	0.006	
4	1.08	0.62	0·024	0.033	0.022	0.012	0.016	
5	1.18	0.65	0.056	0.027	0.025	0.005	0.006	Mean: Carbon, 1.35 Oxygen, 0.007
6	1.33	0.42	0.140	0.030	0.024	0.004	0.007	
7	1.55	0 49	0.100	0.027	0.026	0.010	0.012	Mean of all: Oxygen, 0.0096

Table II.—*Basic Open-Hearth Steel.*

8	0.10	—	—	—	—	0.038	0.036	
9	0.14	0.35	0.020	0 633	0.018	0.010	0 011	
10	0.20	—	—	—	—	0.031	0.028	
11	0.23	0.70	—	0.060	0.026	0.013	0.014	Mean: Carbon, 0.25 Oxygen, 0.021
12	0.26	0.49	0.120	0.030	0.031	0.003	0.006	
13	0.30	—	—	—	—	0.030	0.027	
14	0.32	0.62	—	0 051	0.020	0.040	0.041	
15	0.33	0.62	—	0.057	0 025	0.024	0.021	
16	0.35	0 56	0.182	0.027	0.020	0.005	0.008	
17	0.41	0.52	0.026	0 032	0.023	0.019	0.014	
18	0.44	—	—	—	—	0.029	0.025	Mean: Carbon, 0.52 Oxygen, 0.021
19	0.54	0.69	0.085	0.022	0 024	0.003	0.003	
20	0.55	0.97	—	0.055	0.011	0.016	0.017	
21	0.55	—	—	—	—	0.020	0 020	
22	0.61	0.74	—	0.053	0.021	0.038	0.044	
23	0.66	0.65	0.100	0.033	0.052	0.005	0.006	Mean: Carbon, 0.81 Oxygen, 0.011
24	0.75	0.38	0.025	0.025	0.022	0.025	0.026	
25	0.82	0.67	0.096	0.030	0.028	0.004	0.007	Mean of all: Oxygen, 0.0189
26	1.00	0.67	0.036	0 016	0.025	0.006	0.007	

Consideration of Results.—It had been expected from the results published in the former paper that it might be possible to discover some relationship between the oxygen and the carbon content, but the results quoted lend but little support to this theory. Samples 9 and 12, containing 0.14 and 0.26 per cent. of carbon respectively, contain only 0.011 and 0.005 per cent. of oxygen, while No. 14, with 0.32 per cent. of carbon, contains 0.041 per cent., and even No. 22, with 0.61 per cent. of carbon, also contains 0.041 per cent. of oxygen. One most important conclusion to be drawn is that it is possible to make all kinds of open-hearth steel, even low-carbon low-silicon basic (No. 9), practically free from oxygen—containing only 0.010 per cent. or under. That some steels are made containing more than that amount is, however, abundantly shown by the other results, and it is to be observed that the cheaper steels contain higher oxygen.

Acid open-hearth steel is generally admitted to be of better quality than basic open-hearth, and it has been

† Paper contributed to the Iron and Steel Institute and now open for discussion by correspondence.

‡ "Carnegie Scholarship Memoirs," 1913, page 70.

§ The complete apparatus may now be obtained from Messrs. C. E. Müller, Orme and Co., 148, High Holborn.

suggested that this is due to the higher oxygen content in basic steel. In the foregoing tables all the high-oxygen steels—that is, over 0.020 per cent.—except one (No. 2) are found in the basic group, so that the evidence does support the conclusion that basic steel is higher in oxygen. It is to be noted, however, that only two of the basic steels are higher in carbon than the lowest of the acid group, and no marked difference is to be noted in those samples comparable in carbon content; indeed No. 2, an acid steel, is higher in oxygen than Nos. 23, 25, and 26, which are basic.

An interesting question is raised by the fact that the samples that must have received most hot-working are all high in oxygen. Nos. 14 and 15 were taken from two fish-plates, No. 22 from a rail, while the other samples were from fair-sized billets. The possibility that the oxygen content may vary after the steel has solidified has, so far as the authors are aware, not hitherto been considered. It must be borne in mind, however, that these steels, as judged from their other constituents, were not of the very highest quality, and that Nos. 8, 10, 13, 18, and 21, which are all high in oxygen, were of cheap make. It is hoped to investigate the influence of hot-working on the oxygen content in a subsequent paper.

The results obtained by previous workers are very scanty. The authors have only found the figures given by Cubillo,* who gave for acid open-hearth steel in the ladle 0.004 per cent. of oxygen; and R. H. McMillen,† who has published the following data:—

Sample.	C.	Mn.	Si.	S.	P.	O.	
	p.c.	p.c.	p.c.	p.c.	p.c.	p.c. (i.)	p.c. (ii.)
Basic, open-hearth	0.07	0.06	0.08	0.019	0.008	0.113	0.115
Ditto	0.08	0.22	0.01	0.016	0.008	0.079	0.072
Ditto	0.36	0.69	0.03	0.040	0.046	0.043	0.042

The method of reduction in a current of hydrogen, used by both workers, is open to several objections which have been pointed out in the paper already cited. With regard to McMillen's figures it is noticeable that they are very much higher than those found for any steel examined by the authors. Taking this in conjunction with the fact that no steel examined by McMillen gave a lower value than 0.035 per cent.—even crucible steels, containing 1.17 per cent. and 1.14 per cent. of carbon, showing 0.035 per cent. and 0.045 per cent. respectively of oxygen—the authors are inclined to think that he must have been the victim of a systematic error not recognised.

A necessary and important consequence of low-oxygen content, if the determination of oxygen be made by the method used, is that the gas content must also be very low, at least in respect of carbon monoxide and dioxide. It was shown in the paper already mentioned that the oxides of carbon are reduced to water under the conditions of the experiment; and consequently carbon monoxide and carbon dioxide contained in the steel, or given off from it on heating, are reduced, and their oxygen appears in the final result.

If a steel gives off its own volume of carbon monoxide on heating, the oxygen in the gas represents an amount equal to 0.0091 per cent., a similar amount of carbon dioxide representing 0.0182 per cent.

This conclusion is not invalidated by the fact that the steel is used in the form of fine turnings, as, although gas may be lost during the operation, the oxides of carbon are invariably practically absent from the gases obtained, which consist of nitrogen and hydrogen.

T. Baker‡ examined two ingots of the same steel, to one of which aluminium had been added before casting, and gives the analyses shown in Table III. The oxygen percentage is calculated from the volume and composition of the gases:—

TABLE III.

(1) *Free from Blow-Holes.*

C.	Mn.	Si.	S.	P.	Al.	Volumes of Gas per Gramme of Steel.
p.c. 0.900	p.c. 0.096	p.c. 0.088	p.c. 0.023	p.c. 0.019	p.c. 0.033	1.326

Composition of Gas.					Oxygen Indicated.
CO_2.	CO.	H.	CH_4.	N.	
p.c. 1.68	p.c. 45.54	p.c. 52.00	p.c. 0.72	p.c. 0.08	0.0810

(2) *With Blow-Holes.*

C.	Mn.	Si.	S.	P.	Volumes of Gas per Gramme of Steel.
p.c. 0.810	p.c. 0.050	p.c. 0.080	p.c. 0.028	p.c. 0.019	0.665

Composition of Gas.					Oxygen Indicated.
CO_2.	CO.	H.	CH_4.	N.	
p.c. 0.84	p.c. 42.41	p.c 54.60	p.c. 1.72	p.c. 0.46	0.0366

* Journal of the Iron and Steel Institute, 1903, No. 1, page 293.

† Metallurgical and Chemical Engineering, 1913, vol. xi., page 86.

‡ Carnegie Scholarship Memoirs, 1909, page 219.

These results are somewhat startling as indicating that sound steel contains a higher proportion of oxygen than unsound, a result which would be remarkable in the light of accepted views on the subject. In attempting to account for the very high figures for the gas content of steels obtained by Baker, the authors have been struck by the fact that the Toepler pump used in the extraction of the gases was unprovided with a drying-tube. It is well known that it is impossible completely to remove water vapour along with the gases from any space by means of a mercury pump without this adjunct. Since water vapour would not reveal itself in the blank determinations when steel was not present, and its presence could only be detected by means of a manometer, which was not included in the apparatus, it is possible that practically the whole of the gases obtained resulted from the action on the steel of water vapour present in the apparatus, and from the surface moisture on the metal. This opinion is supported by the evolution of large quantities of hydrogen at low temperatures in Baker's experiments. The balanced reaction,

$$4\,H_2O + 3\,Fe \rightleftarrows Fe_3O_4 + 4\,H_2$$

takes place practically completely from left to right between 200 deg. to 300 deg. Cent.* This explanation is rendered more probable by the fact that other workers on this problem have found a primary evolution of carbon dioxide in all cases, and by the fact that in the sound-steel gases the ratio $H_2 : O_2$ is almost exactly 2 : 1 by volume. The carbon monoxide could be accounted for by subsequent reduction of the oxide by the carbon of the steel. It is possible that Dr. Baker may be able to correct the authors' inference as to the cause of his otherwise puzzling results, and it is hoped that he will be kind enough to mention in the discussion any aspect which may have escaped their attention at the difficult and important researches he has carried out.

By dissolving steel in acid copper-potassium-chloride solution Goutal† obtained the figures given below, from which the oxygen percentage in the last column has been calculated.—

Steel.	Carbon.	C Evolved as CO_2.	C Evolved as CO.	C Evolved as Hydrocarbons.	Oxygen.
	per cent	per cent	per cent	per cent	per cent
Medium soft	0.2867	0.0057	0.0051	0.0009	0.0220
Hard	0.6375	0.0185	0.0059	0.0171	0.0573
Extra hard	1.3775	0.0216	0.0061	0.0158	0.0656

It will be noticed that the oxygen present increases in this case with the carbon content, and reaches the high value of 0.0656 in the case of the highest carbon steel, a result which is remarkable enough to justify a more complete investigation.

Belloc,‡ working on basic open-hearth steel of the composition—

	Per Cent.
Carbon	0.12
Manganese	0 36
Silicon	0.03
Sulphur	0 02
Phosphorus	0.018

has obtained the following figures from which the oxygen in the last column is calculated:—

—	Weight Taken.	Gases Found.				Oxygen Calculated.
		CO_2.	CO.	H	N	
Average sample	50 gm.	p.c. 3.69	p.c. 13.49	p.c. 7.31	p-c. 0.76 c.c.	p.c. 0.0309

This result is of the order which the writers have been led to expect from the results for oxygen content given above.

Zyromski§ finds for soft basic open-hearth steel containing:—

	Per cent.
Carbon	0.05
Manganese	0.288
Silicon	trace.
Sulphur	,,
Phosphorus	0.024

that the following composition and amount of gas is evolved representing the oxygen figure given in the last column:—

CO.	H.	N.	Volumes per Volume of Steel.	Oxygen.
per cent. 7.9	per cent. 57.3	per cent. 34.7	per cent. 5.45	per cent. 0.0043

Although the nitrogen is unusually high in the gases obtained, the oxygen figure is as low as any we have found.

In conclusion, the authors desire to express their indebtedness to Messrs. S. Fox and Co., of Sheffield, and to the Cargo Fleet Iron and Steel Company, of Middlesbrough, for the interest they have shown in the work, and for most kindly supplying some of the specimens; to the trustees of the Dixon Fund of London University for a grant which has defrayed part of the expenses of the investigation; and especially to Dr. F. Rogers for continued encouragement and many helpful suggestions.

* Mellor, "Chemical Statics and Dynamics," page 175.

† *Comptes Rendus*, 1909, vol. cxlviii., page 988.

‡ *Revue de Métallurgie*, 1908, page 469.

§ *Stahl und Eisen*, 1884, page 536.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

New Zealand: The office of His Majesty's Trade Commissioner for New Zealand reports that, according to the local Press, the ratepayers of Westport have sanctioned the installation of a sewerage scheme, at an estimated cost of 28,500*l.*, with 5000*l.* extra for private connections.

Canada: The Imperial Trade correspondent at Toronto reports that a company has been formed in Ontario, with a capital of 2,000,000 dols. (about 411,000*l.*), for the purpose of manufacturing and dealing in iron, steel, and other metals; to construct and operate dry docks, harbours, elevators, warehouses, terminals, wharves, &c., and to carry on the business of a wrecking company. The company intends to construct a dock, 775 ft. long, 104 ft. wide, and 21 ft. over the sills.

Spain: The *Gaceta de Madrid* notifies that tenders will be opened at noon on October 20 at the Dirección General de Obras Públicas, Ministerio de Fomento, Madrid, for the construction of a dock, as an anchorage for small vessels, at the port of Cadiz. The estimated value of the contract is 296,744 pesetas (about 10,990*l.*); a provisional deposit of 14,838 pesetas (about 550*l.*) is required to qualify any tender. The conditions of contract contain clauses to the effect that at the first competition the materials to be used will be confined, with certain exceptions, to products of Spanish manufacture, but that in the event of no decision being arrived at, a second competition, in which foreign products may be accepted, will then take place. In the latter event, Spanish products will have a 10 per cent. margin of preference over foreign.

Morocco: H.M. Chargé d'Affaires at Tangier reports that tenders are invited by the special committee of Public Works for the construction of a lighthouse and adjoining buildings at Cape Nador, near Laraiche. Tenders, accompanied by certificates of competency, will be received by M. le Président du Comité Spécial des Travaux Publics, Dar En-Niaba, Tangier, up to 11 a.m. on November 23. The estimated value of the contract is placed at about 246,284 francs (9850*l.*), and a deposit of 3000 francs (120*l.*) is required to qualify any tender. The contractor must elect domicile in the neighbourhood of the works.

American Locomotive Company.—The gross earnings of the American Locomotive Company for the twelve months ended June 30, this year, were 29,987,438 dols., showing a decrease of 24,880,738 dols. Working expenses, allowance for depreciation, &c., amounted in 1913-14 to 27,425,187 dols., showing a decrease of 20,616,504 dols. The net earnings for 1913-14 were accordingly 2,562,251 dols., showing a decrease of 4,264,232 dols. Interest charges in 1913-14 were 486,124 dols., showing a decrease of 155,055 dols. The balance available for dividend in 1913-14 was accordingly 2,076,127 dols., showing a decrease of 4,109,177 dols. The dividend on preference stock for 1913-14 absorbed 1,750,000 dols., leaving a surplus of 326,127 dols. No dividend is proposed for the past year upon the ordinary stock. The new orders for locomotives received by the company in 1913-14 represented a value of 14,454,831 dols. This total was equivalent to only about 25 per cent. of the productive capacity of the undertaking. The unexecuted orders on the books of the company at the beginning of the past fiscal year were 17,156,388 dols.; at the close of the year they had declined to 4,162,356 dols.

Large Projected Hydro-Electric Station in Norway.—The proposed exploitation of the water-power in the Take Falls, with the co-operation of the Norwegian State, is one of the largest undertakings in the country. The first stage is the building of a power-station with a capacity of 125,000 horse-power, which can be obtained simply by the regulation of the Totak, by retaining the water of the Totak during the high-water season and using the power of the Vinje waters without any regulation. The plan is based upon an English Company contracting for about 100,000 horse-power for a period of thirty years, with the option of a further twenty years at 26 kr. (29s.) per horse-power per annum, the energy to be supplied as alternate current of some 10,000 volts, the factories in question to be erected within a distance of 100 kilometres from the power-station. The Take waters represent one of Norway's largest and best water-power streams. By regulating the Totak and the Vinje waters a capacity of 250,000 horse-power is confidently reckoned upon, and of this 140,000 horse-power will come from the Totak after regulation. Of this the Hyllands Fall represents 15,000 horse-power. The exploitation of either the Totak and the Vinje is not expected to offer any difficulties whatever from a technical point of view, and the cost can, it is confidently asserted, be kept at a comparatively low figure, the existing roads for transport, for one thing, being adequate. The cost of the finished power-station for the first 125,000 horse-power is calculated at 100 kr. (5*l.* 10s.) per electric horse-power, and the next 125,000 horse-power will naturally come out somewhat cheaper.

CATALOGUES.

Ships' Fittings and Furnishings.—From the Carron Company, of Carron, Stirlingshire, we have received a catalogue of cabin-seat stands, smoking-room tables, ventilators, storm-valves, coaling-scuttles, hatch-cleats, and other fittings and furnishings for ships.

Air-Filters.—A small pamphlet, illustrating and describing the Sturtevant water-spray air-filters for cooling and purifying the air supplied to electric generators, transformers, &c., has been issued by the Sturtevant Engineering Company, Limited, 147, Queen Victoria-street, E.C.

Engineers' Small Tools.—From Messrs. Thomas Firth and Sons, Limited, of Norfolk Works, Savile-street East, Sheffield, we have received a copy of a very attractive catalogue, giving full particulars, including prices, of reamers, drills, milling-cutters, saws, &c., made of their "Speedicut" high-speed steel.

Power-Transmission Accessories and Engineers' Sundries.—Messrs. C. J. Edwards and Son, Limited, of 32 to 34, Great Sutton-street, E.C., have sent us a copy of their latest catalogue, giving prices of belting and belt-fasteners, shafting, set-collars, couplings, plummer-blocks, hangers, wall-brackets, pulleys, files, twist-drills, lubricators, bolts and nuts, and many other tools and sundries for engineers.

Electrical Pyrometers.—We have received from Mr. R. W. Paul, of New Southgate, London, N., an interesting and useful catalogue and price-list of electrical apparatus for temperature measurement in industrial and laboratory work. All necessary instruments and accessories for thermo-couple, resistance, and radiation pyrometry, including projection and recording apparatus, are dealt with.

Hydraulic Leathers.—The Leathers Company (Altrincham), Limited, of Grafton Works, Altrincham, Manchester, have issued a little booklet containing some practical notes on hydraulic leathers and the use of hydraulic machinery, and also stating prices for cup, hat, and U leathers. The latter can be made up to 80 in. in diameter; a U leather 72 in. in diameter, which is said to be the largest ever made, is illustrated in the booklet.

Grinding-Machines.—From Messrs. Charles Churchill and Co., Limited, of 9 to 15, Leonard-street, Finsbury, E.C., we have received copies of two pamphlets they have recently issued relating to their grinding-machines. In one of these pamphlets a new gear-box drive for table and work speeds on plain, universal, and internal grinders is dealt with. This enables all the necessary speeds and feeds to be obtained on the machine itself, so that the countershaft is greatly simplified. The other pamphlet contains diagrams showing all the various types of drives with which Churchill grinding-machines can be supplied. It also gives general particulars of standard sizes of plain, universal, and internal grinding-machines.

Fencing.—A catalogue giving full particulars, with prices, of "Crusader" wire-mesh fencing, has reached us from the sole selling agents, the Darlington Fencing Company, Limited, of Hopetoun House, 5, Lloyd's-avenue, E.C. This fencing is claimed to be much stronger than wire-netting, which it is intended to replace, and to have the additional advantage that it can be very easily repaired. Prices are quoted for rolls containing 25 square yards of fencing, with 1-in. to 4-in. mesh, made of 10 to 16 gauge wire. Practically any length and width can be supplied in a single piece. The fencing can also be employed for protecting windows and for guarding machinery.

Aluminium Cables.—We have received from the British Aluminium Company, Limited, of 109, Queen Victoria-street, E.C., an interesting and attractive pamphlet entitled "Power: Its Economical Distribution." It relates to the distribution of electrical energy by means of insulated cables with aluminium conductors, and first compares the cost of aluminium and copper cables of the same capacity. The questions of jointing, scrap values, and rating of cables are all fully dealt with, and a very strong case is made out for the newer conductor. Technical data for bitumen-insulated cables, lead-covered paper-insulated cables, and cables insulated with vulcanised india-rubber, are included, together with some notes on cables for high-tension work.

Polishing and Scouring-Machines.—Mr. Edward White, of Windsor Works, Redditch, has sent us a catalogue illustrating various machines he makes for polishing and scouring small metal goods. Most of the machines, which are extensively used in the steel-toy trades, consist of oak barrels mounted so as to rotate about an inclined axis, but in one of the machines illustrated the goods to be polished are placed in leather bags, which are held in steel clamps and given a reciprocating motion. Another machine consists of a number of small hexagonal tin barrels, which are made to rotate about a horizontal axis by means of spiral gears. They are intended for scouring small quantities of different articles, which can all be kept separate. Any of the barrels can be lifted out and replaced without stopping the others.

Ore-Crushing Mill.—A pamphlet illustrating and describing the Akron Chilian mill has reached us from Messrs. Sandycroft, Limited, of Sandycroft, near Chester, who have taken up the manufacture of this mill for all countries except the United States. These mills are of the high-speed edge-runner type, and have three rollers. They usually operate on ores which have been reduced to about ½ in. size, crushing them down to almost any degree of fineness required. The pamphlet fully describes the construction of the mills, and points out their special features, mentioning among the latter that the rollers can be adjusted while the mill is in operation, and that the bearings and wearing parts are easily accessible for examination and repairs. The mills are also claimed to have an even distribution of feed, and a large screen capacity, as well as a very high efficiency as regards output, water consumption, and wear. Two sizes are made, with 5-ft. and 6-ft. pans, and with capacities of 25 and 50 tons a day of twenty-four hours respectively.

Fire-Appliances.—The Featherstone Manufacturing Company, of 5, Henrietta-street, Covent Garden, W.C., have issued a catalogue of fire-appliances manufactured by them. These include the "Featherstone" automatic valve for fire-hydrants, the special feature of which is that the water is turned on by pulling the hose when the fire is reached. When not in use the nozzle is held in a clip-bracket, which acts as a safety-lock, so that the water can only be turned on when the nozzle is removed. By means of an automatic adaptor, illustrated and described in the catalogue, any existing installation can be arranged to work on the principle above described. The catalogue also gives particulars of a combination-tap and automatic valve for domestic use, a serving-cradle for hose, water-pressure gauges, canvas hose, hose-couplings, &c. Prices are stated for all these appliances.

Air-Compressors, Portable Tools, &c.—Among the catalogues recently issued by the Consolidated Pneumatic Tool Company, Limited, of 9, Bridge-street, Westminster, S.W., is one relating to air-compressors built by the company. The construction of these compressors is illustrated and fully described, and their many special features are pointed out. Full particulars are then given of belt-driven and steam-driven compressors of the single-cylinder, duplex, and two-stage types with capacities ranging from 31 to 2110 cub. ft. of free air per minute. Particulars are also given of portable compressors driven by petrol-engines, and of large two-stage compressors driven by compound steam-cylinders having Corliss valves. These compressors have capacities up to 3480 cub. ft. per minute. The catalogue also illustrates examples of compressors driven by electric motors, and concludes with a number of useful tables relating to pneumatic-power transmission. Other catalogues from this firm deal with "Duntley" electric drills and accessories, portable electric grinders, electrically-operated stone-hammers, scaling-hammers, "Little Giant" pneumatic drills, and a portable mine hoist operated by compressed air. We have also received a catalogue of repair parts for pneumatic hammers, riveters, drills, and other portable tools made by the firm.

Boat-Launching Gear.—We have received from the Welin Davit and Engineering Company, Limited, 5, Lloyd's Avenue, E.C., a very handsome album of illustrations of their well-known launching appliances for ships' boats. The album contains over 340 pages, strongly bound in blue-cloth covers, and its price is one guinea. The first part of the album is occupied with reproductions of photographs and drawings of different types of quadrant davits, of which over 600 installations have been fitted on merchant vessels and warships of all types and nationalities. The Welin planet gear is also illustrated and described. This gear, which can be applied to existing davits, has been designed to enable the boats to be turned out against the maximum list under which the lowering of boats is possible. Illustrations of Lundin decked lifeboats, which are constructed of steel, and of other life-saving craft designed and constructed by the company, are also included. The remainder of the album, rather more than half of it, is devoted to full-page engravings, reproduced from photographs, of steamers on which the firm's appliances have been installed. The book is well printed, and the illustrations are excellent, so that it makes a very attractive publication, and one that is well worthy of a place on the bookshelves of shipbuilding and ship-owning firms.

Steel Plates and Sections.—Messrs. David Colville and Sons, Limited, Dalzell Steel and Iron Works, Motherwell, Scotland, have issued a very attractive catalogue giving particulars of the various sizes, brands, and qualities of steel plates and steel and iron bars they manufacture. The steel is produced by the Siemens open-hearth process only, and the works can turn out over 10,000 tons of ingots per week. The catalogue contains 180 pages bound in blue-leather covers and having gilt edges. It first gives a number of illustrations, reproduced in colours from oil or water-colour paintings, showing the furnaces, rolling-mills, and other parts of the works. These are followed by descriptions of the various brands of boiler, structural, shipbuilding, and special steels made by the firm, and, after these, particulars are given of the tests imposed by different authorities. The greater part of the catalogue is, however, occupied with tables showing the sizes to which plates and sections can be rolled. The sections listed include angles, channels, pillar sections, zeds, tees, rounds, hexagons, squares, flats, cope-bars, convex bars, and many special sections. In all cases English and metric measurements are given, and the sections are coloured to indicate whether they are rolled in steel only, in steel and iron, or in iron only. The catalogue, which is altogether a very useful and highly creditable production, concludes with a number of tables of equivalent English and metric measurements.

Pump-Governor.—We have received from Messrs. Ronald Trist and Co., Limited, Coronation House, 4, Lloyd's Avenue, E.C., a booklet illustrating and explaining their "Thermofeed" differential pump-governor, which is designed to stop any class of steam or power-driven pump if the pressure should become excessive, and to restart the pump when the pressure falls below some predetermined limit. Its method of operation is, briefly, as follows:—Water pressure from the pump delivery is admitted to the lower end of a vertical column, the upper part of which is filled with cylinder oil and is in communication with the upper part of a small cylinder fitted with a spring-controlled piston. When the pressure rises, the piston is forced downwards against the action of the spring, thereby opening a small valve, which controls the supply of steam to another cylinder. This cylinder contains a piston and piston-rod, which are connected to the spindle of a double-beat throttle-valve controlling the supply of steam to the pump, so that when steam is admitted to the cylinder, as above described, the throttle-valve is closed. When the water pressure has fallen sufficiently, the piston of the first-mentioned cylinder is forced upwards by the spring, and the small valve is moved so as to open a passage from the steam cylinder to the atmosphere. The piston of the steam-cylinder, and with it the throttle-valve spindle, is then drawn upwards by means of springs, thus opening the valve and restarting the pump. The device is claimed to be simple, reliable, and quick-acting, and to effect a considerable economy in steam consumption. It can be operated by pressure variations of from 3 lb. per sq. in. upwards.

Water-Strainer.—We have received from the London Electric Supply Corporation, Limited, 25A, Cockspur-street, S.W., a pamphlet illustrating and describing a new type of water-strainer they have put upon the market. The "Deptford" strainer, as it is called, is of the self-cleaning type, and is principally intended to be used to separate solid matter from the circulating water used in surface-condensing plants, though it is, of course, quite suitable for straining water required for any other purpose. It consists of a cast-iron casing containing a perforated cylindrical gun-metal drum, which is slowly rotated about a horizontal axis by worm-gearing. The water enters at the side of the casing, passes through the perforated cylinder from the outside to the inside, and leaves at one end, so that foreign bodies contained in the water collect on the outer surface of the cylinder. The solid matter thus collected is removed by means of a stationary scraper made of hard nickel bronze, and machined to a cutting edge, which bears on the lower part of the perforated cylinder. The dirt falls from the scraper into the lower part of the casing, which is hopper-shaped, and, being out of the flow of the water, it settles, and is removed at intervals by opening a sludge-valve. The strainer is usually placed between the circulating pump and the condenser, so that there is from 10 ft. to 20 ft. head of water available for flushing purposes; the general arrangements can, however, be modified according to circumstances. The pamphlet gives particulars of four standard sizes, capable of dealing with from 250,000 to 1,000,000 gallons of water per hour. It is mentioned that two of these strainers have been working satisfactorily for three years with Thames water, containing large quantities of rubbish of all kinds. During this time it is stated that no parts have required renewal, and the cost of upkeep has been trifling, though the design has been considerably improved since these strainers were installed.

Machine-Tools.—Three sectional catalogues, dealing respectively with combination turret-lathes, automatic screw machines, and universal cutter and tool-grinding machines, have reached us from Messrs. Alfred Herbert, Limited, of Coventry. The turret-lathes have a geared headstock with a single driving pulley, an improved chasing mechanism, a patent dial feed-motion, and all feeds are reversible. These and many other leading features are described in the catalogue, which also gives full particulars of the four sizes made, which have 9-in., 11-in., and 14-in. centres. Particulars of chucks and tools for use with these lathes are also given. The automatic-screw machines, dealt with in a separate catalogue, are made in four sizes, to take 1-in., 1¼-in., 2-in., and 3-in. bars. Full particulars of these machines, and of standard-tool outfits for use with them, are given. This catalogue also deals with an automatic stud and bolt machine, a machine for making copper stay-bolts, and another special machine for making condenser ferrules. The third catalogue illustrates and describes the firm's No. 4 universal grinding-machine, which is intended for general tool-room use, and will do almost any variety of circular and surface grinding. It can also be used for sharpening saws, either on the top or on the face of the teeth, as well as for sharpening all kinds of milling-cutters, reamers, hobs, counter-bores, form-tools, and gauges. Micrometer adjustments are provided so that cutters and reamers can be accurately ground to any desired clearance, and clearance tables are furnished which enable correct settings to be made. The machine will use either cup or disc wheels, so that the advantages of straight clearance can be obtained whenever desired. It can be supplied in a simple form for ordinary cutter and reamer grinding, or complete with various equipments for special purposes. Full particulars of the machine and its accessories, which can be purchased separately, are given in the catalogue. Some useful notes on cutter-grinding, and on the use of the machine generally, are also included.

American Rivers.—A Bill has been passed by the Senate of the United States appropriating 20,000,000 dols. to be expended, under the direction of the Secretary at War, and the supervision of the Chief of Engineers, for the preservation and maintenance of existing river and harbour works, and for the prosecution of projects considered desirable in the interest of commerce and navigation. Allocations for the improvement of the Mississippi from the head of passes to the mouth of the Ohio are to be expended under the direction of the Secretary at War in accordance with plans, specifications, and recommendations of the Mississippi Commission.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

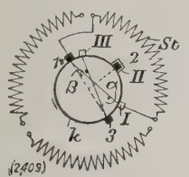
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

2409/14. Siemens-Schuckertwerke, G.m.b.H., Berlin, Germany. Alternating-Current Commutator-Motors. [4 *Figs.*] January 30, 1913.—This invention relates to the speed regulation of electric polyphase commutator motors of the type in which the rotor windings are connected to the mains through slip-rings, and the stator windings are connected to displaceable pairs of commutator brushes. The invention consists in gradually reducing the inclination of the chord joining the brush positions of any brush pair relatively to the axis of the stator winding, and then increasing it in the opposite direction as the brushes pass through the position corresponding to synchronous speed. *s t* is the stator winding, and *k* the commutator. The position 1, I of the brushes, which is only indicated for one phase, corresponds to the lowest speed of the motor, and at the same time compensates the phase displacement; the chord of the arc between the brushes is inclined for this purpose at an angle α relatively to the axis of the corresponding stator winding. In order to increase the speed, the brushes are relatively displaced, but by different amounts. They are coincident in the position 2, II, which corresponds to synchronous speed. In the position 3, III, the motor attains its highest speed, and the phase displacement is again compensated; the chord of the arc joining the brushes is inclined at an angle β to the axis of the stator winding, and in the opposite direction to the former inclination. Since motors of this type generally have a better power factor when running at over synchronous than at under synchronous speeds, it is important that the angles



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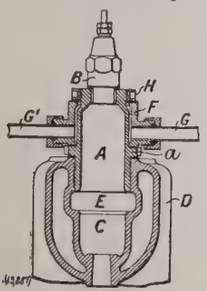
α and β should not have the same value, but the under synchronous value of the inclination α should be increased relatively to the over synchronous inclination β. This is very simply attained if the coincident position of the brushes is not quite symmetrical, as shown, with the axial direction of the stator winding. In the coincident position of the brushes no additional voltage can be impressed on the stator winding to compensate for the phase displacement. When a motor has been constructed, the brush positions in which a good power factor and efficient working conditions are obtained can be determined experimentally both for over and under synchronous speeds. The displacement of the brushes may then be made to conform to the law obtained, by means, for example, of pinions connected to the brush-holders gearing with racks guided by curved discs or in curved grooves of adjustable sliding-plates or resting on suitably-formed sliding cam-plates, the plates being moved by the control lever. If it is desired to avoid any complicated devices, the brushes may be moved very simply by displacing them uniformly but at different rates. In this case, the end positions, corresponding to the highest and lowest speeds and also the coincident position corresponding to the synchronous speed, give very favourable power factors, but in the intermediate positions there are small variations from the most favourable results. In this arrangement, the brush-holders may be moved, for example, by spur-wheels, or by levers from a common driving device, connected to the separate brush-holders of the same pair through different gear ratios. (*Accepted July* 15, 1914.)

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

15,887/13. The Austin Motor Company, Limited, and H. Austin, Birmingham. Internal-Combustion Engines. [2 *Figs.*] July 10, 1913.—This invention relates to the type of vaporiser for heavy liquid fuels (such, for instance, as paraffin), used with internal-combustion engines, in which the vaporisation of the fuel is caused by the transmission thereto of heat from a chamber which is exterior to, but always in communication with, the main combustion space of the cylinder to



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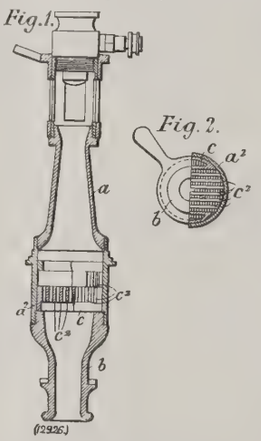
which it is fitted, and is surrounded by a chamber, generally cylindrical, through which the mixture passes to the cylinder or to cylinders of the engine. According to this invention, there is provided in respect of the engine cylinder, or in respect of one or each cylinder of a two-cylinder or multi-cylinder engine, a hollow, and conveniently cylindrical, mounting, which is open at its inner end and closed at its outer end, the open end of the mounting being in constant communication with the main combustion space of the cylinder to which it is fitted, as has been previously proposed. A readily removable ring or casing surrounds and fits around an outer portion of this mounting, and is chambered around its inner surface to provide a space between itself and the mounting, or such space between the mounting and ring or casing is otherwise provided for. An inlet-pipe, for the heavy fuel and air, enters one side of the ring or casing, and communicates with the space between it and the mounting, and an outlet-pipe for the fuel and air passes out from the other side of the ring or casing. A is a hollow cylindrical mounting which is open at its lower end and is closed at its upper end, the sparking-plug B being shown as screwed into the upper end. The mounting A is shown to be screwed into and to form the cap or cover for the induction valve-box C, and the open end of the mounting A is always in communication with the combustion-chamber of the cylinder D through the passage E. Surrounding the upper portion of the mounting A is a ring F which is chambered on the inside, thereby providing an annular chamber between itself and the outer surface of the mounting A. An inlet-pipe G, for heavy fuel and air, communicates with this chamber at one side thereof, and an outlet-pipe G^1 from the opposite side of the chamber carries away the fuel and air which have passed through such chamber, having been heated therein by the heat which passes from the interior of the mounting A, through the wall thereof, to the chamber. The mounting A is formed with a flange a between the lower face of which and the upper face of the valve-box C is inserted a packing. The ring F is tightened down upon a packing which is upon the upper face of the flange a, by means of a nut H, which is screwed upon the upper end of the mounting A, a packing being inserted between the upper face of the ring F and the nut H. Conveniently, the portion of the mounting A upon which the nut H is screwed is of reduced diameter, as shown, the exterior of the mounting suddenly tapering from the larger to the smaller diameter, and the chamber of the ring correspondingly tapering at or near its outer end, as shown. The pipes G and G^1 are fitted within branches of the ring, and the connections made gas-tight by packing-glands. Ribs or other projections may be formed at the exterior surface of the portion of the mounting A which is surrounded by the ring F to provide extra radiating surface within the chamber. (*Sealed September* 17, 1914.)

12,926/13. J. G. Watkinson, London, and P. H. Fletcher, Evesham. Bunsen Burners. [4 *Figs.*] June 4, 1913.—This invention consists in improvements in mixing-tubes for Bunsen burners. According to this invention, a Bunsen tube or burner is employed having an enlarged mixing-chamber at or near the nozzle, such as has been heretofore used, and in the enlarged mixing-chamber is arranged an air and gas-mixer and back-light preventer consisting of a ring having a series of parallel flat bars, or two or more of the rings arranged one above the other, the bars of one ring preferably crossing the bars of the other at a right or other angle. The improvements constituting this invention are especially useful in connection with the Bunsen burners of inverted incandescent burners. Fig. 1 of the drawing is a vertical section (partly in elevation) of part of an inverted incandescent gas-burner. a is the Bunsen or mixing-tube of the burner, having a slightly tapering form, terminating at its lower end, or part adjacent to the mantle-sup-



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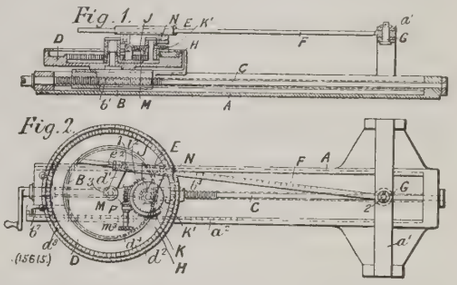
porting nozzle b, in the enlarged mixing-chamber a^2, having within it the air and gas-mixer and back-light preventer for ensuring a perfect intermingling of the gas and air before the same enters the nozzle b, at the mouth of which the combustible mixture is burned as is usual. The mixer c consists of a pair of rings, each ring having a series of parallel bars c^2, the parallel bars c^2 of one ring c being preferably placed to cross at right angles the bars c^2 of the other ring c, as will be best understood by an examination of the sectional part of Fig. 2. Where the pressure of the gas is low one ring only is employed, and in places where the air drawn into the burner is liable to be charged with an abnormal quantity of dust, and two rings are employed, the said rings are arranged with their parallel bars or strips c^2 coincident. By the construction of mixer described, a very efficient mixing of the air and gas is ensured and back-lighting is rendered practically impossible, the mixer being applicable to Bunsen burners generally. (*Accepted July* 15, 1914.)

GUNS AND EXPLOSIVES.

15,615/13. Fried. Krupp Aktiengesellschaft, Essen, Germany. Sighting of Stationary Ordnance. [2 *Figs.*] August 10, 1912.—This invention relates to that class of apparatus for determining the sighting quantities in the indirect sighting of stationary ordnance, in which, when the distance of the gun from a stationary observing station lying away from the gun is known, a mechanical triangle which corresponds to the triangle determined by the gun, the target and the observing station (and which therefore contains a side of a given length corresponding to the fixed distance of the gun from the observing station) can be produced by adjusting one side adjacent to the first-named side according to the distance of the target from the observing station and one angle bounded by the two sides according to the direction of a line supposed to be drawn from the observing station to the target. The object of the invention is to provide an apparatus of this kind, the distinguishing feature of which is, that the scale of the mechanical triangle can be made comparatively large, without the ease of inspection of the reading-off apparatus being reduced. This object is attained according to the invention by making the length of the two sides of the mechanical triangle, which meet at the point corresponding to the target, adjustable each to a scale extending in the direction of the particular side of the triangle, and by providing at that end point of one of the two sides of the triangle, which is movable relatively to the corresponding scale, a graduated disc for indicating the direction of the gun, the direction from the end point which is immovable relatively to the corresponding scale towards the other end point having in the case of one of the two sides a sense opposite to that which it has in the case of the other side, when moving round the triangle in a certain sense. In the frame A of the apparatus, which is conveniently attached to one wall of a cover placed near the gun, is mounted a slide B which can be moved in a longitudinal direction by means of a screw spindle C. The slide B is provided with a pin b^1 about which a dish-shaped circular graduated disc D rotates loosely. To the hub of the graduated disc D is rigidly attached an arm d^1, which is pivotally connected to a sleeve E by means of a pin, the axis of which is parallel with the axis of the pin b^1. The sleeve E is adapted to slide on a graduated bar F, which is pivoted by means of a pin G to a bridge a^1 mounted on one end of the frame A and rigidly secured thereto. The axis of the pin G is parallel with the axis of the pin b^1 and lies in the plane of movement of this pin. The axes to the three pins determine the mechanical triangle which corresponds to the triangle formed by the gun, the target, and the observing station. The corners of the mechanical triangle are denoted in Fig. 2 by 1, 2, and 3, the corner 1 corresponding to the gun, the corner 2 to the target, and the corner 3 to the observing station. The length of the side 3, 2 of the triangle is read off on a distance-scale a^2 inscribed on the frame A by means of a mark which is located on a pointer d^2 secured to the slide B. The length of the side 1, 2 of the triangle can be read off at one end e^2 of the sleeve E on a scale on the graduated bar F. The zero points of these two scales lie at those ends of the two scales which are next the pin G. On the outer edge of the graduated disc D is an angular scale d^2, which corresponds to the angular scale of a fixed graduated sector situated in the observing station. The corresponding reading-off mark is placed on a pointer b^4,



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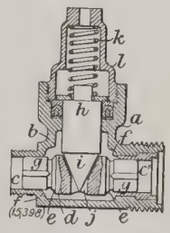
rigidly connected to the slide B. The position of the zero point of the angular scale d^2 is so chosen that the angle which the side 3, 1 of the triangle forms with the side 3, 2 of the triangle when the mark on b^4 points to the zero point, is equal to the angle which the line joining the observing station and the gun forms in the terrain, with the zero direction of the fixed graduated sector placed in the said station. The direction to be imparted to the gun is read off on an angular scale d^3, which is concentric with the angular scale d^2, and likewise inscribed on the graduated disc D, and is based on the same angular unit as the angular scale of the foundation graduated sector of the gun. The corresponding reading-off mark is placed on an annular sector H, movable in a circular guide in the graduated disc D. This annular sector H has internal teeth, with which gear teeth on a sector J. This latter surrounds the hub of a spur-wheel K, adapted to rotate about a pin in an arm M, which in its turn can rotate freely about the hub of the graduated disc D. The arm M is connected to the sleeve E by a connecting-rod N, and the conditions are so arranged that the parts E, N, M and d^1 form a pivoted parallelogram. The spur-wheel K, which is also capable of rotating freely relatively to the sector J, gears with an internal ring of teeth d^4 on the graduated disc D, and carries rigidly mounted upon it a graduated disc K^1, upon which is inscribed an angular scale which enables fractional parts of the unit, on which the angular scale d^3 is based, to be read off. The corresponding reading-off mark is placed on an annular fillet i^2 of the sector J, which fillet partly surrounds the graduated disc K^1. For the purpose of enabling corrections to be made, such as are necessary to allow for the drift caused by the rifling, side winds, &c., the mark on the fillet i^2 can be moved within certain limits by means of a self-locking worm P, rotating in two bearings on the arm M, and gearing with teeth on the sector J. The corrections are read off on an angular scale inscribed on the annular fillet i^2 by the aid of a mark placed on a pointer m^3 fixed to one of the two bearings of the worm. (*Accepted July* 15, 1914).

HYDRAULIC MACHINERY.

15,398/13. J. Stone and Co., Limited, Deptford, F. J. Pike, Beckenham, and H. Neville, Forest Hill. Valves for Hydraulic Systems. [4 *Figs.*] July 3, 1913.—This invention relates to improvements in valves for hydraulic systems, especially such systems as are applicable for operating bulkhead-doors and the like, and more particularly it relates to an improved means for automatically putting the ram of a hydraulic cylinder or cylinders operating each door or device in equilibrium on the cessation or failure of hydraulic pressure in the mains, so that the door or device may be capable of manual operation with perfect freedom. According to this invention, a separate by-passing device is provided in a duct communicating



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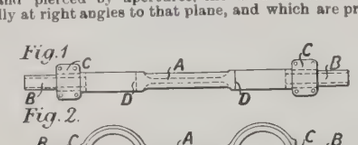
with both ends of the cylinder or with both of the cylinders, which device comprises, firstly, a valve arrangement of such a nature that, when pressure is admitted to either end of the cylinder or to either cylinder, the valve arrangement automatically cuts off communication with the other end or other cylinder, and, secondly, a device normally restrained from action by the pressure, which device, on the failure of pressure, is adapted to actuate the valve arrangement for placing the two ends of the cylinder, or the two cylinders, in direct communication or short circuit. a indicates a casing enclosing a chest or chamber b having two oppositely-situated openings c and c^1 leading therefrom, which openings are placed in communication, one with each end of the cylinder, in the case of a system employing a double-

acting cylinder, or one with each cylinder in the case of a system employing two single-acting cylinders. Within the chest or chamber *b* is placed a double-acting valve *d*, which may be of any convenient form, but is conveniently cylindrical, with valve-faces *e* formed on the ends, and is supported in axial alignment with annular seatings *f* around the two openings *c* and c^1. The valve *d* is preferably supported by two winged projections or axial continuations *g* of the cylindrical-valve member, which projections are adapted to project into and are slidable within the openings *c* and c^1 in the chamber. The ends of the cylindrical or body portion *d* of the valve are adapted, when in either extreme position, to close the corresponding opening in the chamber *b* and prevent the passage of fluid from the chamber through that opening. Thus it will be seen that when one end of the operating cylinder or one cylinder is placed in connection with the pressure-fluid, there will be a flow of pressure-fluid into the corresponding opening in the valve-chamber *b*, which will immediately cause the valve *d* to move across the chamber and close the opposite opening, and thus cut off the connection between the two ends of the cylinder or the two cylinders. In order that the valve may be induced to occupy a midway position upon the failure of pressure in the system, there is provided a plunger *h*, which is situated at right angles to the axis of the valve-body *d*, and substantially midway between the ends thereof when the valve is at its mid-position. The plunger *h* projects into the valve-chamber *b*, and is provided with a conical or other suitable end *i* which projects into a similarly-shaped or suitable hole or opening *j* formed in the valve body *d*. The plunger *h* which is normally forced outwards by pressure in the chest *b*, in which position it leaves the valve free, is pressed up into operative position when the hydraulic pressure fails or is cut off by means of a spiral or other spring *k* acting upon the other end. The spring *k* may be carried in a box or chamber *l* attached to the main casing *a* of the valve. The spring-pressed plunger *h* is preferably provided with a stuffing-box arrangement to prevent leakage of pressure fluid. It will now be seen that when one opening of the valve chamber is placed in communication with the pressure fluid the spring plunger *h* will first be pressed up, and the valve *d* will then be free to move over under the pressure or flow of the fluid and close the opposite opening, as above described. When now the pressure in the system fails from some cause, or is cut off, the plunger *h* will be forced inwards by its spring *k*. The conical extension *i* thereon will thereupon engage with the aperture *j* in the valve *d*, and the extension *i* will, by a cam or inclined-plane action, draw the valve *d* into its mid-position, thereby putting both ends of the cylinders, or both cylinders, in communication, and allowing the door connected thereto to be freely manually operated as desired. (*Sealed September* 17, 1914.)

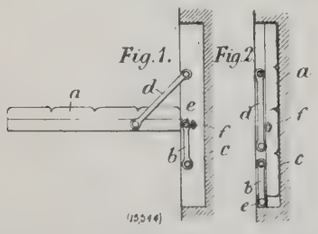
MOTOR ROAD VEHICLES.

21,695/13. Albion Motor-Car Company, Limited, and T. B. Murray, Scotstoun. Motor-Vehicle Rear Axles. [4 *Figs.*] September 26, 1913.—It is very important in motor vehicles, particularly of commercial type running on solid tyres, that the weight of the rear axle and its appurtenances (which is, of course, unsprung) should be as small as possible, that its construction should be as simple as may be, and that such weight as there be, should not be concentrated at the centre of its length where the momentum effect is a maximum, but rather disposed towards its outer ends where this effect for a given mass is at a minimum. According to the invention, the body of the axle, including those portions upon which the rear road-wheels run, may conveniently be a single steel forging, the central portion of which is of H section, thus combining lightness with strength. On either side of this central portion the body of the axle is of circular form in one plane and pierced by apertures, the axes of which are substantially at right angles to that plane, and which are preferably



of circular form. These apertures respectively receive bevel or worm-gearing for the transmission of power to outwardly-extending shafts connected at the outer ends by dog-clutches or other kindred means to the road-wheels. The axle beyond these pierced parts is of tubular form to receive within it these shafts, and on it may be mounted the spring palms and rear wheels. The body A of the axle, including those end portions B upon which the road-wheels run, and including the portion upon which the spring palms C are mounted, is in the form of a single forging with the central portion of H section for the sake of lightness with strength. On either side of the central portion the body of the axle is of circular form in substantially vertical plane and pierced by circular apertures D, the axes of which are substantially horizontal. These apertures receive bevel or worm-gearing for the transmission of power to the usual shafts within the axle ends made tubular for this purpose. The outer ends of these shafts are connected to the road-wheels in the usual manner. (*Sealed September* 19, 1914.)

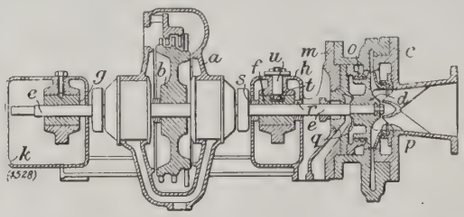
15,544/13. G. H. Lanchester and the Lanchester Motor Company, Limited, Birmingham. Folding-Seats. [6 *Figs.*] July 5, 1913.—This invention has for its object to construct a folding seat, table or the like for use on motor road vehicles and for other purposes, such article being of the type in which links are pivotally attached to the edges of the



article and to suitable points on the support in such a manner that the article can be rigidly supported thereby in a horizontal position, or folded compactly into a vertical position. The present invention comprises the combination with a support, the rigidity of which is independent of the folding-seat, table or like article of a folding portion attached by links to the support and secured in the service position by the simple abutment of its rear edge against the support or stop or stops thereon, and a torsion-rod connecting a pair of opposite links. In the construction of a folding-seat for a motor road vehicle, in accordance with this invention, as shown, the seat *a* has attached, at or near the rear end of each lateral edge, a link *b*, which is pivoted to such end, and is also pivoted to a point on a fixed portion of the frame *c* of the vehicle vertically below the point of connection with the seat. At a convenient distance along each lateral edge of the seat is pivoted another link *d*, which, at its opposite end, is pivoted to a fixed point on the frame of the vehicle vertically above the fixed point of connection with the links first described. By such an arrangement of links the seat can be folded compactly into a vertical position against the side of the vehicle to which it is attached, or it can be turned into a horizontal position, in which it is rigidly secured by the combined action of the links and the abutment either of the rear edge of the seat against the side of the vehicle, or the ends of the links *b* against fixed stops *f*. When in service there is no possibility of the seat moving in any way under the weight of the person occupying the same. To prevent any twisting or binding action in the links when the seat is operated, any convenient opposite pair of links are connected by a torsion-rod. In the arrangement shown, the rod *e* connects the ends of the links *b*, and passes along a socket at the rear of the seat. (*Accepted July* 15, 1914.)

PUMPS.

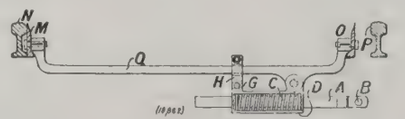
4528/14. G and J. Weir, Limited, and J. Petermoller, Glasgow. Centrifugal Pumps. [2 *Figs.*] February 21, 1914.—The invention relates to centrifugal pumps driven directly by steam-turbines, the turbine and pump rotors being mounted on a common shaft. The object of the invention is to allow of the construction of a unit of this nature which can be put into action quickly without previous heating up, and without serious risk of injury due to unequal expansion, and in which, moreover, the axial clearances between the rotor and stator of the pump can be kept extremely small. In carrying the invention into effect, the pump is constructed of the single-stage, single-admission balanced type, and the turbine of the single-pressure-stage impulse type, the rotor of the turbine, therefore, having very little tendency to axail movement due to steam pressure. The turbine and pump rotors are mounted on a common shaft, but within separate casings. The pump suction is arranged at the side of the pump remote from the turbine, and a bearing is provided for the common shaft between the turbine and the pump, and a second bearing is situated on the other side of the turbine. Means are provided for adjusting the first-mentioned bearing in a direction parallel to the axis of the shaft, and the shaft is provided with a guide-collar on each side of this bearing, each of the two collars being adapted to engage—when necessary—with one or other side of the bearing, in order to limit the axial movement of the shaft and prevent the rotor of the pump from coming into contact with the stator. *a* is the tur-



bine-casing and *b* the turbine-rotor; *c* is the pump-casing and *d* the pump-rotor; *e* is the common shaft for the two rotors, which shaft is supported in a bearing *f* situated between the turbine and the pump and a bearing *g* beyond the turbine. These bearings are supported in casings *h*. *k*, of which the casing *h* is formed integrally with, or rigidly attached to, the adjacent cover *m* of the pump-casing or other structural part of the pump-casing. The pump-rotor is formed with very fine axial clearance at *q*, and any contact between rotor and stator at this place should be prevented. It has also very fine radial clearance at *o* and *p*, and it is of course desirable that if the packing-rings should once touch the impeller *d* and cut a groove in it, this groove should not be widened by the shaft travelling axially. The pump is arranged to be balanced when running, but, when being put into action or on other occasions, there may be a tendency for end movement on the shaft, and it is therefore necessary to provide guide-collars. These guide-collars, according to this invention, are placed on either side of the bearing *f*, and are represented by *r* and *s*. They are fixed on, and rotate with, the shaft, and allow the shaft very little end movement with respect to the bearing *f*. This bearing can have its longitudinal or axial position adjusted by means of the pin *t*, which is carried eccentrically by the shaft *u*, means being provided for rotating this shaft through the necessary angle. The pin *t* works in a slipper, which is adapted to slide in a transverse slot cut in the bearing. The adjustability of the bearing *f* allows of the fine axial clearance or clearances at the pump to be regulated as desired. (*Sealed September* 17, 1914.)

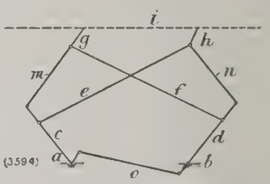
RAILWAYS AND TRAMWAYS.

18,882/13. A. Lines and C. B. Lines, Calcutta, India. Railway Point-Operating Appliances. [3 *Figs.*] August 20, 1913.—This invention relates to an appliance for safeguarding railway switches and their operating rodding from damage—for instance, in the case where switches are burst open by a passing vehicle—and is for use in connection with railway points or switches of the kind which are operated by rodding from a distant signal-cabin. In carrying this invention into practice, a steel or iron cradle is provided which carries a helical spring, through which passes a plunger, the one end of which is provided with an eye which is attached to the operating rodding



by an ordinary double eye and pin. The spring is secured longitudinally on the plunger by two pins, one passing through the plunger at each end of the spring. The ends of these pins project into guide-slots formed in the spring cradle. At one end of the top of the cradle a double eye is formed so as to engage by means of a pin with the single eye which is provided in common practice on existing stretcher-bars. The other end of the top of the cradle is provided with an eye so as to receive two glands or clips which are secured tightly to the stretcher-bar by the glands or clips being pulled in by the tightening of a bolt. The spring-rod A is connected in the usual manner to the point rodding which runs from a lever in the cabin and is connected at eye B. The spring C, which is mounted on the spring plunger A, is of such strength that when the spring-rod A is pulled to the right, the points are moved over to the other running rail. D is the spring cradle with the double eye, by which it is connected to the ordinary single eye with which stretcher-bars Q are usually provided. The spring cradle has also a double or single eye at G by which it is attached by glands H to the body of the stretcher-bar. Passing through the spring-rod are cotter-pins which are free to slide in a slot or recess at each end of the spring-cradle. The action of the appliance is as follows:—When a vehicle forces itself trailing-ways through the points when the points are set against it, the point-blade M is forced open from the running rail N, and point-blade O is forced against the running rail P. As the rodding between B and the signal-cabin is rigid, and cannot yield, the travel given to the stretcher-bar Q is transmitted to the spring-cradle D and to the spring C, which is compressed against one of the two cotter-pins. As soon as the flange of the passing wheel has cleared the points, the energy stored in spring C replaces point-blades M and O in their original position, and the yield of the spring C has prevented damage being done to the point-blades, stretcher-rods, or other connections. (*Accepted July* 8, 1914.)

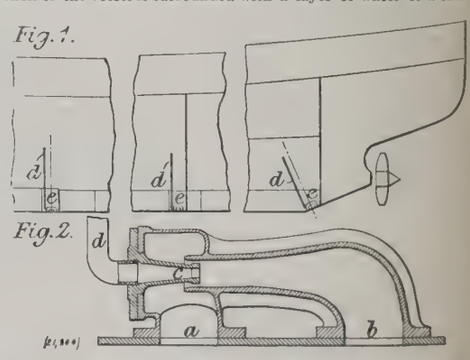
3594/14. Allgemeine Elektricitats-Gesellschaft, Berlin, Germany. Current Collectors, [1 *Fig.*] February 12, 1913.—The invention relates to current collectors for electric-traction systems, and particularly to current collectors of the kind in which two contact members bear on the trolley wire. On high-speed railways it is desirable to use two contact-members in order to obtain an uninterrupted supply of current if one of the contact members jumps off the trolley-wire. This is sometimes done by arranging on the vehicle two separate parallelogram current collectors, each of which supports a contact-member. According to the present invention, two contact-members are provided, each of which is supported on a parallelogram type of frame, the two frames being so connected that they have common lower arms and common fixed axes. There are two parallelogram-type frames, one of which is formed



by the arms *c*, *m*, *f*, *d*, and the other by the arms *c*, *e*, *n*, *d*. The upper arms *m*, *f* of the one frame are pivoted together at *g*, where they support one of the contact-members, and the upper arms *e* and *n* of the other frame are likewise pivoted together at *h*, where they support the second contact-member. The upper arm *f* of the one frame crosses the upper arm *e* of the other frame diagonally, the lower ends of these arms being pivoted at an intermediate point of the opposite lower arms respectively. Thus the two parallelogram frames are interconnected in such a manner that they have common lower arms *c* and *d*, and common fixed axes on the vehicle at *a* and *b*. The reference letter *i* indicates the trolley-wire. In order to strengthen the arrangement it is convenient to extend the lower arms beyond the pivots *a* and *b* as shown, the arm *c* having a bell-crank extension and the arm *d* a straight extension, the two free ends being connected by a link *o*. (*Accepted July* 15, 1914.)

SHIPS AND NAUTICAL APPLIANCES.

21,844/13. Sir W. G. Armstrong, Whitworth and Co., Limited, and E. L. Orde, Newcastle-upon-Tyne. Ice-Breaking Steamships. [4 *Figs.*] September 27, 1913.—Where ice-breaking steamers are working in certain parts of the world they sometimes meet a serious obstacle in the shape of spongy ice, known by the name of "frazil" or "lolly" ice, which is often found extending some 20 ft. or 30 ft. below the sheet of solid surface ice. A slight increase in temperature of the surrounding water is apparently sufficient to dissolve this "frazil" ice, but unless this increase in temperature can be secured, the ice-breaking steamers are generally brought to a standstill, and find it impossible to make progress in either direction. According to this invention, the temperature of the surrounding water is raised by injecting steam or heated water into it by means of a special arrangement of steam-heaters fitted in convenient parts of the bottom or sides of the ship. There are two cases which have to be dealt with:—1. When the ship is prevented from moving by "frazil" or other ice. In this case the whole of the shell of the vessel is surrounded with a layer of water of a tem-



perature sufficient to dissolve the ice. 2. When the ship, although free to move, has to face a large mass of "frazil" ice. In this case heaters are placed in such a position that the heated water is directed towards the bow propeller, and is thus spread amongst the mass of "frazil" which it is desired to break down. The heaters are preferably in the form of ordinary steam injectors, and when necessary, guide-plates are provided to spread the heated water evenly over the bottom of the ship. Fig. 1 is a diagrammatic longitudinal section of an ice-breaking steamship constructed according to this invention. Fig. 2 is a section of one of the heaters. The ship shown is about 220 ft. long, and would be provided with about eight or ten heaters, each of which would deliver say 3000 lb. of steam per hour, but the dimensions of the vessel and the number and capacity of the heaters can be varied within wide limits. The heaters are similar to ordinary steam-injectors, and are provided with an inlet *a* for the cold water from outside, an outlet *b* for the heated water, and a steam-nozzle *c*. These nozzles are supplied by steam-pipes *d*. The heaters are arranged in water-tight compartments *e*. (*Sealed September* 23, 1914.)

FOUNDRY CRANES AND POWER AGENCIES.—No. I.

By Joseph Horner.

When the foundry machinery of the lavish present is contrasted with that of the meagre past, one of the more obvious facts is that the range, the utilities, and necessarily the cost of the power agencies employed for lifting and carrying, are much larger than they were. Some of us remember a time when power of any kind but steam was scarcely known in foundries. That was necessary for the fan and the coal-mill, often the only machines for which power, other than that of human muscle, was employed. When power was employed at all it was not for the machines and plants which have formed the subject-matter of previous articles, few of which, in fact, had come into existence, but for any single form of power agency. That might have been quite proper in the past, but it does not meet the varied and extensive requirements of the present phases of foundry practice. We may look rather more closely into these requirements, taking first extreme illustrations. It is not judicious, hardly possible in fact, to consider the question of crane service apart from the power service or services of a foundry. The extensive installations of foundry machinery, now common, render necessary the comprehensive views which embrace the whole of the power services in the foundry.

Take first, as representative of one extreme, a big marine-shop or a pump-shop, or anyone that deals chiefly with a heavy class of manufacture, and compare it with an ordinary brass foundry, or a foundry that handles mainly cock and valve work

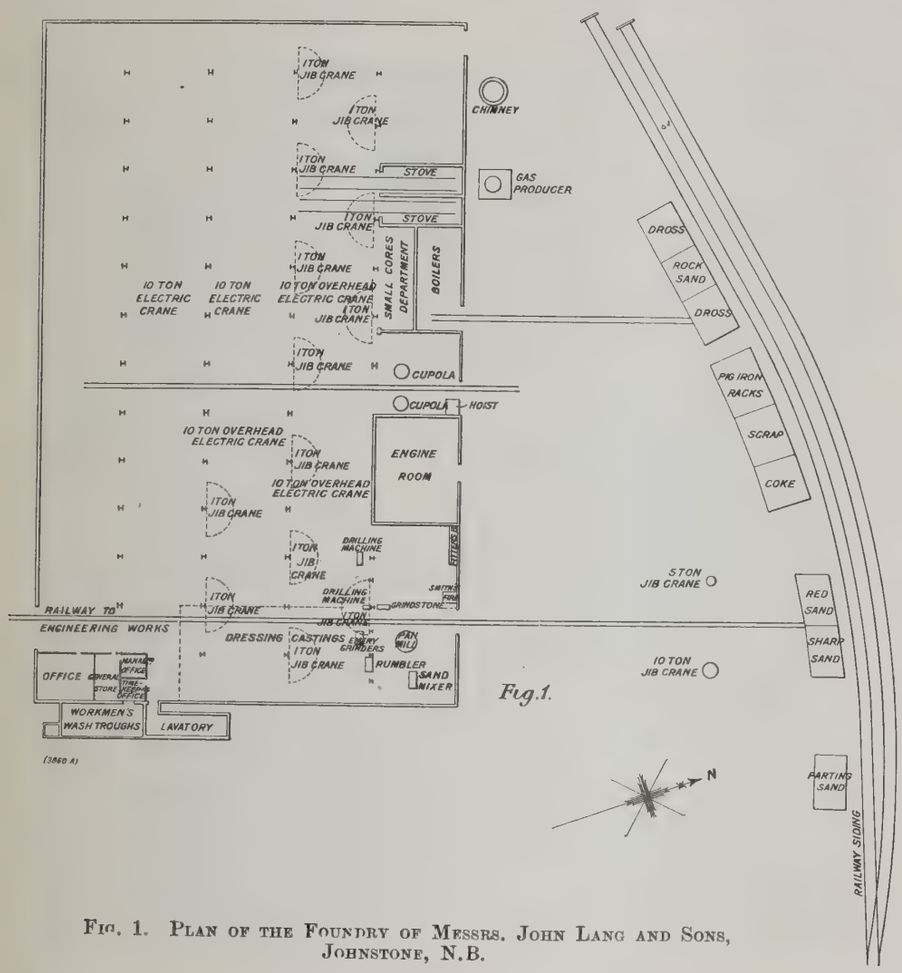


Fig. 1.

Fig. 1. Plan of the Foundry of Messrs. John Lang and Sons, Johnstone, N.B.

the hoisting-machines. And even these were often hand-operated. The exceptions in the minority of foundries were the overhead steam travellers and the hydraulic cranes. Neither compressed air nor electricity had come into the field, or had hardly been suggested. But it must be remembered that at that period large foundries such as are common now were unusual. Few comparatively dealt with specialities, but they executed all kinds of orders indiscriminately, and good prices were obtained for castings. Machine-moulding was in its very infancy, and such machines as existed were almost all hand-operated, and invariably of very small dimensions. The problem of power and the choice of several power agencies therefore did not worry the foundry proprietors and managers of that not so very distant period. Very different is their attitude now. If a big foundry is to be run with one source of power only, the selection of that one requires some prolonged and anxious consideration. Steam, compressed air, pressure water, or electricity, each has strong claims. In connection with the two last agencies, the choice will often lie between the installation of a generating plant or of purchase from a central station. It is impossible to state a case or to suggest a selection that is suitable for all foundries alike. Neither is it desirable in large foundries to be confined now to in brass and iron. Obviously the working plant, the hoisting tackle, the methods of moulding and handling, are as broadly different in each as they can possibly be. But, again, large numbers of foundries occupy a position somewhere between these extremes, inasmuch as they deal with heavy, light, and medium castings. The big general crane-shops, the large railway-shops, the foundries that work for the trades that prefer to order their castings out, the general pipe-shops, and many others, handle a large volume of work ranging all the way from heavy to light in all intermediate grades. In these, therefore, the problems which are peculiar to specialised shops are combined. Heavy, light, and medium castings are made beneath one roof, though properly and usually in areas separated from each other. Loam, heavy green sand, and light hand and machine moulding, all occupy different parts of the big comprehensive foundry, and engage different sets of men. Each also requires different kinds of hoisting tackle, machines, and aids. These are the facts which complicate the questions relating to power for general hoisting and carrying, for moulding-machines, for the preparation and transportation of materials, for cleaning castings, and for the service of the cupolas.

Hand-operated moulding-machines outnumber those which are actuated by power. But for heavy moulds, for the production of which the proportion of heavy machines continually increases, power is necessary. At the same time the light machines which are power-operated also grow in numbers. For these steam is only used slightly, hydraulic power and compressed air being the usual agencies, and electricity in but a very few cases as yet. Compressed air has become an almost indispensable help in most foundries for numerous other services, and therefore that is one point in its favour for the operation of cranes. Several moulding-machines of this kind are built, including the recent heavy jar-ramming types. But the hydraulic machines occur in much larger numbers, and pressure water has no elasticity, is under such absolute and minute control that it seems indispensable in the present stage of machine moulding, where the heaviest work is being done. This being the case, coupled with the fact that the largest and heaviest machines are hydraulically operated, the jar-rammer alone excepted, renders an installation of hydraulic power desirable in shops where heavy machine moulding is in contemplation. A small plant, designed specially for the foundry service, can be installed when the locality is not in the neighbourhood of a system of public supply. Here a firm, which has both a boiler-shop and a foundry, can tap the boiler-shop plant for foundry service. Or, in laying down a plant specially for foundry use, it will be judicious to entertain the project of installing some hydraulic fixed jib-cranes, though in shops where electricity is in service it seems better now to employ this for the cranes. But so valuable is the hydraulic system that where a large volume of heavy foundry work is done a firm would be justified in laying down hydraulic plant to deal with that alone.

The kind of power suitable for the preparation and transportation of sands and other materials may be that of an engine or an electric motor. Most of the machinery of this kind used is belt-and-shaft driven, so that either kind of prime mover, an engine or an electric motor, is equally suitable. The selection may thus depend on what a firm happens to have installed, or to have in contemplation for other purposes. An electrical generating plant may be drawn upon, or an engine—steam, gas, or oil driven—may be laid down.

The kind of power most suitable for cleaning castings is compressed air, both for sand-blasting and for pneumatic tools, and a steam-engine or electric motor for driving tumbling-barrels and emery grinding-wheels, saws, and gate-cutters. A compressed-air plant should be designed for sand-blasting, for reasons which have been given in the articles on "Foundry Plant and Machinery." It is not required for plain tumbling-barrels, which are suitable enough for small, plain castings, though for intricate articles, cored work, and castings of large dimensions, sand-blasting has such great advantages that a special air-compressing plant may be a sound investment.

Power for the service of the cupolas hardly need be considered apart from other agencies, because either steam or electrical driving can be utilised equally well for fans, blowers, and hoists. Hydraulic power also, when available, or compressed air can be employed for the cupola hoists, so that this service may be regarded as a secondary issue by comparison with others of wider scope.

The power suitable for general hoisting and carrying includes hand, steam, pressure water, compressed air, and electricity, all of which, as we have seen, have their applications in other foundry services. The applications of these agencies are made to fixed cranes, to overhead travelling-cranes, overhead trolley tracks, with their hoists, and floor tracks and trolleys. We will briefly consider these in the order named.

Hand-power cannot be ruled out so summarily as some may be disposed to think. Many small foundries are wholly dependent on it, and, as of old, get along very well without motive power of any kind excepting that which is required for driving fan or blower, sand and coal-mills. Small foundries, whether casting iron or brass, would not find power-operated cranes so economical as hand-worked ones, because the service is so intermittent and occasional that the hoisting-machines are standing idle during a large proportion of the time. And this is so no matter whether the work is of light or heavy character. The sphere of the power-operated cranes and hoists is in those shops where lifting is going on nearly continually over some

area or another. When it is occasional only, the service of hand cranes and hoists, operated by the men themselves, is to be preferred to power agencies. Three kinds of lifting-machines are suitable for such services: the overhead hand travelling-crane, the triangular jib-crane of the regular "foundry" type, and the hand-operated hoists or pulley-blocks which run along on overhead tracks. The first two are suitable for all loads, heavy and light; the last is used for the lighter class of service only. None of them interfere with the floor area. The first and last will cover practically the entire area of the floor; the jib-crane is limited by its radius, but is a most useful adjunct to the overhead traveller.

Steam as a power agent, used directly in a steam-engine, is employed in a rapidly-lessening extent. It is used to generate electricity, though large gas-engines frequently fulfil that function with higher economy. Steam travelling-cranes and steam jib-cranes are seldom built now. Steam-engines are often coupled to blowers. Engines are also employed for driving sand and coal-mills, fettling-drums, and other machinery, through shafting and belting; but it is nevertheless a decadent power in foundry service.

Pressure water is perhaps of more value now in the service of moulding-machines than of cranes. The only foundry cranes for which it is suitable are the fixed post-cranes, which are still employed, though generally regarded now in lower favour than the electric types are. Hydraulic power is not suitable for overhead travellers, or hoists, or blowers, or sand-preparing plants, or fettling plants, and is thus put at a disadvantage by comparison with electricity. If installed at all, it is better to restrict its service to the operation of moulding-machines, and, within suitable conditions, to jib-cranes also.

Compressed air is, electricity excepted, the most valuable present power agency in the foundry. It occupies an indispensable place when certain plants are installed, as sand-blasting, and pneumatic tools, for ramming moulds, and chipping castings, and is the only agent possible for these. But it is used extensively for light hoists, for jar-ramming moulding-machines, and for several other types of moulding-machines. The compressing plant is not very expensive in proportion to its numerous utilities in a large modern foundry.

Electricity is now the most largely used, the most mobile, and the most comprehensive power agent in any advanced type of foundry. One great advantage which it has over others is that it is suitable for the intermittent demands made upon it, and foundry work is more or less intermittent. At certain times the cranes and the machines will be idle, or only partly engaged, at others they will be all working at high pressure. No electricity is being used when machines are idle, and, employing suitable motors, the quantity used is proportional to the work done. When cranes are lifting sometimes heavy, sometimes light, loads, the auxiliary hoist is a valuable adjunct peculiar to the electric cranes. So is the rating of motors for the several motions in place of the old wasteful speed transmissions through gears for hoisting, travelling, and cross-traversing. Again, the transmission of the electric current is effected with less loss and inconvenience than that of any other power agent, whether steam, water, or air, each of which is liable to leakage. The cables can be carried in any directions and to distant parts with no appreciable loss, such as occurs in the friction of the other agents, and in temperature losses, or with square shafts or cotton ropes; and where machines are grouped, as in sand-preparation plants, in fettling-shops, in blower-rooms, the separate machines can be belted from shafts driven by a motor suitably located. Electric hoists are also suitable for overhead tracks, more so for the heavier duties than the pneumatic types are. Most engineering firms now use electricity, either of their own generation or purchased from central stations. It is easily extended to the service of the foundry.

The following are the crane types employed in foundries:—

Fixed cranes possess as high a value in the performance of some classes of foundry work as the travelling ones do. Some moulds and cores require much more handling, lifting, turning about, and setting than others do. Again, there are some sections of moulding which hold up or monopolise the services of a crane for a long while, when others also are waiting for its help. It is in such kinds of work that the fixed-post swinging jib-cranes are of exceptional value. A single overhead travelling-crane cannot serve a shop of fair size. Its special value lies in transportation. When boxes require much handling, or are suspended in a crane for a considerable time, the overhead traveller, if occupied thus, is unable to answer the varied calls made upon it, and then the jib-cranes, each covering a limited area, and located against pillars down the shop, become indispensable.

Overhead travelling-cranes are as valuable in large foundries as in machine and boiler shops. They may range in power from 1 ton upwards to the maximum loads handled. Except that they all span the shop or bay, there is not much in common between the designs of different types and sizes made. Hand travellers are still used in the smaller shops; steam-operated travellers now rarely. Nearly all the new travellers are operated by electric motors, and the majority also have a separate motor to drive each motion, the single-motor crane being seldom built, though firms will do so when required. It is not an economical design, though the first cost is less than that of individual motor designs, and it is preferable to any form of steam traveller for foundry service. The heavier the work done in a foundry the more valuable is the overhead traveller. But it is also often used in bays or in shops where light work predominates. A main bay may have a heavy traveller, the side bay or bays lighter ones.

Overhead trolley tracks and hoists come into rivalry with the travellers only when the lighter kinds of work are being done, not exceeding, say, from 3 to 5 tons in weight, and mostly under 1 ton. Traveller girders are supported substantially upon runways, while the hoists are hung from the overhead tracks, which again are attached to roof principals, or to beams—an important distinction. The tracks are preferable to travellers in the light foundries. A large number of hoists can be distributed about, so that no man need have his work hung up, as when waiting for a traveller.

The floor tracks and their trolleys are rivals to the overhead tracks and trolleys, and cranes for transportation purposes only. Their chief value lies in carrying ladles of metal, moulding-boxes, and castings about. They may be laid down to supplement the crane service, though many foundries do without them.

We will now consider in some detail the principal groups of cranes, and dispose first of the jib-cranes in this article.

The jib-cranes have been somewhat overshadowed, and have suffered depreciation in the estimate of some by the increasing adoption of the overhead travelling-cranes, and of the light hoists on overhead tracks. The foundryman does not share that view. They have but suffered a temporary eclipse, since no large foundry which deals with average and general products can afford to dispense with this very useful type. The sphere of utility which these cranes occupy is, as already noted, that of localised work which holds up a crane for long periods. This happens with heavy core making, with loam moulds, with green and dry-sand work, moulded by turning over, and using two or three box parts, with moulds which include a great deal of intricate coring, as cylinders and pumps, and some beds and base-plates. A crane in these cases may be held up in nearly constant service for several hours. On the other hand, the radius of action cannot be larger than the jib of a fixed crane is able to cover—say 12 ft. to 25 ft. The traveller which covers the entire shop area is neither wanted for this kind of service nor may it be retained in use in any one area to the neglect of others. Its proper sphere lies in the transit of tackle and castings about the shop, in incidental and temporary local services over all areas, as taking ladles of metal to moulds to be poured, &c., but not for long-continued or permanent occupation in any one spot. The larger the foundry the more numerous should the jib-cranes be, while the heavier the work done the more essential they are, because their place for heavy duty cannot be taken by the light cranes, which alone can be carried on overhead tracks. In many foundries a dozen or more of these jib-cranes are located over different areas, and often nearly within reach of each other. Their powers vary with the weight of work carried—say

Fig. 2. A Bay of the Heavy Foundry; Messrs. Tangyes, Limited, Birmingham.

1 ton to 10 tons, the latter being heavy. Usually the power range extends between about 2 tons and 5 tons. The heaviest duty is usually that of the loam department, where the castings made are often massive.

A plan view of the lay-out of the foundry of Messrs. John Lang and Sons, of Johnstone, Fig. 1, page 495, affords a good illustration of these arrangements. The bays for heavy work are provided with 10-ton overhead electric cranes. Those for light castings have numerous 1-ton jib-cranes pivoted to the columns which support the roof. The railway tracks, by which the shop is served from the sand-bins, and by which it is connected to the railway, will be observed.

The photograph, Fig. 2, page 496, which illustrates one of the bays in the heavy foundry of Messrs. Tangyes, Limited, of Birmingham, shows a row of jib-cranes ranged down the wall. The bay is also served with two electric travellers.

Having concluded that the jib-cranes are indispensable in any foundry except those which deal with very light castings, as brass, and very light iron foundries, the best selection of cranes come next for consideration. Three types exist: the wall-cranes, which, being located next a wall, sweep round through half a circle only; the independent cranes, which, pivoted in steps in floor and roof, make a complete circle; or those types which are carried on a foundation-plate only. Each is operated by hand, or by hydraulic, or electric, or pneumatic power. Steam, once employed and brought through a central swivel-pipe, must be regarded as obsolete for these. Each of the other agencies is good and suitable under the various conditions already laid down.

When a foundry is bounded by walls alone, the wall-cranes are suitable; but when, as often happens in the later shops, a broad area is divided into several bays, with columns only intervening to support the roof principals, then the independent crane may be preferable. Swinging through a complete circle, it will serve gangs of men in adjacent bays. The foot-step and the top pintle when adopted must have adequate security in the foundation-plate and the top casting. The posts of such cranes must never occupy the centre of a shop or bay.

There is only one broad type of foundry jib-crane, however greatly its details are varied. It is that in which the jib is horizontal, and the framing is composed of post, jib, and strut, forming a triangle, or an approximately triangular outline, since the strut may be curved or cambered to give more room for racking towards the post. The load is racked by means of the jenny or block-carriage running on tracks along the jib. The powers of these cranes may range from 1 ton to 10 tons. A raking jib-crane, or a derrick, would be of no use for foundry service. The horizontal jib permits of exact and easy radial adjustments of the racking carriage, while the pivoting of the jib around the axis of its post enables a considerable floor area to be covered. Sometimes cranes are arranged so closely that two adjacent can lift a joint load at maximum radius, or transfer a load from one to the other. The framework of many of the old cranes was constructed of timber, and this had a long life. The lower faces of the jib and strut were protected from the heat of the metal in ladles with iron plates. But rolled-steel joists or built-up steel sections are now nearly universal.

With respect to the selection of operating agencies, each individual firm must determine its own selection. A great deal might be said in favour of the hand-cranes. Nothing is better, perhaps nothing so satisfactory, as a hand-lift for the delivery of patterns and for the turning over of boxes. With the chain "on the strain" the labourer has perfect control of a delicate lift, responsive to the moulder's signs. So too in lowering tops on bottom parts, where the slightest carelessness might produce a crush of sand, or push a core out of place, the hand-crane is excellent. Only when speed is desired are the power-cranes superior to it. And when service is very intermittent the power-cranes, being more costly to instal, do not recommend themselves to the management by comparison with the cheap and useful hand-cranes.

Most hand-cranes have two speeds of lift through "quick" and "slow" gears, two winch-handles, and a hand-lever band-brake, all situated at the back of the post. The hoisting-drum is at the front, whence the chain or rope runs along over a guide-pulley to the pulleys on the jenny and down to the hook direct, or round the pulley in the snatch or return-block, to which the hook is attached. The racking is done by pulling an endless chain which depends from a wheel, the shaft of which carries a pulley that moves the jenny inwards or outwards. Slewing is done by pulling at the chain-hook. Only the more powerful cranes have gears for this motion. When they have it, a winch-handle operates, through bevel-gears, a vertical shaft, which carries a pinion engaging with a ring of teeth on the foundation-plate.

Figs. 3 and 4 illustrate a typical independent crane of 3 tons power, by Messrs. Thwaites Brothers, Limited, of Bradford, Yorkshire. The framing is made of rolled channels. It has one speed of lift, through double gear. It slews round a central post of wrought iron, stepped into the foundation-plate, bolted into a deep concrete foundation (not shown). Cast-iron cross-girders at top and bottom carry the rollers which run round the post. A is the endless racking-chain running over its sheave-pulley B, the shaft of which is geared to that of the chain-pulley C, whence the jenny or block-carriage D is racked along. The hoisting wire rope E, coming from the drum, passes over the pulleys in the jenny to the sheave F below. Being anchored at the end of the jib, its varying lengths for hoisting and racking are wound or unwound on the drum. A ratchet to sustain the load is fitted at G, and a hand band-brake for lowering at H.

Until the invasion of electricity, hydraulic cranes were the best power-cranes for foundry service. The slow and regular movements produced by water, and the instant control, are ideal from the moulder's point of view, whether in drawing patterns, lowering tops, or rolling over boxes. The fixed character of the cranes is favourable to the supply of water, avoiding the jointed pipes and temporary connections which are required for portable cranes. Many large foundries were thus equipped; many retain those cranes to-day. Where hydraulic power is installed in a foundry for moulding-machines, or in a works for the boiler or plating departments, the inclusion of hydraulic cranes should have very careful consideration. They are modified in design to suit light and heavy duty, and are very easily operated.

The simplest design is the direct-acting, in which the lifting alone is done by the water pressure. In this the vertical movements of the jib are made to lift or lower the load, and these are produced by attaching the jib to the lifting-cylinder, which is of inverted type, moving on the ram, which forms the bottom centre of the crane. The jib in this case has no strut, but a tie coming diagonally from the top of the cylinder to the end of the jib. The changes are rung in several details on this general design. The racking is accomplished by pulling at the lifting-hook which hangs from the jenny. Slewing is performed by a similar pull. In one variation the jib is fixed, and the cylinder is suspended from the jenny, and its water supply is brought through a walking pipe. Loads of 1 ton or 30 cwt. are seldom exceeded in this type of crane. At the next stage, from 30 cwt. to 3 or 4 tons, the lifting-cylinder is carried within the channels of which the mast is built, and the chain from the multiplying pulleys passes over a guide-pulley to the guide-pulleys on the jenny, and round the snatchblock below. Both racking and slewing are effected by hand, the first by an endless chain, and the second by pulling at the hook. In the completely-equipped design, suitable for loads of from 5 to 15 tons, each motion is produced by its own cylinder or cylinders. The lifting-cylinder, located between the mast-cheeks, has one ram in low-powered cranes, and two rams, telescopic, for the high-powered ones, to deal with two separate loads, whence the chain passes to the jenny and snatch. The racking is often done by horizontal cylinders, one being placed on each side of the jib. The slewing is performed by cylinders placed behind the mast. All the levers are brought to the rear or to the front, where the attendant stands.

Electric jib-cranes rank high in utility among the power-cranes. They may be of three-motor design, the motors being separately rated for hoisting, slewing, and racking. Motors are located behind the mast, and a man standing there on a platform has the various controllers within reach. A cheaper design has a single motor only, used for lifting with two speeds, leaving the racking and the slewing to be done by hand. The electric foundry crane is not necessarily an all-electric design, because the maximum loads lifted are not usually large. The 5-ton crane covers most foundry service, and for this an electric lift is sufficient, leaving the traversing and slewing to be done by hand, the first being accomplished by an endless chain depending from a sheave, whence the jenny is traversed in the usual way; the second is done by merely pulling at the load, or by hand-gear

Fig. 3.

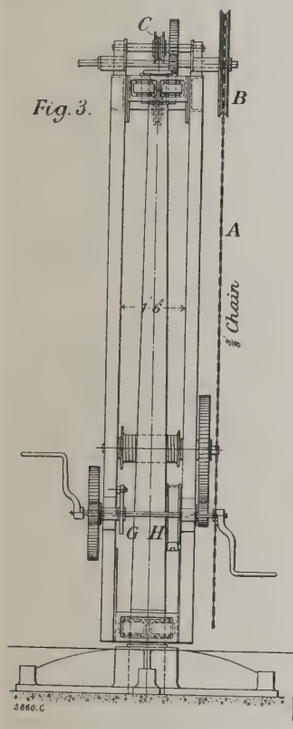
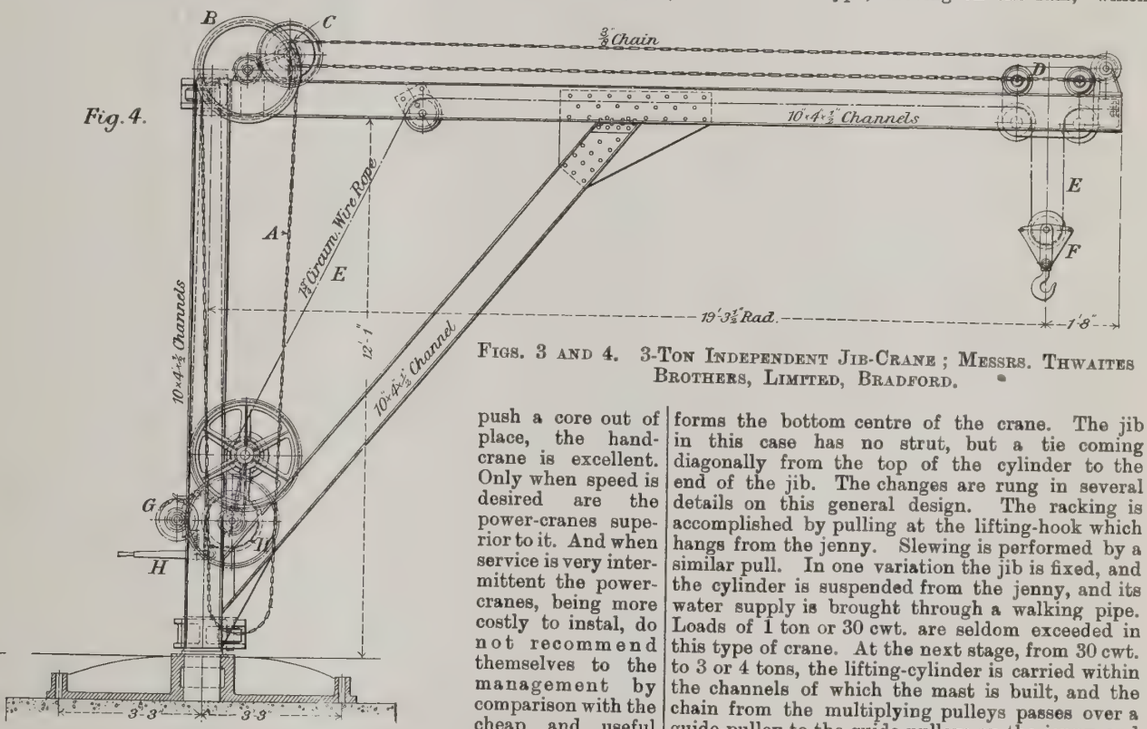


Fig. 4.



Figs. 3 and 4. 3-Ton Independent Jib-Crane; Messrs. Thwaites Brothers, Limited, Bradford.

actuating a pinion and curb-ring. The hoisting-motor is carried on a platform within the framework of the jib and mast, and the switch is located at one side of the mast within reach of the man. The virtue of a hand-lift has been already emphasised. It is therefore fitted to some electric cranes for the delivery of patterns and the turning over of boxes. It is put into and out of action by clutches, so that it or the electric drive can be instantly brought into operation.

The last type of jib-crane is the pneumatic. In this the hoisting cylinder is either carried vertically in the jenny along the jib, and the lift is direct, or it is disposed horizontally. The latter arrangement is often preferred because the headroom under the jib is not reduced by the hanging down of the hoist. These designs will be noticed more fully in the description of pneumatic hoists.

THE INSTITUTION OF MECHANICAL ENGINEERS

An ordinary general meeting of the Institution of Mechanical Engineers was held on Friday last, the 16th inst., at Storey's Gate, Westminster, the chair, in the absence of the President, Sir H. Frederick Donaldson, owing to pressure of Government work, being taken by Mr. Michael Longridge, Vice-President.

The Institutions' Battalion.

The formal business of the meeting having been transacted, the Chairman directed the attention of members to the battalion of engineers which it was proposed to form from the Institutions of Civil Engineers, Electrical Engineers and Mechanical Engineers. The original scheme had been abandoned, but a suggestion had later been received from the Admiralty that a contingent of engineers might be recruited for the Naval Brigade which was being formed. Men had been invited to enlist for this, and the number who had done so up to the 10th inst. had been 500, a fair proportion of members of the Institution of Mechanical Engineers having joined. Three among the latter had been allotted commissions. There were attached to that section of the Naval Brigade a certain number of navvies and artisans, the wives and families of whom were dependent upon the separation allowances, &c. It had been thought advisable to form a small committee to look after those families ; not as regards financial assistance, which would come from the proper funds, but to see that all those cases which needed assistance got it. That committee had been formed of two members of each of the institutions concerned, and at the Council Meeting that afternoon the Institution of Mechanical Engineers had appointed as their members Dr. Clerk and Mr. Patchell, who had had a good deal to do with the recruits. He trusted that the young men who had volunteered for service would all return safe and sound.

The Secretary then read the results of the ballot for the election of new members.

Refrigeration Research.

Sir J. Alfred Ewing, K.C.B., then presented a summary of the "Report of the Refrigeration Research Committee." This Report we commence printing in full elsewhere in this issue.

Before the discussion opened Professor C. Frewen Jenkin made a few remarks. He desired to apologise for an error which would necessitate reprinting the table relating to sulphurous acid in Appendix I. The data had been taken from Mollier's data instead of from Hybl's. The results should have been more carefully checked. We print this table in its correct form elsewhere with the Report. The data used for the charts and tables were known to be faulty, and there was therefore some doubt as to how valuable they really were. They had the advantage, however, that they were consistent, and if used by everyone, reasonable comparisons could be made. In the past, everybody had used data from different sources, making comparison difficult. It was very important that more accurate data should be obtained, and he hoped to do something in this way. He had already completed a small research on the density of brine, the first step for obtaining one set of the data required. A paper on the same subject had just been presented to the Institution containing the results of work done, he believed, by a student of the Liverpool University. Research was hampered at the present time. His chief assistants were absent on account of the war, as were also nearly all his students. The second Appendix was really a paper written by Sir Alfred Ewing. He thought it would be found the most valuable part of the Report. The whole of the theory was more clearly expressed in it than anywhere else.

The Chairman said the subject under discussion was of great importance. The need for some system of rating had been felt for a long time. Suggestions were made in 1906 that research should be undertaken. There had been various papers on the subject, the last, two years ago, being contributed by Mr. Anderson and Dr. Grindley. The Committee on the Efficiency of the Steam-Engine had had a difficult task. Refrigeration was an even more difficult subject, and it was surprising that in so short a time the Committee should have presented such a valuable report.

Mr. F. A. Willcox said that at the time of the papers by Mr. Anderson and Dr. Grindley, he had questioned the utility of a standard of refrigeration. He had since assisted on the Committee, and now agreed with the recommendation that a definition should be adopted. The unit would only be useful to those having sufficient knowledge to indicate the units of refrigeration required for any particular installation. There were two classes of users to be considered—the small and the large. The former generally required a machine as an auxiliary to a larger and more important process, and relied upon the manufacturer or a consulting engineer, or was protected by guarantees. The larger user was either himself an expert or employed a consulting engineer, maintained an expert of his own, or, again, relied upon the manufacturer. One result of the demand for a unit had been the evolution of one that was used in the United States of America and in this kingdom, but was not accepted on the Continent of Europe. That was the "ton of refrigeration," based on the latent heat of fusion of ice. The ton was the 2000 lb. ton, and the ton of refrigeration represented the amount of heat abstracted in forming 1 ton of ice in twenty-four hours, or 288,000 B.Th.U. To convert that into a measure of the capacity of a refrigerating-machine the American Society of Mechanical Engineers had attempted to define the limits of temperature, adopting 90 deg. Fahr. as the temperature of the refrigerating agent in the coils of the condenser, and 0 deg Fahr. in the coils of the evaporator.

One of the largest American makers of refrigerating machinery based their calculations on a temperature of 0 deg. Fahr. in the coils of the evaporator, with the water at 60 deg. Fahr. passing round the coils of the condenser, giving a condensing temperature of the refrigerating agent as 65 deg. A leading text-book issued in this country used 288,000 B.Th.U. per 24 hours while abstracting heat at a temperature of 32 deg. Fahr., the temperature of the water at the condenser being 60 deg. The performance of a machine might be described as so many tons of refrigeration, but no one knew the meaning of that expression. In other instances the term "tons of refrigeration" was used, though in one case the capacity of a machine had been worked out with water at a temperature of 75 deg., and in another with water at 50 deg. The unit proposed by the Committee had the advantage of complete definition. It had been suggested to him that if, in designing a machine, he knew the diameter of the compressor, the stroke, condenser and evaporator surface, &c., there was no advantage in the unit proposed. The unit proposed cooling the brine at 23 deg., whereas another installation might be worked with brine at zero. If the manufacturer stated the units of capacity of the machine, the designer might readily estimate the worth of another machine used for some other purpose, just as the steam engineer, knowing the indicated horse-power developed by an engine, and its revolutions, could form a good idea of the capacity of the engine. It would be a great advantage if the Committee's unit could be universally adopted. There should be no real difficulty in that, since the capacity was commonly expressed as a capability of abstracting so many thermal units from brine at a certain temperature, when the machine was supplied with condensing water at another certain temperature.

Mr. Wilfrid Stokes contended that the conditions of testing should be those met with in ordinary practice. The standard of cooling water was fixed at 59 deg. Fahr., a temperature which, he thought, was low. When higher temperatures of cooling water had to be contended with, the performance of the refrigerating-machine fell off, depending entirely upon the refrigerant used. A further complication arose with multiple-effect compression. At Messrs. Watney, Combe and Reid's brewery there was a large carbonic-acid machine working with water at 60 deg. That machine having been converted from ordinary to multiple-effect compression, the output was increased by rather over 50 per cent., the economy in power being at the same time 15 per cent. Supposing the purchaser of such a machine were desirous of comparing it with another machine working on the ordinary cycle, he would find that, with water at 90 deg., the increase in the output of the multiple-effect compression would be about 100 per cent. as compared with the ordinary cycle, the economy in power being about 50 per cent.

The unfortunate purchaser was therefore met by the complication that, taking the standard proposed by the Committee, he would not in the least know what to expect when working with a machine at a higher temperature, a temperature with which he might have to contend for several weeks or months during the year. The standard, to be complete, should include the performance of the machine at higher ranges of temperature for the cooling water. From his experience of CO_2 compressors, he found that the temperature of discharge of gas from a compressor had a very marked effect upon the production of cold by the machine. Sir Alfred Ewing had suggested that the most economical discharge temperature was when the gas was slightly superheated. He considered that it was a great deal higher than that. If no restriction were placed on the discharge temperature in this ideal cycle, he thought users would work with a much higher temperature than they should permit if the leathers were to have a reasonable life. For leather-packed pistons, therefore, to make the ideal cycle complete, the temperature of discharge should be restricted to that at which the machine might safely be worked over long periods.

The Report contained a slight reference to multiple-effect compression, although not under that name, and it was suggested that comparison should be made, when desired, between the standard cycle and the other cycle. He failed to see how that could be done, particularly as in Clause 7 of the Report the temperature of the refrigerant was to be taken immediately before and immediately after passing the expansion-valve. With multiple-effect compression there were practically always two expansion-valves. The multiple-effect system had been established in practical working for over a year, and had proved itself most economical and reliable, and without drawbacks, and he would urge the Committee to frame their regulations so as to include a comparison between the multiple-effect and the ordinary machine. He would be pleased to place at the disposal of the Committee a demonstration machine, if it would further matters, and also a considerable amount of data in his possession. It was suggested that the refrigerant leaving the condenser should be actually at the temperature of the cooling water. He thought it would be better in practice to allow 2 deg. difference, so that there might be some chance of heat passing from one to the other. Otherwise a little difficulty might arise.

Mr. Henry Brier remarked that the temperature which it was proposed to use with the unit—near freezing-point—would give the manufacturers of refrigerating machinery the trouble of using brine for only about 5 deg. below freezing. On the other hand, if it had been 5 deg. above freezing, it would have enabled them to work with water, which was much more sensible, and more reliable for calculating the thermal units. If taken below freezing at all, why not go down to zero, or the temperature at about which ice was made ?

It was habitual to work at 15 deg. to 17 deg. for ice-making, and if that temperature could be worked to, there would be a practical, valuable result for an ice-making firm. Taking machines used simply for water-cooling at about 40 deg., there would be no wish to go down even to freezing. Many units were at present used by refrigerating firms in which they tested only from 60 deg. to 38 deg., with cooling water at 60 deg. The "ton of ice" had been referred to as a unit. That was hardly ever used. All tests in the workshops were made in the British thermal unit. Would not three units be possible ? There might be a unit for cooling water, say 40 deg., the common temperature employed, down to 33 deg. for ordinary machines, and down to about 15 deg. Fahr. for freezing-machines, or even zero. Accord-

ing to the paper, indications of power might be taken from the compressor or from the steam-engine. He had been criticised for indicating his engine at the steam-cylinder. The recommendation left the ambiguity that the catalogue powers could be put forward as indicated power, either from the compressor or from the steam-engine. It would therefore become advisable to mention which was used, or the Committee should say which was to be adopted. It would be most valuable if some really reliable experiments could be made on multiple-effect compression.

Mr. Shinkles, of the American Society of Mechanical Engineers, who spoke next, remarked that the thoroughness with which the paper was presented and discussed had interested him, and had afforded him a basis for comparison with the manner in which such proceedings were carried on in the States.

Captain H. Riall Sankey remarked that a comparison of the thermal efficiency of a refrigerating-machine with that of the steam-engine had been hinted at. The steam-engine standard chosen by the Institution of Civil Engineers was the Rankine cycle, but there were differences. In Fig. 5 of the report a theta-phi or tau-phi diagram was given, which might be made to represent the Rankine cycle for the steam-engine. Starting at g, where the water began to be warmed in the boiler, heat was taken in as represented by the curve $g\,d$ and $d\,c$, at which point dry steam was formed. Continuing from c to b the steam was superheated, after which $b\,a$ represented adiabatic expansion. Back along the line $a\,g$ represented heat given up in the exhaust In the case of the refrigerator the process was reversed, the start being from a, going up to b, and so backwards. The difference arose at the point e, along the line $e\,f$; that marked what occurred at the expansion-valve. That part of the cycle was non-reversible; but in the case of the steam-engine the whole cycle was reversible. There was another point of difference. The Rankine cycle chosen was that which agreed with the steam conditions of the particular engine under consideration; if a superheated-steam engine, the temperature of the superheat was taken as the higher temperature, and the temperature of exhaust as the exhaust of the engine, whether non-condensing or at any particular degree of vacuum. Therefore the ideal engine chosen for comparison was one which might be called the actual engine idealised. In the case submitted by the report he understood that a particular range of temperatures had been taken to cover all the different temperatures of a refrigerater. Mr. Stokes had practically referred to the point in saying that the cycle adopted would not fit certain conditions. If the refrigerator standard cycle were made to fit the temperatures of the particular refrigerator considered, that objection would disappear. It might make the matter too complicated for refrigeration; he would offer no opinion as to that.

The Report referred to "relative efficiency" as the ratio between the efficiency of the actual refrigerator and the ideal machine. That he regarded as a ratio of efficiencies, not as a real efficiency. The same idea occurred in the case of the steam-engine; the thermal efficiency of the actual engine divided by the thermal efficiency of a corresponding Rankine cycle gave the "efficiency ratio," a term now used generally. The Committee might substitute "efficiency ratio" for "relative efficiency." He desired to congratulate Sir Alfred Ewing on the preparation of the Report, and particularly on Appendix II. In regard to the two forms of the diagram used, the tau-phi and the phi-I, he considered the former to give a better pictorial view of the heat quantities under discussion, but, in a case of actual calculation, he felt no doubt that the Mollier chart was the better one to use. He had formerly prepared a diagram showing what became of the heat units produced in the furnace in the case of a steam plant. It took the form of a stream of water divided into several branches. One showed the loss in the flues; another the heat going through the steam-pipe; another the heat lost in the exhaust; and, finally, a very small stream showed the heat usefully applied in the engine. He thought a similar diagram might be prepared for a refrigerating-machine. He would see whether this could be done, and if so, would add it in a written contribution to the discussion.

The Chairman, before calling on Sir Alfred Ewing to reply, announced that the Report would be read and further discussed at a meeting of the Institution which it had been decided to hold at Manchester on Tuesday, the 20th inst., in the Portico Library.

Sir Alfred Ewing, in replying to the discussion, observed that many of the friendly comments made were useful and apposite. It was a fact that the performance of a machine fell off as the cooling water became warmer, and consequently any statement of rating for one particular temperature of cooling water, or even a particular temperature of the cold body, ceased to apply to different temperatures of one or the other. For any expression of performance it was necessary to assume four temperature differences between which the machine was to work. There was no avoiding that. It would undoubtedly be a great advantage to go a step further and say that when a machine had been rated as of so many units capacity under particular conditions, it could then be inferred that it would be of so many units capacity under other conditions. It would, however, probably be impracticable to go so far without a great deal of experiment. For the full rating of a machine a whole family of curves would be needed, and not the statement based on an individual unit. These curves would have to express the performance of the machine with all sorts of temperatures, both at top and bottom. The unit was, however, better than nothing. It gave a definite figure of performance for one particular temperature condition; that was the full length to which the Committee were prepared to go on the rating question.

He would draw attention to a phrase in the Report bearing on that subject. Their second recommendation suggested that the refrigeration might be stated for particular conditions, or for standard conditions. It was open to the manufacturer to take other conditions than those specified in the Report, and say:—"With these temperature conditions, my machine is capable of doing a certain number of units of refrigeration." That was an intelligible statement, provided the temperature conditions were definitely stated. The report did not exclude that possibility, although it considered it advantageous to take as far as possible one definite set of temperature conditions, as laid down in the report. Another point referred to by Mr. Stokes was the degree of dryness or wetness in the working substance in compression as affecting performance. Mr. Stokes had said that he thought something more than a trifling amount of superheat was desirable. That was perfectly correct. Probably he thought better results would follow with a drier compression than that indicated in the report. The subject had only been touched in relation to the ideal performance in the adiabatic compressor. In such a case, with no exchange of heat between the working substance and the metal of the cylinder, nearly wet compression was the most efficient. That was perfectly consistent with the fact that in practice, where there was such an exchange of heat, dry compression was preferable, since it had the effect of limiting the exchange of heat. That was an altogether different point.

The Report spoke of the ideal cycle under theoretical conditions only, or conditions of adiabatic compression, when, as the Appendix to the Report showed, wet compression was ideally the best.

On first reading the Report it might be difficult to bear in mind that the two parts of the Report dealt with two entirely different things. The first part was concerned with the practical working of refrigerating-machines; the second part with the working of the ideal refrigerating-machine.

The advantages of multiple or compound action were undoubted. The Committee were, however, endeavouring first to lay down a manner of rating that would apply equally well to a multiple or compound machine as to a simple machine; the multiple machine worked between definite limits of temperature just as the simple machine did. The recommendation of the Committee was rather to the advantage of the multiple machine, because it indicated that comparison was to be made between the actual machine (and all the advantages that were given by multiple action) with the ideal simple machine. Consequently a better comparison was obtained, as far as efficient action was concerned, than if an ideal cycle were laid down of the same type as that which the multiple machine actually performed. By taking a simple cycle for the ideal action the multiple machine had all the advantage. The multiple machine being, as he believed, more advantageous than the actual simple machine, it would the better compare with the ideal cycle on the basis of the simple machine. Mr. Brier's remarks concerned the same question, to some extent, as Mr. Stokes's observations—namely, the rating with reference to definite statement of temperatures.

Mr. Brier had asked whether there could not be three units applicable to three different conditions of temperature. There could; indeed, there might be three thousand, because all sorts of ranges of temperature at top and bottom had to be considered, each giving a different unit. But multiplication of units, even to the extent of three, would repel the user by complication; the user would not know which applied to his particular wants. Better, therefore, to begin with one unit of rating, and see what the results were. The Committee had taken a range of 0 deg. to −5 deg for the brine. Mr. Brier had urged something higher, and again something lower, stating that with something higher the use of brine could be avoided in testing, while something lower gave results in better accordance with the ordinary practice of the ice-maker. The temperatures taken were in general agreement with the practice of persons concerned in keeping rooms cold, &c., and were in general agreement with the temperatures discussed for the same general purposes by other bodies interested.

Mr. Brier had also referred to the question of how the power expended in compression was to be measured. The report said the power expended in compression might be measured in two ways—either by indicating the compressor, or, if driving by steam, by indicating the steam-engine, or taking the brake-power of that engine; or, again, if the driving were electrical, by measuring the exact electrical input to the motor. Indeed, there were several ways in which the net or gross power expended in compression could be measured. That, however, did not affect the question of rating; it came into question only when working out the practical efficiency of the machine for the purpose of comparing that with the efficiency of the ideal machine. It was not feasible, he thought, to escape from the possibility of makers or users sometimes measuring the efficiency in one way and sometimes in another. In some cases the only practicable method was to take the indicated power of the compressor; in other cases it was valid and possible to take the external power applied to the compressor and measure that. There would be no ambiguity, so long as the report of the test made it clear which measurement was used. In any case, it did not affect rating.

He agreed with Captain Sankey's criticism of the use of two terms to express one idea. The use of the term "relative efficiency" was really an oversight; the expression "efficiency ratio," used in relation to the steam-engine, had been overlooked; if it had been remembered, it would most probably have been used. Perhaps it might not be too late to introduce it now. He agreed also as to the relative advantages of the graphic diagrams. Captain Sankey had assisted in creating a partiality for the entropy temperature diagram, but when anyone had once become familiar with the Mollier chart, he thought he would have no doubt as to its superiority in practical use.

The Chairman then announced that the next ordinary meeting of the Institution would be held on Friday, November 20, when a paper on "The Effect of Vacuum in Steam-Turbines," by Mr. G. Stoney, of Newcastle-on-Tyne, would be read and discussed.

The meeting having terminated, a meeting of the Benevolent Fund of the Institution of Mechanical Engineers was held, as reported on another page of this issue.

The Manchester Meeting.

As announced by the Chairman at the meeting held in London on Friday last, a meeting was held in Manchester on Tuesday, the 20th, for the purpose of further considering the Report of the Research Committee on Refrigeration. Such a meeting is, of course, somewhat unusual for the Institution, but it will be remembered that a very successful one was held last winter, also in Manchester. The Council, as is well known, has been endeavouring to make the Institution more useful to provincial members, and, with the last notices and issue of the journal, post-cards were sent out asking members if they would like the Report of the Refrigeration Committee to be discussed in centres outside London. The demand from Man-

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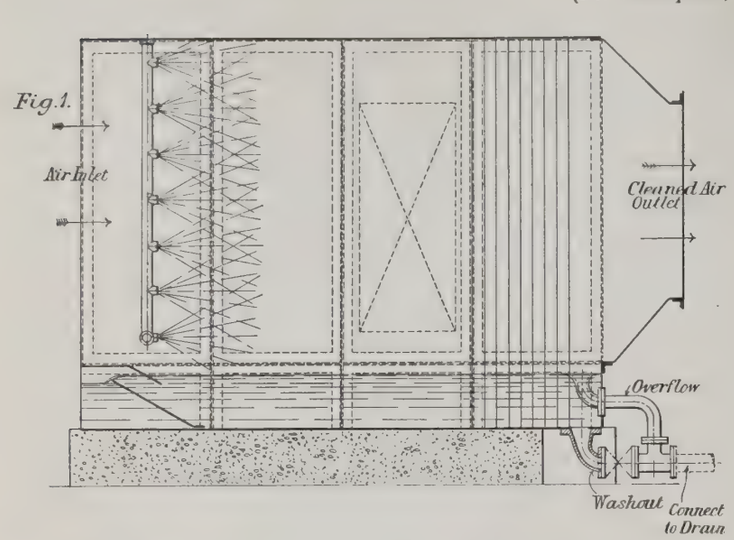

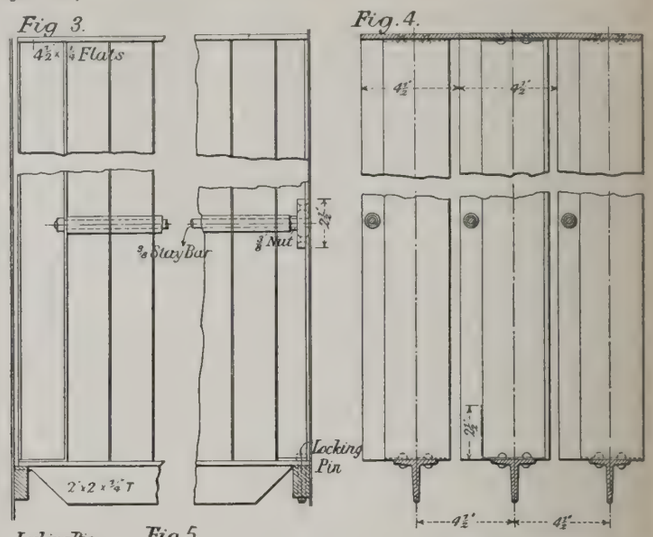

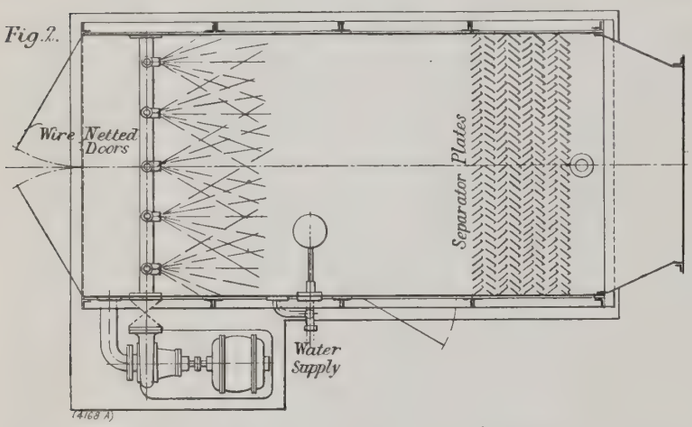

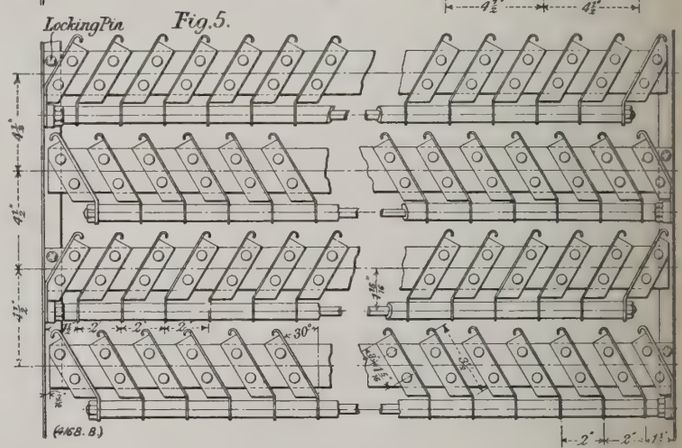

chester seemed to warrant holding a meeting there, and it was consequently held in the Portico Library, Mosley-street, at 8 P.M., on Tuesday last, Mr. R. Matthews, Member of Council, occupying the chair.

In opening the meeting, Mr. Robert Matthews explained how it was he came to occupy the chair. Dr. Hopkinson was unable to be present. Mr. Michael Longridge was absent from Manchester owing to ill-health, and Mr. George Hughes, who had promised to take his place, had been called up to London the day before on urgent Government business. Although he (Mr. Matthews) also had had other work, he felt, when he was asked to preside at the meeting, that it was his duty to do so, but owing to the short notice he was sorry that he had not been able to prepare himself adequately for the task. The paper dealt with a matter of immense interest to Great Britain. The importation of meat was of vital interest to all of us. Thirty-three years ago he had been interested in the Giffard machines and had equipped steamships with cold-air machines. That, of course, was a thing of the past. The compressed-air machines had been replaced by the more complicated and highly scientific machines now in use. He had omitted to mention that Mr. Wemyss Anderson much regretted that other work prevented him from being present that evening.

The Secretary, Mr. E. Worthington, then read the Report of the Refrigeration Research Committee, remarking that he regretted that no member of that Committee had found it possible to be present. The Committee, he explained, was thoroughly representative. On it were gentlemen representing the theoretical side, the industries concerned, the great ports, and the various types of machines in use. At the conclusion of the Report, Mr. Matthews called upon Mr. G. Daniels—who had had connection with the work of the Committee, and was connected with the refrigeration industry in Liverpool—to open the discussion.

Mr. Daniels said that he was afraid he was a poor substitute for Mr. Wemyss Anderson, to whose paper of two years ago the Report was largely due. There were two reasons for putting forward the cycles suggested in the Report:—(1) The scientific reason, and (2) the requirements of the practical man. A man could send out a specification for a steam-engine, and would in response be sure of getting a properly-rated machine. That could not be done at present with refrigerators, owing to the variety of units in use. The proposed unit did not depart far from one already in use. The Committee wanted the views of members as to the suitability of the one they had settled upon. Then at present there was no standard cycle. The Committee had put one forward. Captain Sankey had suggested in 1912 that any cycle adopted should fulfil three requirements: it should be ideal, simple, and should follow as near as possible the cycle of operations of the actual machines. The cycle adopted satisfied these points. Mr. Daniels then proceeded to explain the use of the charts accompanying the Report, and further explained that while the cycle chosen was ideal, it would not necessarily suit the conditions demanded by the practical man. It was, for instance, possible, under some conditions, to get greatly improved results by working away from the theoretical cycle. Speaking as a representative of makers of refrigeration machines, he could say, however, that they were quite prepared to take up the units and cycle which the Committee proposed.

Mr. J. Butterworth said that, unfortunately for the discussion, refrigeration had been practically dropped in the Manchester district. He had taken an academic interest in the matter, and had tested both carbonic-oxide and ammonia machines, and had done a good deal of repair work on them, &c. He had come to the conclusion that there were so many wrinkles and dodges connected with the practical side of the working of such machines that the question of a unit was of comparatively little importance. For instance, with regard to brine. Brine was an excellent thing, but on shipboard it was the worst thing to use. What was wanted was direct cooling. If the frost were kept off the pipes, better results would be secured. Wrinkles in working, and good workmanship, meant more than units and standards. In Manchester they could turn out practical jobs, and there was now a possibility, he understood, of Manchester firms taking up the manufacture of refrigeration machinery. The proposed unit would probably be adopted, but the works would see to it that the job was turned out properly.

Mr. E. Worthington said the Committee was well aware that in all machinery a great deal depended upon wrinkles, because bad handling and workmanship would result in the loss of everything that it was hoped to gain by correct theory. Sir Alfred Ewing laid stress upon the fact that the standard was a thing which did not actually exist. It was an ideal adopted for comparison purposes.

Mr. A. Saxon, who followed, welcomed the Report and the policy of reading it in Manchester. It followed, he imagined, upon the very successful meeting they had had last year, and he felt that, if they were silent on the matter, it might be taken to mean a lack of interest. Without much knowledge of the subject, he was glad to have the Report, as a wide fund of information was valuable to the engineer. The subject of refrigeration was important. Some well-known firms specialised in the matter, and wanted, he thought, to be a kind of law unto themselves. He did not agree with the views of the last speaker but one. There had been room for research, and he complimented the Committee on their findings. The ideal unit was certainly wanted, and he thought it time that what he might call the haphazard and hit-and-miss methods at present in use should be abandoned. The Committee should continue its work, and follow up its inquiry for the data still wanted.

Mr. C. W. Hunt, although not connected with the Institution, being a member of the Manchester Association of Engineers, welcomed the discussion of papers of the Institution in Manchester. He was

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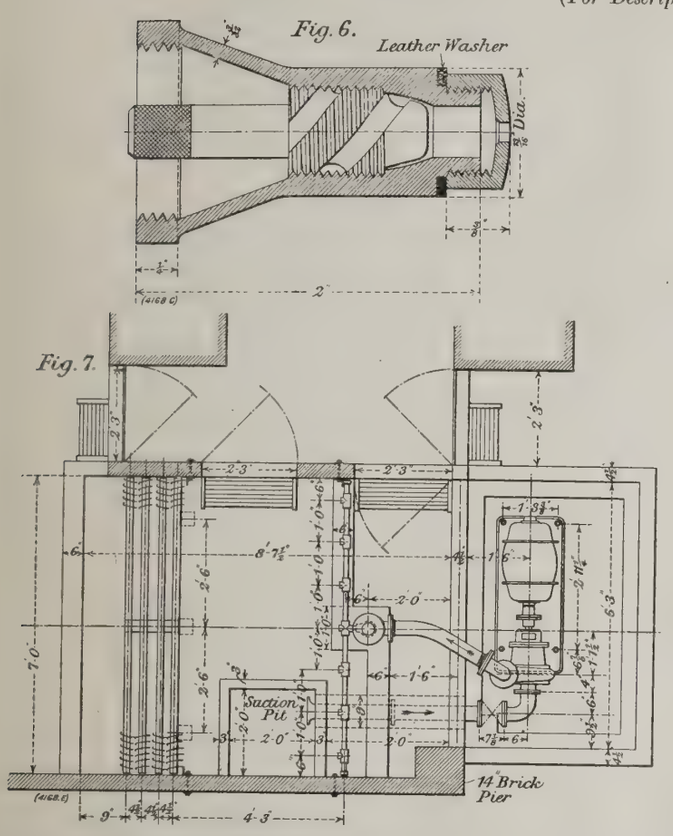

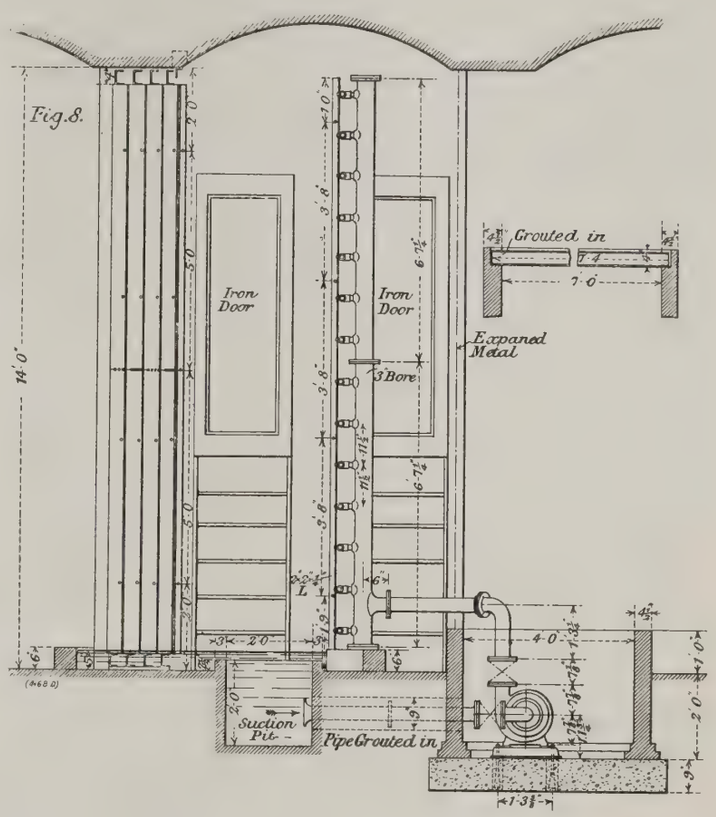

a student in the matter of refrigeration. He had had experience in South Africa, where the matter was one of great importance, as it was elsewhere in hot climates. It was excellent that relative values should be assessed in the manner accomplished in the Report, and he thought the values given should be adopted. He would like to go a step further. Could not the values proposed be given an official status? The authorities drawing up the Report were the highest possible, and if their findings could be adopted by the State, it would be of value to the whole world. They would be more widely recognised.

Mr. Drummond Paton said the whole matter of refrigeration was one of the transfer of heat. Had any data been collected with regard to the transfer of heat from the gases under different conditions? He would like information with regard to the coefficient of heat transmission under different conditions.

Mr. Robert Matthews said, with regard to remarks on wrinkles and dodges, there had been a lot of trouble with the early Giffard machines. The first patent for a cold-air machine was, he believed, taken out by Sir W. Siemens, in 1856; but the matter lay dormant long after that. In the Bell-Coleman system the attempt was made to compress the air isothermally by injecting water into the suction. The system appeared satisfactory from the labour-saving point of view, but it had the drawback that ice and snow formed, and cut the slide-valve badly. In an early patent taken out by himself he had got over the injection trouble by jacketing, but ran the risk of freezing up his water-jackets. The valves were also jacketed, and the snow in the cylinder was reduced. He also used Corliss valves under the cylinder, and the piston raked the snow and ice into the valve-pockets. They never lost a cargo in the ships which adopted those machines. The Giffard machines came later, and then Linde introduced the chemical systems. These made headway very slowly, because a burst pipe or other defect might cause a lot of trouble, and heavier insurance had to be paid on cargoes cooled by such machines. As workmanship, &c., improved, these points, of course, were more easily coped with.

Mr. Daniels, in reply to the discussion, said that the argument that units were no good because of the greater effect of bad workmanship, could be applied to all classes of machines, as, for instance, the gas-engine, which could be greatly altered by little adjustments; yet units were not discarded for that reason. The use of brine in ships was dictated by practical requirements. With brine they had a reserve of cold. If direct expansion were adopted, there was only a small quantity of vapour in the pipes, and if the machine varied, the temperature would rise quickly. Brine enabled a uniform temperature to be maintained The Centigrade degree had been chosen with a view to the universal adoption of the unit. A great deal of data on heat transmission was in the hands of makers, but it was regarded as secret. Figures were given, however, in Mr. Anderson's paper. From these it appeared that about 100 or 150 units per hour could be transmitted per foot of 1-in. wrought-iron pipe. The unit would undoubtedly be useful. At present there was nothing parallel to steam-engine practice, and, with such different systems of rating, prices obtained in tenders were no guide.

Mr. R. Matthews then called upon the meeting to pass a vote of thanks to Mr. Daniels for explaining the Report, after which he asked for suggestions as to a convenient date for the next Thomas Hawksley lecture, to be given in Manchester. It would be delivered by Mr. W. J. Bryan. The date proposed was either November 3 or November 6. He also added that members had requested that the Report on Refrigeration should be read in Manchester. Liverpool members had also asked for a meeting, but the number of requests from Manchester was the larger. He could not help thinking that if it had been read in Liverpool instead, it might have been better discussed. The meeting then terminated.

THE BENEVOLENT FUND OF THE INSTITUTION OF MECHANICAL ENGINEERS.

The second general meeting of the members of the Incorporated Benevolent Fund of the Institution of Mechanical Engineers was held at Storey's Gate on the 16th inst., immediately following upon the conclusion of the ordinary general meeting of the Institution reported elsewhere. The chair was taken by Mr. Mark Robinson, in the absence of Sir H. Frederick Donaldson.

The Secretary read the notice convening the meeting and also the minutes of the first general meeting held on October 24, 1913. The Chairman then directed attention to the fact that the accounts in the report of the Committee of Management, which had been issued to members, and was now submitted to the meeting, related only to 1913. Certain small grants had actually now been made.

The Chairman then proposed for election, to fill vacancies arising from the retirement and death of certain members of Committee, the following gentlemen, namely:—Sir Robert A. Hadfield, D.Sc., &c.; Dr. William H. Maw; Mr. James N. Paxman; Mr. Charles Wicksteed. Mr. W. Patchell seconded the proposal, which was put to the meeting and carried unanimously. The re-election of Mr. Arthur Huson as Honorary Treasurer was then proposed from the Chair, was seconded by Captain Sankey, and carried unanimously. The Chairman further proposed the re-election of Mr. Edgar Worthington as Secretary to the Fund. This proposal was seconded, and carried unanimously. It was then proposed by Mr. Oxley, and seconded by Mr. Patchell, that Mr. J. P. Maginnis and Mr. Sidney Sharp should be re-elected as honorary auditors. The proposal was carried unanimously.

The Secretary then proceeded to explain the accounts, pointing out that certain figures had to be added thereto to bring matters up to date. Since, for instance, the date at which the total of 3855*l.* 6s. 8d. for donations, subscriptions, &c., was reached, the funds had increased by 1667*l.* in donations and 191*l.* from annual subscriptions. The total number of ordinary members was at present 120. The Committee urged an increase of these members. A carefully-prepared form of application for benefits was now available to any member of the Benevolent Fund. One of the supporters had to be a member of the Institution or a well-known public personage, and, without exception, one must be a member of the Fund.

The Chairman, commenting upon the figures, urged that every endeavour should be made to

increase the number of annual subscribers; the figure of 120 being very small relatively to the number of members of the Institution. Mr. Edw. Batten considered the fewness of subscribers to be disappointing. He felt that it would be a help if some indication could be given of the need for the fund. If a large number of members gave even a very small subscription, it would produce a considerable annual income. He was confident that if the actual need was known, a large number of subscribers would come forward. In reply to this, the Chairman remarked that members had been freely circularised as to the need for the fund. It was not imaginable that the funds could be in excess of requirements. Small grants had already been made (out of accumulated interest) in deserving cases, but with a total income approaching only 500*l.* a year, even the humble efforts at relief already attempted would be impossible unless further support was given to the fund. Mr. Michael Longridge thought it would help matters if the Committee stated from time to time the amount needed to treat adequately cases coming under their notice.

The Secretary pointed out that although the voting power belonged to the 120 members mentioned and donors of 10*l.* 10s. and upwards, quite a large number of persons had donated less than 10*l.* 10s. The number of contributors was therefore much greater than the number indicated by the voting members. Captain H Riall Sankey agreed that a small sum per member would produce a considerable sum per annum. If it were known that a sum of even 2s. would be received, there would probably be a great many more subscribers. The Royal Engineers had a similar fund, the subscription to which was limited to one day's pay, which in the case of subalterns did not amount to much. The total, however, represented a good sum.

Mr. W. H. Patchell did not consider that adequate treatment could be given to the business before the meeting at the hour and occasion selected, and hoped that some more suitable time might be chosen for future meetings. The proceedings terminated with a vote of thanks to the Chairman.

WET AIR-FILTERS.

Wet air-filters of one kind and another have been in use for many years for cleaning and purifying air for large buildings, and in conjunction with humidifying plants for the textile industry. A more recent development is in connection with the ventilating air supply to electrical machines, particularly turbo-alternators. The first practice with such machines was to employ dry filters, and they are still very largely fitted, but during recent years the wet filter has been used for the same service. Both types are satisfactory, and there is no need that we should attempt to make the special case of one or the other. We may say, however, that, other things being equal, in the case of a machine up to about 3000 kw. capacity the dry filter will in general be the cheaper in capital cost. From 3000 kw. to 5000 kw. the costs will be about equal, and above 5000 kw. the wet filter will be the cheaper. In all cases the upkeep costs of the dry filter will probably be higher, owing to the necessity of cleaning, and at times replacing the cloth filtering medium. In smaller sizes this greater upkeep cost will not necessarily outweigh the capital saving on the dry filter. The running costs of the wet filter will usually be higher, since it must include some pumping system for the circulation of the cleaning water. There is no corresponding power expenditure for the dry filter. Taking everything into account for a 3000-kw. set, there is little to choose on the score of cost per annum between the two types.

Messrs. Balcke and Co., Limited, of Broadway-court, Broadway, Westminster, London, S.W., who have long made dry filters, have recently introduced a wet type, and two characteristic examples, together with some details, are illustrated in Figs. 1 to 8, pages 500 and 501. The filter may be used for electrical machines, or for general air-cleaning, and examples of both applications are illustrated. Figs. 1 and 2 show the standard form of filter which would normally be employed for a turbo-alternator. As will be seen, the arrangement is very simple. The filter consists of a rectangular iron box, galvanised after construction, containing a series of water sprays at one end, and a series of baffle-plates at the other. Each end of the box is open, the air entering at one end and leaving at the other. The inlet end is furnished with perforated doors or louvres to admit the air freely, and to prevent interference with the spray-nozzles. The outer end is formed to fit an air-duct which would carry the cleaned air away to the machine. The bottom of the box forms a water-tank, and the same water is used over and over again, being circulated by means of a small motor-driven centrifugal pump. The pump draws from a sump at the back end of the filter, which is separated from the main part of the tank by a sloping partition. A baffle-plate overlaps the partition. The flow of water towards the sump is very slow, so that all impurities, except the most minute, settle to the bottom of the tank without getting into the sump. Floating particles are stopped by the baffle.

The tank is provided with an overflow and a make-up supply fitted with a ball-tap, which keeps the level correct. A cock and wash-out connection to the drain are fitted at the front end, and all that is necessary for cleaning out is to open this cock and flush the tank down with a hose. The arrangement of the baffles can be seen from Fig. 2, while details to a larger scale are given in Figs. 3 to 5. As will be seen, they consist of a series of galvanised-iron strips set at 45 deg. to the longitudinal centre-line of the filter, alternate rows being set in opposite directions. Each baffle is provided with an upright channel at its back edge, into which the particles of moisture and impurities are thrown and drain to the bottom of the filter, preventing any deposit being carried through from one row of baffles to the next. The arrangement is built up of strips bent over and riveted to a T-iron bearer at the bottom, and the case at the top, and stiffened with through-bolts and pipe-washers. Details will be clearly understood from Figs. 3 to 5.

The spraying arrangement consists of a horizontal pipe connected to the pump delivery, and leading to a series of vertical risers, to which the nozzles are fitted. The nozzles are of the type illustrated in Fig. 6. They are of gun-metal, and do not easily choke. If necessary, access may be had to them through the inlet doors while the filter is working. It will be clear that the fine spray thrown by the nozzles opposes no resistance to the flow of the air through the filter, but, on the contrary, assists it, and eases the load on the generator fan. The air resistance of the filter when working is equivalent to about 2 mm. of water. This is, of course, constant, and compares with a resistance of 1 mm. for a dry filter when first cleaned, rising to 6 or 8 mm. when dirty. Experience has shown that the baffling arrangement is so effective that even on continued overload no free moisture has ever been found to pass the next to the last set of baffles. The last set is fitted as a final and almost unnecessary precaution. The usual speed of air through the filter is about 10 ft. a second.

Our remaining two illustrations on page 501, Figs. 7 and 8, show a filter recently installed by Messrs. Balcke in connection with an ozonising plant for the Baker Street and Waterloo Tube Railway. The arrangement and proportions of the plant differ from those of that shown in Figs. 1 and 2, but in all essentials the two filters are the same, and no detailed description of Figs. 7 and 8 is necessary. The filter, as will be clear, is a large one. One point which may be noticed is that fewer baffles are used than in the standard filter we have described. This is on account of the different class of work for which the second plant is intended. Being installed to clean air for a railway, it is less essential that no free moisture should get through than is the case for an electric generator. Advantage has accordingly been taken of this fact to omit some of the baffles and build a slightly simpler and more compact plant.

INDUSTRIAL NOTES.

The General Federation of Trade Unions has just issued a manifesto, of which the following is an abstract:—

"In Germany and in Austria, and also in the neutral States of Europe and America, persistent attempts are being made to misrepresent the attitude of the British Labour movement towards the Government, and towards the crisis through which Europe is passing. Extracts from speeches and cuttings from newspapers are collected, and conclusions drawn which cannot be justified by facts, and which do not represent the real opinion of the British working-class movement.

"Under such circumstances, an organisation like the General Federation of Trade Unions, which represents, and is to a great extent interested in the financial stability of, 1,006,904 trade unionists, must remove all doubt concerning its own position and intention.

"It cannot better begin this task than by stating that it is, and always has been, on the side of international as well as industrial peace. It has consistently tried to develop fraternity between peoples of different nationalities; it early identified itself with the international trade-union movement, attended its congresses, contributed to its upkeep, and endeavoured to extend its influence. With the General Federation and its members, faith in the common interests of working humanity, and determination to advance them, was warm and strong, while the possibility of war was regarded as one regards the shadow of an indescribable catastrophe.

"The Federation entertains no delusions concerning the consequences of war, or the share of these which the class it represents will bear; and in placing its position before the world it is actuated only by the desire to prevent misapprehension, and to secure effective national and ordered consideration of all those interests it directly or indirectly represents.

"To fully analyse and discuss the causes of the war and the responsibility for its outbreak is beyond the intention of the Management Committee. Sufficient for the moment to say that, in the opinion of millions of trade unionists, the responsibility for the war does not rest upon the policy or conduct of Great Britain.

"This opinion is supported from our own side by documentary evidence, and by the fact of our own unpreparedness, and from the opposing side by the utterances of their soldiers, their statesmen, and their teachers, and by their terrible and immediate capacity for striking effective and terrorising blows.

"Of this capacity to strike the Press of the world has, since the beginning of August, borne daily testimony. The intention to strike whenever and wherever opportunity offered has been openly and generally expressed, and was facilitated by the fact that the German army is in effect always mobilised.

"Concerning the preparations for war it is difficult, and perhaps futile, for the non-military mind to speak, but even to the non-military mind the feverish activity of men who during June swarmed and worked like ants on the strategic railways of Germany had a sinister significance and strengthened the impression that, however peaceful the desires of the German people might be, their masters had already determined on war.

"It is obvious that the immediate participation of Britain in the war was neither desired nor expected; her day would gladly have been postponed. Loyalty to herself, to her best traditions, and to her treaty obligations made abstention from the conflict impossible, and to-day her people, especially her work-people, are determined to support not only the neutrality of heroic Belgium, but the honour of nations and the inviolability of treaties.

"Once involved in such a war, the duty of the movement stood out clearly. It became necessary, apart from all personal considerations of friendship, to offer the fiercest resistance to the aggressor, and to make any sacrifice necessary to bring the war to a definite and honourable conclusion; to join with others in making the fullest provision for this policy; to see that the political circumstances arising were used to develop and broaden national life and outlook, and particularly to insist that the economic and moral disabilities of war should not fall altogether on the shoulders of the poor.

"A real love of country inspired the leaders of the people to ask of the manhood they represented the greatest of all sacrifices. In acting so there was no desire to arouse or develop racial animosities, but there was a general determination to prevent in this country the outrages on women and children, and the massacres and burnings which have desolated both Belgium and Northern France.

"Not less imperative than the problems of national defence are those problems which affect the political and economic life of the State during the war, and which will continue to affect it long after the war is over. The consideration of these does not imply hostility or lack of patriotism; it simply indicates foresight and a desire to turn the extraordinary circumstances of the war to national account. Some of the problems which affected transport and the public services have been dealt with on communal lines. Under the stress of war, the Government assumed control of the railways and fixed maximum food prices; the impossibilities of years became actualities in an hour when the alternative was national disaster. The lessons learned in the hour of danger must not be lost, but improved upon, and return to anarchic methods must be strenuously fought. If railways can be nationally and effectively controlled, co-ordinated, and worked under abnormal war conditions, they can be so dealt with under the easier conditions obtaining in times of peace.

"War has compelled the Government to give practical effect to the admission, long made verbally, that the State was responsible for the physical efficiency of its units, and measures of relief have been planned. The Management Committee is certain that these measures are altogether inadequate, and cannot meet the situation. The Management Committee also insists that works of relief must be also works of utility. Nothing so discourages men as to find that their work is without intrinsic value or use; nothing so infects so-called "relief" with the taint of pauperism. The pamphlet on "Unemployment," published by the Management Committee in 1911, suggests examples of useful and co-ordinated work.

"The Government has paid for the material things

THE COAL-HANDLING PLANT ON THE UNITED ST

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Fig. 2.

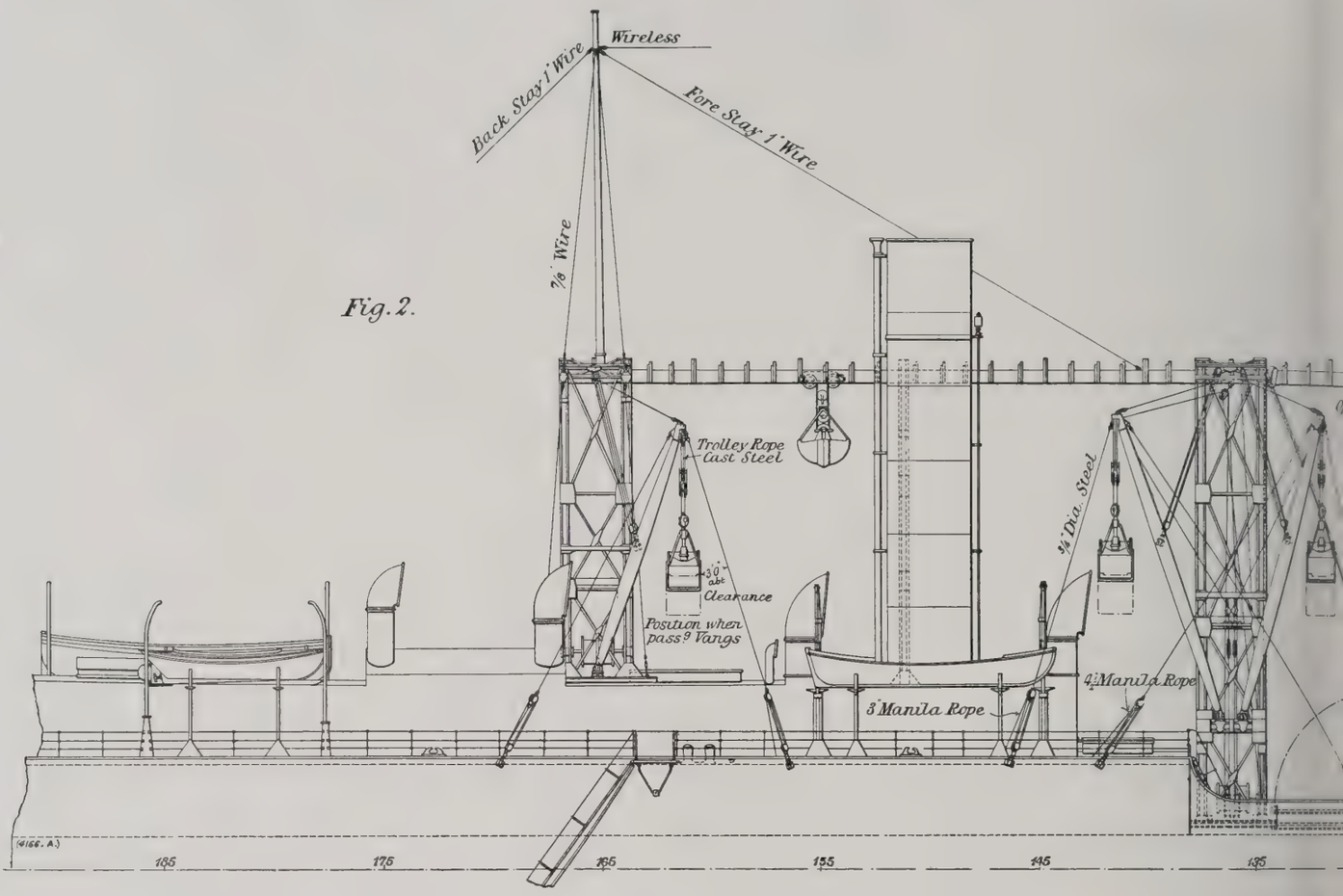
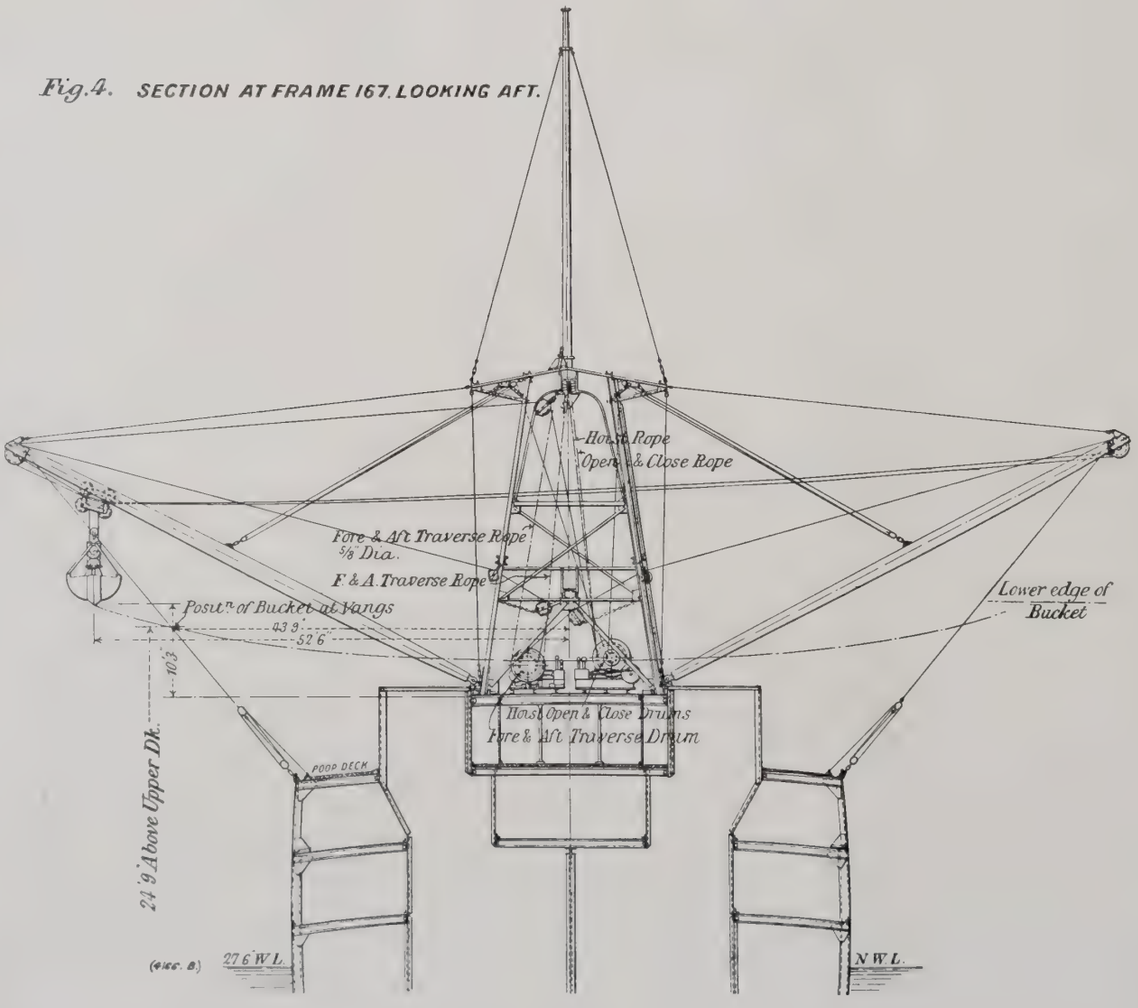
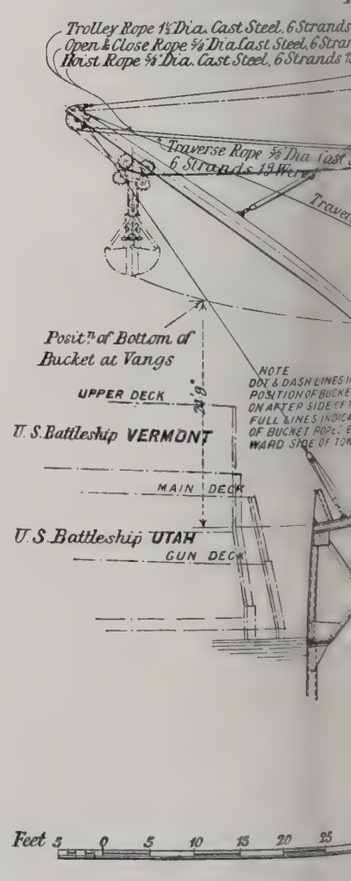


Fig. 4. SECTION AT FRAME 167. LOOKING AFT.




Trolley Rope 1¼ Dia. Cast Steel, 6 Strands
Open & Close Rope ⅝ Dia. Cast Steel, 6 Strand
Hoist Rope ¾ Dia. Cast Steel, 6 Strands
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ECTRICALLY-PROPELLED FLEET COLLIER "JUPITER."

(p. 503).

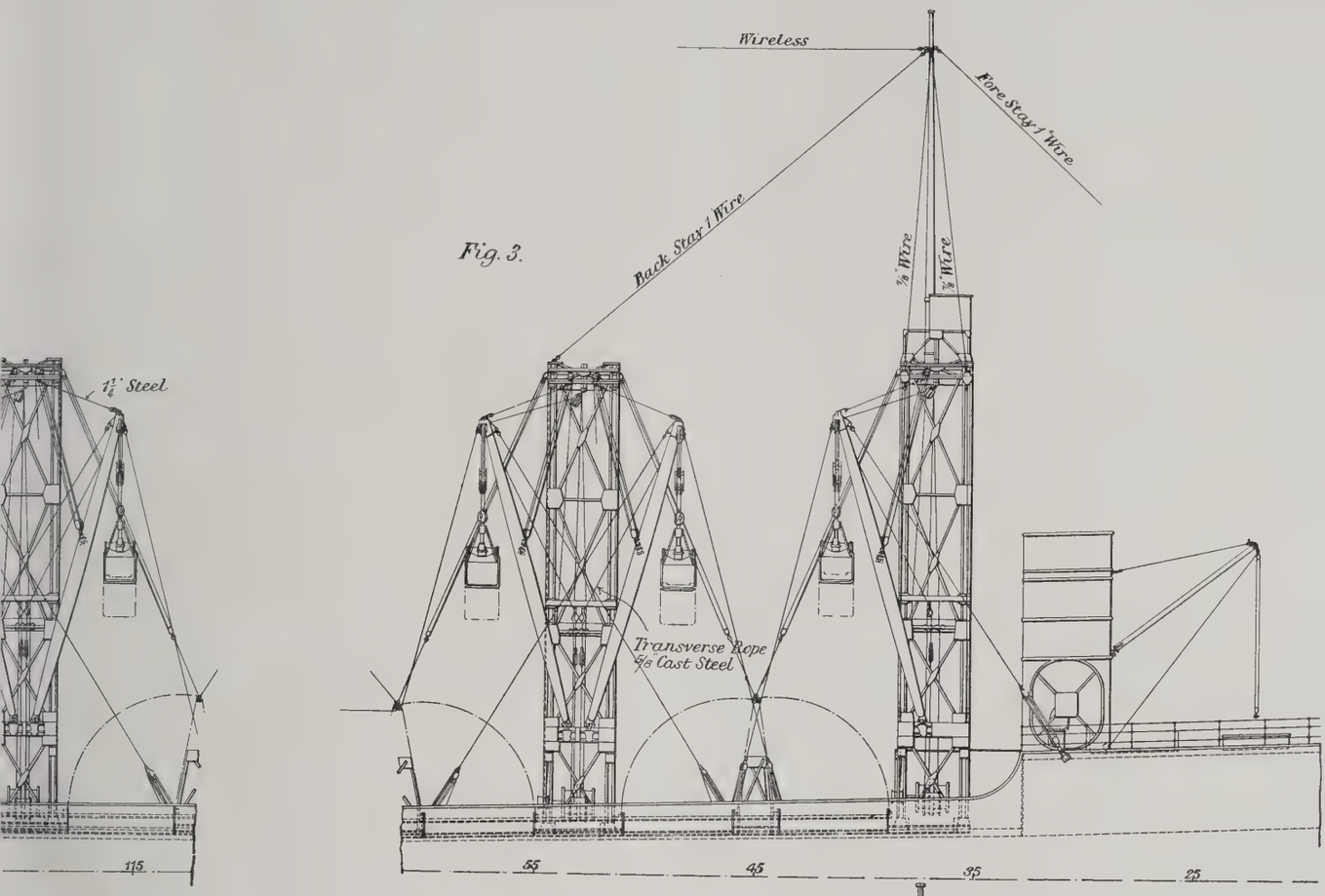


Fig. 3.

FRAME 98 LOOKING AFT.

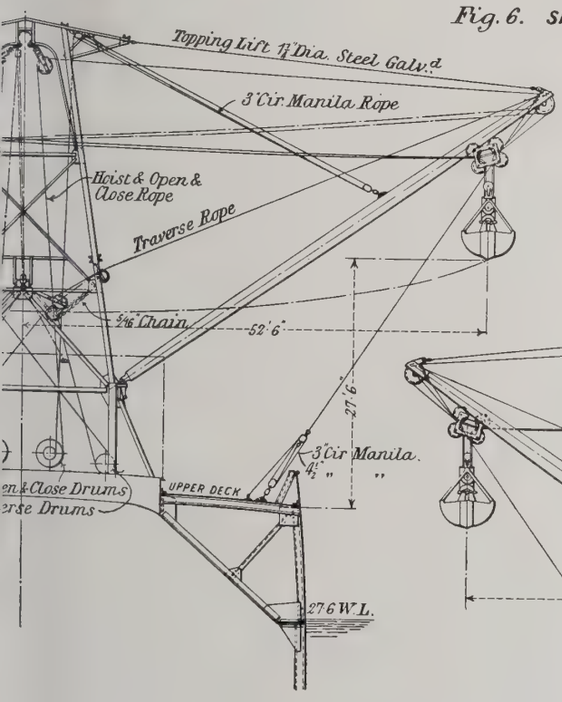
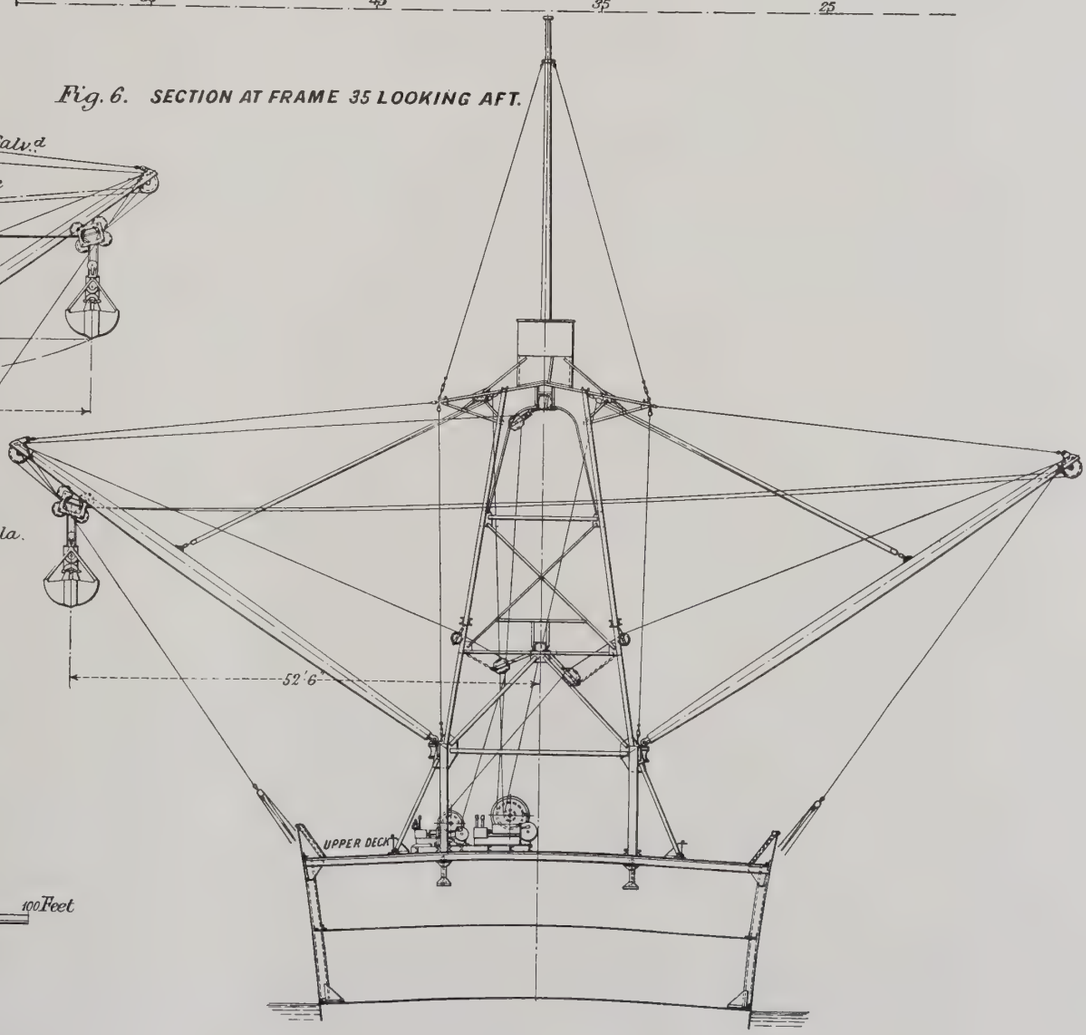


Fig. 6. SECTION AT FRAME 35 LOOKING AFT.



it required for the war, it has extended its financial assistance and credit to banks and private concerns, and it would act illogically if it hesitated to meet the demand for payment for that human element, without which States cannot exist or wars be made. Surely if the human element voluntarily places itself at the service of the State, it is the duty of any Government to pay for this at least as fairly as it paid for its coal and its corn.

"Great Britain is the richest country on earth, yet she largely depends upon charity for the care and comfort of her discharged soldiers and sailors. The biggest effort yet made in this direction is totally inadequate; even the Prince of Wales's Fund, large as it seems to the thoughtless, can only relieve a tithe of the distress which already exists. In this war the men at the top of the social scale have given their lives freely, and it would be ungenerous not to give credit for, and express appreciation of, their gallantry and self-sacrifice. The workman, too, at the call of his country has left his job and his home, and is doing his share, and doing it voluntarily; but there is a large percentage of the comfortable class whose main contributions during this crisis have been in the nature of criticism and advice. It is these who must be made to contribute, and to contribute regularly and in proportion to means. If one-half of last year's increased profits upon industry and commerce could be exacted by means of a special income-tax, the totals of all the voluntary funds would be instantly eclipsed, and the basis of a practicable fund provided.

"It is necessary to at once withdraw from the realm of chance and charity the interests of the soldier and his dependants. For ages writers and poets have joined in singing the praises of soldiers, extolling their sacrifices and glorifying their prowess. Times have changed, and to-day there is a labour movement, dissatisfied with mere vocal effort, and strong enough, and also wise enough, to see that the soldier receives more than adulation in life and laurels in death. To leave him or his dependants to the care of charity is unworthy of a great nation. Inquisitorial methods and voluntary effort must give place to specific scales of pay and proper public State control.

"Reform in the Army itself must be pressed, particularly in the direction of increasing allowances and facilitating promotion from the ranks. An immediate minimum of 1*l.* per week is not too much to ask for soldiers or sailors who are wholly or partially disabled by wounds or disease contracted in active service. There is also need for more humane treatment of the dependants of men who die of disease, similarly contracted, shortly after discharge. The fact that these reforms will cost money should not retard their institution. We believe in a voluntary Army; we expect it to cost more per head than if it were obtained by conscription; we believe also that the relationship of the Army to the State needs overhauling, and a Royal Commission, including representatives of Labour with personal and first-hand knowledge of labour conditions and needs should be appointed now.

"The co-ordination of existing charities and relief funds is imperative. Already in London much has been done to prevent the waste and overlapping consequent upon the multiplicity of organisations, but much remains to be done, and it will be done better and more sympathetically if organised labour co-operates.

"Amongst the voluntary associations which may justly demand consideration at the moment, the trade unions stand pre-eminent. Some have made magnificent efforts to meet the distress consequent upon unemployment, but they cannot indefinitely continue their disbursements. The contributions and benefits were calculated on a peace basis. They never attempted to secure, nor could they have secured, had the attempt been made, contributions equal to the requirements developed by a great war. The collapse of their efforts would mean more than trade-union humiliation and bankruptcy, it would mean national disaster. Subsidies have already been promised and given. These must be extended and increased, and wherever trade unions have securities not easily realisable these should be taken over, where request is made, by the State, and the unions given the equivalent in cash.

"The sickness and disablement which will follow upon the war must disturb the actuarial equilibrium of most approved societies, and these should combine to secure themselves from the disaster which threatens unless the State shoulders at least that part of the burden arising from the war.

"In the furtherance of all these objects the Management Committee is prepared to act with all the force and influence at its command, and it invites the co-operation of all persons or organisations who desire to realise the objects set forth. In explaining the position and advancing the claims of the people, it wishes to avoid the folly of the Chauvinist and the meanness of the merchant who haggles while death waits at the door; it speaks only in the discharge of the duty, and it is certain of the co-operation of those who were responsible for its election. It does not overlook its obligations to the workers in other lands, and it hopes that with the destruction of the Prussian militarist caste, which for forty years has worked for war, international friendships and efforts may be renewed; but for the moment its whole duty lies at home."

The director of the Department of Labour Statistics, Board of Trade, gives the following information on the labour market in September:—

Employment in September was below the level of the months immediately preceding the war, but, on the whole, it showed a considerable recovery as compared with August. There was still a great deal of short time, but both this and the number of workpeople entirely unemployed were much less. To some extent the situation as regards employment for men has been relieved by the large number of enlistments.

Work on Government contracts caused great activity in certain trades, and in some districts the shipbuilding, engineering, woollen, worsted, hosiery, boot, leather, clothing, and some miscellaneous trades have been very busy, with much overtime. Employment also improved in the coal-mining, iron and steel, tinplate, and cotton trades, and in the provincial districts of the building trades. There was some shortage of agricultural labourers, owing to the number of men joining the army.

Compared with a year ago, when employment was good, there was a general decline, which was most marked in the pig-iron, tin-plate, textile, and pottery trades. The shipbuilding industry, however, remained at about the same level as in September, 1913.

The changes in rates of wages taking effect in September affected 2100 workpeople and amounted to 170*l.* per week. All the changes were increases, but none affected a large body of workpeople.

The number of disputes beginning in September was 23, and the total number of workpeople involved in all disputes in progress during the month was 13,025, as compared with 49,804 in August, 1914, and 131,496 in September, 1913. The estimated total aggregate duration of all disputes during the month was 229,800 working days, as compared with 526,900 in the previous month, and 1,449,800 in September, 1913.

At the date of publication the number of disputes in progress was 22, involving about 8000 workpeople.

Cases dealt with during the month included saddlers and general leather-workers, in the Birmingham and Walsall district; granite quarrymen, Devonshire (Chudleigh district); printers, London; painters, Edinburgh; joiners, Helensburgh; boot and shoe operatives, Leicester; steel-workers, West of Scotland.

Under the Coal-Mines (Minimum Wage) Act, His Honour Judge Moss had succeeded the late Mr. B. Francis-Williams, K.C., as chairman of the Joint District Board for North Wales.

It had been agreed by the parties that the Railway Conciliation Scheme, which would otherwise expire on November 30, should remain in operation. During the month the chairman of the Lancashire and Yorkshire Board had been appointed to consider certain matters.

The average weekly number of vacancies notified to all labour exchanges for the four weeks ended September 11, 1914, was 29,339, as compared with 26,874 in the previous four weeks, and with 22,460 in the four weeks ended September 12, 1913. The average weekly numbers of vacancies filled for the same periods were 23,107, 21,162, and 16,898 respectively.

According to Reuter's Amsterdam correspondent, Swiss importers are reported to have sent representations to the Swiss Federal Council and to the British Minister at Berne, asking both to use their influence in London to facilitate the import of raw materials and raw wool in order to prevent a crisis among Swiss industries. This confirms the paragraph we gave on page 486 *ante*.

In the monthly report for October issued by the United Society of Boiler-Makers and Iron and Steel Shipbuilders, the secretary makes the following statement:—"Our returns to hand show an improvement on last month. We have 553 less on our books out of employment. During the first month of the war there was a good deal of dislocation and loss of time through the break-up of squads due to our members joining the various branches of the national services. Part of the dislocation was also due to the transference of our members from merchant work to urgent Government work.

"When we consider the shock caused by the sudden and dramatic declaration of war by one Power after another amongst the nations of the Old World, and the constant strain of continuous battles extending over hundreds of miles, involving millions of men armed with the most deadly weapons for the destruction of life and property, it is remarkable that in our trade and in other trades we have so quickly restored almost normal conditions.

"We have made it clear to the Government and to private employers of labour that no ill-considered action of ours will in any way jeopardise our trade prosperity or hinder the making and the keeping in the firing-line of the strongest and most efficient Army and Navy.

"For this restored confidence in industrial and financial affairs we are much indebted to the Government, who in this great crisis have handled home affairs in a businesslike manner, such as no previous Government have ever equalled. This success has been achieved through the practical advice and co-operation of our Labour Members in Parliament and our trade-union leaders throughout the country. I hope that through a continuance of the present co-operative efforts of all classes our trade will be continued and improved, for if we can accomplish this, we can also maintain and increase our fighting forces until victory is won, and the earlier we can make this clear to our enemies the sooner they will throw up the sponge.

"As a result of our appeal to the Government for a subsidy to enable us to meet the extra expenditure on unemployment benefit due to the war, it is some satisfaction that the Government have decided that in addition to the one-sixth already payable from the Board of Trade, we may have a further third of our unemployment benefit refunded, on condition that our unemployment is abnormal and that we pay a levy to assist our own funds. In other words, for every 12s. paid in unemployment benefit we may have 6s. returned from the Board of Trade. I trust our members will give the proposal of the Government their favourable consideration when the question is submitted to them, as it shortly will be."

Notices given to the workmen, to the number of about 200, employed in the Lidgett seam at the Hoyland Silkstone Colliery, terminated on the 14th inst. This seam has now been temporarily closed, owing to the large number of men who have enlisted. Work will be found in the other pits of the company for as many as possible of the men who remain. Notices were posted up on the same day intimating that workmen would be employed subject to one day's notice.

COAL-HANDLING PLANT ON THE UNITED STATES FLEET COLLIER "JUPITER."

We reproduce on our two-page plate detailed drawings, and on pages 504, 505, and 508, perspective views of the coal-handling plant of the United States fleet collier Jupiter, as these are of special interest at the present time, in view of the importance of the rapid recoaling of warships. The Jupiter, which was built in conformity with the rules of the American Bureau of Shipping, at the Mare Island Navy Yard, cost, including indirect charges, but excluding leave, holiday and disability, 254,400*l.* The ship is of the twin-screw single-deck type, designed for a speed of 14 knots when at a loaded displacement of 19,230 tons, the draught then being 27 ft. 6 in. In addition to having interesting equipment for the handling of coal and oil-fuel, the vessel is notable, as the propellers are driven by electric motors, current being supplied to these by turbine-driven generators, the shaft horse-power available for propulsion being 5500. The dimensions of the vessel are as follow:—

Length over all	542 ft. 2½ in.
Length between perpendiculars	520 ft.
Length on load water-line	520 ,,
Beam, extreme	65 ft. 1⅛ in.
Beam, moulded	65 ft.
Draught, mean designed	27 ft. 6 in.
Displacement on designed draught	19,230 tons
Displacement per inch on load water-line	64.75 tons
Area of midship section, moulded	1,655 sq. ft.
Area of load water-line plane	27,140 ,,
Area of wetted surface at 27 ft. 6 in. draught	27,750 ,,
C.B. above bottom of keel	14 ft. 5½ in.
Transverse metacentre above C.B.	12 ,, 11¾ ,,
Longitudinal metacentre above C.B.	624 ,, 6⅞ ,,
Coefficient of fineness, block	0.7215
Ditto midship section	0.9783
Ditto L.W.L. plane	0.7954
Ditto cylindrical	0.7375

The naval complement is 11 officers and 148 men; of the latter 55 are deck hands, 10 are artificers, 59 are in the engineer department, and 15 in the commissariat department, the remaining nine being for special work.

The ship has four decks forward and five aft, with poop and forecastle at a slightly higher level than the upper deck, as shown in the perspective view of the vessel completed (Fig. 1, page 504). Amidships, however, in the cargo space, there is only one deck. The interior is divided into compartments by nine watertight bulkheads, five of which have been made oil-tight for the carrying of liquid fuel as cargo, while the double bottoms are arranged in fifteen compartments, several of which are rendered oil-tight, to be utilised for cargo space when the holds above them

THE UNITED STATES ELECTRICALLY-PROPELLED FLEET COLLIER "JUPITER."

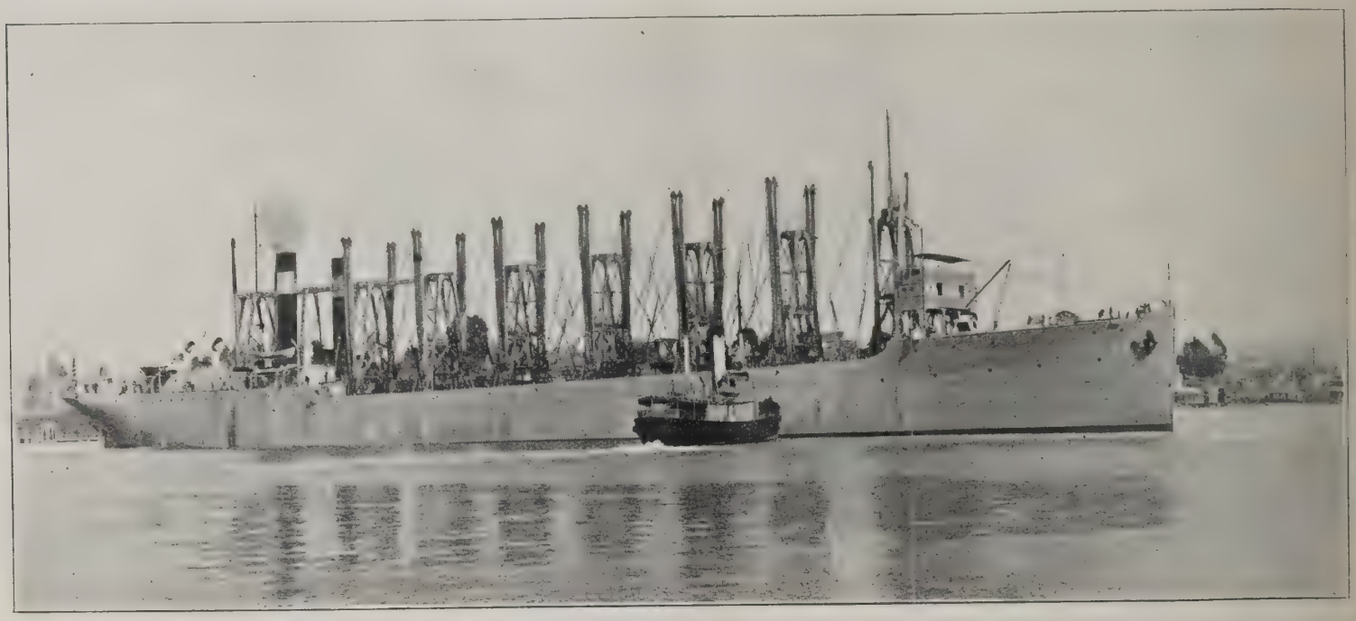


Fig. 1. View of Ship Completed.

are used also for oil. The crew is accommodated on the upper and berth decks aft, the chief petty officers on the port side of the upper deck aft, there being a sick bay on the starboard side, while the officers are arranged for on the poop-deck. The store-rooms are on the lower deck aft and on the lower and berth-decks forward. The oil-cargo pumps are accommodated forward in a compartment which extends from the level of the forecastle deck to the top of the forward peak tank; there are also two peak tanks aft.

There are thirteen holds for coal and oil, the liquid fuel being carried in eight of these, arranged in pairs on each side of a forward and aft bulkhead, with the necessary cofferdams. The holds for coal, however, extend the whole width of the ship, being of the self-trimming type. The propelling machinery is arranged aft, and the coal-bunkers are between the cargo-holds and the machinery compartment. The total cargo capacity is 966,265 gallons of oil and 9856 tons of coal, or, alternatively, 405,617 gallons of oil and 11,377 tons of coal.

The coal-handling gear was furnished by the Mead Morrison Manufacturing Company, and the stipulation of the contract was for the delivery of 100 tons per bucket per hour when the gear was operated by winchmen of one week's experience. We take the main particulars of our description from a paper by Lieutenant S. M. Robinson, of the United States Navy, contributed to the Journal of the American Society of Naval Engineers. In this paper he stated that the support for the booms and rigging is a series of towers; each consists of two A-frames tied together with cross-braces. There are seven of these towers in the waist of the ship and one on the superstructure. There is a single A-frame between the two after (7 and 8) towers, which acts as an additional support for the fore-and-aft trolley-way which runs between towers 6 and 8. This trolley-way is a semi-box girder, and takes the place of the athwartship cable-span when transferring coal from the aftermost hold to No. 1 bunker. Fig. 2, on the two-page plate, is a longitudinal section showing the single-frame tower aft and the aftermost towers, which are typical of all in the waist of the ship. The trolley-way for the conveyance of coal from the holds to the ship's bunkers is also seen. Fig. 3 is a longitudinal section showing the forward towers.

At each tower, except those at each end, there are four jibs or booms, two on each side of the tower; the end towers have only one boom on each side. The outreach and the gear of these booms is well shown on the cross-sections on the two-page plate, Figs. 4 to 6, showing respectively the aft, the midship and the forward towers. The constructional details of the towers and booms will be further understood by reference to the perspective views on page 508. The heel of each boom, it will be seen, is stepped into a socket on the side of the tower, and is supported by a standing-wire topping-lift; there are two guys for holding the boom in the proper position in a fore-and-aft direction, Figs. 2 and 3. The athwartship cable-span, which acts as a track for the trolley, Figs. 5 and 6, runs from a boom-head on one side of the ship to a boom-head on the other side, the forward pair of booms on each tower plumbing the hatch just forward of it, and the after pair of booms the after hatch. The cable-span gives a travel of 20 ft. beyond each side of the ship, and has a sufficient height to clear 20 ft. above the collier's deck. Each boom has a manila topping-lift for topping it up into a vertical position for housing; it is held in this position by a pin and also by a wire preventer.

There are two winches, as shown in Figs. 4 and 6, on the two-page plate, and Fig. 7, on page 505, one clam-shell bucket of 1 ton capacity (Fig. 8), and a trolley for each pair of booms (Fig. 9). One winch has two drums, one for holding, the other for opening and closing; the other winch has one drum for traversing. The trolley consists of a carriage with two sheaves in the top half, which travel on the cable span, and with four sheaves in the lower half, these being for the opening and closing and holding lines. The line for traversing also makes fast to the trolley, but runs through no sheave in it. The grab-bucket is provided with an upper head, to which the links are pivoted, and with a bottom head, to which the segments of the shell are pivoted; there is a triple-block in the lower head and a double-block in the upper head. The shell of the bucket is $\frac{3}{8}$ in. steel plate, reinforced at the mouth with 1-in. by 8-in. steel jaws, bevelled at the cutting edge. The shell segments are hinged to the bottom head, and are connected by links to the upper head; the construction of the bucket is such that when suspended from the upper head the segments will swing open and stay open until the upper and bottom heads are pulled together by the opening and closing line, which reeves through the blocks in the upper and bottom heads. There are supplied ten 1-ton and three $\frac{3}{4}$-ton grab-buckets.

The bucket, as shown in the various sectional drawings, is suspended in a bight by both the opening and closing and holding lines, thus making these lines independent of the position of the trolley. The traversing line is continuous, so that it unreeves on one side of its drum as fast as it reeves off on the other side. One end of the opening and closing line makes fast to a boom-head (the one on the opposite side of the ship from its winch); it then reeves over a sheave in the trolley, then through triple and double blocks in the bottom and upper heads of the bucket, then back through a sheave in the trolley, then through a sheave in the boom-head (the one on the same side of the ship as the winch), then up to a sheave in the top of the tower, then down to the drum of the winch, where it makes fast (Fig. 5). The lead for the holding line is practically the same as that for the opening and closing line; the difference is that it reeves through a single block attached to the upper head of the bucket. The main function of this line is to support the bucket when the opening and closing line is slacked off; the normal position of the bucket being wide open, it immediately swings into this position as soon as the opening and closing line is slacked. When this line is closing in, the double and triple blocks on the bucket are pulled together, and this pulls the halves of the bucket together, and keeps them that way as long as the line is kept taut. The opening and closing line really acts also as a hoisting-line, and as soon as the bucket is closed, both opening and closing line and holding line are taken in together, and both act to hoist the bucket. The traversing line makes fast to a pin on the trolley, then reeves through a sheave at the boom head, then through a sheave (fairlead) on the side of the tower, then through a sheave in the tower, then around the winch-drum, then through a sheave in the tower, then through a sheave (fairlead) on the side of the tower, then through a sheave in the boom-head, then back to a pin on the trolley, making the circuit continuous from one side of the ship to the other.

The hoisting-engine has twin cylinders, 10 in. in diameter and 12 in. stroke (Figs. 6 and 7); it runs in one direction only, and has a throttle operated by a foot-lever. It has two drums, both of which are engaged by conical clutches covered with leather; these are operated by hand-levers. There is a friction brake band for locking the holding drum, and this is operated by a foot-lever; this brake is used when it is desired to keep the bucket suspended for any considerable period of time. The hoisting-engine also has an extension gipsy head for hoisting hatch-covers, booms, &c. The winch is operated by steam at 135 lb. pressure per square inch.

The trolley-engine has twin-cylinders, each 8½ in. diameter and 10 in. stroke; it has reversing links for changing the direction of rotation, and these are operated by a hand-lever; the throttle is operated by a foot-lever. The drum is split in halves by a plane at right angles to its axis; one-half of the drum is locked by a key to the rotating shaft, and the other half is locked by a conical friction device operated by a thrust-screw and nut on the end of the shaft. This clutch is ordinarily in all the time when running and is only thrown out when it is desired to take up the slack of the trolley-wire, which must always be kept taut; to take in the slack of this wire the friction half of the drum is slacked off and held from rotating by a brake-band operated by a hand-lever; the other half of the drum is then rotated until all the slack is taken up; the engine is then stopped and the halves of the drum are locked together by the thrust-screw and jam-nut. The after trolley engine has an extension on the drum-shaft and a second trolley drum on this extension; the second drum is thrown in or out by a clutch, and is used for operating the fore-and-aft trolley (Fig. 2) and taking coal out of No. 13 cargo hold for bunker purposes. The gear for holding, opening and closing is all rove off on the after tower for fore-and-aft coaling in practically the same way as for the transverse method, except that the leads are in a fore-and-aft direction instead of athwartships.

In addition to the use of buckets coal can also be handled by either the transverse or fore-and-aft method by using four-pronged hooks for bags or by using skips, the latter being intended particularly for the ship's bunkers. Each bucket requires two men to operate it, one man to open and close and hoist and lower, and another man to traverse. The bucket-operator has two hand-levers and one foot-lever to

DETAILS OF COAL-HANDLING PLANT ON THE U.S. FLEET COLLIER "JUPITER."

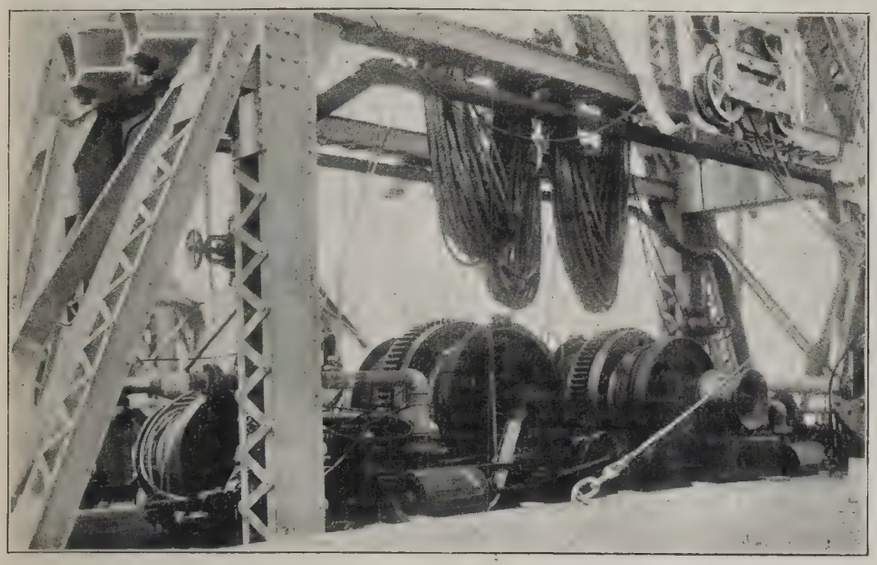


Fig. 7. Arrangement of Winches under Towers.

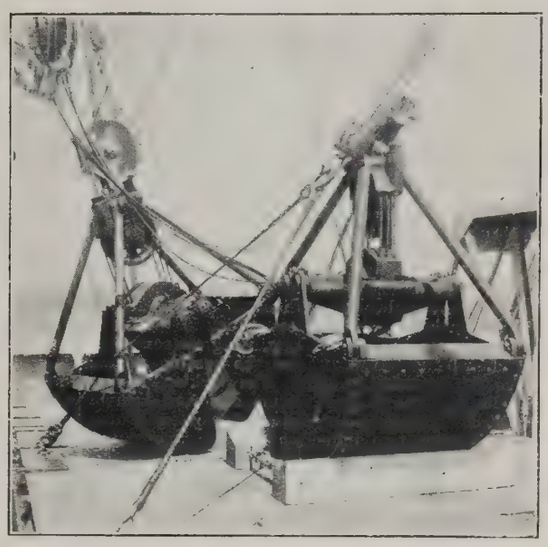


Fig. 8. The Coal-Grab Buckets.

Fig. 9. Trolley and Operating Gear for Winches.

operate; his right-hand lever operates the opening and closing, and the left-hand lever the holding line; the foot-lever operates the throttle of the engine. The trolley-operator has a hand-lever for moving the reversing-links and a foot lever for the throttle. Starting with the bucket open and on the coal in the hatch, the operation is as follows:—The bucket-operator puts his right foot on his throttle and starts his engine, then throws in with his right hand the opening and closing drum, which pulls the bucket together, then throws in with his left hand the holding-drum, and the two drums hoist the bucket to the desired height; he then takes his foot off the throttle and stops his engine. The trolley-operator will already have his links thrown in the proper position, and when the bucket comes up clear of the hatch he starts his engine by putting his left foot on the throttle-lever, and, when he has moved the bucket over the deck of the battleship, he takes his foot off the throttle and stops his engine; he then throws his links into the reverse position for the return trip. As soon as the bucket is over the deck of the battleship, the bucket-operator throws out the opening and closing drum, and the bucket immediately swings open. The trolley-operator then starts his engine and returns the bucket to the hatch, when he stops his engine and throws over his links for the next trip. As soon as the bucket is over the hatch the bucket-operator releases his hoisting and holding-drums, and lets the bucket drop on the coal, completing the cycle. The bucket will probably close as it drops, in which case the bucket-operator will throw in his holding-drum just before the bucket catches the coal; the bucket will then open, and he can throw out his holding-drum, dropping the bucket on the coal.

The operating-platform is situated about 25 ft. above the deck, and inside the tower. The levers are placed here, and are connected up to the engines by means of shafts and bell-crank levers. From this position the operator can always see the bucket, both when taking coal out of the hatch of a ship and also when taking it from a barge or another ship alongside. The levers were changed to this position after a trial with them when placed on the deck alongside the winches. A great deal of trouble was experienced with the operation under these latter conditions, and it was also necessary to have a third man stationed at the rail to give signals when taking coal from a barge alongside.

As regards the oil-handling system, Lieutenant Robinson says:—For filling and emptying the cargo-holds, there are four 6-in. gate-valves on the forecastle, and 6-in. wrought-iron pipes, which lead from these valves down through the forecastle, where two on each side join into an 8-in. pipe, and these two 8-in. pipes in turn connect to a 10-in. riser, which leads down to the pumps in the pump-room. There are also two 6-in. connections with blank flanges on the side of the ship which also join the 10-in. riser. In the pump-room there are two 14-in. by 12-in. by 12-in. horizontal duplex pumps, manufactured by the Canton Hughes Company. They are rated at 1000 gallons per minute each, with a steam pressure of 130 lb. From these pumps two 10-in. wrought-iron suction and filling lines lead aft along each side of the centre-line bulkhead, with a 10-in. stop-valve in each oil-hold operated by hand-wheel on the upper deck. These lines are carried on the top of the floor in holds 1, 2, 3, and 4, and in the double bottom under holds 5, 6, 7, and 8. An 8-in. connection for the flooding-tank is provided on the suction side of the pump and carried to the sea-valve in the forward trimming-tank. A 10-in. Macomb strainer is fitted on each pump-suction. Each oil-hold is also provided with a 2-in. hand-pump suction, which leads to a manifold on the bulkhead and thence to a hand-pump on a grating in the pump-room. Heating-coils of 1-in. pipe are fitted about the 10-in. suction in each hold; they are supplied with steam from the pump-room and drained into the auxiliary exhaust on the upper deck. Cross-connections in the pump-room allow pumping with either one or two pumps, from one hold to another, overboard or from overboard. A No. 3 "Sirocco" fan placed on the berth-deck above the pump-room is connected to the 10-in. oil suctions for removing gas from the various holds.

The fire-main and flushing systems can be operated by the salt-water sanitary pump, ballast-pump, or the fire and bilge-pump. The salt-water sanitary pump is a 6-in. by 8½-in. by 6-in. horizontal duplex Blake pump rated at 350 gallons per minute. The ballast-pump is a 7½-in. by 9-in. by 10-in. vertical duplex Blake pump rated at 660 gallons per minute. The fire and bilge-pump is a 12-in. by 8½-in. by 12-in. vertical duplex Blake pump rated at 590 gallons per minute. All three pumps have 6-in. suctions from the same sea-chest, which is in the starboard forward corner of the engine-room near the pumps.

The fire and bilge-pump and ballast-pump have a cross-connection to a 5-in. discharge, to which the fire-main connects. There is a 7-in. galvanised wrought-iron riser which leads from this cross-connection up to the forward engine-room bulkhead on the starboard side to the level of the berth-deck; from here a 4-in. branch is led up under the poop-deck and aft, reducing in size to 2½-in. diameter, and supplying 2½-in. fire-plugs on the upper and poop-deck. The 7-in. riser continues forward under the berth-deck on the starboard side until it reaches the forward fire-room bulkhead, where it divides into two 6-in. branches, one running forward on the starboard side, and the other on the port, both above the upper deck. These branches are both reduced in size to 3½ in., and supply 2½-in. fire-plugs on the upper deck and forecastle. There are 3½-in. stop-valves, which admit water to the top-side ballast-tanks, and also to the cofferdam. In

the fire-room 2½-in. connections are taken off for both ash-shoots. Both of the forward branches, and also the after one, are controlled independently by cut-out valves.

The refrigerating system of the ship is most complete, there being, for instance, a 3-ton ammonia ice-machine, a 7-in. by 10-in. ammonia compressor and 9½-in. by 10-in. engine, a brine-tank, 4 ft. 9½ in. by 22 in. by 4 ft. 1 in., a 4½-in. by 2¾-in. by 4-in. duplex double-acting Deane pump for circulating cooling-water, a similar pump for circulating brine, and a refrigerator-room divided into four compartments, and containing 2884 cub. ft. stowage space. The ammonia-machine and brine-tank were furnished by the Vilter Manufacturing Company, of Milwaukee.

As regards the propelling machinery, we gave in previous issues drawings and details of the installation (see ENGINEERING, vol. xciv., pages 273, 387, and 412). It may be stated here that the boiler installation includes three double-ended cylindrical boilers 23 ft. 0¾ in. long over all, with a diameter of 16 ft. 3 in. Each boiler has eight furnaces 40 in. in diameter, with a fire-grate 5 ft. 7½ in. long, the grate surface of each boiler being 150 sq. ft., and the heating surface 6460 sq. ft., a ratio of 1 : 43.06. The working pressure is 190 lb., and the Howden system of forced draught is applied. The main engines consist of one Curtis turbo-generator, two induction motors, two water-cooled rheostats, and one switchboard, the excitation for the main generator being taken from one of three 35-kw. generators utilised for the electric lighting and motor working of the ship. The turbo-generator furnishes power to the motors, of which there is one on each propeller shaft. All changes of speed are made by changing the speed of the turbine, thus varying the frequency of the generator, and consequently the speed of the motors. The following data regarding the turbines and turbo-generators are taken from Lieutenant Robinson's paper, and should be read in reference to the sectional drawings published in ENGINEERING, vol. xciv. :—

Turbo-Generator:

Weight of bed-plate	16.3 tons
Length ,, ...	25 ft. 2⅜ in.
,, over all	27 ,, 7¼ ,,
Height, extreme	9 ,, 5¼ ,,
Number of bearings	3
Turbine bearing, diameter	8 in.
,, ,, length	14 ,,
Middle bearing, diameter	14 ,,
,, ,, length	39 ,,
Generator bearing, diameter ...	10 ,,
,, ,, length	20 ,,

Turbine:

Weight	28.7 tons
Revolutions per minute	1990
Number of stages	9
,, rows of moving blades (two rows in first stage)	10
Number of rows of fixed blades (first stage)	1

Turbine-Blade Data.

Stage.	Length of Blade.	Thickness of Blade.	Width of Blade.	Thickness of Base.	Material of Blade.
	in.	in.	in.	in.	
1	1¼	1/16	0 29/32	1/8	Monel metal.
—	2¼	1/16	0 29/32	1/8	,,
2	1¼	1/16	1	1/16	Phosphor-bronze.
3	1⅝	1/16	1	1/16	,,
4	2⅛	1/16	1	1/16	,,
5	3⅛	1/16	1	1/16	,,
6	5	1/8	1	1/8	,,
7	6¾	1/4	1	1/4	Monel metal.
8	8¾	1/4	1	1/4	,,
9	11⅜	1/16	1 9/32	1/16	,,

Turbine-Wheel Data.

Stage.	Diameter.	Width of Hub.	Width of Tip.	Clearance Between Hubs.
	in.	in.	in.	in.
1	62¼ (aft), 61¼ (forward)	5	3.519	1/2
2	62¼	4 13/16	1.5	3/32
3	61⅞	4 23/32	1.5	3/32
4	61⅝	4 23/32	1.5	3/32
5	60⅝	4 23/32	1.5	1/2
6	58½	4 31/32	1.75	1/4
7	56⅝	5 1/16	2.125	1/4
8	54½	5 13/32	2.375	1/4
9	52½	5 3/8	2.25	1/32

Clearances.

	In.
Between nozzles and first moving blades, first stage	0.080
,, first moving blades, first stage, and fixed blades	0.080
Between fixed blades and second moving blades, first stage..	0.080
Between nozzles and moving blades, second stage	0.120
Ditto third stage	0.120
Ditto fourth stage	0.140
Ditto fifth stage	0.140
Ditto sixth stage	0.160
Ditto seventh stage	0.160
Ditto eighth stage	0.180
Ditto ninth stage	0.180

Generally the turbo-generator follows the practice in the electrical industry of the United States. According to a paper read by Mr. W. L. Emmet, at the last summer meeting of the Society of Naval Architects and Marine Engineers, held at New York, there is only one feature about the generating unit which is different from the type of units ordinarily used for electrical purposes—that is, that the governor is so designed that it can be set to hold any desired speed through a wide range, the adjustment of the governor being the normal method of speed variation used in this vessel. The ship can also, if desired, be controlled by a throttle, so that the governor is simply a convenience, and in no sense a limitation. The windings of the generator which carry the alternating current are on the stationary part, and are insulated with non-fusible material. The generator obtains its own ventilating air by powerful impellers attached to the ends of the rotor. This air is delivered from the top of the generator through a duct which connects to the space from which the fire-room blowers take their air supply. The heated air from the motors also passes out of the engine-room through similar ducts. The revolving parts of the motors are connected to water-cooled resistances through collector-rings, and means are provided by which these collector-rings can be short-circuited, so that the rotor-circuits are closed upon themselves. Such a condition, with the resistances cut out, is the normal state of efficient operation, the resistance being used only for the purpose of giving a large torque in reversion. The vessel can be operated with the resistance continually in circuit. With this connection, the immediate movement of either motor in either direction is very convenient, and this method of operation is normally used in manœuvring in narrow waters or about wharves. The ship can, however, be manœuvred and reversed without the use of the resistance, and while this method has not yet been fully experimented with, it is thought that her reversal even without the resistance will be as effective as that of vessels having existing types of equipment.

Since the Jupiter's apparatus was designed a method of designing induction motors has been developed which will give all the desired characteristics for reversal without the use of external resistance. Such motors will have squirrel-cage rotors, which are of a simpler character than the wound rotors now used. While the method of control and operation of the Jupiter is extremely quick and simple, the operations necessary with this new type of motor will be simpler still. With this new method it will be extremely easy to accomplish all the operations of speed control or reversal of either propeller from the bridge if desired.

After having been docked and the hull cleaned, the Jupiter made a set of standardisation runs, and a 48-hour unofficial trial. On this 48-hour trial the ship averaged 14.78 knots. The average power delivered by the generator was 5000 kw., corresponding to about 6300 indicated horse-power. The average revolutions of the propeller were 115 per minute.

MERCHANT VESSELS UNDER CONSTRUCTION.—Lloyd's Register of Shipbuilding Returns for the quarter ended September 30, which take into account vessels of 100 tons and upwards only, the construction of which had already begun, and excluding warships, show that there were 486 vessels, of 1,723,550 tons gross, under construction in the United Kingdom, as against 477 vessels and 1,722,124 tons on June 30 last, and 508 vessels and 1,987,254 tons on September 30, 1913. Of the vessels being built in the United Kingdom at the end of September, 389, of 1,266,164 tons, are under the inspection of the surveyors of Lloyd's Register, with a view to classification by that Society.

THE EXPANSION OF TRADE.—In Amsterdam there is a Commercial Intelligence Office (Bureau voor Handelsinlichingen) at 16, Oudebrugsteeg, which is subsidised by the Government and controlled by Professor O. Kamerlingh Onnes, for the purpose of aiding the expansion of trade. This institution receives samples of goods for exhibition, and answers questions as to foreign and home markets, and as to the places or firms from which goods can be obtained, or when they are likely to find a demand. This is done free of charge, but applicants are required to give references to a bank and to two commercial firms, and to send stamps for postage at the Continental rate. Inquiries as to the financial status of firms are not entertained.

THE NEW ARMY.—Since August 1, out of the employees of Messrs. Charles Burrell and Sons, Limited, of Thetford, who employ in ordinary times about 400 hands, 107 have joined the colours. One of the directors, Captain C. W. W. Burrell, is also serving. On the outbreak of the war it was recognised that those that remained at home owed a duty to help those who had enlisted, as far as they could, and so they agreed to subscribe weekly 2½ per cent. of their wages to a fund, out of which donations are being given to the various needs that have arisen out of the war. In Sir John French's last dispatch there appear the names of two officers, Captains Bearne and Pery-Knox-Gore, of the A.S.C., who are both old pupils of the firm.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with a dull tone, and no dealings were recorded. Buyers' quotations for Cleveland warrants were steady at 48s. 3d. cash and 48s. 6d. one month, but sellers quoted easier at 48s. 7d. cash and 48s. 10d. one month. The market was firmer in the afternoon, and although no dealings took place, sellers of Cleveland warrants advanced their prices 5d. per ton to 49s. cash, 49s. 3d. one month, and 49s. 9d. three months. Buyers named 48s. 7d., 48s. 10½d., and 49s. 6d. respectively. On Friday morning Cleveland warrants got stronger, and 2000 tons were done at 49s. cash, and 49s. 3d. twenty-one days, and closing sellers quoted 49s. 1d. cash, 49s. 4½d. one month, and 49s. 10½d. three months. The afternoon session was quite idle, but the upward movement continued, and sellers of Cleveland warrants named 49s. 4d. cash and 49s. 7d. one month. On Monday morning business was again at a standstill, but Cleveland warrants were firmer, and sellers quoted 49s. 6d. cash, 49s. 9d. one month, and 50s. 3d. three months. In the afternoon the market was idle, but the tone continued firm. At the close the quotations for Cleveland warrants were called 49s. 7½d. cash, 49s. 10½d. one month, and 50s. 4½d. three months, sellers. On Tuesday morning the tone was steady, and 3000 tons of Cleveland warrants were put through at 49s. 8d. cash, 49s. 10½d. and 50s. one month, and from 50s. 3d. to 50s. 6d. three months. Closing sellers' prices were 49s. 9d. cash, 50s. one month, and 50s. 7d. three months. There was nothing doing in the afternoon, and Cleveland warrants were 1d. down. When the market opened to-day (Wednesday) Cleveland warrants were almost stationary, except that buyers were offering a trifle less than yesterday. No dealings were recorded, and sellers' closing quotations were 49s. 8d. cash, 49s. 11½d. one month, and 50s. 6d. three months. In the afternoon the market was again idle, and sellers of Cleveland warrants quoted a shade easier at 49s. 7½d. cash, 49s. 11d. one month, and 50s. 5d. three months.

Sulphate of Ammonia.—The market for sulphate of ammonia has exhibited a slightly better tone lately, and there is more inclination on the part of buyers to place forward orders. Prices show a hardening tendency, and the current quotation is 11*l.* per ton, Glasgow or Leith, for prompt lots, and about 11*l.* 5s. per ton, Glasgow or Leith, for forward deliveries.

Increase in Steelworkers' Wages.—The men employed in the "steam section" of the West of Scotland steel trade were recently informed that their wages would be increased by 10 per cent., as from October 12, and the first payment at the advanced rate was made last Saturday. The wages are regulated by a sliding-scale, adjusted by a Conciliation Board, and the present increase is based on a 1*l.* per ton rise in the selling price of ship-plates two months ago. The advance, which averages an increase of 3s. 6d. per week, will benefit over 2000 men.

Scotch Steel Trade.—One week is very much like its predecessor in the Scotch steel and iron trades at the present time, and movement is indeed very slow. Prices, although inclined, to be easier, are still very high, from the buyer's point of view; but sellers, who had previously to work on a very thin margin owing to Continental competition, are still of opinion that their demand for a higher basis for their products is really not unjust. Raw material is dear, and labour is also better rewarded, and the latter is scarce as well, so that a higher standard of prices is a necessity. Of course, the sudden advance on the outbreak of hostilities had the effect of checking enterprise to some extent, but it is freely anticipated that a better state of things will prevail before long. Not only is the home demand rather quiet, but orders from abroad have also fallen off, and, with the exception of one or two markets, the general inquiry is poor. With the shipbuilding industry not booking much new tonnage, the demand for ship-plates is not heavy, and the same may also be said of sections. Makers of black sheets report that they are not overburdened with specifications of any kind, although the heavier gauges are keeping them going fairly well.

Malleable-Iron Trade.—No change of any importance can be reported with regard to the demand for malleable iron. Some establishments are moving along fairly satisfactorily, while others have difficulty in securing enough for a decent week's work.

Scotch Pig-Iron Trade.—No improvement has taken place in the Scotch pig-iron industry, and makers are rather quiet. The local demand continues poor and export inquiries are on a somewhat restricted scale. Prices are still easier, but customers are not yet inclined for anything but very limited dealings, owing to the rather unsettled state of the world's markets; but the firmer tone in warrants may have the effect of inducing some fresh business and of hardening prices.

Scotch Imports of Iron and Steel.—The registered imports of the undernoted kinds of iron and steel into the ports of Glasgow, Greenock, Grangemouth, Leith, Dundee and Aberdeen, during the month of September, are given below, and make interesting reading :—

	Ex Continent.		Ex U.S.A.	
	Tons.	Value.	Tons.	Value.
		£		£
Iron bars, angles, &c.	23	253	—	—
Steel bars, angles, &c.	—	—	66	485
Iron and steel hoops and strips	195	2117	1141	8619
Iron and steel plates and sheets, not under ⅛ in.	5	96	—	—
Iron and steel plates and sheets, under ⅛ in.	—	—	—	—
	223	2466	1207	9104

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—So far as house-coal is concerned, the local position does not show much activity. At the dépôts there is pronounced weakness, and stocks would be accumulating at the pits but for the action of producers in reducing output so as to conserve supplies of timber. The decline is easily accounted for. Last month householders bought big supplies for winter-stocking purposes, and now that prices have advanced the run has suddenly ceased. Values, however, are firm, and are likely to appreciate when there is a continuance of cold weather. There is no improvement in the steam-coal position. The local industrial demand is fully maintained, which, considering the huge requirements of the armament factories, is something to be thankful for; but the export demand is even on a smaller scale than a week ago. A moderate tonnage of gas fuel is going inland on contract account. As in the case of hard coal, shipments are smaller. Slacks are weaker, and with the increase of stocks and the absence of any improvement in the Lincolnshire position, there is a good deal of underselling of listed values. Coke is a fair market; prices are steady. Quotations:—Best branch hand-picked, 16s. to 16s. 6d.; Barnsley best Silkstone, 12s. 6d. to 13s. 6d.; Derbyshire best brights, 12s. 6d. to 13s. 6d.; Derbyshire house, 11s. to 12s.; best large nuts, 11s. to 11s. 9d.; small nuts, 9s. 3d. to 10s. 3d.; Yorkshire hards, 11s. to 12s.; Derbyshire hards, 9s. 9d. to 10s. 9d.; best slacks, 7s. to 8s.; seconds, 4s. 9d. to 5s. 9d.; smalls, 1s. 9d. to 2s. 9d.

Iron and Steel.—Though South Yorkshire manufacturers do not show undue eagerness to capture Germany's cheap native trade, a considerable amount of foreign business is being diverted into local channels, and the number of firms benefiting is quickly increasing. In this respect valuable assistance is being given by the Sheffield University, with whose approval a scientific advisory committee, consisting of the members of the Science and Applied Science, and the Department of Economic Faculties, is to be formed to assist in the extension of export trade by directing manufacturers, experimenters, and inventors to scientific and technical literature bearing upon the difficulties with which they are presented in dealing with new problems, and by putting manufacturers into communication with suitable scientific and practical expert opinion, and giving other similar help or advice. The foundation of this committee is subject to the understanding that it shall do no work which could readily, and in the ordinary way of business, be done by local professional experts. The committee should be of real assistance to the South Yorkshire manufacturers. This is but another instance of the gratifying tendency to bring practical and theoretical science into active co-operation for the general advancement and broadening of British industry. Raw material is quiet, but consumption keeps pace with production, and the undertone is steady. West Coast hematites are quoted at 81s., East Coast at 73s. 6d., Lincolnshire foundry at 59s. 8d., Lincolnshire forge at 58s. 8d., Derbyshire foundry at 56s. 9d., and Derbyshire forge at 55s. General trade in bars, which stand at 8*l.* 5s., is a little better. Sheets are unaltered at 9*l.* 10s. Government requirements of steel goods are exceptionally large. Guns, shells, trenching tools, and bayonets are being turned out at the highest possible speed. Piece manufacturers have booked some good orders. Special steel is being made for the United States, South Africa, India and Australia, railway wheels and axles for India, and locomotives and wagons for several of the English and Irish railways, including the Hull and Barnsley and Metropolitan Railways. Trade in billets is on the increase, and work is more plentiful in the lighter sections of industry.

RETAIL FOOD PRICES.—In a detailed examination of the changes in retail food prices since the outbreak of war, given in the *Labour Gazette* for September, it was shown that a sharp general rise in the first week of August raised the average level of prices at the 8th of that month to 15 or 16 per cent. above the normal level of July. This was followed by a fall in the prices of most articles, and at September 12 the average net advance had been reduced to about 10 per cent. Subsequent information as to the movement of prices between September 12 and October 1 shows that, on the whole, a slight upward movement took place between those dates. There were appreciable increases in the prices of sugar, eggs and fish, and although the price of potatoes continued to fall, the general net increase over July prices, at October 1, averaged about 12 per cent. Combining the various changes in prices in the proportions in which the different articles are estimated to enter into working-class expenditure, there was an average increase, between August 29 and October 1, of nearly 2 per cent., raising the general level of prices at the latter date above the normal level of July, 1914, by about 13 per cent. in the larger towns, and nearly 11 per cent. in the smaller towns and villages. Of the different articles, sugar still showed by far the greatest increase at October 1, averaging 86 per cent. in the larger towns and 76 per cent. in the smaller; but the prices of imported meat, eggs and fish, and, to a lesser extent, of bacon, flour, margarine, bread, and the cheaper cuts of British beef and mutton, were also appreciably above the normal level of July. On the other hand, little change had occurred in the price of tea, coffee, cocoa, and milk; the price of butter, which rose sharply during the early part of August, had reverted almost to the normal level, and potatoes were much cheaper than in July.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—A very quiet, though less pessimistic, feeling prevails in iron-trade circles. Very little pig is changing hands just now, and some customers are not taking out full supplies against contracts. What business is passing is still confined chiefly to transactions in small lots for early delivery. Values of Cleveland pig show some improvement on those of a week ago, but hematite quotations are falling a little. A few inquiries for pig-iron for Scandinavia and Italy are reported. Producers of Cleveland pig complain that current quotations are unremunerative, but, notwithstanding this, they are anxious to keep their furnaces going through the winter months, and are determined not to blow out if they can avoid doing so. There are at present seventy-one blast furnaces in operation on the North-East Coast. No. 3 g.m.b. Cleveland pig is 50s. f.o.b., though possibly in odd cases purchases can be made from second hands at 49s. 10½d. No. 1 is 52s. 3d.; No. 4 foundry, 49s. 6d.; No. 4 forge, 49s. 3d.; and mottled and white iron, each 49s. Both makers and merchants offer Nos. 1, 2, and 3 East Coast hematite at 63s. 6d., and any serious effort to buy even at below that figure would probably receive favourable consideration. Producers consider the market quotation lower than it should be, but it is still high in comparison with values of Cleveland pig, for whereas mixed numbers of hematite for long stood at 8s. to 10s. above No. 3 Cleveland, the difference now is 13s. 6d. There is little or nothing passing in foreign ore, and in the continued absence of transactions it is difficult to definitely fix quotations. Sellers still quote on the basis of 17s. 6d. ex-ship Tees for Rubio of 50 per cent. quality, but an impression prevails that no difficulty would be experienced in making substantial contracts on the basis of 17s. Imports of iron to Middlesbrough to date this month are officially given at 107,458 tons. Freights Bilbao-Middlesbrough are very firm at 4s. 6d. Coke keeps dear. Average Durham blast-furnace kinds are 17s. 6d. to 17s. 9d. delivered at Tees-side works.

Iron Trade Statistics.—According to the quarterly returns of the Middlesbrough Chamber of Commerce, there were at the end of September last forty-seven blast-furnaces in operation within the port of Middlesbrough, as compared with fifty-five at the end of September a year ago. During the third quarter of the year the production of pig-iron in Middlesbrough was 572,000 tons, of which 300,000 tons was Cleveland iron, and 272,000 tons hematite, spiegel, basic, and other special irons. For the previous quarter the output was 595,000 tons, 355,000 tons of which was Cleveland pig, and 240,000 tons hematite, &c.; and for the corresponding quarter a year ago the make was 667,000 tons, 407,000 tons being Cleveland and 260,000 tons hematite, &c. Imports of foreign iron-ore to Middlesbrough last quarter reached 484,371 tons, as compared with 490,768 tons during the previous quarter, and 549,211 tons during the third quarter of 1913. The total imports of ore for the nine months amount to 1,494,184 tons, as compared with a total of 1,745,194 tons for the same period last year.

Stocks and Shipments.—The stock of Cleveland pig-iron in the public warrant stores now stands at 106,125 tons. Since the beginning of the month the stock has been increased by 3161 tons. Shipments of pig-iron from the Tees to-date this month average 2098 tons per working day, the total despatches being returned at 37,779 tons, 32,819 tons of which have gone from Middlesbrough, and 4960 tons from Skinningrove. To the same date last month the loadings were given at 28,524 tons, or a daily average of 1584 tons, and for the corresponding part of October a year ago the clearances reached 64,698 tons, or an average of 3594 tons per working day.

Manufactured Iron and Steel.—There are no new features of moment in the manufactured iron and steel trades. Works are kept busy. New orders are somewhat scarce. Billets are in good demand in consequence of the cutting off of supplies from Germany and Belgium. Principal market quotations stand:—Common iron bars, 8*l.*; best bars 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 5s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 8*l.*; iron ship-rivets, 9*l.*; steel bars (basic), 7*l.* 10s.; steel bars (Siemens), 7*l.* 15s.; steel ship-plates, 7*l.* 5s.; steel ship-angles, 7*l.*; steel boiler-plates, 8*l.* 5s.; steel strip, 7*l.* 5s.; steel hoops, 8*l.*; steel joists, 7*l.* 2s. 6d.—all less the customary 2½ per cent. discount; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 7s. 6d.; steel railway sleepers, 7*l.*—all net at works; and galvanised corrugated sheets, 24 gauge, in bundles, 14*l.* f.o.b.—less the usual 4 per cent.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Admiralty and dry descriptions of steam-coal have shown strength; other qualities have exhibited little change. So far as Admiralty and dry classes are concerned, colliery-owners have secured ample orders. Forward business is somewhat at a standstill, but there is every reason to anticipate that a favourable state of things will be maintained. Patent fuel and coke have been about stationary. The best Admiralty large steam-coal has made 21s. to 22s.; best secondary qualities have brought 19s. to 20s.; other secondary descriptions, 18s. to 18s. 6d.; best bunker smalls, 8s. to 8s. 3d.; and cargo smalls, 5s. 6d. to 6s. 6d. per ton. The best household coal has realised 19s. to 20s.; good households have made 17s. to 18s.; No. 2 Rhondda large has brought 13s. to 13s. 6d; and No. 2 smalls have made 7s. to 7s. 6d. per ton. Special foundry coke has been quoted at 27s. to 30s.; good foundry coke at 20s. to 24s.; and furnace coke at 17s. 6d. to 18s. 6d. per ton. As regards iron ore, Rubio has realised 17s. to 18s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Bristol Engineering Society.—At a meeting of the Engineering Society formed under the auspices of the University of Bristol, Professor Munro, President for 1914-15, delivered his inaugural address. The professor dealt at considerable length with the water supply of ancient Rome. The Romans, he said, were essentially a constructive race; they were highly educated, and were a people who understood the principles of hydraulics. Ancient Rome was supplied with water by four aqueducts which delivered 51,000,000 gallons daily; this was a quantity much in excess of modern demands; and to-day the surplus water which still flowed through the old aqueducts was utilised for generating electric current. The professor laid stress upon the fine gateways and arches which the Romans built wherever it was necessary for an aqueduct to traverse a highway. Of the water supply of ancient Rome 240 miles, he stated, lay underground, while for 42 miles it was above ground. The good state of preservation of the Roman aqueducts was due principally to the stone used in their construction—Tufa, a stone of volcanic origin, and soft enough when first exposed to the air to be worked with bronze tools, produced exceedingly hard and durable building materials after exposure to the atmosphere.

Dowlais.—The blast-furnaces have had a full output, and some pig-iron has been passed into stock. The Goat Mill has been engaged upon large heavy steel rails, cogging steel, tin-bar, and large square mercantile steel. The steel-sleeper press has also been fully occupied. The Big Mill has been employed upon tram-rails as well as upon sole and fish-plates. The mechanical department of the works has been well occupied.

Welsh Coal Exports.—The cargo exports of coal from Bristol Channel ports in September amounted to 1,388,798 tons, as compared with 2,510,338 tons in September, 1913. The exports of bunker coal in September were 322,337 tons, as compared with 421,487 tons. Cargo exports entirely ceased in September to Russia and Germany, while shipments to Belgium were only trifling. There was also a considerable contraction in the deliveries to France.

The Mining Engineers.—The Association of Mining Electrical Engineers has postponed its visit to South Wales, which was to have taken place this month. The postponement is due to the fact that a large number of the members of the Association are now on active service. Hopes are entertained that the Association will carry out its Welsh programme next year, but, of course, everything depends upon the duration of the war.

THE NEW ARMY; MECHANICAL TRANSPORT.—It was announced last Saturday that there were still a few vacancies for competent wheelers and engine-smiths in connection with the mechanical transport formations of the Army, and highly-trained men were requested to communicate at once, in writing, with Mr. Frederick G. Bristow, F.C.I.A., Secretary, the Commercial Motor-Users' Association (room 58), 83, Pall Mall, London, S.W., when their applications would be forwarded to the proper quarter.

THE NAVAL AND MILITARY AEROPLANE ENGINE COMPETITION, 1914.—The Army Council have decided, on the recommendation of the Judges' Committee, to make the following awards:—The prize of 5000*l.* to the Green Engine Company for the Green 100-horse-power water-cooled engine No. 1, which best fulfilled the requirements of the competition and possessed the greatest percentage of attributes desirable in an aeroplane engine; awards of 100*l.* for each engine to the undermentioned firms in respect of the engines entered by them which performed successfully the eliminating trial of a six-hours' continuous run at full power:—

	£.
Argylls, Limited	100
Beardmore Austro-Daimler Engine Company	200
British Anzani Engine Company	100
Dudbridge Iron Works Company	300
Gnome Engine Company	200
Green Engine Company	100
Sunbeam Motor-Car Company	100
Wolseley Tool and Motor-Car Company	200

The Green aeroplane engine, to which the War Office has just awarded the 5000*l.* prize offered in the Naval and Military Aeroplane Engine Competition, is of practically the same construction as the engine which we illustrated in our issue of January 30, this year. The Green engine is not only of purely British construction, in accordance with the rules of the above competition, but it is entirely of British design, and owes nothing either to foreign brains or foreign capital. In the past the Green engine has distinguished itself in every competition in which it has taken part. Out of eight competitions for the Michelin trophies, offered for the longest or fastest flights on aeroplanes of all-British construction, the Green has captured seven, and was a close runner-up in the eighth, only losing because the competitor's supply of petrol ran short. Both the Alexander Prize Competitions for 24-hours' non-stop runs on a test-bench were won by Green engines. Mr. Hawker's meritorious effort to win the *Daily Mail's* Seaplane Circuit of Great Britain was made with a Green engine, which put up a world's record for seaplanes flying in the attempt. His failure was due to no fault of the engine.

THE COAL-HANDLING PLANT ON THE U.S. ELECTRICALLY-PROPELLED FLEET COLLIER "JUPITER."

(*For Description, see Page* 503.)

Fig. 10. Coaling-Towers, Looking Forward.

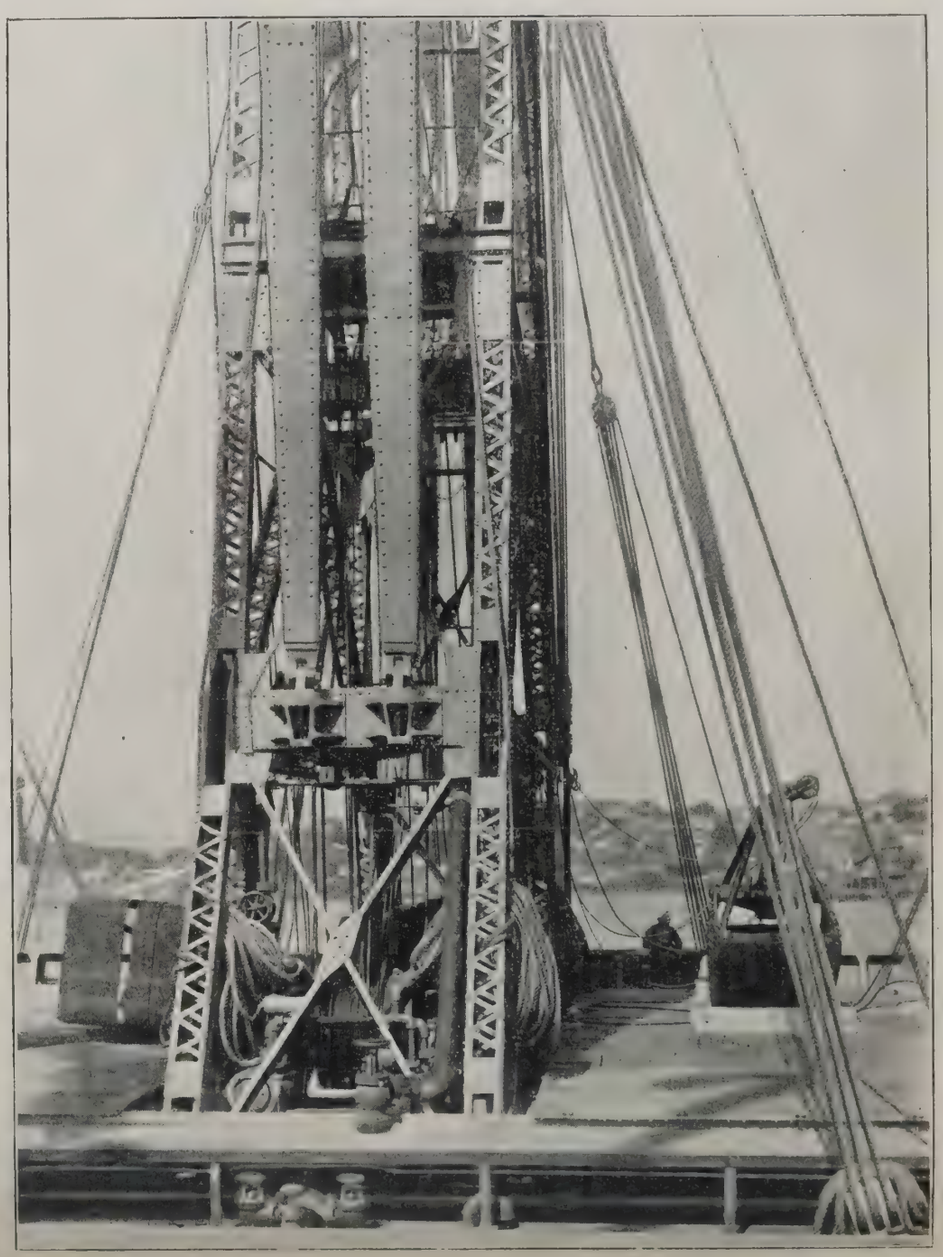


Fig. 11. Coaling-Towers, Looking Athwartship.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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With a Two-Page Plate of the COAL-HANDLING PLANT ON THE UNITED STATES ELECTRICALLY-PROPELLED FLEET COLLIER "JUPITER."

NOTICES OF MEETINGS.

The Institution of Electrical Engineers.—Thursday, October 29, at 8 p.m. Inaugural address by the President, Sir John Snell.

The Institution of Locomotive Engineers.—Saturday, October 31, at Caxton Hall, Westminster. A paper will be read by Mr. E. L. Ahrons, M.I. Mech. E., Vice-President, Nottingham, on "The Internal Disturbing Forces in, and Balancing of, Locomotives (with special reference to Three and Four-Cylinder Engines)." The President, Mr. A. J. Hill, M. Inst. C.E., Locomotive Engineer, G.E.R., will take the chair at 7 p.m.

The Institution of Municipal Engineers: Eastern and North-Eastern District.—Saturday, October 31, at 11.45 a.m., at the Guildhall, Lincoln, for routine business. In the afternoon visits will be paid to the city, to the water works, the gas works, the electricity works, and the sewage works.

NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to some Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, OCTOBER 23, 1914.

RELATIONSHIP BETWEEN SCHOOL AND WORKSHOP.

Industrial efficiency depends very largely on the relationship between school and factory. This is not only because in the school the future artisan lays the base of the foundation of his career as a workman, but also because there is need for a continuance of education in association with apprenticeship, and advantage is to be won by a fuller recognition of the function of the teacher in directing, as far as is prudent, the pupil in the day school or at evening classes along the line of activity most suited to his characteristics or natural aptitude. This problem is ever with us; but it is forced into the greatest prominence in our present state of emergency; firstly, because of the transfer of so many of our efficient and energetic workers from the industrial army to the defensive forces of the nation; secondly, because there are in front of us great prospects for commercial expansion associated with intensified international competition; and, thirdly, because the prevalent conditions, with their disorganisation and uncertainties, require that the numbers who are not specially trained for, and placed firmly on, the industrial ladder shall be minimised. It was therefore appropriate that the President of the Board of Education—Mr. J. A. Pease—in his recently issued encyclical to his "colleagues in the national service of education," should deal not only with the immediate necessities of the war situation from the educational standpoint, but with the broader issue of the relationship of the school and the factory.

Mr. Pease places some reliance on the retention of pupils beyond the age of fourteen, not only to meet the future generally, but also some of the special emergency difficulties. Many youths who leave school at the compulsory age-limit, which, in Mr. Pease's opinion, is too early, and involves loss, cannot find a subsistence in "blind-alley" occupations on account of the temporary derangement of commerce and industries, and being, therefore, all the more dependent on the State, can readily be made subject to some degree of compulsory education beyond the age of fourteen. With the regulations by which this may be brought about we have no concern, but clearly if, as a consequence of the conditions mentioned, it is possible to bring under systematic educational agencies many who, under normal conditions, would be "lost to education," the net result may be a gain, by producing groups of industrial recruits better equipped as regards physique, mental habits, and specific attainments for trades and permanent occupations in which they may be expected to start at or about the age of sixteen.

But Mr. Pease, too, looks beyond the present emergency, and recognises that after the present upheaval there will be many permanent changes. He thinks that the future will bring a clearer consciousness of the value and possibility of school life and training, in so far as there will be an increased incentive to press forward the vocational side of State-directed education. "Let the children remain at school to prepare themselves for the enterprises of their manhood and womanhood." This sweeping recommendation, in itself a counsel of perfection, will, we fear, need some qualifying. It is obvious that the more thoroughly a youth is grounded at school in, say, the essential mathematics and technical drawing of the engineer (to take a particular case), and the more intimately he has become acquainted with the properties of materials and the purposes of machines, the more rapidly and fully will he profit from his apprenticeship in the shops. Yet it may be remarked that there is nothing novel in that reflection. On the other hand, as there is bound to be an increased demand for capable youths to fill vacant places in the various fields of human activity, it follows that preparation at school for specific lines of work may receive more consideration from educational authorities, and be commenced at a somewhat earlier stage than has been customary with us. Might it not also happen that increased endeavour will be made to devise and apply reliable means for discerning qualities and tendencies, and adequate schemes for fostering ability associated with character, as the great assets of the nation. It is in this direction that we look for augmented efficiency, and no doubt the speculations of Mr. Pease foreshadow reforms with such ends in view.

The world of work needs capable workers in every station; but every station does not need precisely the same kind of ability. Plato recognised diversities of nature, and therefore differences in adaptability for different occupations. So he is now numbered among the advocates of vocational training. These theorists (or, should we say, hard-headed, matter-of-fact, practical men?) urge us to determine as early as possible the direction in which the natural ability of a young person promises to be most applicable, and thereafter to bring to bear upon that natural ability well-ordered specialised education for the work he will have to face. The trouble, of which the Board of Education is doubtless well aware, lies in determining what line should be selected for the prospective worker. Accuracy of judgment and wisdom, not to say fairness of advice, may be difficult to secure in many cases, with as sequel the risk of individual and national loss.

Here and there in Britain of late years organised efforts have been made to arrive at a reasonably just process of selection for the objects here indicated. Of these efforts, that which has been pursued for six years or so by the School Board of Edinburgh merits attention; and it may be confidently predicted that what Edinburgh has done will prove of special value in determining the development of the general scheme which is more or less definitely implied in Mr. Pease's circular letter. The Education Act (Scotland), 1908, empowered school boards to maintain, or combine with other bodies to maintain, "an agency for collecting and distributing information as to employment open to children on leaving school." This simple phrase became the starting-point of a far-reaching movement. In September, 1909, an Educational Information and Employment Bureau was established in Edinburgh on the principles which that eminently able and unsparing worker, Mrs. Ogilvie Gordon, D.Sc., of Aberdeen, had long and vigorously advocated. The School Board aimed at advising young persons as to the pursuits for which they were suited; supervising the young worker, and guiding his steps; arranging a system of further education to meet industrial needs; collecting and distributing information regarding conditions and opportunities; establishing a bureau in which employers and those who sought employment could be brought together. These objects soon began to be carried out with remarkable success.

A simple, but sound, card system, in which pointed information from schools plays a vital part, has been in operation from the start; but at the stage of entrance on employment the intermediary is a Labour Exchange officer, who occupies, in the School Board buildings, a room adjoining that of the Educational Officer of the Board. Under this system, which, be it observed, has no element of direct compulsion, there has been a marked diminution of "blind alley" employment, and a very remarkable increase in attendance at the continuation courses provided by the Board. Scottish school boards are empowered, if they see fit, to compel the attendance at evening schools of youths between fourteen and seventeen. As yet, experiments in that way are rare, almost all the boards

preferring, in the meantime, to do what they can to demonstrate the importance of continuation work, and so to induce a natural flow of evening students. In Edinburgh the leakage between the day school and the continuation classes has fallen from 60 per cent. to 25 per cent. While this represents a high-water mark, similar, if not quite so decided, results are being reached all over Scotland. Even in rural districts progress is recorded. In London and in very many towns in England the voluntary system of continuation schools has proved successful in a high degree. That success means that the idea of vocational training has taken root. Young people starting with a good broad basis of the rudiments of general education, rigorously demanded by virtually all the authorities who have tackled the problem, find provided for them attractive and well-considered courses of instruction, both practical and theoretical, directly applicable to the careers on which they are embarked. Their work proceeds with interest and enthusiasm, and even for that large number who will not pass from the wage-earning class there is the gain of a wider and more intelligent outlook, and of a finer appreciation of the nature of the services that are being rendered. Certain large firms—notably, those of Messrs. Cadbury Brothers, Limited, Messrs. Brunner, Mond and Co., and Messrs. Lever (to mention only three) — have organised within themselves wonderfully complete schemes of apprentice education, in which this wider view of the meaning of work is brought home to employees. Needless to say, in the earlier years of these continuation courses this is the dominating idea. Further, as the programmes which have been gradually evolved include much more than trade-training, there is ample facility for the discovery of those who are of finer quality and capable of occupying in due time positions of responsibility. It is in this eliminating aspect of education that we take special interest. We do not place small value on the general effects of the continuation school or on its importance in preparing for and supplementing apprenticeship training, but we deem the separating out and the encouragement of those who can attack to good purpose higher technical and commercial studies a function of incalculable importance, and therefore one that fully justifies the lavish outlay on the whole system. Machinery for this function is in full operation in many large industrial centres. The future will see further development and more general use of such machinery.

So far our experiments have been voluntary, and the success which has attended them makes us hesitate to subscribe without reservation to the opinion, frequently announced from platform and Press, that "compulsory attendance at the continuation school in the daytime between the ages of fourteen and eighteen is absolutely indispensable." In the current issue of the *Journal of Education*, the editor repeats for the second time that "a German of knowledge and some insight," when asked what he thought of the prospects of the war, replied, "We are very hopeful; the continuation schools have been doing their work." We may later consider in some detail the schemes of compulsory continuation work which have been arranged in Germany. Meanwhile it may be said that from very immature years the non-secondary-school youth of Germany get segregated into groups, and that for each of the many groups elaborate courses relating respectively to the life-work of the members of the several groups are administered with precision. The butchers, bakers, shoemakers, barbers, chimney-sweepers, and so on, are almost predetermined, so early is the choice of a trade effected, and the prospective members of each occupation receive isolated, specialised instruction. Dr. Kerschensteiner, the director of education in Munich, tells us that the interest in education of an industrial community is best aroused by creating and providing for group interests—one trade one school. Even the coachmen and drivers have special schools and special curricula, including, with technical instruction, such subjects as religion, citizenship, and police regulations.

We cannot now discuss the application of such an extreme systematisation to our education. Possibly the characteristics of its people, the social stratification, and the Government control account for the success which has been claimed for the German plan of continuation schools. To us, development along the lines on which we have been proceeding is full of promise, and, with Mr. Pease, we believe that the present disturbed conditions will supply a strong stimulus and guide for further progress.

FOREIGN MACHINERY FOR THE AGRICULTURIST.

An enormous trade in agricultural machinery, in traction-engines, steam-rollers and power-driven ploughs, and in fencing-wire, barbed wire, and wire netting is done annually in almost all parts of the Old and New Worlds. For many years Great Britain has enjoyed a very large share of this trade, but during the last decade Germany has extended enormously in this direction, and this extension has largely been at the expense of manufacturers in the United Kingdom. The mere fact that lands previously considered as the preserve of British engineers are now becoming accustomed to the presence and the wares of the ubiquitous German might not in itself be a matter for serious comment, but the following examples will show that the present situation is one which certainly requires most careful consideration.

Let us take, for instance, the import of road traction-engines and steam-rollers into Egypt, under British control, last year and the year before last. So recently as 1912 British and Germans, who held the whole import trade in this particular type of machinery between them, sent almost exactly equal amounts. In a short twelvemonth the position had, however, completely changed, Germany sending forty times as much as Great Britain, or 94 per cent. of the total import. Again, Great Britain has less than $\frac{1}{140}$th of the total import into the British Dominion of Canada in the same class of machinery—namely, road traction-engines.

It is not surprising that the United States of America, with her vast territories given up entirely to agriculture in the south and west, and a huge demand coming also from the farmers of Canada and Mexico, should have a vast output of machinery for agricultural purposes. It is equally natural that the United Kingdom, with her huge colonies throughout the world, should make a speciality of agricultural machinery. But why should Germany be a serious competitor to these two nations, and what have been the real reasons for her great recent advance in this class of machinery? It is the purpose of this article to offer some suggestions in relation to this matter, in the hope that English engineers may have their attention directed to markets which have been lost, but which may now be regained.

It will be as well, first, to consider which are the best and most profitable markets of the world; second, what types of machinery are most required; and third, what are the reasons for the recent success of Germany in this branch of engineering trade.

Germany and Austria exported together to Russia last year 650,000*l.* worth of agricultural implements, and 380,000*l.* worth of traction-engines and rollers, a total export of over a million pounds. The British reply to this was 2300*l.* worth of implements and 18,700*l.* worth of engines and rollers, a total export of 21,000*l.* Italy's total import of traction-engines and rollers, implements and wire for fencing and similar purposes, was from Germany and Austria over 150,000*l.* worth, and from England about 30,000*l.* worth. A similar summing up for Roumania shows the extraordinary figures of 355,000*l.* to 1300*l.* worth; for France, 113,000*l.* worth to 33,000*l.* worth; and for Brazil, 311,250*l.* worth to 254,500*l.* worth. The analysis of the Brazilian figures is very interesting. Of the total of 254,500*l.* worth from the United Kingdom, 217,800*l.* worth is attributable to implements and tools, against 20,000*l.* worth from Germany. On the other hand, Germany exports to Brazil seven times our own export of traction-engines and rollers. It is obvious, then, that there is an opportunity for vast expansion in the five countries mentioned above.

The subject may be summarised by mentioning that the following countries are the largest importers of this type of engine from Germany and Austria, given in order, beginning with the country taking the largest amount:—Russia, Brazil, France, Roumania, Egypt, Italy, and Spain. It may therefore be fairly argued that these countries will be the best fields for British expansion during and after the war.

In considering types of traction-engines, in the sale of which Germany has had such a signal success, statistics may again be referred to, and these prove most conclusively that it is in the heavier models of these engines that the largest trade can be done. In three countries, however, Russia, Brazil and Egypt, a very large trade might be developed by English engineers in lighter types—that is to say, in engines weighing less than 6 tons. An interesting point was brought to the attention of the writer when he visited one of the large agricultural implement and road-engine factories of North Germany twelve months ago. He was told there is a ready sale for English-built road engines for running in conjunction with thrashing-machines amongst the large farmers who compose that most militant and pro-German caste of the whole German Empire, the Prussian Agrarian party. The engines most commonly supplied are 10 and 12 horse-power, but there is some demand for 8 horse-power and 14 and 16 horse-power models. If Germans of the class referred to themselves recognise the superior qualities of some makes of British engines, it is surely a conclusive proof that the reason for the great German successes in the sale of these machines in certain directions is not due to the superiority of the machines themselves, but rather to the fact that Germans support the efforts of their engineers by most complete and systematic commercial work and salesmanship. This they do by studying the special requirements of different countries and various classes of customers, and, above all, by always employing travellers who know the languages of the countries they visit, by printing their catalogues in those languages, and by conducting their business and invoicing their goods after the manners and customs of the countries in question. A very large number of the heavier models—that is, those over 6 tons in weight—are sent to Russia and France, and one imagines that the great majority of the engines supplied to these two countries are now being used for transporting the men and material, who are seeking to destroy the designers and makers of the very machines they are using.

When considering agricultural tools and implements, it will be found that British machinery is an easy favourite in the British Empire, in Brazil, and in Argentina, Venezuela, Columbia, and Mexico. Germany, on the other hand, exports enormously to Russia, Roumania, Italy, France, Bulgaria, Turkey, the Dutch East Indies, and in smaller quantities than the United Kingdom to the Union of Africa and the Republics of Central and South America; and it must not be forgotten that Germany's total export of agricultural implements is twice the value of the corresponding machinery sent from Great Britain.

In relation to implements and tools, it will be found there is a wide field for expansion in the construction of ploughs of all kinds, cultivators, grubbers, barrows, rakes, forks and spades of various descriptions, shovels, hoes, and, specially, sickles and scythes. It may be taken as a general rule that Englishmen will always buy the best machine obtainable, without paying much attention to its country of origin, and the fact that not a single plough or ploughshare came to this country from either Germany or Austria last year speaks well for the high-class machines built by English engineers who specialise in this type of machinery. Why, then, are our exporters content with a paltry export of a few hundred pounds' worth of ploughs to Russia, when Germany is sending annually 337,000*l.* worth and Austria 6000*l.* worth of these machines? It is true that Russia is now seeking to manufacture much of her own machinery in this direction, but there is still a market for those who will strive to secure it, for all kinds of wheel-ploughs. Swing-ploughs need not be considered, as there is no call for these in Russia.

Germany and Austria have also a large export trade in ploughs to Roumania, Italy, Bulgaria, South Africa, Turkey, and France; hence English engineers should pay special attention to these countries. In cultivators, grubbers, and rakes Germany's large export to Russia, Roumania, France, and Italy ought not to continue unchallenged, and her large export in spades and hoes to the Dutch East Indies should also be noted. It would appear that 17,000*l.* worth of her total export of 20,000*l.* worth to the last-mentioned country is for these spades and hoes.

Austria seems to fall as far behind her ally in

the manufacture and export of machinery as she does in military prowess, but in one single particular she has had unquestionable success. This is in the supply of scythes and sickles, which she exports to that country of hand-cutters, Russia, to the extraordinary annual value of 141,000*l.*

Germany's total wire export is 3,176,000*l.* worth, Austria's 51,000*l.* worth, and Great Britain's 1,058,000*l.* worth; these figures being for all types of wire, including uninsulated electric wire. Germany exports annually something like 650,000*l.* worth to this country, 190,000*l.* worth to Australia and New Zealand, 275,000*l.* worth to Japan, and 269,000*l.* worth to Argentina. The United Kingdom, which might surely manufacture more of the wire for its own use than has been done recently, sends to Australia just half the amount sent by Germany, 16,000*l.* worth to Japan, and 85,000*l.* worth to the Argentine Republic.

Turning to the question of the vast amount of fencing-wire, barbed wire, and wire netting used in all agricultural countries, the engineer finds himself confronted by problems which might appear to be more those of the natural scientist than of the practical mechanic. Take, for instance, the supply of fencing-wire for South Africa. If an unbiassed Afrikander wishes to purchase a supply of wire, he will find there are three principal kinds to choose from. The English wire is the most expensive, the American second, and the German very much the cheapest. The English wire is vastly superior to the German, being made by a special and more expensive method; it does not break or sag easily, and is not nearly so subject to damage through climatic variations. The American wire is not equal to the English, but is better than the German. One fault is always found with it, however—namely, that it is too hard and brittle, and, consequently, is liable to break wherever bends or joins or twists occur. In Australia, we read, English barbed wire is noted and bought for one very important quality that the German barbed wire does not possess. This is the longer barbs with which it is furnished. Although the short barbs of the German wire are useful enough to prick the thin-skinned horses and cattle of the plains, the thick-fleeced sheep of the uplands take no notice of them whatever, and need the long-barbed English wire to restrain them from wandering too far afield.

It seems clear, then, that to be able to compete with Germany, British wire-manufacturers should endeavour, first of all, to alter in two main directions. They should make, in addition to their present manufactures, a less serviceable wire, to be offered when, on account of good climatic conditions, it will suffice, and also to make the cheaper short-barbed wire, similar to that of the German competitor, to be used in districts other than sheep-pasture lands. In South Africa the largest demand is for Nos. 8, 10, 12, 12½, 14 and 16 B.W.G. The four types most wanted are black varnished fencing-wire for inland use, galvanised wire for coastal regions, galvanised barbed wire (generally 12 or 12½ gauge), and binding-wire. Wire netting is, of course, also required there, as everywhere. In Australia the largest call is for Nos. 12½ and 14 B.W.G. galvanised. Short-barbed wire in the costal regions, and long-barbed wire in the sheep-pasture districts, has a ready sale. There is a good demand also for No. 10 B.W.G. soft galvanised wire for six-strand fences, but few manufacturers seem prepared to meet this demand. It is as well to mention here that fencing standards are imported almost entirely from the Continent at a very cheap price. The usual size is 1 in. by $\frac{3}{16}$ in. by 4 ft. 6 in, and they should be sent unpunched, as they are then admitted as "bar iron," and consequently are duty free. In New Zealand Nos. 8 and 10 black varnished wire has a large sale in the dryer districts. Practically no wire is exported to Canada except from the United States, the Canadian wire-manufacturers being quite able to meet local demands. The demands for wire from India are constantly increasing, and British wire holds its own well there. Outside the British Empire, as already remarked, there are several large fields for extension, and before leaving the subject a word may be said about wire-netting. English wire-netting is intrinsically good, but the fault has to be found with it, as with so many other English goods, that the finish is not worthy of the material used. This naturally militates strongly against the sale of the English wire netting.

A general review of the whole situation with regard to British exports of agricultural engines, implements, tools, and wire may now be made, in the hope that British engineers will take the opportunity presented by the war to extend their exports of machinery to some of those countries which know it far too little, and thereby recoup themselves for the certain losses which must occur in other directions, as, for instance, in the supply of steam-tractors to Northern Prussia. Prussian farmers will probably have no money with which to buy anything, and, if they had, they would hardly wish to buy from the country they are being taught to regard as "perfidious Albion."

One does not wish to labour the points of "finish" and "commercial slackness" too much, as they have been already very fully dealt with in these columns. As each fresh phase of the subject is considered, however, it is felt most strongly that justice is not done to British engineers by the exporters and commercial men whose business it is to sell the machinery. The salesmen may reply that they are not given the assistance in their selling, of which the engineers of other nations make so great a point; but it is very certain that both should combine to ensure that for the future British machinery, which is undeniably first in quality, should also become first in quantity in the markets of the world.

As a final example of the way in which the machines and other products of German engineers are distributed in every corner of the word, the *Wire Verband* of Germany may be described. The wire industry of Germany is largely in the hands of four large firms. These are all quite independent, but combine together for exporting. The arrangement come to is to the effect that each shall do a certain share of the exporting, and any one firm exceeding the pre-arranged figure shall pay a certain percentage of its profits into the general fund. In this way the elimination of competition in selling naturally occurs, and exporting being controlled from a central office, a system covering the whole world can be instituted without difficulty, at less expense than the firms separately could exploit two continents. A consular service, of a most up-to-date kind, gleans every type of technical and commercial information likely to be of assistance to the wire-manufacturers, and the State railways offer special cheap freight rates for goods for export. The shipping companies also give cheaper rates for German manufactured goods, and thus the engineer, the merchant, the shipper, and the State combine to reduce costs to the utmost minimum.

IRON-ORE DEPOSITS IN FRANCE.

In a recent article under this title (see page 421 *ante*), based upon a paper which was to be read by Mr. Paul Nicou at the Paris meeting of the Iron and Steel Institute last month, we gave figures showing the iron-ore resources available in the eastern and western districts of France. We are now able to put before our readers a few complementary data concerning mainly the iron-ore deposits of the French southern districts, data which we have received from our French correspondent. These latter deposits appear to be much less in extent than those reviewed by Mr. Nicou in his paper above referred to, but the ore they yield is of a better quality and deserves notice.

In the first place, we may state that the output of iron ore in France was estimated for 1913 at a total of 21,714,000 tons. In 1912 the total was 19,160,000 tons; it was 16,400,000 in 1911, and 10,000,000 in 1907. The large increase in the output is due in a great measure to the working of the deposits in Eastern and Western France, and not to the yield of the Pyrenean mines, which remains practically stationary. On an average, the annual yield of the Pyrenean iron-mines does not exceed 300,000 tons. The total output of French ore compares, therefore, favourably with that of other countries, the German output being 27,000,000 tons, that of the United States being 60,000,000 metric tons, whilst the output of the Spanish mines is only 8,000,000 tons. The French exports of iron ore are also largely on the increase; they amounted to 2,150,000 tons in 1907, to 6,176,000 tons in 1911, to 8,324,000 tons in 1912, and to 9,746,000 tons in 1913. For this latter year, the figures sent to the various countries are not yet available, but those for 1912 show that 4,672,000 tons were exported to Belgium; 2,798,000 tons to Germany; 615,000 tons to Holland, but mainly in transit for German works: and 215,000 tons to Great Britain.

The average price at the pit-bank of the ore in France in 1912 was about 4.85 francs (about 4s.) per ton, which is slightly above the price for 1911. The total value of the ore extracted in France in 1912 was about 92,875,000 francs (3,715,000*l.*).

The French iron ore is generally divided into three classes. There is, in the first place, the "pure" hematite iron ore, in which the phosphorus content is less than 0.075 per cent. The quantity mined of this high quality ore is about 2 per cent. of the total quantity mined throughout the country, and its average price for 1912 at the pit-bank was about 7.23 francs (about 5s. 10d.) per ton. There are, in the second place, the moderately phosphoric ores, containing up to 1.70 per cent. of phosphorus, and the phosphoric ores for basic pig, containing over 1.70 per cent. of phosphorus. This latter quality formed over 91 per cent. of the total output, and its average price is 4.52 francs (about 3s. 8d.) per ton at the pit-bank. The average price of the moderately phosphoric ores is 5.82 francs (about 4s. 9d.) per ton, and a relatively small quantity of the latter is extracted from the southern departments of France. As a general rule, the "pure" iron ores come from the Pyrenean region.

The Pyrenean iron ores are hematites and carbonates, having a very low percentage of phosphorus and sulphur, and although they are exported in somewhat large quantities, they have given rise to a local industry not without importance. The deposit in the Eastern Pyrenees is that in which the "pure" ores are mostly met with; their value is increased by the fact that they are manganiferous. The percentage of iron they contain rarely falls below 50 per cent.; the hematites frequently contain 52 per cent., and the roasted carbonates 55 per cent. The deposits are in two divisions, one called the Northern, or Prades, division, in which is located the Fillols workings, the other being the Southern, or Batère, division. These deposits are on the northern and southern slopes of the Canigou mountain range, between Prades and Céret, west-south-west of the town of Perpignan. All the mines are at an altitude of from 800 m. to 1600 m. (2625 ft. to 5250 ft.), and, in order to deliver the ore, aerial ropeways have had to be put down which supply branch lines connected to the Southern of France Railway system.

The quantity of ore available in the Pyrenean basin has so far only been roughly estimated; some experts put it down at 30 million tons, and others at double that figure.

The ores met with in the Ariège Department, also in the Pyrenees district, are of somewhat similar composition to those of the Canigou range. Among the workings are those of Rancié, in the Vicdessos valley, and those of Rabat, Chateauverdun, and Riverenert, these latter between the towns of Foix and St. Girons. In the Tarn Department the basin contains 2,000,000 tons. In the Western Pyrenees, towards the Bay of Biscay, the main deposit is at St. Etienne de Baïgorry, on a line which runs as far as the Spanish frontier to St. Jean-Pied-de-Port, laid mainly to serve the deposit in question.

There are in all in the Pyrenean region twenty-two mines and nineteen open-air workings, which yield the annual output of about 300,000 tons referred to above.

The same region also contains the major part of the manganese mines—seven for the whole country—met with in France. The workings at Vieille-Aure, in the High Pyrenees, yield annually about 3000 tons—a very small quantity compared with that of other countries. The Aude Department yields 1150 tons annually. France imports every year about 225,000 tons of manganese ore, and exports about 2300 tons.

NOTES.

Liability for Damage Caused by Hostile Aircraft.

As the great war drags its weary length along it is impossible not to realise that our enemies have ever in mind the possibilities of invasion. Things have moved on since Napoleon made his great demonstration on the other side of the narrow seas. The fast cruiser, the submarine, and the airship all tend to make what must always be a desperate enterprise somewhat less desperate; and even if we are successful in preventing an invading force from landing, it is quite possible that a considerable

amount of damage may be occasioned to property. When considering the effects of the war upon commercial relations, most people have hitherto been content to discuss its probable effect upon contracts at home and abroad. Attempts have been made, both by statute and Royal Proclamation, to define and explain the law as it affects debtor and creditor, the position of neutrals, and contracts between British subjects and the citizens of hostile countries. Whether these problems have been satisfactorily answered we do not now pause to inquire. We desire to draw attention to certain questions which will also become urgent should invasion be even partially successful. Since invasion has hardly ever been considered to be within the bounds of possibility, it will be found that most contracts make no provision for war risk. Let us take, for instance, the lease of a factory or mill, drawn in accordance with standard forms. It will contain no clause fixing the liability for damage caused by the enemies of the King. If a hostile airship were to drop a bomb and wreck a building, the liability of landlord or tenant would not, in general, be defined by the lease. To ascertain that liability one has to grope along the dusty highway of the common law; and, strange to say, one has to travel back to the seventeenth century to find any clear pronouncement on the matter. From a case decided in the year 1640, it appears that where a house is let on a repairing lease, it is the tenant who is liable to make good all damage caused by the King's enemies. That is one of the risks which he undertakes. It is plain, however, that if the landlord is under liability to repair the main walls and timbers, the liability for damage occasioned to the structure would be on him, while the tenant would have to perform his covenant as to the interior. It follows that the prudent tenant should insure against war risks. Whether there is much risk of damage being caused by a bomb dropped from a Zeppelin we need not inquire. Suffice that a small sum spent on insurance may purchase a certain amount of peace of mind. The terms of the policy should, however, be carefully scrutinised. One form which we have seen merely deals with the damage which may be caused by a hostile bomb; it does not cover the risk of injury from spent shot or shell fired from an anti-aircraft gun. Apt words should be inserted to place that burden upon the broad shoulders of the underwriters, and care should be taken to see that they are broad enough to carry it.

Action of Metals on Water.

The eleventh International Pharmaceutical Congress which met in 1913 charged Dr. W. P. Jorissen, of the University of Leiden, Netherlands, with compiling a report on "The Action of Lead, Copper, Nickel, Zinc, and Aluminium on Water." This report has just appeared in the *Comptes Rendus* of the Congress, and it is instructive in itself and also for the reason that the ample literature references comprise quotations from Dutch workers and from bodies like the Austrian Gesundheitsamt at Vienna, whose work is frequently overlooked. On the other hand, some of the most recent researches are not yet included in the report, of course. We should prefer to speak of "the action of water on metals," rather than of "the action of metals on water." For the chief object of the investigation was to study the behaviour of metals when in contact with water, especially ordinary water containing both air and certain salts. The report discusses the potentials which the various metals—not only those especially mentioned just now—assume in normal solutions of their salts. The order of the metals is: Mg, Al, Mn, Zn, Cd, Fe, Co, Ni, Sn, Pb, H, Cu, Bi, Sb, Hg, Ag, Pt, Au. In this series magnesium stands at the positive end, hydrogen marks the zero (because the potentials are referred to the hydrogen electrode), and the metals copper to gold appear on the negative side. The order depends somewhat on the respective salt solutions, a point still further to be investigated; Dr. Jorissen is also studying the influence of air when passed through the solution in which the metal is immersed. The report does not deal with iron in particular, because the corrosion of iron has a literature all to itself; but the phenomena of passivity and of stress are considered. The over-voltage—*i.e.*, the additional electromotive force required to liberate hydrogen from the surface of certain metals and its dependence upon the surface condition—is likewise discussed, of course. The position of ordinary aluminium in the electrochemical series is somewhat uncertain; the position above indicated belongs to the amalgamated metal; and the anomaly of the ordinary metal is apparently due to its being covered by a surface film of oxide. In dry air it keeps well, in moist air it oxidises superficially, but the film does not grow; distilled water has very little action, even in the presence of carbon dioxide; ordinary water may pit the metal even in the absence of air; cold-worked aluminium corrodes locally, annealing at 450 deg. Cent. stops local corrosion. In solution of sodium chloride and in sea-water the local corrosion is strong. Amalgamated aluminium decomposes diluted sulphuric acid, whilst amalgamated zinc does not. In pure distilled water, free from gases, zinc keeps bright for years; in the presence of oxygen some hydroxide is formed, which is very sparely soluble in water, more soluble in salt solutions; the presence of carbon dioxide makes little difference. In these respects pure and good commercial zinc behave pretty much alike; rain-water takes up zinc from zinc roofs. Nickel is hardly attacked by air, moisture, diluted acids (hydrochloric and sulphuric), and sea-water. Pure tin is not attacked by water or diluted sulphuric acid, as long as air is absent. Tin-lined water-pipes become streaky with oxide and with the impurities of the water; in the presence of air sea-water corrodes tin, which is important for condenser-tubes, especially as the tin lining on copper or brass is generally very thin. The corrosion of lead by water and the contamination of the water by lead have repeatedly been discussed in our columns of late. Jorissen points out that as lead chloride, and still more the sulphate, are much more soluble in water than the carbonate, the danger of lead-poisoning is increased by the presence of metallic sulphates or chlorides. The general conclusion is that the action of a potable water on lead and zinc cannot be predicted from the composition of the water; special experiments are required, and that conclusion confirms the views of previous investigators.

LITERATURE.

The British War Fleet: Its Inception and Growth throughout the Centuries. By Fred T. Jane. London: S. W. Partridge and Co., Limited, Old Bailey. [Price 10s. net.]

This is not a book prepared hurriedly to meet the special demands of readers during war time. It is the outcome of what one might call a life-long interest and study of naval affairs. It was begun, and probably ended, before the outbreak of war, and is therefore intended to fill a more permanent place in the bibliography of the Navy than the more or less evanescent and topically interesting books which are being published at the present time.

The author, in his preface, states that his aim is not so much to trace the evolution of strategy and tactics as to review the development of the *matériel* of the fleet. He admits that, as a "vague generalisation," it may be correct to say that in the scheme of the book the shipbuilder is put into the limelight instead of the ship-user, but at the same time he demurs to the view that this is precisely correct; in "exact fact each, of course, is, and ever has been, dependent upon the other. Nelson himself was curtailed by the limitations of the tools provided for him. Had he had the same problems one or two hundred years before, he would have been still more limited; had he had them fifty or one hundred years later—who shall say?" Mr. Jane, however, seems to have been unable to trace the influence of the shipbuilder on the work of the ship-user, or *vice versa*, to any great extent in the earlier history of the Navy—up to the Crimean War. This is, perhaps, inevitable, because it can scarcely be said that relatively great progress was made in the design, structure, or fighting munitions of warships up to that time. So that it is doubtful if Nelson would have experienced greater limitations if he had had to fight the glorious fight of Trafalgar 100 years earlier. On the other hand, the *matériel* to-day is so enormously superior that, while strategy is the same, tactics has been immensely influenced, as the events of the last two months have clearly demonstrated.

The author has drawn the pure chronological view. This was more or less unavoidable in the accomplishment of his end, but unless the treatment is with a master-brush there results from this system a lack of broad effects, so that it is difficult, without very close study, to discern the prominent features and high lights which alone help to a clear conception of the panoramic picture. Thus, in the first half of the book, extending to some 150 pages, the story brings prominently to the front achievements in strategy and tactics. It is true that once and again there are indications of improvement in design, notably by Phineas Petts. Although large ships were recognised at an early period as conferring great advantage, we find little development in this respect until modern times. In the fifteenth century few ships were of more than 120 tons. The Grace de Dieu, of the sixteenth century, was of 1000 tons. The beginning of the seventeenth century found the largest ship, also of 1000 tons—namely, the 68-gun Triumph. The Royal Sovereign, laid down in 1635, and launched in 1657, had a length on the keel of 128 ft. and over all of 232 ft., a width of 58 ft. and a tonnage of 1141. The Britannia, the best of the first-raters towards the end of the seventeenth century, was of 1739 tons, being 146 ft. long by 47 ft. 4 in. beam, and carried 100 guns. At the beginning of the nineteenth century the largest ship—the Caledonia—was of 2616 tons, and carried 120 guns. The author indicates that limitations in the size of ships were imposed by the length of timbers which could be grown, and we agree with him that strategy and tactics scarcely had material influence in the design of these earlier ships.

From Mr. Jane's treatment of what may be termed the "modern Navy," one can only, from this narrative, realise that a more dominant influence than strategy and tactics was the development of applied science, and in this respect the author has failed to throw illumination on the features in the picture of progress which he has painted. The new era opened with the inception of the ironclad, although the introduction of iron and of steam (which is dealt with in the ninth chapter of the book) may seem to mark a new beginning. Whether the Crimean War, as the author contends, was "probably the most important war in its indirect results on the Navy that ever took place" is doubtful. Was it not rather a coincidence that the Crimean War was fought at the dawn of the period when scientific activity was having its effect through particular influences tending to increase the efficiency of the warship? It is true that at that time steam was in much use, especially in merchant ships; that the screw-propeller had established its superiority over side paddles; that the ordnance manufacturer was beginning to appreciate the fact that the old small-bore muzzle-loading gun had become obsolete; and that batteries on board ship, and even the sides of iron ships, could be more effectually protected by heavier plating. Again, in the structural details of ships, Scott Russell had exercised a powerful influence.

From this time forward the author deals with the evolution of the ship of to-day in eras, taking the life-work of the four successive Chief Constructors of the Navy—Reed, Barnaby, White and Watts—as marking the beginning and end of these eras respectively. It is in the treatment of the work of these designers that one experiences a little disappointment. The chronological order is exclusively followed, and each year's naval programme is dealt with, and although the subject of the disposition of the armament, bow *versus* broadside fire, muzzle-loaders *versus* breech-loaders, the extent and efficiency of armour protection, and water-tight sub-division as a protection are incidentally dealt with, there is entirely lacking a consideration of the influence of contemporaneous developments in chemistry, metallurgy and thermodynamics. The strategist and tactician may determine what he considers the most desirable preponderant in the various elements which go to make an all-round efficient warship, and Mr. Jane touches on this subject with that experience of naval affairs that he undoubtedly possesses; but in the evolution of the warship as we know it to-day a most important factor was the development in the three branches of applied science which we have enumerated.

Thus, for instance, in most of the eras the author satisfies himself with a tabular statement of the principal ballistics of the guns belonging to the respective eras; referring only incidentally to the introduction of wire-winding, and one or two kindred points. There is nothing said about the increased power of explosive compounds as propellants in guns, and of their influence on the

striking energy of the guns. Again, their effect on the gun structure is ignored. In addition, there was the advance in the tensile strength of materials, which has greatly assisted towards the increase in the ratio of energy to weight of gun. Moreover, the improvement in the form of projectiles, and the advance in the destructive effect of the explosive charge in such projectiles, is not brought clearly to the forefront. Here, again, it would have been possible to trace the influence of projectiles in the design of ordnance, because it is accepted that the increase in calibre in recent years is not aimed at in order solely to increase the range, but also to increase the bursting charge, and consequently the destructive effect, when the projectile has reached its billet. With a less muzzle velocity, and consequently a reduced rate of deterioration of the gun, greater destructive effect is attained. Not a word is said of the enormous increase in efficiency of gun-mountings, including the loading mechanism, which, with the superior sighting mechanism in use, must have its effect on tactics, by reason of the greater rate of hitting obtainable. There has been saving in weight all along the line as the result of the work of the artillery engineer, associated with the chemist and metallurgist; so that, without affecting adversely any other elements of design, it has been possible to increase the direct offensive power of the ship.

Again, only incidentally is the improvement in armour mentioned. To be completely illuminative of the progress in warship-building it is surely necessary that there should be included in a review references to the influence successively of the compound, Harveyised, Krupp cemented, and of later systems of intensifying the hardness of plates and their resistance to projectile penetration. Only in this way has it been possible to meet the increasing force of attack by the gun within reasonable limits of thickness and weight. This question, again, brings to the foreground very conflicting opinions regarding the general efficiency of armour protection and the end desired by the designer in determining the thickness and disposition of the armour. This question Mr. Jane does touch upon in connection with successive ships, but our complaint is that the uninformed reader is not adequately impressed with such influences continuously at work towards the improvement of the design.

This remark is still more justified in connection with thermodynamics. The introduction of the Parsons turbine is mentioned, but in a most inadequate way, because one lesson which the work done by the Navy during the past two months establishes in tactics is the influence of high speed. The work of the Arethusa at the Bight of Heligoland, and the performance of her sister-ship, the Undaunted, with four of the latest destroyers, off the Dutch Coast, were illuminative of the advantage of speed. The turbine, in association with oil-fired water-tube boilers of the "express" type, has enormously reduced the weight absorbed by high-powered machinery, enabling more powerful machinery to be applied within reasonable limits of weight, and therefore augmented speed, without making too great a sacrifice of other elements of design. It has, too, made it possible for ships cruising at low speed to spring, like a dog from the leash, to the highest rate of movement in the shortest possible time. Without the developments in boilers and machinery it would not have been possible to attain the higher speeds in all types of ships. This ought to have been a dominant feature in any panoramic picture of the Navy, brought out with such a broad brush that the eye could discern it at a glance, and the mind be impressed by its significance relative to the whole view.

The book is thoroughly up to date, and embraces a chapter on airships; but it is surely misleading to classify the work of the Dominions under the heading of "Auxiliary Navies." In conclusion, there is an interesting chapter on general matters of the last hundred years, while a splendid series of coloured illustrations, from originals by Mr. W. L. Wyllie, R.A., adds to the general acceptance of the book. In addition there are elevations of the later ships, showing the armour and disposition of guns, along with photographic reproductions of several. With the addition of two or three chapters bringing into the foreground scientific influences on design, the book would have been of great value as an educational influence on a subject probably the most vital to the British nation. It is, nevertheless, a useful contribution to the subject.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. VIII.

By Frederick William Lanchester, M. Inst. C.E.

Rapidity of Fire and Its Measure.

The measure of the rapidity of gun-fire from an aeroplane or dirigible as an index of its fighting value depends upon the nature of the objective or target. It is evident that in some cases the mere number of projectiles per minute is the most important factor, as, for example, in attacking any object in which a hit is a hit whether the projectile be large or small. In other cases, where the mischief done is in any reasonable relation to the weight of the projectile, the *total weight* of projectiles discharged per second (or per minute) affords a better criterion. In view of the comparatively flimsy and fragile nature of aircraft it is doubtful whether the *energy equivalent* of the discharge will ever be of the importance that obtains in the case of the battleship, where the destruction of the enemy depends to a very large extent upon the number of foot-tons with which he is assailed. Thus it is doubtful whether a factor representing the horse-power of the offensive armament would, as applied to the fighting aeroplane, have any useful signification. Now it is scarcely probable that in the immediate future the fighting-machine can be furnished with complete bullet-proof protection, at least such as can be considered effective at short range. Consequently we may take it that it is quite unimportant whether the bullets used in its destruction be of the usual British 215 grains or the 162 grains of the Mannlicher, or the 530 grains of the old Enfield. The advantage of size and weight only becomes important when a single hit is sufficient to carry away an important strut or structural member which would have been penetrated without great injury by a bullet of ordinary size. Thus, so long as we are dealing with ordinary rifle, pistol, or machine-gun fire, we are concerned merely with the number of bullets that can be discharged per unit time, and this number—*i.e.*, number per minute or second—fairly and properly expresses the value of the armament. This, of course, does not mean that the weight and muzzle energy of the bullets are of no importance whatever; it is merely an expression of the fact that with such weapons as are commonly available the differences, such as they are, and important though they may be in other applications, are not appreciable in relation to attack of aircraft on aircraft.

When we pass to the consideration of weapons capable of throwing explosive projectiles, it is impossible to maintain, or even suggest, any direct basis of comparison. The effectiveness of shell fire depends entirely upon the conditions being present necessary to the correct timing of the fuse—that is to say, either the range must be known with great accuracy and the time-fuse mechanism correspondingly perfect, or the nature of the target must be such as to permit of the effective employment of an impact fuse of some description. Granted that the necessary conditions exist, the destruction wrought by any given type of explosive projectile may be taken as, in a measure, proportional to its weight. However, there are cases when a 3-lb. shell would be just as effective as one of 18 lb., as, for example, if it were to strike the motor or fuselage of an aeroplane in flight, and so, in assessing the value of shell-fire by the aggregate weight of the projectiles thrown, it is evident that we should only be making an approximation to the truth.

If we go further and endeavour to compare the relative value of armament of diverse type for aeroplanes, as, for example, in computing the relative merits of machine-guns and small artillery in any given case, we are inevitably thrown back on examining the service for which the armament is required; it is impossible to institute a direct quantitative comparison which would be generally applicable. If it be conceded that in any particular case a given weight in the form of shell is of greater effect than the same weight in the form of bullets, then we have a *prima facie* case for the use of artillery. If, on the other hand, it is conceded that the bullets would do the greater mischief, then a machine-gun armament is indicated. However, although the weight of ammunition is a matter of first importance, the weight saving and convenience of the machine-gun in itself are sufficient to give it a preference where the other advantages are not overwhelmingly against it.

It has in the preceding paragraph been rather assumed that the capacity of the armament, as represented by its weight-rapidity factor of fire, is a constant; this is a matter that depends, firstly, upon the mechanism of the gun. The Lewis gun, which has been taken throughout these articles as representative of the machine-gun in its aeroplane usage, will fire as an ordinary maximum 600 rounds, or 18½ lb. of lead per minute. Unfortunately, there is no standard 1-pounder with which to institute a comparison. The 37-mm. gun is given by different makers as throwing in some cases a projectile weighing 1 lb., and by others the same bore is given as throwing 1½ lb. Also the question arises whether an automatic gun of this size is, on account of its heavy mean recoil, an altogether workable proposition. The Vickers automatic 37-mm., for example, is made in two weights; one of these throws a 1-lb. shell at 1800 foot-seconds at 300 rounds per minute, at which speed of discharge the recoil reaction would be about 300 lb. The weight of this gun is given as 3¾ cwt. This gun is quite unsuited to aeroplane service, both from the point of view of recoil and weight; there is, however, a lighter type by the same firm, of the same calibre, semi-automatic, throwing a 1½-lb. projectile with a velocity of 1200 ft. per second, the weight of the gun being given as 110 lb. Presumably the maximum rate of fire of this gun would be about thirty rounds per minute, or the weight of metal thrown per minute, 45 lb. This is about 2½ times the weight per minute given above for the machine-gun.

Quite apart from mechanical details, however, a real limiting factor exists in the *recoil reaction* to the momentum per second permissible, and this limit may be taken as applying whatever the type of gun may be; consequently, since the muzzle velocity of one type and another is not widely different, the weight discharged per second or per minute will have an approximate maximum for any particular aeroplane no matter what the type of gun may be. This is the reason why it is possible and, in the writer's opinion, advantageous to employ duplication, or even fit three or four barrels in the case of the machine-gun; whereas an automatic 1-pounder under like conditions could not reasonably be allowed to fire at over 60 or 80 rounds per minute.

At present there are very few cases in which the automatic or semi-automatic 1-pounder could compete with the machine-gun as an aeroplane arm. If such a thing existed as an impact-fuse of such sensitiveness that it would explode with certainty on encountering balloon-cloth, the 1-pounder would be an excellent weapon for the destruction of the airship or dirigible. Every particle of a shell exploding within the envelope is effective, and the fragments of a shell leave wounds in the envelope and give rise to loss of gas of a more serious character than that due to the rifle or machine-gun bullet. Beyond this the danger to the crew (and structure in the case of a Zeppelin) is considerably greater under these conditions than under equivalent machine-gun fire. It may be some time, however, before the impact-fuse reaches the required degree of perfection.

In the writer's opinion there is room for a well-designed light-weight automatic to fire 14-oz. shell at a moderate velocity, say 1200 ft. per second, with a maximum rate of 100 rounds per minute, the weight of the gun to be kept, if possible, under 100 lb.; the length should be kept as short as the requirements of the internal ballistics permit. The value of such a weapon would, however, almost entirely depend upon the development of the ammunition, and in particular, as already pointed out, the perfection of the impact-fuse to a point not yet altogether in sight.

Armour in its Relation to Armament.

We have already given considerable attention to the question of armour in connection with the primary function of the aeronautical Arm—the attack on and co-operation with the other Arms of the Service. It is now time to extend our study to the secondary function of the Arm, and discuss the question in relation to problems of aerial attack and defence. The first instalment of the conditions that have to be fulfilled by the aeroplane constructor arises directly from the consideration of its primary function; thus it is already given us that the armament to be of maximum service must be capable of action to the full in a downward direction with the greatest angle of fire both forward and aft, and laterally, that the limitations imposed by structural considerations permit. Similarly,

we know that the initial need for armour is mainly to resist attack from below. These facts remain, and cannot be altered by the additional duties imposed when aeroplane attacks aeroplane. We may, and, in fact, shall, have to provide for a far wider range of fire; we shall need to make provision for training our gun or guns upward as well as downward; likewise we may find it expedient to provide protection against fire from above as well as beneath. But any extended scheme of armament or protection so developed takes essentially as its starting point the more elementary condition.

The first result of importance that may be said to arise from the above facts is, in an aeronautical engagement, the *importance of the upper berth.* The machine that is able to attack from above is protected by its armour from the enemy's fire, and is able to attack under the conditions for which its armament was initially provided. Beyond this, the taking of the upper position at the start, or perhaps, we may say, before the start, gives the power to outmanœuvre an enemy, in spite even of inferior speed capacity in the ordinary acceptation of the term. The initial difference in altitude represents an initial store of potential energy that may be drawn upon when the opportunity occurs; this is, in fact, the principle utilised by the hawk, the kite, and other birds of prey. The objective of securing the upper berth, or position, or "gage," if we adopt the old-time word used by naval writers, will probably prove to be, and will remain, the key or pivot on which every scheme of aeronautical tactics will, in some way or another, be found to hang.

The question of employing armour as a protection from attack from above, or even against dropping fire, is one that requires consideration on an entirely different basis from that of attack from below. In the latter case, the employment of protection in some degree may be looked upon as essential. The steel employed may be thin and only sufficient to be effective above some prearranged altitude, but, nevertheless, it is essential. Protection from attack by other aeroplanes, or, more broadly, aircraft, is another question; we may express the utility of armour under these conditions definitely in terms of gun-power. To make this clear let us take the case of two machines in combat—an aeroplane duel, in fact—and we will take it that at their average distance apart or range the mean number of shots fired by either to score a decisive hit is found to be 600. Now if either aeronaut by the employment of armour or gun-shields, or equivalent device, can reduce the effective target offered by his machine to one-half that previously presented, it will on an average take 1200 shots to knock him out in lieu of 600 without protection. But in order to provide for the weight of his armour he must cut down his armament; he must sacrifice either his gun weight, and with it his speed of fire, or he must carry a lesser total weight of ammunition, and risk finding himself without means of attack, this being virtually synonymous to being without means of defence. If the only alternative were the cutting down of the speed of fire—tersely, if he were to substitute, say, 30 lb of armour for 30 lb. of gun—and if this represent half his total gun capacity, involving a reduction in his speed of fire by one-half, then the change might be considered as *nearly* justified, since he would receive two shots for every one he could discharge, but would at the same time be proportionately less vulnerable.

Obviously, *rate of fire* should be one of the last things to be sacrificed; but the alternative—a reduction in the load of ammunition—involves a curtailment of the period of activity, and, as a corollary, an increase in the number of machines required for a given combatant duty. Once admit the necessity for such additional machines, and we must estimate the sacrifice or price that is paid for the armour in terms of the loss of fighting strength due to the absence of a section of the air-fleet occupied in replenishing. This is evidently a most serious matter under the best conditions—*i.e.*, when fighting in the immediate vicinity of the base. If, however, an air-fleet were engaged far afield, the sacrifice of rapidity of fire, rather than reserve of ammunition, might well prove to be the less of evils.

The foregoing illustration shows that, tangibly or intangibly, the matter is one of figures, or, at the worst, a balance of advantages not capable of ready numerical expression. It may thus not always be possible to lay it down definitely whether in theory given conditions mean the abandonment of armour or otherwise; but nevertheless the fact is determined by the sum of the conditions, and where theory is dumb the decision will require to be taken on actual experience, as in analogous problems that arise in naval construction.

It is, perhaps, opportune to draw attention here to the difference between *shield* and *armour* as a means of protection. The shield is essentially mobile, it is moved round and about to give the best protection possible, according to the direction of attack. A shield commonly forms part of a gun-mounting, but this is by way of being an accidental circumstance; the gun has to be trained on the enemy, and so the shield is made part and parcel of the gun, so that it automatically takes the best position for the gunner's protection. In the aeroplane, however, the pilot is of almost more importance than the gunner; hence this traditional method of handling the shield may not be the best possible arrangement. Perhaps it will be found advantageous to provide the pilot with a shield separately mounted or otherwise adjustable. There is rarely any intention in the case of a shield to give full and complete protection as is done with armour. It is an error to suppose that partial protection is of no value; every square inch covered diminishes proportionally the chances of a fatal hit, and so increases the fighting value of the machine, just as would a commensurate increase in rapidity of gun-fire. On the other hand, as already insisted, armour or shield that is insufficient in thickness is worse than useless. It is probable that where (owing to the considerations already discussed) it may not pay to fit armour it will still be found profitable to provide shields to give partial protection to both gunner and pilot.

THE BRITISH ASSOCIATION IN AUSTRALIA.

From its very beginning the Australian meeting of the British Association was overshadowed by the War—and yet in spite of this it was a decided success. When the main party arrived at Fremantle in the morning of August 4, by the Orient liner Orvieto, and was entertained at lunch in Perth, the Mayor, in welcoming the guests, dwelt on the extreme gravity of the situation, but was able to state that England was, so far, not directly involved in the war. Reinforced by the strong advance party of geologists, archæologists, biologists, &c., who had been studying Western Australia for a week or longer, the members proceeded round Cape Leeuwin and through the Great Australian Bight to Adelaide. On that journey the captain of the Orvieto informed his passengers that he had been advised to avoid the usual track and to mask his lights; but no news of the actual declaration of war by England reached the members. Yet when they anchored at Adelaide on August 8 they found the papers full of telegrams—grossly inaccurate—of terrible engagements both on land and at sea. The war in distant Europe, 12,000 miles away, had already made itself felt in Australia. The question of the defence of the home and of the Old Country relegated all other questions to the background, certain branches of business came to a standstill, and mines discharged their men. The Commonwealth elections were coming on, moreover. The British Association meeting seemed doomed. The Euripides having on August 8 brought another strong contingent of over-sea members to Adelaide, the party was practically complete, and concerted action could be taken. A meeting of the chief officers and influential members assured the Australian organising committee that the British Association would, of course, willingly consent to any modification of the great programme that the interests of the country demanded. But the hosts thought that they could carry the programme through, and it was carried through, with a few minor changes.

As soon as the war rumours assumed definite shape, Sir Oliver Lodge—who, as last year's President of the Association, remained acting President until he vacated the chair on August 14, at Melbourne, in favour of Professor Bateson—took the opportunity on the Orvieto of emphasising that science knows no nationality; he felt convinced members would bear that in mind. The party included scientists of various nationalities; France happened not to be represented this year. When proposing a vote of thanks to the new President at Melbourne, the Governor-General of the Commonwealth, Sir Ronald Munro Ferguson, said that the war risks to which they had so unexpectedly been exposed enabled them to realise that all men of science were brothers. In the afternoon of that same day honorary degrees had been conferred on a number of distinguished scientists, and the Vice-Chancellor had accentuated the fact that all the members of the over-sea party, without exception, were the guests of the Commonwealth. The welcome could not have been warmer and more general, indeed, though Sir Arthur Morgan, after the concluding discourse delivered at Brisbane by Sir Edward Schäfer, remarked that he feared at first that the crisis, to which the minds of the people were directed, might interfere with the warmth of the welcome. No doubt the political complications rendered the task of the hosts very difficult and delicate. But hospitality could not have been practised in a more thorough and cordial way, and all the visitors will gratefully remember "Hospitable Australia."

On landing every member was presented with a free railway pass which took him, in sleeping-cars, over thousands of miles of railway. His luggage, identified by his number, was collected beforehand and delivered at his address in the respective centre. We mentioned in our introductory article* that members were each supplied with a little diary, giving the names and numbers of all the members, the routes by which they intended to proceed out and back, and the preliminary programmes at the five centres, Perth, Adelaide, Melbourne, Sydney, and Brisbane. In addition to this diary, which was a happy innovation due to the assistant secretary of the Association, Mr. O. J. R. Howarth, M.A., and which proved most useful, members were at each centre presented with a local excursion guide and a booklet stating the train by which the member had to travel, the number of his berth and the number of the conveyance which would take him to his new address. It was, of course, a difficult matter to accommodate on the trains and in the towns the 307 over-sea members, to which were added a large body of local members, moving with the party from centre to centre. Each over-sea member was entertained in hotel or club, or privately, throughout the meeting. On the whole the arrangements worked very well; some luggage was delayed, of course; a little confusion arose at the railway stations, where the conveyances could not always quickly be found in spite of the exertions of the many honorary stewards; and some members discovered that their hosts lived at inconvenient distances from the reception rooms. Such things are unavoidable; but there was never any reason for serious grumbling; perhaps the hosts may have wondered occasionally at the complacency with which the visitors accepted private hospitality as if they were staying in hotels they had themselves selected.

Members of the advance party to Western Australia were the first to appreciate Australian hospitality. Everything was prepared for them, and they soon recognised that the south-west of Western Australia—a barren country apparently, practically devoid of railways, even on comparatively recent maps—does not merely rely on its gold-mines, but has quite a network of railways leading to fertile fields and orchards, and that the Trans-Continental railway to South Australia is already being built from both ends, Kalgoorlie and Port Augusta. Lectures were given at Perth as at the other centres. At Adelaide, again, the programme consisted mainly of excursions, entertainments and discourses; the contemplated ball was converted into a reception, but a ball afterwards took place at Sydney. The excursion to Broken Hill occupied five days—that is, nearly the whole time of the Association's stay in South Australia. The party first went to Port Pirie, a distance of 169 miles, where the Broken Hill Proprietary smelt or concentrate the lead and zinc ores which are now chiefly mined at Broken Hill; silver ores have become scarce there, but silver and gold are gained as most valuable by-products, of course. The concentrates used to go by ship chiefly to Germany, just as did nearly the whole of the electrolytic copper of the Kembla works, in New South Wales, which works practically deal with most of the Australian copper. That is one of the reasons why the war at once created a serious

* See page 225 *ante*.

situation in Australia. From Port Pirie the party crossed the northern end of the Spencer Gulf over to Hummocky Point, in Eyre Peninsula, and went by rail another thirty odd miles further on to the Iron Knob and the Monarch, two mountains consisting of splendid hematite, which is already being shipped to the new steel furnaces of the Broken Hill Proprietary at Newcastle, in New South Wales. This new iron industry is of the greatest importance for Australia, and a big plant is rising at Hummocky Point for the shipment of the ores; by rail the distance would be 1500 miles. From Port Pirie the party then went by the railway, which brings the ores down to Port Pirie, up to Broken Hill, again a distance of 268 miles, where a number of different firms have mines and works.

Throughout this excursion members saw vast stretches of red ground on which little more than low shrubs ("salt bush") grow; by no means waste land, however, for the salt bush makes an excellent food for sheep. Water is very scarce, of course; as much as 5s. and more may have to be paid for 100 gallons, if at all obtainable at settled rates; as a rule the price is fixed, and when the drought becomes severe, as it was during the visit of the Association, the price is not raised, but the supply is cut down. Port Pirie draws its water, at 1s. per 1000 gallons, from the Betaloo Reservoir, a State undertaking. Broken Hill is supplied from the private Stephen's Creek Reservoir, at 1*l.* per 1000 gallons for domestic use. The gold-fields of Western Australia receive their water from the Coolgardie scheme, at 6s. per 1000 gallons, through a 30-in. pipe, carried from the hills near Perth, 300 miles to the gold-fields. Broken Hill itself, a town of 50,000 inhabitants, is situated not in South Australia, but on the other side of the border, in New South Wales; but Port Pirie, in South Australia, is the natural outlet for its produce, and the railway from Broken Hill to Adelaide, a distance of 335 miles, crosses the mountains at a height of nearly 3000 ft. Most of the Australian railways have to overcome considerable heights.

On August 12 the over-sea party proceeded by three special trains to Melbourne, 483 miles by rail, passing close to Adelaide through beautiful hills, gardens, and fields. At Melbourne, on August 14, the meeting was formally opened by Sir Oliver Lodge, and Professor William Bateson, F.R.S., Director of the John Innes Horticultural Institution, London, delivered the first part of his address in the crowded Auditorium Hall, both the Governor-General and the Governor of Victoria, Sir Arthur Stanley, being present. The Sections met on the Friday, Tuesday, and Wednesday. The population of Victoria in particular displayed the warmest interest in the proceedings of the Association; more, indeed, than one would have gathered from the somewhat scanty space-allowance which the daily Press granted the reports of the sectional proceedings. The excursions to Ballarat and Bendigo again attracted others besides miners and chemists; the excursions to Bacchus Marsh and the Macedon district were chiefly intended for geologists; those to Warburton and Emerald introduced the visitors to the high eucalyptus trees (over 200 ft. high), and also to the chemical works of Messrs. Cuming Smith, the only manufactory of wood-distillery products in the country; the excursions to Marysville, the National Park, the Central Research Farm at Warribee, and the irrigation area of Bacchus Marsh were arranged for farmers, botanists, and members of general interests.

Having spent a week at Melbourne, the party entrained for Sydney, a journey of 583 miles, where they arrived on Thursday, August 20. There the President delivered the second part of his address, the sectional proceedings were resumed, and members had the choice of a long list of more than twenty excursions. The two excursions to the Jenolan Caves proved the greatest draw; the caves are in the Blue Mountains, the finest scenery of which was seen on this occasion, and the caves are also the home of some characteristic Australian animals, which are becoming very rare, though especially protected; the wallaby (the name is given to several kinds of small kangaroos) is almost tame there. Engineers could go to the Federal Territory, Canberra, and the great Burrinjuck Dam near by; to the Murrumbidgee irrigation area, to which this dam belongs; to Bulli and the Cataract Dam, which supplies Sydney with water, and to the Hawkesbury Bridge. A special Sydney Harbour trip was also provided. The Electrolytic Copper Works at Port Kembla, on the coast, south of Sydney, should also be mentioned here; the works are the only electrolytic copper refineries in Australia, and all the copper from the Mount Morgan Mines (Queensland) and from Tasmania is refined there. Geologists went to West Maitland, to Hawkesbury—the Hawkesbury sandstone, up to 1000 ft. in thickness, is one of the chief rocks in the east of the State—and other places; agriculturists and geologists as well, to Coonamble and the North-West and elsewhere; fisheries could be studied at Port Hacking; and the National Park, a reserve of over 33,000 acres, on a plateau rising to 900 ft., was likewise visited by many members. The Coonamble trip meant a journey of 900 miles by rail and motor; the water supply of this town is from artesian bores, but the water corrodes the iron pipes.

The journey from Sydney to Brisbane, a distance of 725 miles, occupied 28 hours. The route passes over Hawkesbury Bridge, in scenery which resembles and rivals, if not surpasses, that of Sydney Harbour, and *via* Newcastle (which the main line circumvents, as the district is swampy), and across New England (the northern part of New South Wales)—reaching at Ben Lomond a level of 4473 ft., 70 ft. higher than Ben Nevis, the highest point of the United Kingdom—into Queensland, and then across the wonderfully fertile plains known as the Darling Downs (2000 ft. above sea-level), down to Brisbane. The journey involved again a change of train at the frontier, because the Queensland gauge is 3 ft. 6 in., whilst New South Wales has adopted the standard gauge of 4 ft. 8½ in., and Victoria has the broad gauge of 5 ft. 3 in. The sectional business having been concluded at Sydney, the five days up to Monday, August 31, were devoted to discourses and excursions. Members felt tired by that time, and the excursion to Ipswich, and the railway workshops of Queensland there, was abandoned. There 1700 men turn out 16 large locomotives, 50 carriages, and 600 wagons annually; the shops are the largest of their kind in Australia and supply practically all the rolling-stock of the State in the beautiful varieties of Australian timber. Most members preferred to visit the bush of the Blackall Range, the pineapple and banana plantations and the Cane Sugar Works of the Moreton Central Sugar Mill at Nambour. Geologists inspected the Glasshouse Mountains—peculiar isolated rocks rising more than 1000 ft. above the plains, probably volcanic necks left after the denudation of the soft sandstone. Two meat works, on the River Brisbane, were also visited; the most recent works of the Australian Meat Export Company are not quite finished yet; they are being equipped on the American plan. Miners had the choice between the gold-fields of Gympie—a three days' excursion—and the Mount Morgan gold and copper mines, near Rockhampton, 420 miles from Brisbane—a five days' journey. A trip to the northern portion of Queensland and the Great Barrier Reef would have required a week at least, even if most hurried.

The concluding discourse was given by Sir Edward Schäfer, very appropriately on "The British Association," and the meeting dispersed. Some members had already hastened back by train from Sydney to catch the Peninsular and Oriental liner Malwa, because the Orvieto, by which many members had intended to return, had been commandeered by the Government. Other members returned by the P. and O. liner Morea, or *via* Thursday Island and Java; others, again, *via* San Francisco or Vancouver. The special excursion to New Zealand was abandoned on account of the war. New Zealand had not joined Australia in inviting the Association; but New Zealand had issued special invitations to distinguished scientists from various countries, and that official excursion was cancelled. The war, which had apparently not much disturbed the meeting itself, caused members a good deal of inconvenience and delay on their return journeys. It had indirectly interfered in many other ways, of course. Yet the meeting was a decided success. The exact numbers of those attending were not published during the meeting. But more than 4700 members joined in Australia, which brings the total attendance to above 5000, a record figure, never approached before. So far the Manchester meeting of 1887 had been the biggest gathering with its 3838 members and associates. In Australia almost all the participants enrolled as full members, some for their own centre only, a good number for several centres or the whole meeting. This fact testifies to the great interest taken in the proceedings. For the local members did not enjoy the many privileges of the over-sea party, as it would manifestly have been impossible for the Commonwealth to treat thousands of their citizens as their guests on railways and in hotels. It must be borne in mind that the meeting was a visit, not to a State, but to a Continent. Not much can be done in the study of a Continent within a month; but that everything was done to render the visit most instructive and interesting, our epitome will help to show. In some respects Australia was seen at her best, perhaps, towards the end of her winter. In the hot season a different first impression might have been gained, especially in Western Australia and Queensland, though Victoria and New South Wales might have appeared more beautiful. But the impression was decidedly pleasing. Australia is certainly a very promising country, more beautiful, more advanced, more fertile and less arid than some of the visitors had expected. The development has been gradual, steady and healthy, and vastly more than the five million people now inhabiting a Continent nearly as big as Europe should find comfortable homes in Australia. But we reserve further general remarks for our concluding article, because many characteristic features were dwelt upon during the sectional proceedings.

The task of the President of such a gathering is not enviable. Over and over again Professor Bateson had to respond to speeches of cordial welcome, and to acknowledge exceptional kindness shown under exceptionally difficult conditions, and the fact that he always found the appropriate words soon made him a very popular President. If the hosts were as pleased as the guests were, everything will be well. The general officers of the Association were:—Treasurer: Professor J. Perry; General Secretaries: Professors W. A. Herdman and H. H. Turner; Assistant Secretary, O. J. R. Howarth; Assistant Treasurer, H. C. Stewardson. The list of honorary local organising officers in Australia is too long to be reproduced. We mention a few names of men, otherwise hardly referred to in these columns, upon whom a large share of the work fell:—Professor Orme Masson, F.R.S., of Melbourne, representing the Federal Council; Professor T. W. Edgeworth Davis, F.R.S., and Dr. H. G. Chapman, of Sydney; Professors Baldwin Spencer and H. Payne, of Melbourne; Professors B. D. Steele and T. E. Jones, of Queensland; Professors Stirling and Kerr Grant, of Adelaide; Professor W. J. Dakin, of Perth; and Professor T. Thomson Flynn, of Tasmania. Dr. A. R. D. Rivett, the General Organising Secretary, of Melbourne University, devoted his full time for more than a year to his work, which took him to England before the Birmingham meeting.

Heredity.

Professor Bateson's presidential address created a considerable stir; but the subject, "Heredity," though touching the engineer as it touches everybody personally, hardly concerns engineering. Professor Bateson is an evolutionist, and as such a follower of some of his eminent predecessors in the presidential chair. In South Africa, in 1905, Sir George Darwin selected the fascinating theme of cosmic evolution. The President of the Dundee meeting, 1912, Sir Edward Schäfer, sought to establish that the laws of biology and those of physics and chemistry were not independent of one another and incompatible with one another, but identical. Last year Sir Oliver Lodge, dwelling on the problems of physics and of life, characterised the present age as one of rapid progress and of profound scepticism as well. In a certain sense, that was the keynote also of Professor Bateson's address. Every theory of evolution, he insisted, had to accord with the facts of physics and chemistry. But evolution was no longer to be regarded in the light in which it had appeared till lately, and he exposed his own views with special regard to heredity, attempting to give the essence of the discoveries made by the analytical method of Gregor Mendel, a monk, who died at Brünn, in Austria, thirty years ago. The belief in natural selection and in the survival of the fittest, Professor Bateson declared, was shaken; natural selection could not have been the chief factor in delimiting the species of animals and plants.

The problem for the modern student was: "If a population consists of members which are not alike, but differentiated, how will their characteristics be distributed among their offspring?" Mendel

had studied this by cross-breeding; the terms "pure-blood," "half-blood," had no sense; the Hebrew expression of the seed of Abraham gave a truer notion of genetic heredity. Analytical breeding proved that the characteristics of offspring were decided by "genetic factors"—to use a non-committal term—and as the factors for different characteristics were independent of one another, a man might be pure-bred as to musical ability, and cross-bred as to the colour of his eyes. Sex influenced the heredity of colour-blindness, &c., in a peculiar, not yet understood way. There was no positive proof so far of contemporary acquisition of new factors, but variation by loss or by fractionation of factors was a genuine phenomenon of contemporary Nature. Dealing in the second part of his address particularly with the "polymorphic" condition of animals and plants—*i.e.*, with the fact, which he welcomed, that populations consisted of individuals of many types breeding together with perfect fertility—Professor Bateson pointed out that an individual could only transmit factors which he had received from his parents, and if a factor came from one parent only, half the offspring only would, on average, inherit it. That was more easily studied in abnormal features (the Hapsburg lip, colour-blindness) than in normal characteristics (colour of the eye). The popular notion that any parents might have any kind of children was quite erroneous, but heredity should, of course, be studied forward (from parent to child), not backward, in pedigree fashion (from heir to ancestors). Man differed from animals in one important respect: he had prodigious powers to preserve many inferior and defective members of his species. Those powers should be judiciously exercised. The State should not permit the union of "social vermin;" but Professor Bateson would not go further at present, at any rate, than to restrain marriages between defectives; though something might also be done to reform medical ethics: "to prolong life, at whatever suffering, might have been right when diagnosis was uncertain." Professor Bateson said that he would not in general deplore the lowering of the birth-rate in already over-populated countries; in normal stable conditions population was stationary. In the light of the Mendelian knowledge, the discussion whether a race was pure or otherwise had almost lost all significance.

(To be continued.)

WORLD'S ZINC OUTPUT AND THE WAR: REDUCED OUTPUT.

The zinc output of the world is seriously affected by the war. The sources of supply are extremely limited, and the more important occur in or near the areas in which fighting is either taking place, or may do in the near future. The world's zinc supply is obtained from Europe, Japan, Australia, and the United States. In Europe the zinc industry is distributed as follows:—

Country.	Number of Plants.	Production, 1910, in Tons.	Production, 1913, in Tons.	Increase and Decrease.
Germany .. .	34	251,040	289,870	+38,830
Belgium ..	13	190,230	217,920	+27,690
Great Britain	17	69,530	65,190	− 4,340
France ..	5	57,890	—	—
Spain .. .	2	7,200	78,280	+71,080
Holland .. .	1	23,120	26,810	+ 3,690
Austria-Hungary ..	4	14,660	23,920	+ 9,260
Norway .. .	1	—	10,230	—
Russian Poland ..	2	9,510	8,380	− 1,130
Total	79	623,180	720,600	+97,420

The zinc output of Australia and Japan in 1913 was extremely limited, only 11,300 tons, whilst that of the United States has been steadily increasing for many years. In 1910 it reached 269,180 tons, and last year 346,670 tons, an increase of 77,490 tons; the consumption during 1913 was 295,370 tons, leaving a surplus for exportation of 51,300 tons. The German zinc-smelters are situated in Upper Silesia and North-West Germany; the former are within 5 or 10 miles of the Polish-Russian frontiers, near the point where Germany, Austria, and Russia abut on each other, whilst the Russian-Polish smelters are in the same locality, but on the Russian side of the frontiers. It is probable that the war may compel the whole group to suspend or curtail operations, and it appears unlikely that the output, even if maintained, can be made available for trade, unless outlets can be found through neutral States, the production being purchased by, say, Italian agents and shipped as Italian merchandise. The zinc-smelters of Western Germany are in the vicinity of Liége, and are distributed within a radius of about 90 miles of that centre. They will all be affected by the war, unless an outlet can be obtained through Dutch agents *via* the Rhine and Rotterdam. The Belgian zinc works are completely wiped out for the time being; nearly all are situated between Liége and Namur, and around Verviers. The French zinc-smelters are outside the war area, but their output is relatively small, less even than that of this country, and only about 20 per cent. that of Germany. Scarcity of labour may, of course, seriously handicap them. The zinc output of Europe during the current year, and the continuance of the war, will be, as shown by the figures quoted above, very seriously curtailed. Stocks are very limited, and, owing to the war, probably not available, or only by roundabout means.

The European zinc-smelting centres not affected by the war are those in Great Britain, Spain, Holland, and Norway. Their aggregate output during 1913 amounted to 180,510 tons, whilst the output of the zinc-smelting centres in Europe affected by the war amounted to 600,090 tons (estimating the French output at 60,000 tons for last year). There may consequently be a deficiency in the world's output during the next twelve months of no less than 419,580 tons. To what extent our industrial activities dependent on zinc supplies will be affected can scarcely at the moment be accurately gauged.

Readjustments to the new conditions are now in hand. The reduced zinc supplies may be neutralised by a reduced spelter market. In the United States the zinc-smelting industry has during recent years been increased out of all proportion to the consumption, and there is consequently a large surplus available for export. Small supplies of zinc are also obtained from Mexico and Canada, and are imported into the States; these might now be diverted to this country. The Mexican output ceased during the recent disturbances, but with the establishment of more peaceful conditions supplies may now be again available, and should find a ready market in England. There are considerable stocks of spelter in Europe, probably 100,000 tons at the outbreak of the war, but a considerable proportion may be cut off, so that until peace is concluded it may be disregarded; but after the war these stocks may adversely affect prices. Considerably over 65,000 tons of spelter are smelted in this country in our own plant, and our enormous output of galvanised iron requires large imports in addition.

British imports of zinc ore have shown a tendency to decrease during recent years, as shown below:—

	Tons.	£
1910	92,570	570,600
1911	74,390	495,300
1912	67,330	481,600
1913	64,670	417,600

We obtained our main supplies of zinc ore from Australia, Italy, Algeria, Germany, Spain and France, in the order named. Last year only 990 tons came from Canada, and only a few tons from the United States.

Our imports of crude zinc in cakes are increasing:—

	Tons.	£
1909	102,570	2,249,000
1911	115,230	2,866,100
1913	145,000	3,450,600

The main imports came from Germany, 64,179 tons, valued at 1,503,020*l.*, last year, out of a total of 145,000 tons, = about 45 per cent., and from Belgium 53,500 tons, valued at 1,291,010*l.*, equal to 37 per cent.; the remaining 18 per cent. came in small quantities from Holland, Tunis, Japan, Mexico, and other small contributaries. It appears that with the German and Belgian supply cut off, the industry depending on this raw material must soon disappear, and all labour engaged become unemployed. It appears likely, however, that our requirements may be provided through American channels and work found for our men.

Our exports of British zinc ore are insignificant, but they are increasing—only 1643 tons, valued at 7274*l.*, in 1909, and 13,378 tons, valued at 61,097*l.*, last year; between the two dates the increase has been continuous. Our exports of crude zinc or spelter in cakes are also small—in 1909, only 7404 tons, valued at 159,969*l.*, and last year, 9496 tons, valued at 208,113*l.*

Martell Scholarship in Naval Architecture.—The Martell Scholarship in Naval Architecture has been awarded by the Council of the Institution of Naval Architects to Mr. F. J. A. Pound, of Portsmouth Dockyard, who is now proceeding to the Royal Naval College, Greenwich. The scholarship is of the value of 100*l.* per annum, and tenable for three years.

The Institution of Automobile Engineers.—The Institution have under consideration the formation of a Technical Committee to consider points of construction which are in need of scientific investigation, and it is likely that such a Committee will be formed at an early date, and that it will include men who are connected with the construction of automobiles, as well as those who are already conducting scientific research.

THE LATE ENGINEER-CAPTAIN CHARLES B. LECKY.

We regret to have to announce the death, suddenly, at Ross Cottage, Havant, of Engineer-Captain Charles Beresford Lecky. Engineer-Captain Lecky was born on September 14, 1863, and entered the Service on July 1, 1885, serving as an engineer student in the training schools at Portsmouth and Keyham. He was granted a commission as assistant engineer on July 1, 1886, and served over three years on the North America and West Indies Station in H.M.S. Canada, as assistant engineer and engineer, being promoted to the latter rank on September 1, 1890. As engineer he served in H.M.S. Pique; in torpedo-boats at Malta; in H.M.S. Spider, used for instruction of engineer cadets; in H.M.S. Leven, a torpedo-boat destroyer; and in H.M.S. Pallas, on the North America and West Indies Station.

He was promoted to chief engineer on September 1, 1900, and was specially selected for appointment in charge of the machinery of the Admiralty yacht Enchantress. He was promoted to engineer-commander on September 1, 1904, and served in this rank in H.M.SS. Latona, Hogue (North America and West Indies), and Sutlej. He was then appointed as assistant to the Captain of Devonport Dockyard, in which post he remained until placed on the Retired List, with the rank of engineer-captain, on September 14, 1913.

Engineer-Captain Lecky was awarded the Diploma of Commander of the Order of the Crown of Italy, for services rendered at the Messina earthquake in December, 1908, while serving in H.M.S. Sutlej. Engineer-Captain Lecky was a zealous, hard-working officer, and his genial personality made him many friends.

NOTES FROM THE UNITED STATES.

Philadelphia, October 8.

The general condition noted a week ago in iron and steel still prevails. At this time less than half the producing capacity is employed. General reduction in wages is contemplated, though the purpose of this is not apparent, there is no complaint over prices, and competition is virtually absent. The lethargy is widespread.

All calculations are upset. Progress is being made towards the solution of the banking problem, but it is beset with difficulties. The railroad hearing or re-hearing for an advance in freight will be heard October 17. Even if granted, the roads will not expend money liberally for a while. With fully half the capacity idle, prices remain practically unchanged. The export trade for the week showed a marked improvement, but far below what the volume of inquiries would indicate. Wire is wanted freely. A growing export demand appears probable. Consumption of mill products is ahead of production. Stocks in warehouses are steadily being depleted. When the better conditions return the country will be bare of stocks. Wire plants are running almost to capacity. Pig-iron is accumulating at furnaces. Large consumers have enough to last them through the year. Foundry work is slack. English consumers will not pay the asked price for steel billets. If Southern pig-iron freight rates are reduced large shipments to Northern markets will follow the expected trade revival, and to that extent interfere with Northern iron.

A further falling-off in furnace output is in sight. The sheet-mills are enjoying a good trade. Railroads are practically out of the market, and car-builders have scarcely any inquiries.

EMPLOYMENT FOR BELGIAN REFUGEES.

To the Editor of Engineering.

Sir,—I am sure that everything possible should be done to find employment for distressed Belgians in this country where this is possible, and where our own British workpeople will not suffer in consequence of their employment.

Having this in mind, it has occurred to us that amongst the numerous Belgian refugees arriving in this country there may be a number of experienced motor mechanics. If this is so, we shall be pleased to do all in our power to find such men temporary employment at our Acton works.

The position is that considerably over 200 of our men have joined the Forces, which places at our disposal certain temporary vacancies. We can do with turners, millers, drillers, men used to capstan lathes, grinders, tool-makers, &c.

If you could let it be known through the medium of your esteemed journal that we are open to afford what help we can in the above direction, we shall esteem it a favour.

Applications should be addressed to, or personal calls made at, our works, Acton, London, W.

Yours truly,

D. Napier and Son, Limited,

H. T. Vane,

October 20, 1914. General Manager.

A STANDARD IN REFRIGERATION.

*Report of the Refrigeration Research Committee of the Institution of Mechanical Engineers.**

The Committee appointed "to consider and define a Standard in Refrigeration and its Units of Measurement" have held several meetings, and have exercised the power to add to their number under which they were appointed. They have secured the co-operation of several gentlemen concerned in the refrigerating industry as makers or as users of refrigerating machines, with the result that the membership now stands as follows:—

Sir J. Alfred Ewing, K.C.B., LL.D., F.R.S. (Chairman); Mr. J. Wemyss Anderson, M.Eng.; Mr. Samuel R. Beale; Mr. W. Worby Beaumont; Mr. Asa Binns; Mr. W. G. Brettell; Sir James Dewar, F.R.S.; Mr. W. S. Douglas; Mr. J. H. Grindley, D.Sc.; Mr. G. C. Hodsdon; Professor C. Frewen Jenkin; Mr. Magnus Mowat; Mr. F. A. Willcox, and Mr. Hal Williams.

After consideration and discussion of the subject referred to them, the Committee beg leave to submit the following conclusions:—

Two distinct matters arise from the terms of reference:

1. To consider what standard, if any, should be used for the practical rating of refrigerating-machines, as a means of expressing the amount of refrigerating effect which the machine is capable of producing under specified conditions such as occur in ordinary practice.

This involves two points—namely, the unit in which refrigeration is to be measured and stated, and the temperatures between which a machine should, for the purpose of rating, be assumed to act.

2. To consider what theoretical cycle of action should be adopted as a standard for comparison with the actual performance of a refrigerating-machine working under any conditions, as a means of judging how nearly the real action approaches the ideal.

The uses of such a cycle would lie in the analysis of tests and the criticism of actual performances; also in the design of refrigerating plant, taking account of ratios (determined by experience) between real and ideal performance in machines of given types.

With regard to the question whether any standard should be used for the practical rating of refrigerating machines, the Committee are aware that some refrigerating engineers hold the view that no standard of the kind is likely to be useful on account of the variety of purposes for which such machines have to be designed. On the other hand, the practice of some manufacturers in adopting a more or less arbitrary method of rating is evidence that some standard is wanted, though it could not in any case be expected to have universal application. There are certain of the commoner uses of refrigerating plant in which the function to be fulfilled is substantially the same, and the machines differ only in their capacity. Some convenient unit of refrigerating effect would accordingly appear to be desirable as a means of rating them. A rating of machines on this basis, once it came to be generally understood, would probably be appreciated by users as well as by manufacturers, and might be especially serviceable to consulting engineers in specifying for tenders. The Committee are accordingly of opinion that a suitable unit of rating should be established, to be based on some intelligible and perfectly unambiguous measure of performance; and, further, that the basis should be such as to make it possible that the unit might meet with general acceptance for international use. They believe that this condition is fulfilled by the unit recommended for adoption in this Report.

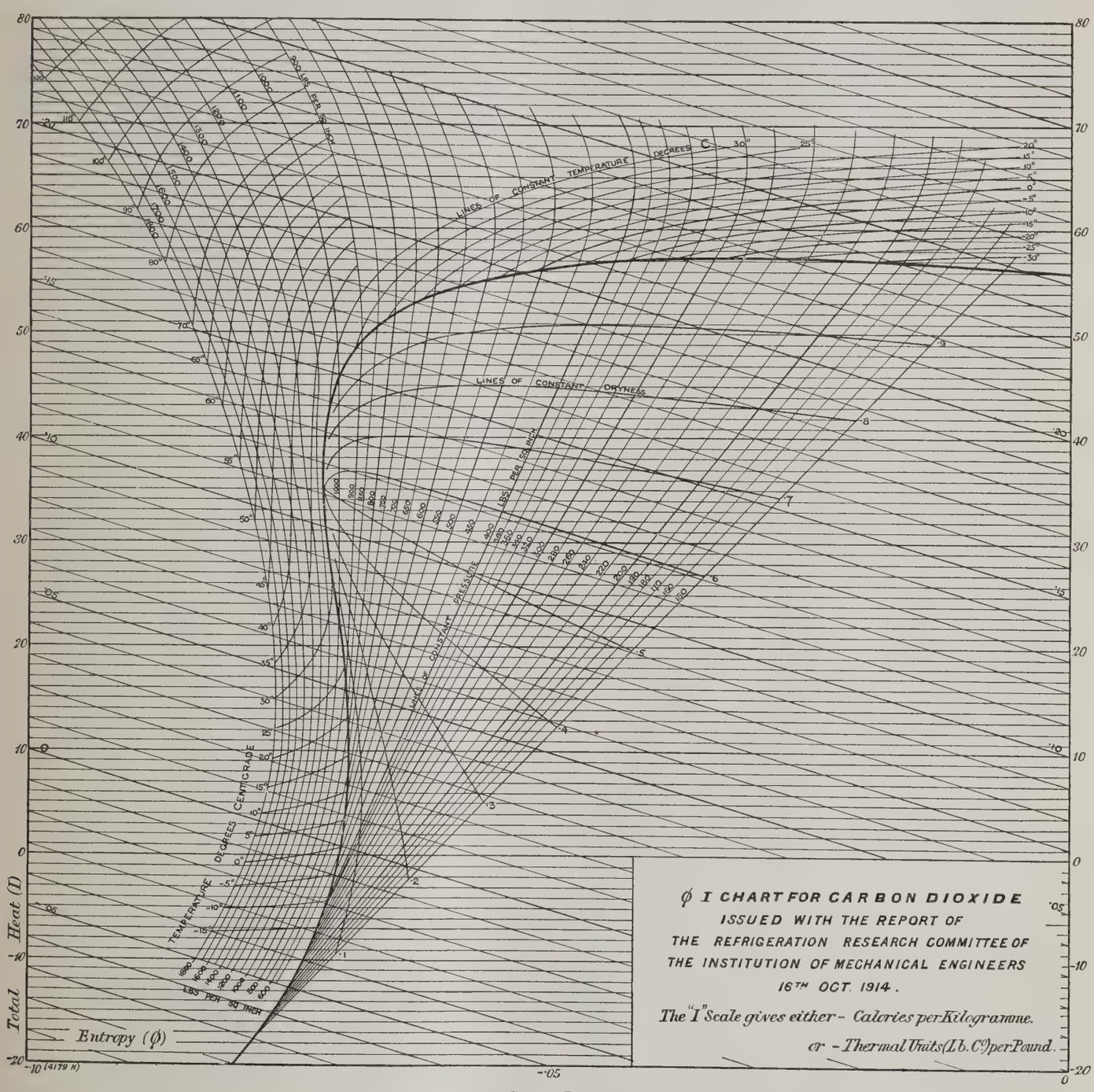

LINES OF CONSTANT TEMPERATURE DEGREES C
LINES OF CONSTANT DRYNESS
LINES OF CONSTANT PRESSURE
LBS PER SQ INCH
TEMPERATURE DEGREES CENTIGRADE
Total Heat (I)
Entropy (φ)
φ I CHART FOR CARBON DIOXIDE
ISSUED WITH THE REPORT OF
THE REFRIGERATION RESEARCH COMMITTEE OF
THE INSTITUTION OF MECHANICAL ENGINEERS
16TH OCT. 1914.
The "I" Scale gives either - Calories per Kilogramme.
or - Thermal Units (Lb. C° per Pound.

CHART I.

(I.)

The standard for practical rating must be based on:—

(*a*) The amount of heat extracted per unit of time, and

(*b*) The temperatures between which the machine works as a heat-pump—namely, the temperature of the source from which heat is taken, and the temperature at which heat is discharged.

For the purpose of practical rating, we are concerned not directly with the limits of temperature of the working substance, but with the temperatures external to the machine, between which the heat is pumped.

Thus, in the normal case of a machine working under steady conditions to keep brine cold by extracting heat

* Paper read before the Institution of Mechanical Engineers, October 16, 1914.

from it, and discharging the heat to cooling water, the temperatures to be considered for the purpose of rating are four in number—namely, the upper and lower temperatures of the brine and the upper and lower temperatures of the cooling water.

For rating purposes definite values have to be assigned to these four temperatures. The following are considered to be suitable for adoption as standard values :—

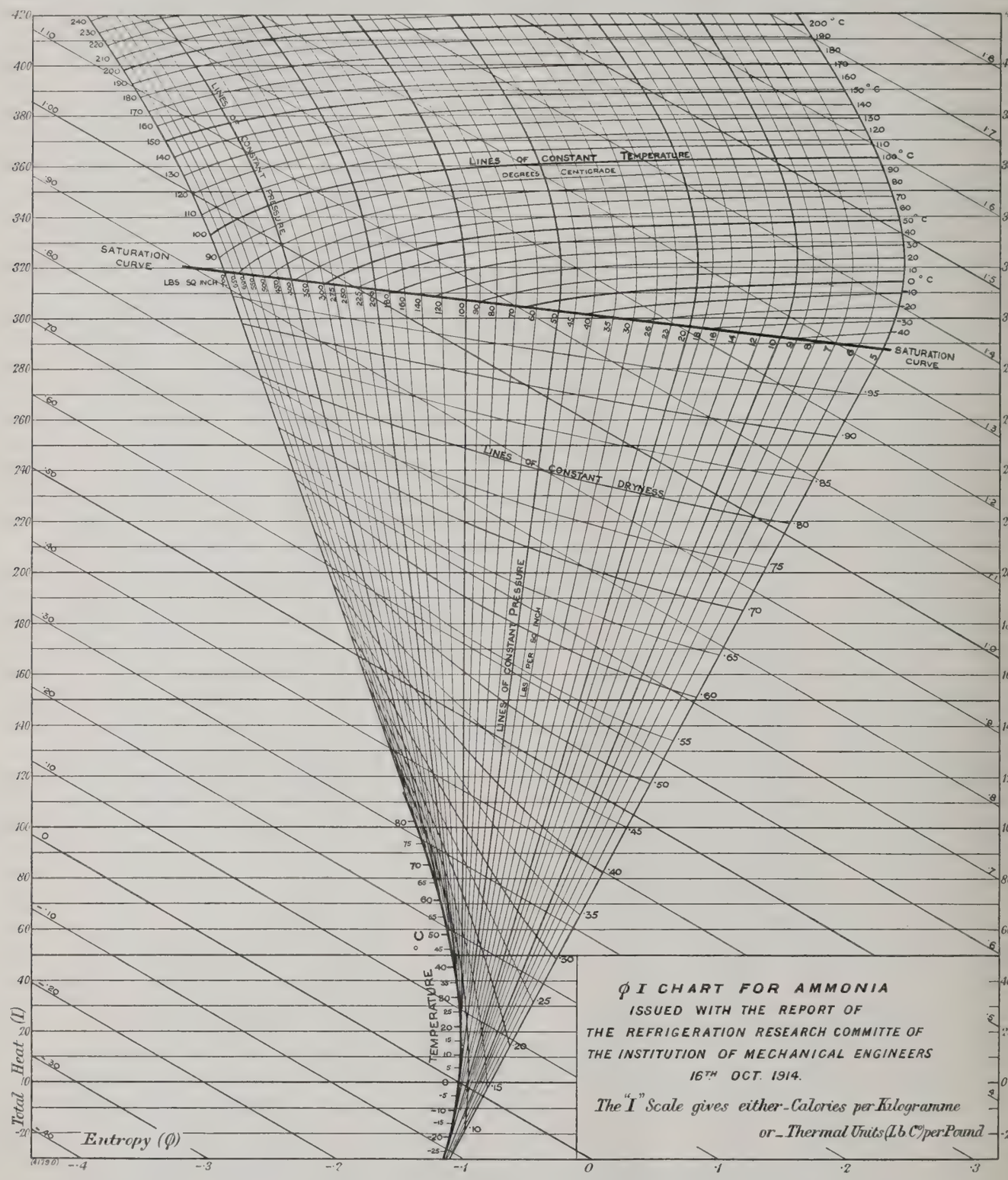
For the brine	Upper limit 0 deg. Cent. (32 deg. Fahr.) Lower limit – 5 deg. Cent. (23 deg. Fahr.)
For the cooling water...	Upper limit 20 deg. Cent. (68 deg. Fahr.) Lower limit 15 deg. Cent. (59 deg. Fahr.)

It may be remarked that in specifying the standard conditions the range through which the brine is cooled (5 deg. Cent.) has been made somewhat wider than is usual in practice, with the object of facilitating the accurate measurement of refrigerating effect in tests made for the purpose of rating.

Next, as regards methods of specifying the amount of heat extracted per unit of time, the Committee have considered the practice that is occasionally resorted to of using a unit based on the making of ice from water at 0 deg. Cent. or at some arbitrarily chosen temperature. They are of opinion that the objections to such a method of rating are so serious that they cannot recommend it. Any rating on an ice-making basis is liable to confusion with the actual output of a machine employed in the manufacture of ice, which may be very different.

They have accordingly looked for some other unit which would be free from such objections, and have come to the conclusion that the most simple and unambiguous form of statement would be to express the cooling effect of a machine in calories per second, the calory being the amount of heat required to change the temperature of 1 kg. of water by 1 deg. Cent.

One calory is $2.2046 \times \frac{5}{3}$, or 3.9683 B.Th.U. One calory per second is, therefore, equivalent to $3.9683 \times 60 \times 60 \times 24$, or about 342,860 B.Th.U. per day. Mr. Wemyss Anderson* quotes 288,000 B.Th.U. per day as a unit of refrigerating effect recognised in the United States, and suggests 322,000 B.Th.U. as a British standard. It will be seen, therefore, that the calory per second is a unit of much the same order of magnitude, only slightly larger.


LINES OF CONSTANT PRESSURE
LINES OF CONSTANT TEMPERATURE DEGREES CENTIGRADE
SATURATION CURVE
LBS SQ INCH
SATURATION CURVE
LINES OF CONSTANT DRYNESS
LINES OF CONSTANT PRESSURE LBS PER SQ INCH
TEMPERATURE °C
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φ I CHART FOR AMMONIA
ISSUED WITH THE REPORT OF
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THE INSTITUTION OF MECHANICAL ENGINEERS
16TH OCT. 1914.
The "I" Scale gives either-Calories per Kilogramme
or-Thermal Units (Lb C° per Pound

Chart II.

It is accordingly recommended :—

1. That the refrigeration produced by a refrigerating-machine be expressed in calories per second. This unit is equivalent to 342,860 B.Th.U. per day of 24 hours.

2. That the refrigeration may be stated for particular conditions or for standard conditions.

3 That the standard conditions be defined as follow: —The temperature limits to be steady ; the temperature

* Proceedings of the Institution of Mechanical Engineers, 1912, page 998. Engineering, November 29, December 6, and December 13, 1912.

of the cooling water to range from 15 deg. Cent. (59 deg. Fahr.) at inlet to 20 deg. Cent. (68 deg. Fahr.) at outlet, and the temperature of the brine to range from 0 deg. Cent. (32 deg. Fahr.) to −5 deg. Cent. (23 deg. Fahr.).

This mode of rating may be taken as applying to absorption machines as well as to vapour-compression machines.

In cases of cooling by direct expansion, without the use of brine, the same method of rating will apply, except that the conditions have to be modified by specifying for the lower limit of temperature that of the working substance itself.

It is considered that a temperature of − 10 deg. Cent. (14 deg. Fahr.), as a lower limit for the working substance, will harmonise with the conditions which have been laid down for machines using brine, and this figure will also be in accordance with the standards of temperature adopted by the Association Française du Froid.*

The Committee accordingly recommend :—

5. That, in the rating of a direct-expansion refrigerating-machine, the temperature of the vapour in the evaporator be taken as − 10 deg. Cent., and that the conditions as regards cooling water be the same as those laid down for machines using brine.

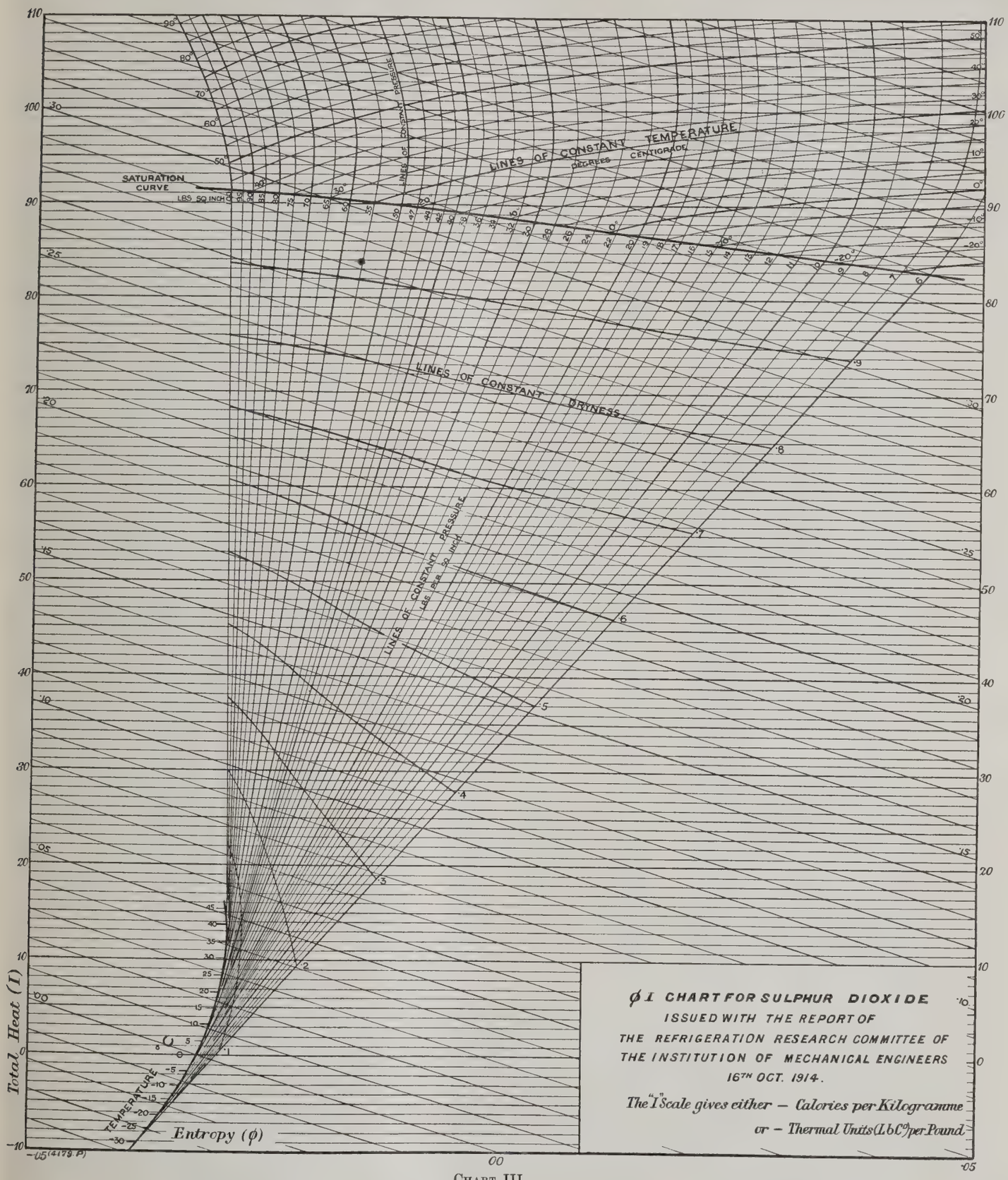

LINES OF CONSTANT TEMPERATURE
DEGREES CENTIGRADE
SATURATION CURVE
LBS SQ INCH
LINES OF CONSTANT DRYNESS
LINES OF CONSTANT PRESSURE
LBS PER SQ INCH
TEMPERATURE
Entropy (φ)
Total Heat (I)
φ I CHART FOR SULPHUR DIOXIDE
ISSUED WITH THE REPORT OF
THE REFRIGERATION RESEARCH COMMITTEE OF
THE INSTITUTION OF MECHANICAL ENGINEERS
16TH OCT. 1914.
The "I" Scale gives either — Calories per Kilogramme
or — Thermal Units (1 b C°) per Pound

CHART III.

(II.)

As regards a theoretical cycle of comparison, we are

4. That the refrigeration produced under standard conditions be called the "rated capacity" of the machine.

Thus, a machine may be classed as having a rated capacity of one unit if it produces a refrigeration of one calory per second (say 342,860 B.Th.U. per day) in steady working under the standard conditions specified above. Similarly, a two-unit machine is one which, under the same conditions, produces a refrigation of two calories per second, and so on.

* *Cf.* Professor L. Marchis's paper presented to the Third International Congress of Refrigeration, Washington, Chicago, 1913.

concerned with the internal action of the working substance, and the temperatures to be considered in this case are accordingly not those external to the machine, but those of the substance itself at various stages of the cycle.

The theoretical performance in a vapour-compression machine using any assigned working substance assumes adiabatic compression to take place between constant-pressure limits of suction and discharge.

These two pressures must be known, also the temperature to which the working fluid may be cooled before passing the expansion valve.

With these three data there will (for any working substance) be some particular degree of dryness—that is to say, some particular proportion of vapour to liquid at the beginning of compression, which (with adiabatic action) will theoretically be the best in the sense of giving the maximum coefficient of performance in the ideal cycle. When the degree of dryness at the beginning of compression is determined, the temperature of superheating reached at the end of compression follows.

The essential data, therefore, for determining the ideal cycle are the suction and discharge pressures, and the temperature before the expansion-valve, if the cycle is specified as that which, with those temperatures assigned, will give as a matter of theory the highest coefficient of performance in adiabatic action.

Further, in order to secure the highest ideal efficiency, the working substance should be cooled before passing the expansion-valve to a temperature as nearly as possible equal to that of the supply of cooling water. It is therefore proposed in all cases to take the temperature at which cooling water is supplied as the temperature to which the working substance is supposed to be cooled before passing the expansion-valve, in calculating the ideal cycle of comparison.

It is accordingly recommended :—

6. That the ideal cycle to be adopted as a standard for comparison with actual performance be the most efficient cycle employing adiabatic compression, in which the pressures of suction and condensation are the same as those that occur in the actual process of working, and in which the substance is cooled, before passing the expansion-valve, to a temperature equal to that at which, in the actual process, the cooling water is supplied.

7. That the pressures of suction and condensation referred to in Recommendation 6, for the actual process of working, are to be the pressures measured just after and just before the substance passes the expansion-valve.

This last recommendation is required in order to make the conditions for compression definite in cases where there is any substantial drop in pressure between the compressor delivery and the expansion-valve, or between the lower side of the expansion-valve and the compressor intake.

In some refrigerating machines the action is compound, in the sense that the compression occurs in two stages, with cooling of the substance between the two; or the expansion by throttling takes place in two stages, with a return of part of the substance to the compressor after the first stage. The Committee do not consider it necessary or advisable to complicate the use of a standard cycle of comparison by specifying ideal cycles special to such operations. They think it better that any actual machine employing such a compound process for the purpose of getting an augmented efficiency should still have its performance compared with that of an ideal machine using the standard cycle.

The coefficient of ideal performance C_i is found by dividing the heat taken in by the work expended in the standard cycle.

Similarly, the coefficient of actual performance C_a is found by dividing the refrigerating effect actually produced by the work expended in driving the compressor in the real performance of the machine.

The ratio $\frac{C_a}{C_i}$ is a fraction which shows how nearly the real performance approaches the standard ideal. This ratio may be called the "relative efficiency."

The coefficient of actual performance is found by direct measurement of the refrigerating effect produced in actual working, and of the work expended. The work may be reckoned either as the indicated work done in the compressor, or as the total work required to drive it; and as the indicated work is materially less, it is important in all statements of actual performance to state clearly which of the two methods of reckoning the work is employed. When practicable, both the indicated work and the total work should be given in stating the results of a test.

In recent years the theory of refrigeration has been much simplified as well as rendered exact by the use of the function I—namely, the total heat of the working substance in any state.† This function has been employed by Dr. R. Mollier as one of the two co-ordinates in a chart by means of which the state of the substance may be completely exhibited at any pressure and temperature. With such a chart it is easy to trace the changes which the working substance undergoes in the ideal cycle, and to determine by measurement on the diagram the values of the quantities involved.

For the calculation of the ideal performance, by far the most convenient procedure is to sketch the ideal cycle on the Mollier ϕI chart, in which the co-ordinates are the entropy and the total heat. Each of the quantities, the heat taken in, the heat rejected, and the work done, is then found by reading off numbers on a scale. This diagram forms so powerful and easy a means of analysis in problems of refrigeration that its use cannot be too strongly commended to the notice of engineers.

The entropy-temperature ($\phi\tau$) chart, though probably more familiar, is less convenient, but when properly used it also affords a means of exhibiting the ideal cycle and of finding the coefficient of ideal performance. For this purpose the chart should include a set of lines of constant total heat, which enable the process of passing the expansion-valve to be represented in the diagram as part of the complete cycle.

† Called by some writers the "heat content" and by others the "enthalpy."

APPENDIX I.

Charts and Tables Showing Properties of Substances Used in Refrigeration.

Pressure.	Temperature.		Volume of Saturated Vapour.
lb. per sq. in.	deg. Cent.	deg. Fahr.	cub. ft. per lb.
	Carbonic Acid.		
200	−32.0	−25.5	0.463
225	−28.3	−18.8	0.409
250	−24.8	−12.7	0.365
275	−21.7	− 7.0	0.330
300	−18.7	− 1.7	0.301
325	−16.0	+ 3.2	0.276
350	−13.4	+ 7.9	0.255
375	−10.9	+12.3	0.236
400	− 8.6	+16.5	0.219
450	− 4.3	+24.3	0.191
500	− 0.3	+31.4	0.169
550	+ 3.4	+38.1	0.150
600	+ 6.8	+44.2	0.134
650	+10.0	+50.0	0.120
700	+13.0	+55.4	0.108
800	+18.6	+65.5	0.0878
900	+23.6	+74.6	0.0720
1000	+28.3	+82.9	0.0565
1050	+30.5	+86.8	0.0460
1070	+31.3	+88.4	0.0352
	Ammonia.		
6	−49.2	−56.6	41.6
8	−44.2	−47.6	31.6
10	−40.2	−40.4	25.75
12	−36.8	−34.3	21.75
14	−33.8	−28.9	18.79
16	−31.2	−24.1	16.56
18	−28.8	−19.8	14.82
20	−26.6	−15.9	13.45
25	−21.8	− 7.2	10.88
30	−17.7	+ 0.1	9.17
35	−14.2	+ 6.5	7.93
40	−11.0	12.2	6.99
45	− 8.1	17.4	6.25
50	− 5.5	22.1	5.66
60	− 0.83	30.5	4.77
70	+ 3.3	37.9	4.12
80	+ 6.9	44.5	3.63
90	10.3	50.5	3.25
100	13.3	56.0	2.936
120	18.8	65.8	2.466
140	23.6	74.5	2.124
160	27.9	82.3	1.868
180	31.9	89.4	1.666
200	35.5	95.9	1.504
225	39.6	103.2	1.340
250	43.4	110.1	1.208
275	46.9	116.4	1.098
300	50.2	122.4	1.007
350	56.2	133.2	0.863
400	61.6	142.9	0.752
450	66.6	151.9	0.665
500	71.1	160.0	0.597
550	75.3	167.6	0.539
600	79.3	174.7	0.491
650	83.0	181.4	0.449
700	86.5	187.7	0.414
	Sulphurous Acid.		
5	−32.0	−25.6	14.1
6	−28.6	−19.5	11.9
7	−25.8	−14.4	10.3
8	−23.2	− 9.7	9.04
9	−20.8	− 5.4	8.10
10	−18.6	− 1.5	7.35
12	−14.7	+ 5.6	6.17
14	−11.2	+11.8	5.34
16	− 8.2	+17.3	4.70
18	− 5.4	+22.3	4.19
20	− 2.8	+26.9	3.80
25	+ 2.7	+36.9	3.08
30	+ 7.4	45.4	2.59
35	11.6	52.8	2.24
40	15.3	59.5	1.97
45	18.6	65.5	1.76
50	21.6	71.0	1.59
60	27.1	80.8	1.33
70	31.9	89.3	1.15
80	36.1	97.0	1.01
90	40.0	103 9	0.90
100	43.5	110.3	0.82

Specific Heat of Calcium Chloride Brine.

Temperatures.	Density* 1.19 Twaddell* 38.	Density* 1.20 Twaddell* 40.	Density* 1.21. Twaddell* 42
deg. C.			
−25	0 697	0.685	0.674
−20	0.702	0.690	0.679
−15	0.707	0 695	0.684
−10	0.712	0.700	0.689
− 5	0.717	0.705	0.694
0	0 722	0.710	0 699
+ 5	0.727	0.715	0.704
+10	0.732	0.720	0.709
+15	0.737	0.725	0.714
+20	0.742	0.730	0 719

* The density is measured at 60 deg. Fahr. (15.5 deg. Cent.) National Physical Laboratory Report, 1909.

In a note which is appended to this Report the Chairman has given an outline of the theory, in which the meaning of the quantity I and its use is indicated, and has explained, with examples, the application both of the $\phi\tau$ and the ϕ I diagrams in considering ideal cycles. He has also shown how the ϕ I diagram allows the maximum coefficient of performance to be readily determined.

ϕ I charts of entropy and total heat for each of the three substances in practical use have been drawn for the Committee by Professor C. F. Jenkin, and are appended to this report on pages 517, 518, and 519.

In all these charts the pressures are given in pounds per square inch. For temperatures the Centigrade scale is used throughout, and the absolute zero is taken as − 273 deg. The use of the Centigrade degree has the great advantage of making the numerical values of I agree with those used by Continental writers. When the Centigrade degree is adhered to in charts or numerical tables the unit of heat may be understood to be either the pound-degree Centigrade, or the calory, for as I is in one case pound-degrees per pound, and in the other kilogramme-degrees per kilogramme, its numerical value is the same.

The ϕ I chart for carbonic acid (page 517) uses Dr. Mollier's figures, but with British units of pressure, and with some additions based on the recent researches of Professor Jenkin and Mr. Pye.*

For the other two substances the experimental data available are much less complete, and the figures are accordingly subject to greater uncertainty. A ϕ I chart for ammonia is drawn in Mr. Grindley's paper.† A comprehensive discussion of the data for ammonia will be found in Bulletin No. 66 of the University of Illinois (January 27, 1913), by Professor Goodenough and Mr. W. E. Mosher. They have given an extended table of numerical values and have drawn a ϕI chart for that substance, by using equations founded on the experiments which they considered most trustworthy. In the chart on page 518, which must be regarded as no more than provisional, their figures are adopted, but the chart is drawn here for Centigrade degrees. The chart for sulphurous acid, which must also be regarded as no more than provisional, uses the values given by Dr. J. Hybl.‡

Professor Ostertag, in his "Berechnung der Kältemaschinen auf Grund der Entropie-Diagramme" (Berlin, Julius Springer, 1913), gives $\phi\tau$ charts for all three substances in a form suitable for use in dealing with refrigerating problems. On these the necessary lines of constant total heat are drawn. These charts will be found convenient by engineers who desire to use the $\phi\tau$ method. The pressures are stated in Continental units,§ and will require conversion by those who wish to work with pounds per square inch. The values of ϕ need no change, nor do those of I, provided the pound-degree-centigrade be used for the unit of heat. The data used by Professor Ostertag for ammonia and sulphurous acid differ in some respects from those used in drawing the charts which accompany this Report.

A great advantage of charts for representing the properties of any working substance and analysing its operation, is that they allow numerical tables to be dispensed with, as well as numerical calculations of the effects. The ϕI chart or the $\phi\tau$ chart gives all necessary information as to quantities of heat and energy in a form far more compact and accessible than any tabular statement. The refrigerating engineer must, however, know the volume occupied by the working substance in the state of saturated vapour at various temperatures, as well as the relation of temperature to pressure in saturated vapour. Accordingly tables (Appendix I.) have been added giving this information, by way of making the data sufficiently complete for practical purposes. So far as ammonia and sulphurous acid are concerned the figures should be accepted with reserve, pending a more exact knowledge of the physical properties of these substances.

A table of the specific heat of calcium chloride brine is also added, the data for which are taken from the Report of the National Physical Laboratory for 1909.

In conclusion, the Committee recommend that the Council of the Institution should consider the desirability of authorising them to carry out experimental researches with the object of supplying such data as are not now available regarding the physical properties of the substances used in refrigeration.

(Signed on behalf of the Committee)
J. A. Ewing, Chairman.

(To be continued.)

The Surveyors' Institution.—The session of the Surveyors' Institution will open on the 9th prox., when the President, Mr. Howard Chatfeild Clarke, will give his presidential address. The Gold Medal awarded by the Council, in respect of the best paper read during the previous session, will be presented to Professor W. G. Fearnsides, in respect of his paper on the "Part Played by Water in Macadam Road Construction." Ordinary general meetings will be held on November 23, December 14, January 11 and 25, February 8 and 22, March 8, April 12 and 26, and May 10. On November 23 Mr. Edwin Savill will read a paper on "The Home-Grown Wheat Supply Available in War Times." The remainder of the session will be taken up in discussing the Acquisition of Land for Public Purposes, introduced by Mr. Andrew Young and Mr. L. O. Mathews; Land Tenure, introduced by Mr. Joshua Bury and Mr. J. G. Head; Rating, introduced by Mr. Isaac Dixon and Mr. E. H. N. Ryde; and Housing, introduced by Mr. Strachan Gardiner and another.

* *Philosophical Transactions*, vol. ccxiii., 1914, page 67.
† Proceedings of the Institution of Mechanical Engineers, 1912, page 1046. Engineering, December 6, 1912.
‡ *Zeitschrift für die gesammte Kälte-Industrie*, April, 1913, page 65.
§ Namely, in "atmospheres," 1 atmosphere being taken as 1 kg. per sq. cm., or 14.223 lb. per sq. in.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Australia: With reference to the call for tenders by the Victorian Railways Commissioners for the supply and delivery of (1) 25, or alternatively 100, five-feed lubricators for locomotives, and (2) 500 steel disc wheels for new rolling-stock, H.M. Trade Commissioner for Australia reports that contracts in connection therewith have now been awarded. A contract for 350 of the steel disc wheels was given to the Melbourne representative of a German firm, and has necessarily been cancelled, but no fresh tenders are to be invited.

Spain: With reference to various classes of material required from time to time by the Spanish Government Departments which may have to be obtained from abroad, the *Gaceta de Madrid* contains an additional list of goods for which foreign competition will be admissible. This new list includes the following supplies:—Metal-working machinery; wood-working machinery; leather-cutting and stamping machinery; constructional material for air service; high-tension and special steel of all kinds, in bars, sheets, &c.; steel boiler-plates; ship's paints, &c.; copying-machines; electric dynamos and accessories for lighting of railway carriages; portable fire-extinguishers; locomotives for rack railways. The *Gaceta de Madrid* notifies the grant of a ninety-nine years' concession to the Compañía de los Ferrocarriles Andaluces, for the construction of a normal-gauge railway from the station of Luque Baena, on the Puente Genil-Linares line to Baena, Province of Córdoba. The estimated cost of the undertaking is 672,000 pesetas (about 24,900*l.*). H.M. Consul-General at Barcelona reports that an engineer in that city desires to get into touch with United Kingdom manufacturers of the following articles:—Tramway materials, including points and crossings, fish-plates, bolts and screws, rails, grips, tools and materials for repair of the permanent-way, light rails and trucks for constructional work, &c.

CATALOGUES.

Ships' Steering-Gear, Winches, &c.—The Carron Company, of Carron, Stirlingshire, have issued a sectional catalogue of steam steering-gears, hand-power screw steering-gears, wheel and pinion steering-gears, hand-power winches, and steam ash-hoists for ships.

Electric Wiring Accessories.—An illustrated catalogue giving prices and particulars of lamp-sockets, ceiling-roses, cut-outs, and other fittings and accessories for indoor and outdoor electric wiring work, has come to hand from Messrs. Pass and Seymour, Inc., of Solvay, N.Y., U.S.A.

Pulley-Blocks.—From Messrs. Youngs, of Ryland Street Works, Birmingham, we have received an illustrated catalogue giving particulars of the "Ryland" worm-geared pulley-blocks. These blocks are fitted with self-sustaining lowering and control brakes, and are made for loads up to 3 tons.

Milling-Machines.—We have received from the Newton Machine-Tool Works, Inc., of 23rd and Vine-streets, Philadelphia, U.S.A., a catalogue dealing principally with horizontal milling-machines of the planer type. Full particulars are given of the various sizes made, and some interesting illustrations showing the tools at work are also included. A few examples of vertical milling-machines, slotters, grinding-machines, boring-machines, planers, cold saws, and other tools are also illustrated.

Engraving-Machines.—Messrs. Taylor, Taylor and Hobson, Limited, of Stoughton Street Works, Leicester, have forwarded us a copy of their latest catalogue of engraving-machines, one of which was illustrated and described in ENGINEERING, vol. lxxi., page 665. The machines are now made in three patterns: one suitable for all kinds of general work, another specially designed for working on very large plates, and a third used for engraving large and heavy pieces of work, such as motor-car tyre-moulds, gun-mountings, &c. They can be used for cutting raised or sunk letters or designs in any material. Several examples of work performed on these machines are illustrated in the catalogue.

Locomotives.—We have received from Messrs. Andrew Barclay, Sons and Co., Limited, Caledonia Works, Kilmarnock, Scotland, a catalogue in which they illustrate and give particulars of the various types of locomotives they are regularly building. Most of them are tank-engines for industrial work, such as that in iron and steel works, collieries, quarries, plantations, &c.; but a few examples of passenger locomotives are included, together with some engines constructed to comply with special conditions. Among the latter may be mentioned fireless locomotives on the thermal-storage system, articulated locomotives, and locomotives fitted with cranes. The illustrations also include some exceptionally heavy hauling-engines for mineral traffic and goods-yard work.

Boring-Mill.—The Pratt and Whitney Company, of Hartford, Connecticut, U.S.A., have issued a pamphlet containing a very fully illustrated description of their sidehead boring-mill, and pointing out its many interesting features. One of the latter is the fact that the sidehead may be lowered below the work-table when not required, thus enabling larger work to be swung on the table. In this way work up to 44 in. can be dealt with by the vertical head, whereas the limiting diameter for work under the sidehead is 38 in. Another point which makes the machine very convenient for working is that all the operating levers can be reached by the machinist while standing practically erect and observing the work on the table. The pamphlet is extremely well printed, and the illustrations are first-class.

Link-Belts and Sprocket-Wheels.—The Link-Belt Company, of Chicago, Ill., U.S.A., have sent us a catalogue section giving very full particulars of Ewart detachable link-belts for elevators, conveyors, and power transmission. Standard sizes are made with pitches ranging from 0.902 in. to 6.15 in., and the ultimate tensile strength of these belts varies from 700 lb. to 14,000 lb. Many special sizes are, however, also listed, and the smallest of these has a pitch of 0.495 in., and a tensile strength of 240 lb. All these chains are illustrated by reproductions from untouched photographs. The most commonly used forms of attachments for the belts are also illustrated, and prices are stated for these, as well as for the belts themselves. Full particulars of sprocket-wheels are also given.

Colliery and Mining Plant.—Copies of their latest catalogues, enclosed in a neat leather-covered box, have reached us from Messrs. Head, Wrightson and Co., Limited, of Stockton-on-Tees. Two of the catalogues are devoted to Marcus screens and conveyors, which, it will be remembered, are of the reciprocating trough type, and are largely used for transporting coal, cement clinker, grain, sugar, and other materials. Other catalogues deal with "Nissen" stamp-mills, pithead gears and cages, "Nota Nos" coal-washers, coal-shipping plant, steel chimneys, cast-iron and steel tanks, and Drage continuous vacuum filters. The latter are used for extracting gold from the pulp produced by previous treatment of the ore, and they are claimed to extract over 99 per cent. of the gold present in solution.

Drilling and Grinding-Machines.—Messrs. A. A. Jones and Shipman, Limited, of New Century Works, East Park-road, Leicester, have sent us a copy of their latest catalogue of radial and vertical drills and grinding-machines. Among its contents we noticed a 24-in. high-speed vertical drilling-machine fitted with ball-bearings. This machine is capable of drilling holes up to 2 in. in diameter at the highest speeds and feeds attainable with modern high-speed drills. A special feature of the other vertical drills listed is the fact that the entire column and arms are cast in one piece. These drills are fitted with gun-metal self-oiling bearings, and with the firm's new cross-axle feed mechanism, which is absolutely positive and practically instantaneous; it also enables a fixed bracket to be used, since the worm-wheel and worm are always in mesh. Particulars are also given of sensitive drills, multiple-spindle drills, and radial drills; some of the latter are of the all-geared type. The firm's universal grinder for tool-room work and for grinding all kinds of cutters, reamers, taps, arbors, &c., has been redesigned and improved in many respects, and a larger and new design of universal machine, for wet and dry grinding, is now being manufactured. These and other grinding-machines are very fully dealt with in the catalogue.

Air-Compressors.—We have recently received from Messrs. Alley and MacLellan, Limited, of Polmadie, Glasgow, a copy of their latest catalogue of "Sentinel" air-compressors. The catalogue, which contains 160 pages, bound in paper-covered boards with cloth back, illustrates and describes the construction of the various types of compressors made by the firm, and also gives dimensions, weights, prices, and other particulars of compressors, with capacities ranging from 25 cub. ft. to 25,000 cub. ft. of free air per minute. Compressed-air motors, reservoirs, after-coolers, water-traps, air-meters, and other accessories for power transmission by compressed air are also dealt with, and, in addition to this, the catalogue contains useful articles on two-stage compression, the commercial efficiency of air-compressors, the choice of steam-driven compressors, air-piping, air-lift pumping, the air-consumption of pneumatic tools, the use of compressed air for forging-hammers, &c. An immense amount of practical data, not to be found in any text-book with which we are acquainted, is included in these articles. It has been collected by the firm over a period during which they have made and sold over 2000 compressors, and is exactly what is required by the practical man. The catalogue is also extremely well printed and illustrated, and very conveniently arranged. It is, in fact, quite the best publication of its class that has yet been brought to our notice.

Boiler-Furnace and Mechanical Stoker.—We have received from Clyde Evaporators, Limited, of 90, Mitchell-street, Glasgow, a pamphlet relating to the Meikle patent boiler-furnace and mechanical stoker. The pamphlet illustrates and describes this appliance, and illustrates its application to Lancashire and Babcock and Wilcox boilers, though it is equally applicable to Cornish, marine, and other types of water-tube boilers. The furnace is trough-shaped, with horizontal dead-plates and inclined fire-bars on both sides, and a central ash-trough. Coal, which is delivered on to the dead-plates from hoppers in front of the boiler by means of screws, falls on to the fire-bars, where combustion takes place, and the ashes and clinker fall into the central trough. This trough contains another specially designed screw, the object of which is to break up the clinker, and draw it, together with the ashes, to the front of the boiler. A small quantity of water is supplied to the trough to moisten the ashes and prevent dust from being carried into the flues. The furnaces work under forced draught, air being supplied by a fan to the spaces behind the fire-bars, and additional air is delivered through passages in the ash-trough to air-spaces in the bridge, where it mixes with the gases from the furnace, and completes their combustion. The advantages of these furnaces are set out fully in the pamphlet, and the results of trials, in which one of them was compared with hand-firing, are included.

Laundry Plant.—Messrs. Hill and Herbert, Limited, of Great Central-street, Leicester, have sent us a catalogue of laundry machinery and dry-cleaning plant, of which they supply complete installations. The catalogue includes washing-machines (one of which is of the open-ended type), starching-machines, hydro-extractors, wringers, ironing and finishing-machines, goffering-machines, gas-irons, drying-rooms, and all kinds of accessories for laundry work. Special attention is called to the firm's four-contact glossing-machine for polishing collars, cuffs, &c. This machine has two central gas-heated glossing-rollers which rotate between a pair of felt rollers placed above and below them. The collars, &c., are first fed in between the lower felt roller and the two heated glossing-rollers, and are conducted upwards by a curved plate, so that they pass between the glossing-rollers and the upper felt roller, and are then returned to the operator's hand. The arrangement thus gives four glossing contacts during one passage through the machine. The glossing-rollers run at a higher speed than the felt rollers, so that a good polish is obtained without excessive pressure. The catalogue also deals with steam-engines, boilers, and gas-engines.

Vacuum-Brake Apparatus.—The Consolidated Brake and Engineering Company, Limited, whose London address is 41, Moorfields, E.C., have issued a new illustrated catalogue of vacuum-brake apparatus. The firm's standard combined-type cylinders in seamless solid-drawn steel casings, for use on carriages and wagons, are first dealt with, and a separate-chamber or engine-type cylinder is next described. These cylinders are both packed on the usual rolling-ring principle; but cylinders of the diaphragm type are dealt with later in the catalogue. These cylinders are intended for use on vehicles which stand idle for considerable periods, during which time the inner surfaces of the cylinders are liable to become corroded; such corrosion would, of course, be detrimental to the rolling-rings of cylinders of the usual type. The catalogue illustrates and describes ball-valves, release-valves, rapid-acting valves or accelerators, detector-valves, piston-rods, pipe-couplings, and other details of vacuum-brake equipment. It also deals with the firm's new "Crab" cylinder and "Equable" rigging, which enable a reduction in dead-weight of from 3 cwt. to 6 cwt. per vehicle to be made; several other advantages are claimed for this arrangement. Vacuum-brake apparatus for use on the rolling-stock of electric railways is also illustrated and described in the catalogue, and a complete schedule of details for all types of apparatus is included.

Road-Rollers and Traction-Engines.—Messrs. John Fowler and Co. (Leeds), Limited, Steam-Plough Works, Leeds, have sent us copies of two of their recently-issued catalogues dealing, respectively, with steam road-rollers and traction-engines. The road-roller catalogue gives full particulars, with prices, of rollers varying in convenient steps from 6 tons to 16 tons in weight. Convertible road-rollers and traction-engines, and various types of scarifiers, are also dealt with. Accessories for road-making, such as traction-wagons, living-vans, water-carts, &c., are also included in this catalogue. The other catalogue deals with traction-engines for agricultural purposes and general transport work, giving very full particulars of single-cylinder and compound engines of 5, 6, 7, 8, and 10 nominal horse-power. The construction of these engines is illustrated and described, and a complete general specification is given. Numerous extracts from testimonials from users are included, together with illustrations showing the engines in use for practically all kinds of haulage work. The catalogue also deals with traction engines, fitted with cranes and superheaters, showmen's engines, provided with dynamos for electric lighting, steam ploughing-engines, a special type of engine for colonial use, and various accessories such as traction-wagons, tender-wagons, and water-carts. Boulton wheels and Bottrill wheels for road locomotives and traction-engines are also illustrated and briefly described in this catalogue. The former are especially suitable for use where heavy loads have to be transported over roads paved with stone sets. They have cast-steel rims with square recesses, into which wooden blocks strengthened with steel liners are fitted. The blocks are kept in position by means of steel eyebolts and springs, and elastic cushions are fitted at the backs of the blocks to take up any excessive jar on the wheels. When in motion the weight of the engine presses the blocks into contact with the road, thereby increasing the bearing surface, preventing slipping, and avoiding excessive wear on the roads. Bottrill wheels are suitable for use on rough or soft ground, or when loads have to be hauled over wet or dry sand; they are also suitable for direct-traction ploughing work. In these wheels two sets of steel shoes, arranged so as to "break track," are attached to the rims by means of flexible steel ropes. The shoes are automatically laid down and taken up as the engine proceeds, thus distributing the weight over a very large area, and enabling loads to be hauled over ground into which ordinary wheels would sink. The Bottrill wheel was illustrated in ENGINEERING on December 20, 1912, page 844.

THE IMPERIAL INSTITUTE.—The third quarterly number of Vol. xii. (1914) of the Bulletin of the Imperial Institute contains, among the results of recent investigations conducted by the scientific and technical staff of the Institute, reports on Timbers from Various Countries, Para Rubber from the Gold Coast and Sierra Leone, Funtumia Rubber from the Gold Coast, and Ceara Rubber from Papua. Other articles deal with the Utilisation of Waste Fish as a Source of Manure, and the Tin Resources of Australia, South Africa, and Nigeria.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

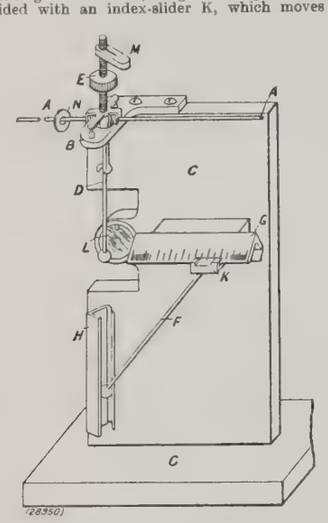
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

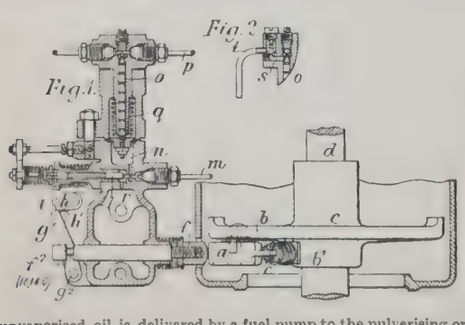
28,950/13. R. W. Paul, London. Magnetic Balances. [2 *Figs.*] December 16, 1913.—This invention relates to magnetic balances for demonstrating and measuring the forces between the poles of two magnets or the force on a magnetic pole in a magnetic or electro-magnetic field. A magnetic balance constructed according to this invention comprises a balance-beam supported on a stand and adapted to hold a magnet with one pole at the centre of motion, the other pole being vertically below when in the normal position; guides are provided on the stand for holding the second magnet, one pole being adjustable along the vertical, and the other along the horizontal, line drawn through the lower pole of the swinging magnet. A is the balance-beam, turning on a support B fixed to the stand C; D is a magnet, clipped by one of its pole-ends to the balance-beam, and E an adjustable bob or counterpoise. These parts are shown in the zero or non-deflected position. A second and similar magnet F is held by its extremities in guides G and H, the guide being suitably graduated and provided with an index-slider K, which moves with the



magnet. The guides are fitted with attachments for retaining the magnet F in any position in which it may be placed, its poles being always respectively on the horizontal and vertical lines through the lower pole of the magnet D, the zero position of which is indicated by sighting it against its image on a mirror L provided with a suitable index-mark. A horizontally adjustable weight or flag M provides means for adjusting the swinging magnet to the zero position previous to inserting the magnet F in its guides, and the beam A is graduated and provided with a rider-weight N, which can be set at a definite distance from the centre of motion. These adjustments having been made, the balance is ready for use in the ordinary way; the second magnet may be placed in the guides and adjusted until the repulsion between the similar acting poles brings the swinging magnet back to the zero position, the reading on the horizontal scale being then noted, and the operations being repeated with different weights or different positions of the same weight, the law of inverse squares may be verified. Using three magnets, and measuring the force between the individual poles, pole strengths can be computed. (*Sealed October* 1, 1914.)

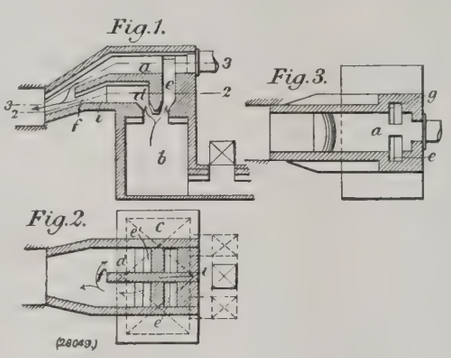
GAS-ENGINES, PRODUCERS, HOLDERS, &c.

16,140/13. Willans and Robinson, Limited, and J. M. Ferguson, Rugby. Internal-Combustion Engines. [3 *Figs.*] July 12, 1913.—This invention relates to improvements in internal-combustion engines of the type in which



unvaporised oil is delivered by a fuel-pump to the pulverising or vaporising apparatus. According to this invention, an emergency governor is provided, which, in the event of the failure of the main governor, cuts off the fuel supply by opening a valve in the pipe connecting the fuel-pump to the engine cylinder. *a* is a weight, one end of which is pivotally connected to an arm or disc *b* on a boss *c* on the shaft *d* of the engine, whilst the other end is connected by a spring *e* to a plate b^1 on the arm *b*. *f* is a plunger pressed outwards by a spring. In the plunger *f* is a groove f^2, in which is a pin on an arm *g* pivoted at g^2. The end of the arm *g* engages with a recess h^1 in a pivoted quadrant *h*, which normally holds out of action a plunger *i* acted upon by a spring, which is stronger than the spring which holds a valve *l* on its seat. *m* is a pipe leading from the air blast and in communication with the cavity *n*. The pressure of the air holds the valve *o* on its seat in the fuel-pipe *p* against the action of the spring *q*. When the engine exceeds a predetermined speed, the weight *a* flies out against the action of the spring *e* and strikes the plunger *f*, thus tripping the valve *l* and opening the cavity *n* to the atmosphere through the passage *r*. The pressure in the cavity *n* being reduced, the spring *q* withdraws the valve *o* from its seat, allowing the fuel to pass through the passage *s* to the pipe *t*, open to the atmosphere, as shown in Fig. 2, instead of to the cylinder. The gear for operating the valve may be operated by the emergency governor, by means of electro-magnets, or by a Bowden wire, the wire being attached to, or the electro-magnet acting upon, the lever *g*. (*Accepted July* 22, 1914.)

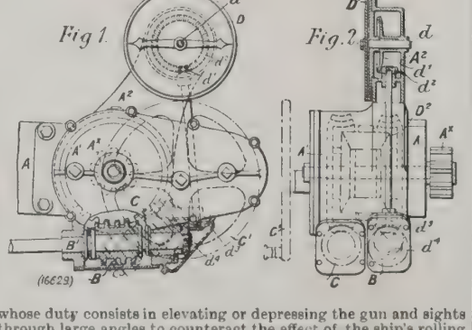
28,049/13. F. K. Siemens, London. Regenerative-Gas Furnaces. [13 *Figs.*] December 5, 1913.—This invention relates to regenerative-gas furnaces having a unidirectional heating flame, and consists of an improvement in or modification of the invention described in the Specification No. 10,824, of 1912, as improved upon or modified by Specification No. 17,956, of 1913, wherein the gas and air-flues communicate with each other through openings or narrow passages in such manner as to result in the formation of a flame at various points within the furnace, one of such flames being the unidirectional heating flame of the furnace, while the other flame or flames serve to heat the regenerators. The preheated air, immediately after leaving the hot regenerator-chamber indicated at *b*, divides into two streams, the main part, which supports combustion of the heating flame, passing through the passage *d* towards the inlet port *f* of the furnace hearth, while a comparatively small volume of the air flows through the passage *e* into the gas flue *a* where combustion is initiated. Of the air which passes to the port *f*, the main part combines with the gas from the flue *a*, and produces a unidirectional regenerative flame traversing the furnace hearth in the direction indicated by the arrow in Fig. 1, while the remainder of the air flows around the end of the partition wall *i*, and passing through the opening e^1, reaches the cool regenerator-chamber *c* which has to be heated.



This pure air mixes with and serves to burn a portion of the gas which issues from the flue *a* through the vertical duct *g*, thus producing a flame at this place serving to reheat the regenerator *c*. Upon the flow of air being reversed, the same operation will take place symmetrically, but in the reverse directions. The hot air from the regenerator *c* branches into a main stream and a smaller one, the latter passing upwards through passage *g* to initiate combustion in the gas-flue *a*, while the main stream itself again divides into two, part providing the oxygen required for the production of the heating flame of the furnace, the remainder flowing around the end of the partition wall *i* and passing into regenerator *b* through duct *d*, mixing on its way with live gas derived from the gas-flue *a* and passing into the regenerator chamber, the flame so produced serving to reheat the cooled regenerator. The flame which serves for initiating combustion in the gas-flue, and which is produced by introducing air through the opening *e* or *g*, as the case may be, into the stream of gas in the flue *a* may be dispensed with, for which purpose slides or dampers covering the openings or tap-holes *e*, *g* may be provided so that, for example, the hole *e* may be shut off when the air is flowing in the direction indicated by the arrows in Fig. 1, or the hole *g* when the direction of the air-currents in the furnace is reversed. (*Accepted July* 22, 1914.)

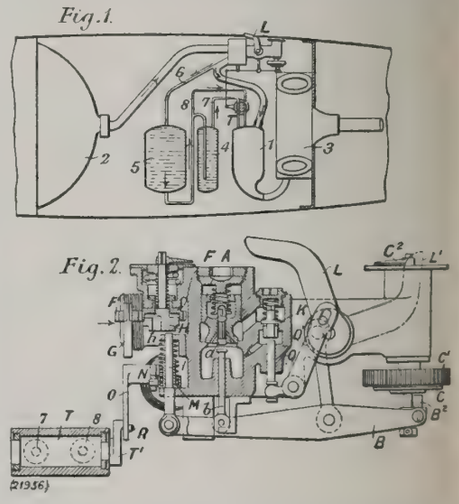
GUNS AND EXPLOSIVES.

16,629/13. Sir A. T. Dawson and G. T. Buckham, London. Breech-Loading Guns. [2 *Figs.*] July 19, 1913.—This invention relates to the elevating mechanism disclosed in Specification No. 5673, of 1912, in which a naval gun-mounting is provided with two elevating hand-wheels, one under the control of the gun-layer, and the other under the control of an auxiliary number



whose duty consists in elevating or depressing the gun and sights through large angles to counteract the effect of the ship's rolling or pitching and tossing movements on the laying of the gun, the hand-wheels operating upon the elevating pinion or its equivalent through the intermediary of worm, differential and worm, or other gearing used in conjunction with automatic locking devices, such that while each hand-wheel can be actuated independently of the other, the movements of either of the hand-wheels will not affect or interfere with the movements of the other. According to the present invention, the applicants provide, in conjunction with elevating machanism as set forth above, an indicating device which is situated in a suitable position to be readily observed by the auxiliary elevating number, and which is operated by the gun-layer, so that the auxiliary elevating number is notified of the direction in which the gun should be moved, without the necessity of providing an open sight for the use of the auxiliary elevating number. A is the side bar which is attached to one of the side cheeks of the carriage, and A^1 is the casing carried by the side bar and containing the differential gearing interposed between the elevating pinion A^* and the main and auxiliary elevating hand-wheels. This differential gearing may comprise two worm-wheels, one of which gears with a worm B actuated by the main elevating hand-wheel (not shown) and the other with a worm C actuated by the auxiliary elevating hand-wheel C^1. D represents the indicating device operated by the gun-layer. In the example shown, the indicating device D is in the form of a pointer, which is engraved in a bold and distinct manner on a rotary dial D^1 mounted on a spindle *d* carried by a bracket A^2 which forms part of the casing A^1. This spindle is suitably connected, for example, by bevel-wheels d^1, d^2, d^3, d^4 and a shaft D^2, with a spindle B^1 of the main elevating worm B, so that when the gun-layer elevates or depresses the gun, he at the same time angularly displaces the dial D^1, thus indicating to the auxiliary elevating number by means of the pointer D the direction in which the gun should be moved by him, his duty being to move his hand-wheel C^1 in the same direction and approximately at the same speed as the dial as aforesaid. (*Accepted July* 22, 1914.)

21,956/13. E. Schneider, Le Creusot, France. Automobile Torpedoes. [3 *Figs.*] September 29, 1913.—This invention relates to automobile torpedoes of the kind in which the compressed air that drives the propelling engine is heated prior to its admission to the engine. For this purpose, the apparatus for heating the compressed air has, as is shown diagrammatically in Fig. 1, in some instances comprised a combustion-chamber 1 arranged between the compressed-air reservoir 2 and the engine 3. The air coming from the reservoir 2 through a pipe 6 forces liquid hydrocarbon and water from the reservoirs 4 and 5 into the chamber 1 through the pipes 7 and 8 respectively. The invention consists in the provision of means for passing cold air at reduced pressure through the heating or combustion-chamber and the pipe leading therefrom to the engine, prior to any admission of liquid hydrocarbon and water to the said chamber, the engine being run by this cold air until air at higher pressure is admitted to the chamber when the liquid hydrocarbon and water is also admitted. T designates a cock common to the pipes 7 and 8 for the admission of liquid hydrocarbon and water to the combustion-chamber. In accordance with the invention, this cock is connected mechanically with an adjustable mechanism that retards the operation of the valve A—*a* for the full admission of air to the engine. The movement of the push-rod *b* to lift the valve A—*a* is prevented, during a predetermined number of revolutions of the engine by the striking of a member I against one element H of a clutch H—F, the other element F of which is actuated by gearing F1—G from the engine. The push-rod *b* and the member I are actuated by the usual balance-lever B, the movements of which are produced by the movements of the starting-lever L. K is the usual reduced-admission valve, which is lifted as soon as the lever L is shifted into the position L^1 by the intermediary of a lever Q^1 and of a rod Q. The balance-lever B actuates the stopping mechanism



C—C^1—C^2 by means of the finger B^2 in the known manner. A washer or collar M fixed to the member I and supporting the spring of this member is provided with a pin N, which actuates a bell-crank lever O pivoted at a fixed point and provided with an elongated hole. A pin R, carried by an arm T^1 integral with the cock T, engages in the elongated hole. The operation is as follows:—At the moment at which the lever L of the starting-valve is brought rearwards to L^1 the engine starts at low speed with cold air, owing to the fact that the valve K and the member I are only lifted to the extent necessary for throwing in the clutch H—F, this travel being insufficient to open the valve A—*a* and rotate the cock T. The cock T therefore remains closed so that the water and the liquid hydrocarbon do not reach the combustion-chamber. When at the end of a predetermined number of revolutions of the engine the member I engages in an orifice A in the clutch element H, the clutch F—H is thrown out of operation, and the full-admission valve A—*a* then opens fully and the engine commences to run at its normal speed. At the same time the member I in rising opens the cock T by the intermediary of the collar M, the lever O, and the arm T^1, and the water and the liquid hydrocarbon then reach the combustion-chamber to enable the heating of the air to commence. It will, of course, be understood that the ignition cartridge is so arranged that its firing does not take place until the end of the low-speed running when the valve A—*a* opens fully. With this object the firing may be controlled by a device connected with the push-rod *b* or with the member I in any known manner. At the moment at which the torpedo stops, the member I is returned by the balance-lever B to its initial position; the collar M is then caused to descend and close the cock T; consequently the liquid hydrocarbon and the water cease to flow to the combustion-chamber. (*Accepted July* 22, 1914.)

GRANARY AT GLASGOW HARBOUR.

For many years there has been periodical agitation for the construction throughout the country of large granaries for the storage of food-stuffs, in order that there might be no possibility of a famine in the event of war. The silent but effective "pressure" of the Navy in the present crisis has so far shown that those who contended in favour of absolute ensurance of the command of the sea, as preferable to such tentative measures, were right. Such expedients as immobile defences on the coast and the storage of immense quantities of grain and food-stuffs are more or less secondary, and one effect of the present war will undoubtedly be the universal recognition of the advantage of fulfilling the primary condition of making the Fleet so strong that over-sea commerce can be maintained by Britain, and, for that matter, by all Powers at peace, in the event of a great war taking place. Nevertheless, the immense granaries, which are increasing in number at the great shipping ports, are welcome, because, while directly intended for convenience in the discharge and subsequent distribution of the grain imported from time to time, they indirectly afford facility for ensuring such a supply at the outset of the war as will carry the country over the period before the Navy has completely asserted its superiority; in other words, until it has established in fact, as well as on paper, complete command of the sea.

The latest of these granaries to be completed is that built by the Clyde Navigation Trustees at the port of Glasgow, and opened in May last. At that time we gave a brief description of the granary and of the general arrangement of the elevating and conveyor plant for dealing with the grain, and we now fulfil the promise we then made by beginning this week the publication of complete drawings illustrative of this latest addition to the otherwise complete installation of harbour appliances at this progressive port. Great progress has been made in recent years towards the perfection of grain-discharging and conveying machinery, and while the Glasgow granary may not be as large, or the conveying machinery as extensive, as corresponding appliances at the great grain-exporting harbours of Canada, the United States, and some other countries, the structural details, alike of the granary and the design of machinery for discharging grain from ships and distributing it into and out of silos, are thoroughly representative of the best practice of the day, and of great and prolonged experience.

The granary has been erected on the north bank of the Clyde, at the recently-completed Meadowside Wharf, 2½ miles from the centre of the

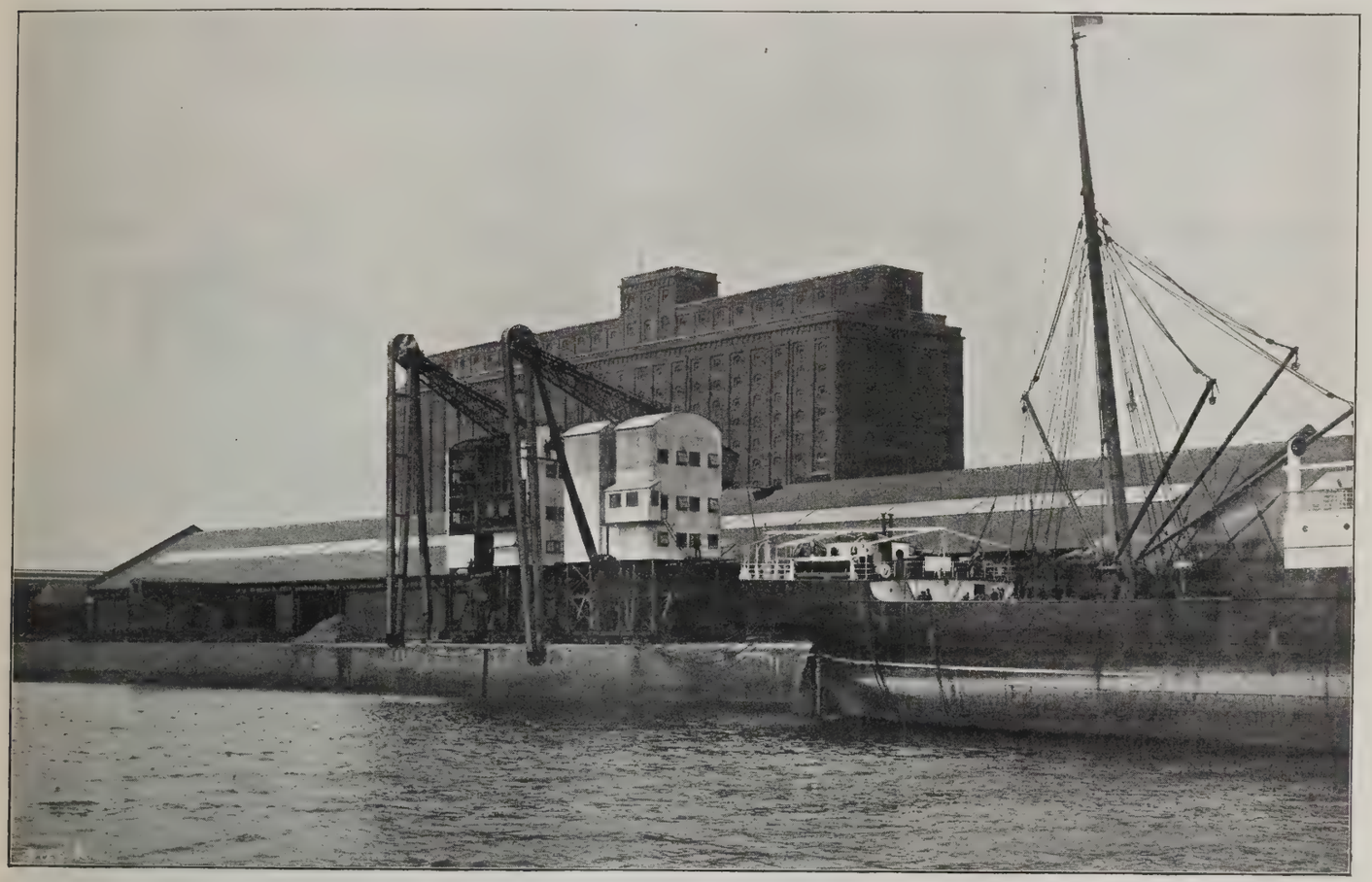


Fig. 1. Perspective View, looking North.

Fig. 2.

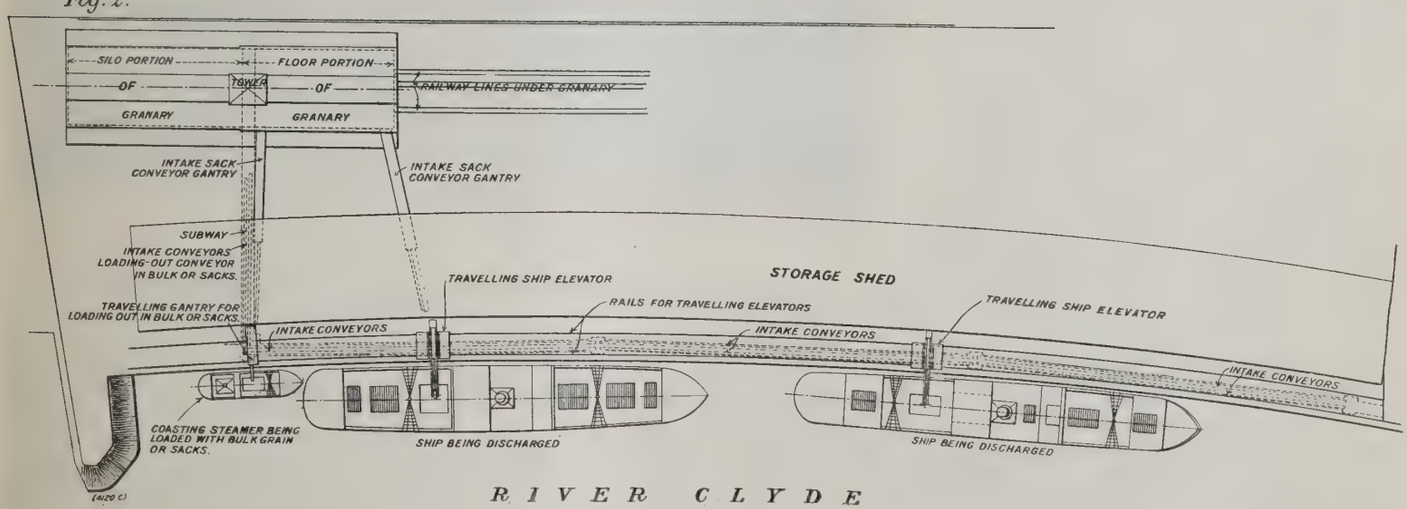


Fig. 2. General Plan.

city. At the wharf there is berthage for three of the largest of grain-carrying ships, and for the discharge of these there are two travelling ship-discharging elevators, as shown in the perspective view, Fig. 1, and the plan, Fig. 2, on page 523, each capable of raising grain from the holds of the ship at the rate of 250 tons per hour. These discharge the grain, after weighing it, on to either of two conveyor-bands, working in a subway built parallel with the face of the quay. These bands transfer the grain ultimately to conveyors running at right angles to the quay, and, as shown by the dotted lines on the plan, into the bottom of two elevators fitted in a tower near the centre of the granary. These elevators, which, like those on the quay, have each a capacity of 250 tons per hour, extend to the top of the tower shown in the perspective view, which rises to a height of 160 ft. from the ground-level, and has dimensions of 36 ft. by 24 ft.

The arrangement of the elevator and the distribution conveyor-bands within the granary are well shown in the general drawings of the building given on Plate XXXVII. Fig. 4 is a longitudinal section of the building from the west to the east, and Fig. 5 a plan, through the silos and storage-floors, part of the building being of the former and part of the latter system. Fig. 6 is a plan of the ground floor, or loading-platform, showing the shoots from the silos and storage-floors for feeding the bands for redistribution of the grain, for delivery in bags to carts, railway-trucks, or in bags and in bulk to river craft. Fig. 7 is a cross-section through the silos, Fig. 8 at the central elevator-tower, and Fig. 9 through the floor storage part of the building. The elevators within the tower discharge on to two conveyor-bands which run east and west from the top of the tower within a conveyor-gallery, extending to the ends of the building, and at a height of 131 ft. above ground-level, as shown in Fig. 4. From the conveyors in this gallery there are side shoots discharging through the top floor into the series of silos (Figs. 7 and 8), or on to any one of the eleven storage floors, into which the other part of the building is divided (Figs. 4, 8, and 9).

The building has a total length inside of 312 ft., a width inside of 72 ft., and a total storage capacity for 31,000 tons of grain. The part arranged with silos is 168 ft. long, and there are 150 separate bins, of which thirty-eight are 102 ft. in depth, while the others are 84 ft., the collective capacity of all the silos being 20,000 tons. The section of the building divided up into floors is 144 ft. in length, and the eleven storage floors are arranged for a depth of 5 ft. 6 in. of bulk grain on each floor, and the total quantity which may be thus accommodated is 11,000 tons. A sacking-off floor, 12 ft. 6 in. in height, runs the whole length of the building, at a height of 15 ft. 6 in. above ground-level, to permit of railway wagons passing beneath on three lines of way, alongside which there are three loading-platforms (Figs. 4, 7, 8, and 9). The height between the successive storage floors is 8 ft. 6 in. For turning over the grain there are three lines of conveyors in the basement (Figs. 6 to 9), dealing with 100 tons per hour, extending from the ends of the building to the main elevators, or to an auxiliary elevator alongside, which also delivers on to the distributing bands in the conveyor-gallery. This auxiliary elevator can also be used in connection with an automatic weigher, having a hopper capacity of 3000 lb., for parcels of bulk grain which it is desired to weigh in process of loading out or turning over. For taking sacks of flour or grain into the granary there are two inclined band-conveyors, each capable of dealing with 500 sacks per hour. These conveyors, which start from ground-level near the front of the quay-side shed, pass through the roof of the shed, and are carried by two steel trunks across the intervening space, to enter the granary at the sixth floor. A sack-band running inside the granary distributes the sacks on this floor, and, by means of patent sack-shoots, to any of the lower floors and to railway wagons, carts, or basement-bands for loading-out to craft at the quay. One of the sack intake-bands is also continued by an inclined band along the east end and north side of the building, by means of which the sacks can be taken to the twelfth floor, and delivered on to a distributing-band there, similar to that on the sixth floor. This inclined band inside the granary is enclosed by partition walls and sloping ceilings, and alongside the band there is a walking space, with short stairs at intervals, giving access to the successive floors. Details of a portion of this enclosure are given in Figs. 10 to 15, on page 525.

For grain that is to be loaded into river or coasting steamer or lighter there is an outgoing band, running for the most part in the same subway as the bulk grain intake bands between quay and granary. The outgoing band, which is capable of taking 100 tons of bulk grain or 500 sacks per hour, is fed by means of the longitudinal bands in the basement of the granary, and leads to a travelling-gantry at the quay side, from which the grain in sacks or bulk is delivered to the steamer or lighter.

The system of sack-shoots and bulk-shoots to wagons is shown in Figs. 4 and 7 to 9. The railway lines pass through the building, and by means of an electric traverser, placed in a pit at the west end loaded wagons can be transferred to other lines between the granary and the goods-shed (Fig. 3). On the sacking-off floor there is an installation of twelve—to be increased to twenty—portable automatic weighers for weighing grain before delivery to carts or railway wagons. In addition to a passenger-hoist there is a stairway from top to bottom of the building (Fig. 5).

Fig. 3. General View, looking West.

Leaving for the present the mechanical equipment of the granary, we turn first to a consideration of the constructional details of the building. Two methods of construction were adopted in the granary building. The outside walls of the floor granary are built of brickwork, and the internal structure is formed with cast-iron columns, rolled-steel joists, and concrete floors. The system is illustrated on the sections and plan on Plate XXXVII., and in part by the details on page 525, Figs. 10 to 15. The outside walls of the silo portion of the granary and division walls of bins are of reinforced concrete, but the outside walls have a facing of 9-in. brickwork, so as to preserve a uniform appearance throughout the building. The details of the reinforced-concrete structure will be illustrated and described in our next article.

The granary is founded on boulder clay, which, for a distance of about 100 ft. from the west end of the area covered by the building, is at surface level. From this point it falls away towards the east end, where it is at a depth of 10 ft. below the surface. In order to distribute the great pressures under the columns and walls of the building, a 6 to 1 concrete foundation layer, 2 ft. in thickness was laid on the boulder clay over the whole area of the building; it was stepped down at the east end. On the top of this foundation layer, granolithic concrete seats, 115 in number, and 6 ft. square by 18 in. in height, were laid, to form the rests for the column bases. The maximum pressure on the top of the foundation layer of concrete is 14 tons per sq. ft., and on the top of the boulder clay $3\frac{1}{2}$ tons per sq. ft. In designing the floors and columns for the floor granary a live load of $2\frac{1}{2}$ cwt. per sq. ft. was taken for each storage floor, with $1\frac{1}{2}$ cwt. per sq. ft. on the loading-platform, sacking-off floor, and conveyor-gallery.

The outside walls are constructed of red-clay brickwork, with piers 4 ft. wide, spaced at 12-ft. centres, and intermediate wall-panels. The thickness of the brickwork in panels varies from 42 in. at the ground level to 14 in. at the conveyor-gallery, and the projection of the piers is 9 in. outside and inside. At the level of each floor a continuous recess was formed round the inside of the walls, into which the concrete floors are carried. The central portion, which is 24 ft. in width, is higher than the rest of the building, to contain the conveyor-gallery. The side walls of the gallery (Figs. 7 and 9) are carried on 12¾-in. by 14-in. compound girders, made up of two 12-in. by $3\frac{1}{2}$-in. channel sections, with 14-in. by $\frac{3}{8}$-in. plates at top and bottom. The elevator-tower, 36 ft. long and 24 ft. in width, built above the conveyor-gallery, carries the heads of the grain-elevators and the motors for driving the same. The external walls (Fig. 8) are of brickwork, the east and west end walls being carried on compound girders similar to those already described. The maximum pressure on the brickwork of the granary is 10 tons per sq. ft.

GRANARY AT GLASGOW HARBOUR.

MR. W. M. ALSTON, M. INST. C. E., ENGINEER TO THE CLYDE NAVIGATION TRUST, GLASGOW.

(*For Description, see Page* 523.)

Fig. 4. LONGITUDINAL SECTION OF BUILDING

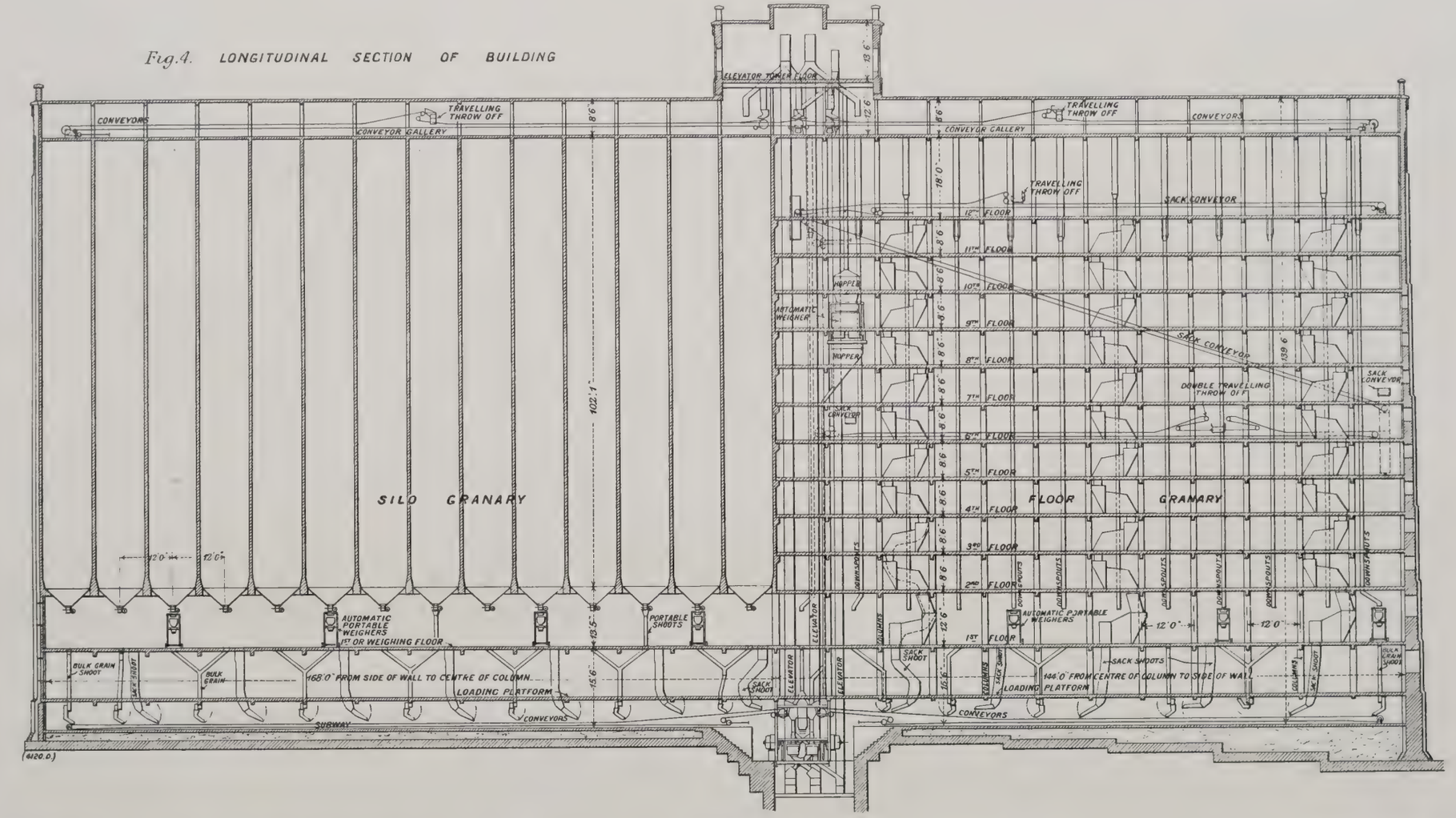
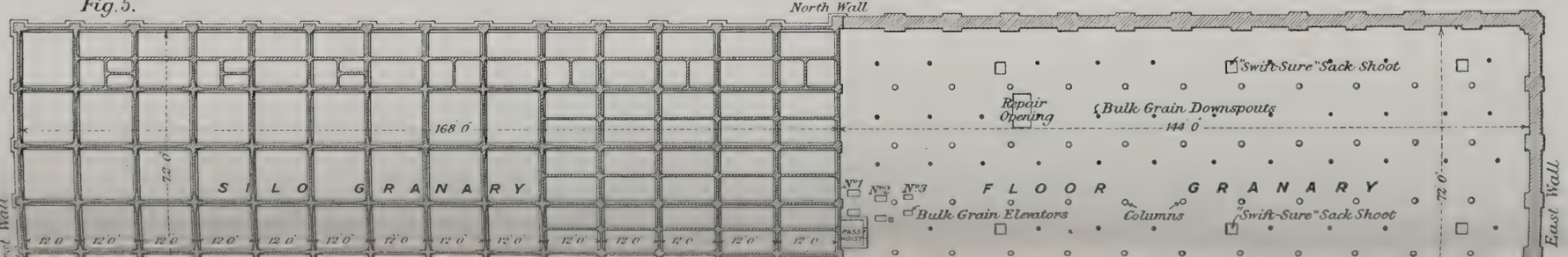


Fig. 5.



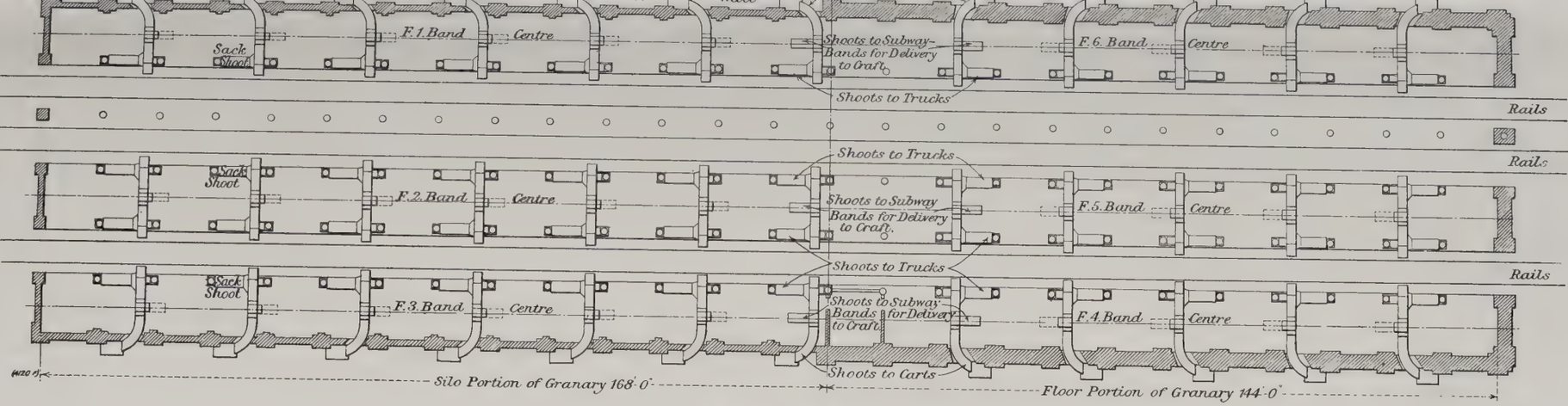
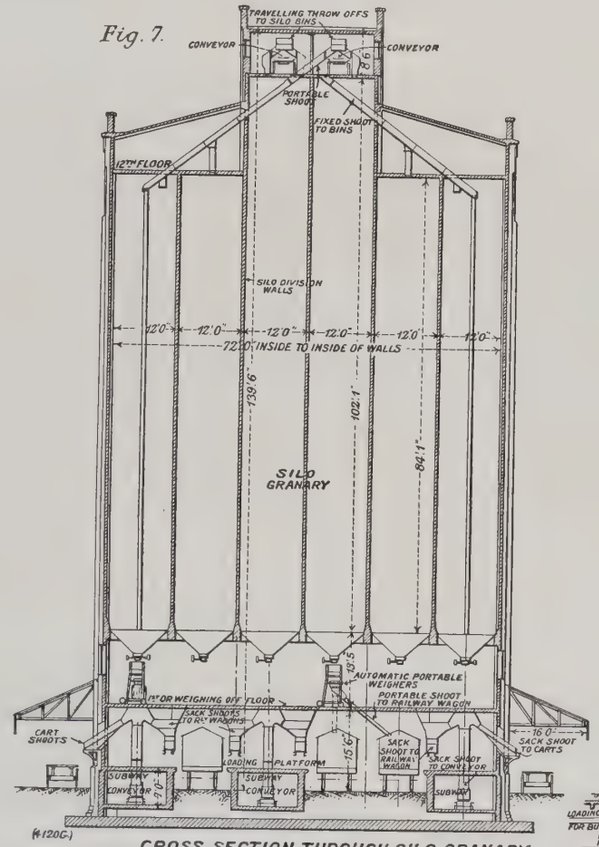
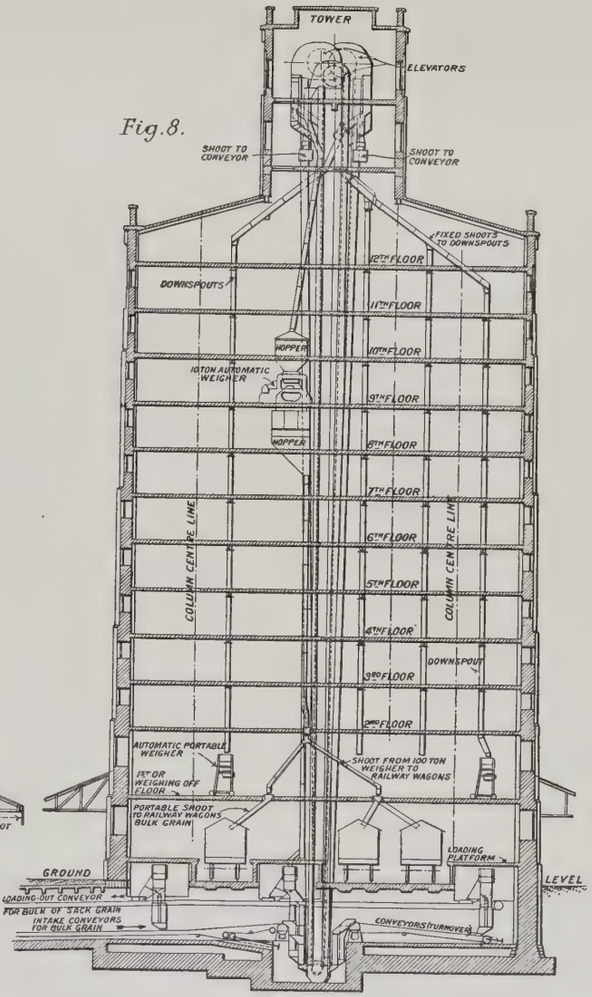


Fig. 7.



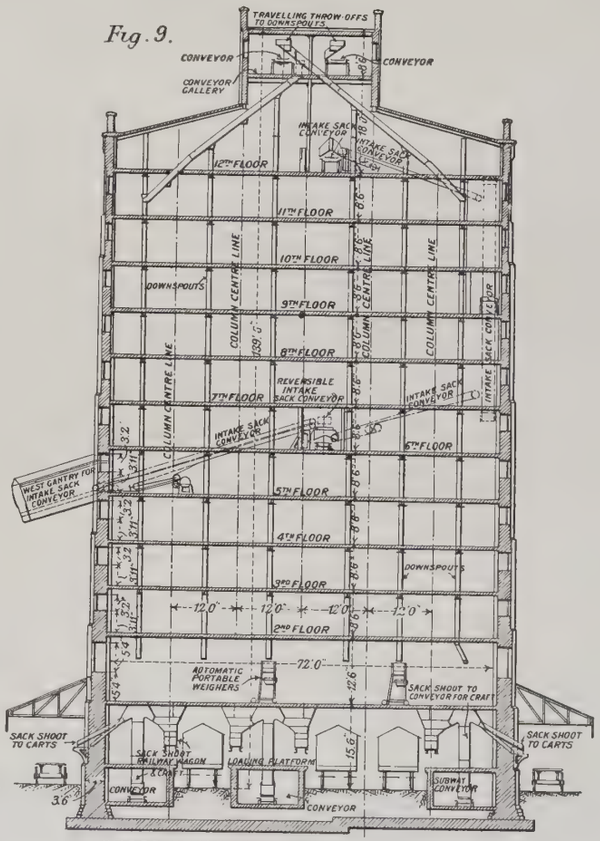
CROSS SECTION THROUGH SILO GRANARY LOOKING WEST.

Fig. 8.



CROSS SECTION THROUGH ELEVATOR TOWER

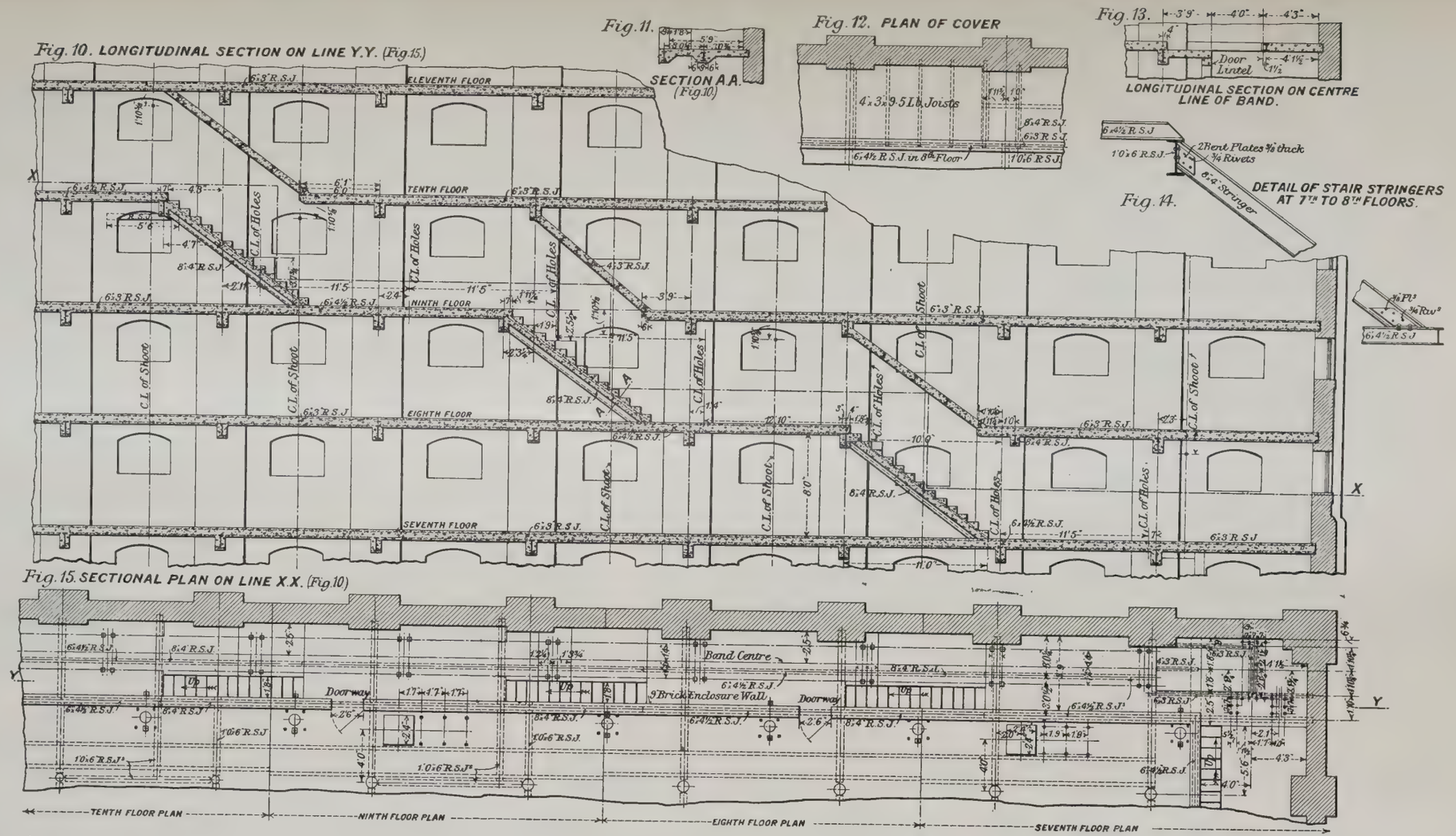
Fig. 9.



CROSS SECTION THROUGH FLOOR GRANARY. LOOKING WEST.

GRANARY AT GLASGOW HARBOUR.

MR. W. M. ALSTON, M. INST. C.E., ENGINEER TO THE CLYDE NAVIGATION TRUST, GLASGOW.



The cast-iron columns carrying the floors vary in diameter from 18 in. at the ground-level to 4½ in. at the conveyor-gallery. The foundation columns are cast with a 4-ft. square base, which rests on the granolithic concrete seat on the foundation layer. The remaining columns—which are 17 ft. in length, extending through two floors—are cast with flanges at the top and bottom, with four holes for ⅞-in. bolts in each flange. An annular groove, ½ in. by ½ in. in section, is formed in the top flange of each column, and a corresponding projection on the bottom flange, the projection fitting into the groove of the column immediately below. Near the centre and top of each column two brackets and lugs are cast, for the purpose of carrying and fixing the main transverse rolled-steel joists of the floors. The columns are all formed with projections on the outer surface to take the rendering of the cement plaster, which was applied after erection. The flooring and the stairways alongside the inclined sack band are illustrated in detail by Figs. 10 to 15. The transverse rolled-steel joists of the floor are 12 in. by 6 in. by 44 lb., spaced at 12-ft. centres throughout. The ends of these beams rest on the column brackets, to which they are bolted by means of two ¾-in. bolts. At the external walls the joists rest on Arbroath coddings set in the brickwork. The longitudinal rolled-steel joists which rest on the top of the main transverse beams are 6 in. by 4½ in. by 20 lb., spaced 4 ft. apart in the sacking-off floor, and 6 in. by 3 in. by 15 lb., spaced 3 ft. apart in the remaining floors of the building.

The concrete forming the floor, which has a minimum depth of 7 in., was laid so as to provide a cover of 1 in. on the bottom of the longitudinal joists; and also to envelop the main transverse beams. The concrete consisted of 1 part cement to 2 parts Kilsyth sand and 4 parts whinstone chips from Hillhouse Quarry, Troon. A layer, 1 in. in thickness, of 3 to 1 granolithic concrete was laid on the top of the ordinary concrete of all floors, loading-platform, and conveyor-gallery. Including this, all the floor steel-work had a concrete covering of at least 1 in.

The roof of the floor granary was constructed in a similar manner to the floors. The sloping roof over the twelfth floor on each side of the conveyor-gallery was carried on 8-in. by 4-in. transverse beams spaced 12 ft. apart, one end of each being connected to the compound girder carrying the conveyor-gallery side walls, while the other end rests on the main side wall of the building. The longitudinal roof joists are 4 in. by 3 in., spaced 3 ft. apart, and embedded in concrete having a 1-in. covering on the top and bottom, giving a roof 6 in. in thickness. The conveyor-gallery and elevator

tower have flat concrete roofs, 6 in. in thickness, the supporting transverse beams being 8 in. by 4 in., and the longitudinal joists 4 in. by 3 in. The whole surface of the roofs, both sloping and flat, was covered with asphalt to a thickness of 1 in. Roof-lights were formed in the sloping side roofs to provide light for the twelfth floor.

(*To be continued.*)

LITERATURE.

Intermetallic Compounds. By Cecil H. Desch, D.Sc., Ph.D., F.I.C. London: Longmans, Green and Co. [Price 3s. net.]

The question here considered is the manner and extent to which metals are capable of forming definite chemical combinations among themselves, and the means of recognising those combinations as true chemical alloys. That such bodies exist has long been known, but they have not been widely studied till late years, owing to the difficulty of isolating them in a pure state and of submitting them to critical analysis. But now that the subject has come to the fore, the experimental study of alloys has proceeded at so rapid a pace that conclusions have been accepted on insufficient warranty. The literature of the subject has become confused, and there is need to review much of the evidence on which apparently accurate chemical formulæ have been assigned. Dr. Desch's book comes as a timely reminder to warn us of the necessity of using greater caution, to adopt severer and more varied tests, and to sift experimental data with greater thoroughness. We are dealing here with practically new problems, obscure, for they stand on the borderland of the unknown, and their solution is to be sought tentatively, but whose results can well exercise an important bearing on engineering science.

The method of investigating this recondite subject that most readily occurs to a chemist is to attempt to extract the pure compounds from an alloy by some physical process, as filtration, crystallisation, volatilisation, or removing the excess of metal by solvents. Filtration at high temperatures is difficult, crystallisation from an indifferent solvent is inapplicable, and the results of fractional crystallisation are apt to be misleading owing to the impossibility of removing the adhering mother-liquid completely from the crystals. The adoption of methods suggested by ordinary chemical procedure is responsible for burdening chemical literature with an extremely large number of formulæ and descriptions of supposed compounds, the majority of which are probably unreal. In consequence of the difficulty both of manipulation and of interpreting the results derived, these methods have been superseded by the use of the "freezing-point curve" or the determination of the chemical equilibrium of a binary system. Two substances are mixed in known proportions and allowed to cool slowly. The temperature of the mixture is recorded when solid matter is perceived in the liquid. This is the "freezing-point," or the temperature at which this particular mixture is saturated or comes into equilibrium with a particular solid. By varying the mixture a number of "freezing-points" can be deduced from which the "freezing-point curve" can be drawn. In the simplest cases, in which the substances neither combine chemically nor form mixed crystals, the curve consists of two branches cutting at the eutectic angle, either branch corresponding to the formation of primary crystals of either substance. Curves of this type do not absolutely disprove the existence of a compound, but render its presence extremely improbable. When a compound does exist whose melting-point lies in the region above the "freezing-point curve" of the two metals, it gives rise to a separate branch, cutting the other branches. Such a branch, however, may be due to polymorphic modifications between the components, and it is not always easy, or even possible, to distinguish the two cases. In the early days of research Dr. Desch intimates that misinterpretation was frequent, and that the effects of hurried conclusion on insufficient grounds have not yet been entirely removed. It may happen that the intermediate branch of the liquidus passes through a maximum temperature far above the freezing-point of the component metals. As an example, the author quotes the compound Au Mg, with a freezing-point of 1150 deg., while that of gold is 1062 deg., and of magnesium 650 deg. In such a case the interpretation of the curve is unambiguous; an intermediate compound must be present, the high freezing-point of which indicates that it is formed from these components with liberation of a large amount of energy.

Usually, when experiment has shown a distinct maximum, the inference of the presence of an intermetallic compound is justified, but erroneous interpretation is possible. The lead-thallium series provides such an instance, where the "freezing-point curve" has a very flat maximum. Then additional criteria have to be employed, and much of the present treatise is devoted to the discussion of appropriate means available, and the nature of the evidence that can be deduced from each test. In the particular case of lead-thallium the introduction of a third metal, tin, influencing the position of the maximum, affords a fairly conclusive test, but oftentimes it is necessary to trust to cumulative evidence to decide between a conglomerate or a compound. Thermal analysis alone is an unsafe guide, and has often been found misleading. Other controls are needed, and among these must be given a prominent place to microscopic examination. Perhaps more limited in scope, but not less certain in its indications, is the determination of the difference of electric potential existing between the metal and its alloys.

The author reviews the use that has been made of these tests and of some other lines of inquiry whose prosecution seems hopeful. Unfortunately, the possibility of isolating intermetallic compounds in a pure condition is remote, and our knowledge of their properties can only be studied in the alloys in which they occur. Enough is known to show that the presence of intermetallic compounds can exert profound influence on important physical properties of alloys, such as density, hardness, magnetic susceptibility, &c. We approach here questions of an eminently practical character, but the method of attack must await a further advance in theory. This survey of much original work is a valuable contribution to chemical literature, and will do much to facilitate that advance. Those engaged in such researches will welcome this exhaustive record of the position the inquiry has reached.

Hydraulics. For Engineering Students and Engineers in Practice. By W. M. Wallace. London: The Technical Publishing Company, Limited. [Price 4s. net.]

One of the most notable developments in modern engineering consists in the adoption of methods for utilising and economising energy in directions in which it had been previously disregarded; and if some salient examples stand out more prominently than others, yet in every department of engineering science the struggle for a more careful management can be traced. Hydraulics has felt the movement, as have other branches, and the author of the volume now under notice claims that the results of recent research and invention demand the appearance of a new book. His treatise, however, must be regarded rather as stimulative than complete. It is intended for the practical engineer and the student reading for university and similar examinations. In endeavouring to meet the wants of two classes the author has encountered difficulties. These may be illustrated by a reference to the treatment of Bernouilli's theorem, a theorem that lies at the foundation of the whole science of hydraulics. The university student will find no rigorous proof that would satisfy his examiners, but the practical engineer will find something that will stand him in very good stead. The author recalls an illustration by Froude, that was presented to the British Association forty years ago, in which it was shown, by the different levels at which water stood in piezometer tubes attached to a pipe of gradually varying aperture through which water was allowed to flow, that the smaller the section the higher the velocity and the lower the pressure. Such an experiment is very forcible, and may convince where mathematical reasoning fails to appeal. In other places the author does not scorn similar devices to hold the attention. At the beginning of a new subject he will tell the student what he proposes to do, and will interest him by putting the main principle succinctly and leave the mathematical demonstration till later. But these demonstrations are usually very simple, and the author keeps constantly in view the applied side of the science.

The topics discussed cover the usual ground. An introductory chapter dealing with some simple hydrostatic problems is followed by a discussion of the flow of water under several conditions, and of the effects of interference with that flow. Pressure due to impact of water on a surface is treated in this section, illustrated by reference to the Pelton wheel and the blade of a turbine. The chapter on turbines, with a short reference to, or comparison with, the steam-turbine, is, however, unsatisfactory, considering the immense developments which have taken place in prime movers of this type during recent years, as well as the varied applications both on land and sea. Recent research and invention are nowhere more fully exhibited than in the increasing efficiency of the turbine, an efficiency that has reacted on the earlier types of reciprocating engines, and in a practical book of this nature a more exhaustive survey might have been anticipated.

Three chapters are devoted to pumps, and, considering the space, the treatment is more thorough, a feature being made of the forms of explosive pumps, which are coming more into vogue, and appear to have an important future. We then go back to theoretical matters, or the combination of theory and practice, as illustrated in the measurement of the flow of water over weirs and in channels. The Venturi meter and the Pitot tube are described in this section, but the explanations need expansion by a competent teacher. Bazin and Kutter's formulæ, that have done duty in so many works of this kind, reappear, but the author does not seem to be enamoured with either the sufficiency of the formulæ or the accuracy of the numerical constants involved. He quotes with approval another formula given by Mr. E. C. Thrupp, which appears to be founded on experiments limited to the water flow of the Thames and Kennet Rivers. Bazin had the advantage of a very large experience, but most engineers would be prepared to give a wide margin to the deductions, however obtained. In the chapter on "Fluid Friction" there are some interesting observations on the resistance of ships and of dirigible balloons, utilising results obtained from measurements and experiments in the Tank of the National Physical Laboratory. But here, as elsewhere in the book, the subject is dropped when it begins to be interesting. This suggests that there are too many subjects treated within a small space to permit adequate ventilation of each, so that the author has really not had a fair chance of doing himself justice.

Text-Book on Wireless Telegraphy. By Rupert Stanley, B.A., M.I.E.E. Illustrated. London: Longmans, Green and Co. [Price 7s. 6d. net.]

Surely the needs of every grade of student have been met by the writers of text-books on wireless telegraphy, and one might well beg for a pause in the unending stream of literature that runs so persistently in one direction. Mr. Stanley can only repeat what has been so frequently said in similar treatises. The same assertions are made, the same difficulties are slurred, the same apparatus is set up, and the same results necessarily follow. There is no new feature in this compilation—nothing original—upon which one can dwell with satisfaction. The facts are all correct, the illustrations are good and pertinent; the author no doubt fondly persuades himself that he has put matters more clearly and instructively than other writers, because he has had to systematise his knowledge and construct a coherent, reasoned statement which satisfied himself; but we cannot see that this book will assist anyone to acquire a more exact mastery over technical details, or provide a clearer insight into underlying principles, than do many excellent treatises that have lately appeared. We have, however, only one fault to find—that of surplusage.

THE MANHATTAN BRIDGE, NEW YORK.

By Frank W. Skinner, Member of the American Society of Civil Engineers.

(*Continued from page* 437.)

Superstructure—(*continued*).

Erection of Towers.—The sections of the pedestals were delivered by lighters and unloaded by their derricks, which placed them on a set of about forty 2-in. steel balls on the bed-plates. They were thus easily rolled to accurate position, jacked up, the balls removed, and the sections lowered to final bearing. The 40-ton lower sections of the columns were erected by the lighter derricks, and a stiff-leg wooden derrick with a 10-ton 60-ft. boom erected the two duplicate steel tower travellers,

THE MANHATTAN BRIDGE, NEW YORK.

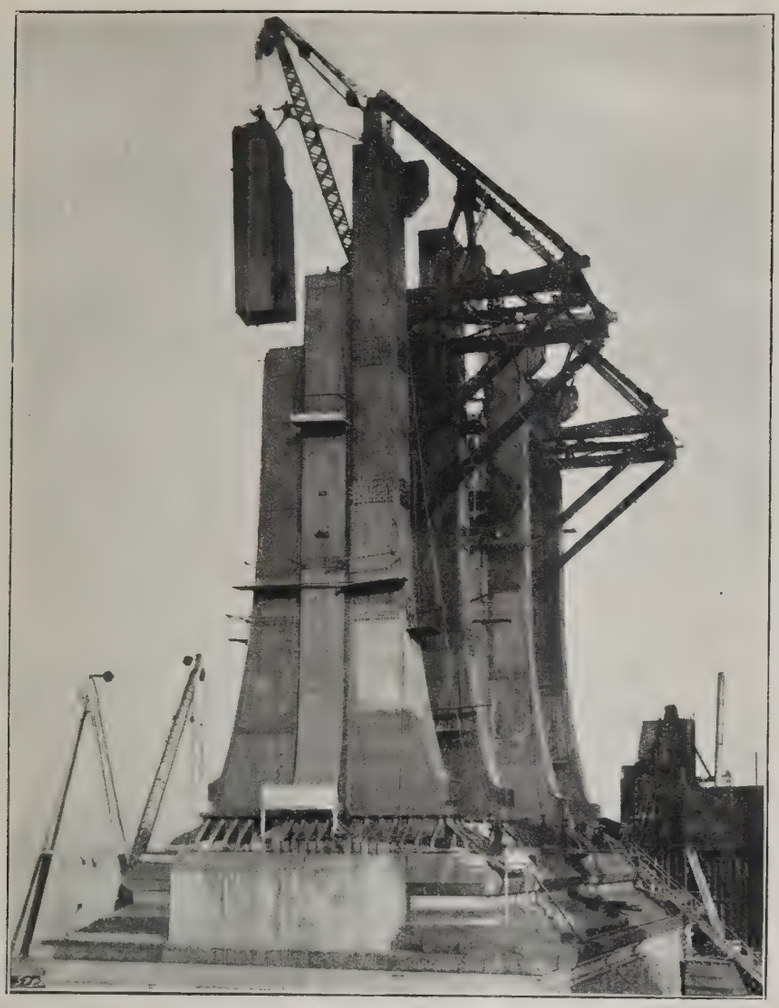


Fig. 62. Erecting the Brooklyn Tower.

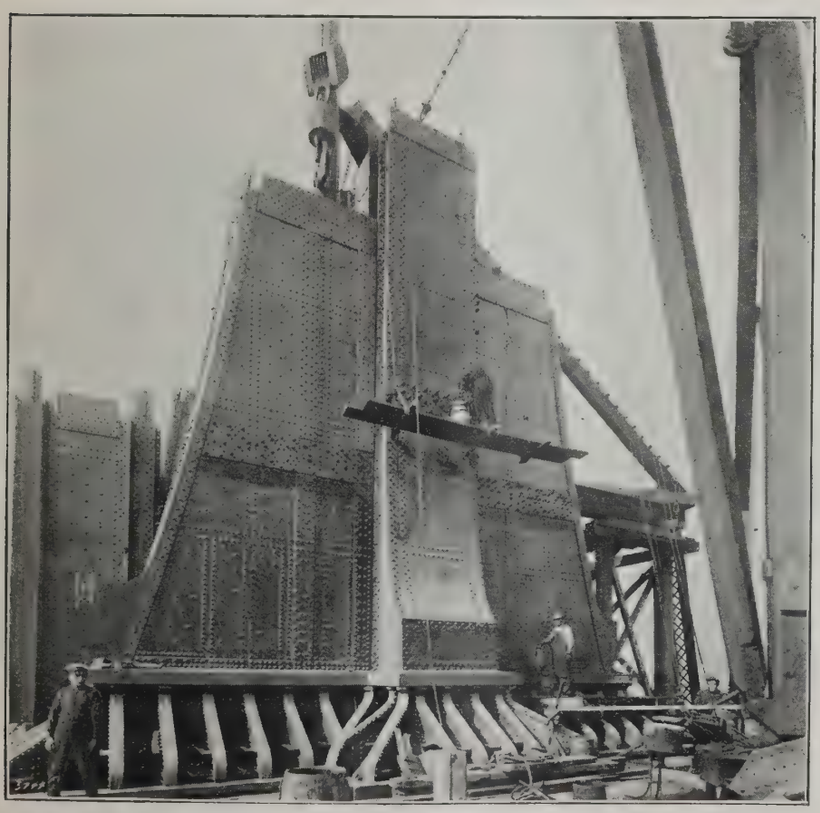


Fig. 63. Base and Pedestal of the New York Tower.

each with a 21-ft. by 34-ft. horizontal I-beam platform supported by two triangular bracket-like trusses on the shore face of the tower and proportioned for a total load of 260,000 lb. These travellers are shown in place in Fig. 62, annexed, whilst a view of the base of the New York tower in course of erection is represented in Fig. 63.

At platform level the columns were enclosed by riveted yokes with friction rollers on all faces, and the feet of the brackets were secured to the columns by pairs of screw-end U-bars. The 45-ft. derrick boom had a 10-part tackle for 35-ton loads, and a 14-part tackle for 50-ton loads, both rove with $\frac{3}{4}$-in. steel cable. The corresponding topping lift tackles had 14 and 18-part tackles and were all operated by stationary hoisting-engines on the pier masonry. For hoisting the 64-ton maximum column sections the tackles were rigged with extra sheaves outside the regular blocks, and the number o f parts in hoisting and topping lifts were increased to 16 and 20 parts.

Each of the travellers and its equipment weighed about 130,000 lb., and was hoisted 25 ft. from storey to storey in two or three minutes by two 13-part tackles rove with a single $1\frac{1}{2}$-in. Manilla line, with both ends operated by the two hoisting-engines of the same tower, thus equalising the stresses. The four travellers erected about 2000 tons of steel in sixteen days. The work was done by a total force of about 400 men and an equipment consisting of the travellers, hoisting-engines, pier derrick, two storage scows, a 100-horse-power boiler plant, a forced-draught steam-turbine blower, an air-compressor, and thirty pneumatic hammers on each side of the river.

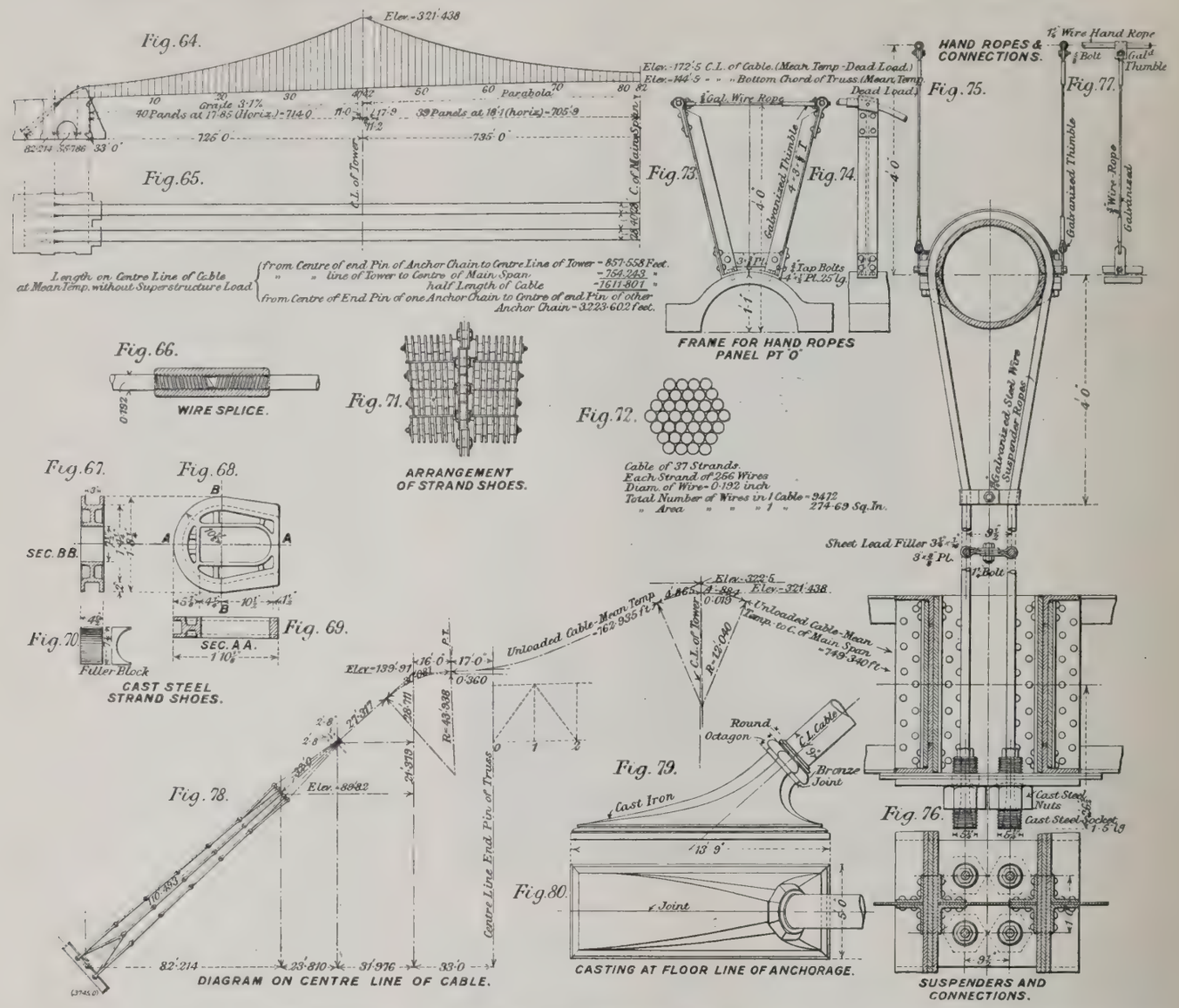
Design of Main Cables.

Each of the four main cables is about 3223 ft. long, $21\frac{1}{4}$ in. in diameter, weighs about 1500 tons, and has a theoretical maximum stress of 18,000,000 lb., a specified ultimate strength of at least 55,000,000 lb., and a versed sine varying from 144 ft. to 152 ft., according to load and temperature. The lengths along the centre line of the cable between the principal points are as shown in Figs. 64, 65, and 78, page 528. Each cable is made with 9472 galvanised wires, 0.192 in. in diameter, with a specified ultimate strength of 215,000 lb. per sq. in. before galvanising (actual tested strength averaged about 225,000 lb.). The wire was drawn in 3000-ft. lengths, with the ends spliced by sleeve-nuts engaging cold-rolled threads which developed an average of 97 per cent. of the strength of the body of the wire. A detail of these joints is illustrated in Fig. 66. The wires form continuous loops, arranged in thirty-seven strands in each cable, with pin connections to the anchor eye-bars. The strands are compacted into a solid cylindrical mass, clamped by cast-steel suspender-bands, illustrated in Figs. 85 to 91, page 529. Special bands, represented in Figs. 92 and 93 and Figs. 94 to 97, were used near the ends of the cable, between which it is wound with galvanised-iron wire. The suspenders engaging the castings on the cables are four-part steel-wire ropes, $1\frac{3}{4}$ in. in diameter, with conical cast-steel sockets on the lower ends, threaded for nuts bearing on the main floor-beams. This connection is illustrated in Figs. 75 and 76, page 528.

Construction of Cables.—It was at first proposed to make the cables on solid platforms on shore perpendicular to the bridge axis, but this idea was abandoned, and they were made, *in situ*, much in the usual way, on temporary suspended platforms. Sixteen $1\frac{3}{4}$-in. ropes, 3300 ft. long, and weighing together 17,000 lb., were delivered on separate reels by boat to the foot of the Manhattan tower. One end of each was led over the top of the tower and back to the anchorage, and fastened there. The reels were towed across the river, four at a time, in ten-minute trips, the ropes dropping to the bottom of the river. The remainders of the ropes were unwound from their reels, hoisted to the top of the Brooklyn tower, secured to the anchorage pier, and adjusted to a height of about 170 ft. above water-level at mid-span. Not more than 2 minutes was required for hoisting each rope.

Under each of the three spans of the falsework cables there were placed four $\frac{3}{4}$-in. storm-cables, one cable in the plane of each set, anchored to the tower and abutment piers at about roadway level, and attached to the falsework cables by vertical ropes about 54 ft. apart, which were stressed to draw them into reversed catenaries nearly tangent to the upper cables at the centre of the main span, and near the anchor-piers. This combination of

THE MANHATTAN BRIDGE, NEW YORK; DETAILS OF CABLES.



cables (see Figs. 99 and 100, page 536), together with some auxiliary diagonals from the roadway level of the towers, produced a funicular structure of considerable rigidity against vibration and deflection.

On the sets of upper cables light transverse wooden cantilever beams, about 35 ft. long, were set about 21 ft. apart, and on their extremities working platforms, four in all, 8 ft. wide, were built on the centres of the future main cables, and 30 in. below them. These platforms were connected by a transverse foot-bridge at the centre of the main span, and each of them was protected by two wire-rope hand-rails, and carried nine approximately equidistant small towers, supporting the sheaves for the carrier-rope used in cable-making.

An endless $\frac{3}{4}$-in. wire carrier-rope, in the plane of each main cable, and about 4 ft. above it, was carried on a 6-ft. horizontal sheave installed on each anchorage pier. Electric motors on the Brooklyn pier operated the carrier-ropes at a speed of about 450 ft. per minute. At equidistant points on each carrier-rope were mounted two goosenecks, with 4-ft. sheaves, by which the cable wires were drawn across the river.

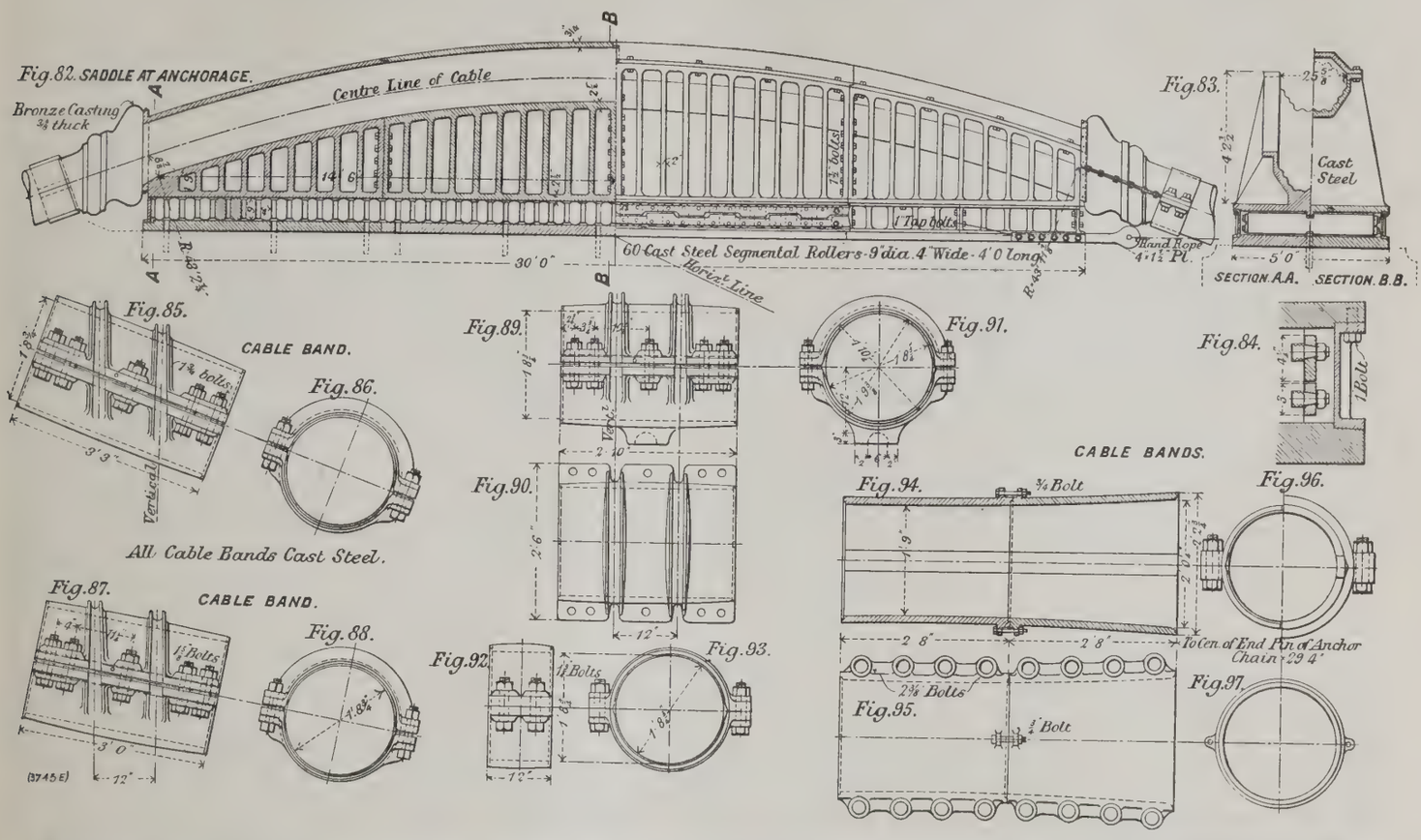
Four-ton reels, containing about 80,000 ft. of wire each, were mounted on horizontal axes in the planes of each main cable on both anchorage piers. The free ends of the wires were made fast to the anchorages; the bights were engaged in the carrier-sheaves, and hauled across by them to the opposite anchorages, removed, and put on shoe-castings temporarily attached to the anchor-chain eye-bars. The wires were adjusted at the tops of the towers and at the centre of the main span to a guide-wire, clamped in position, and so wound back and forth continuously on the shoes shown in Figs. 67 to 70,

Fig. 81. Connecting Strands to Eye-Bars.

above, bights being simultaneously engaged on the carrier-sheaves over opposite anchorages as soon as the preceding bights were released. A plan showing the arrangement of these strand-shoes is given in Fig. 71. Each carrier-rope thus hauled two bights, or four wires, at once, or sixteen in all, normally an efficiency greatly in advance of any previous similar work, and which resulted in laying as many as 218 wires in one cable in one eight-hour day.

After 256 parts of wire had been laid on one pair

THE MANHATTAN BRIDGE, NEW YORK; DETAILS OF CABLES.



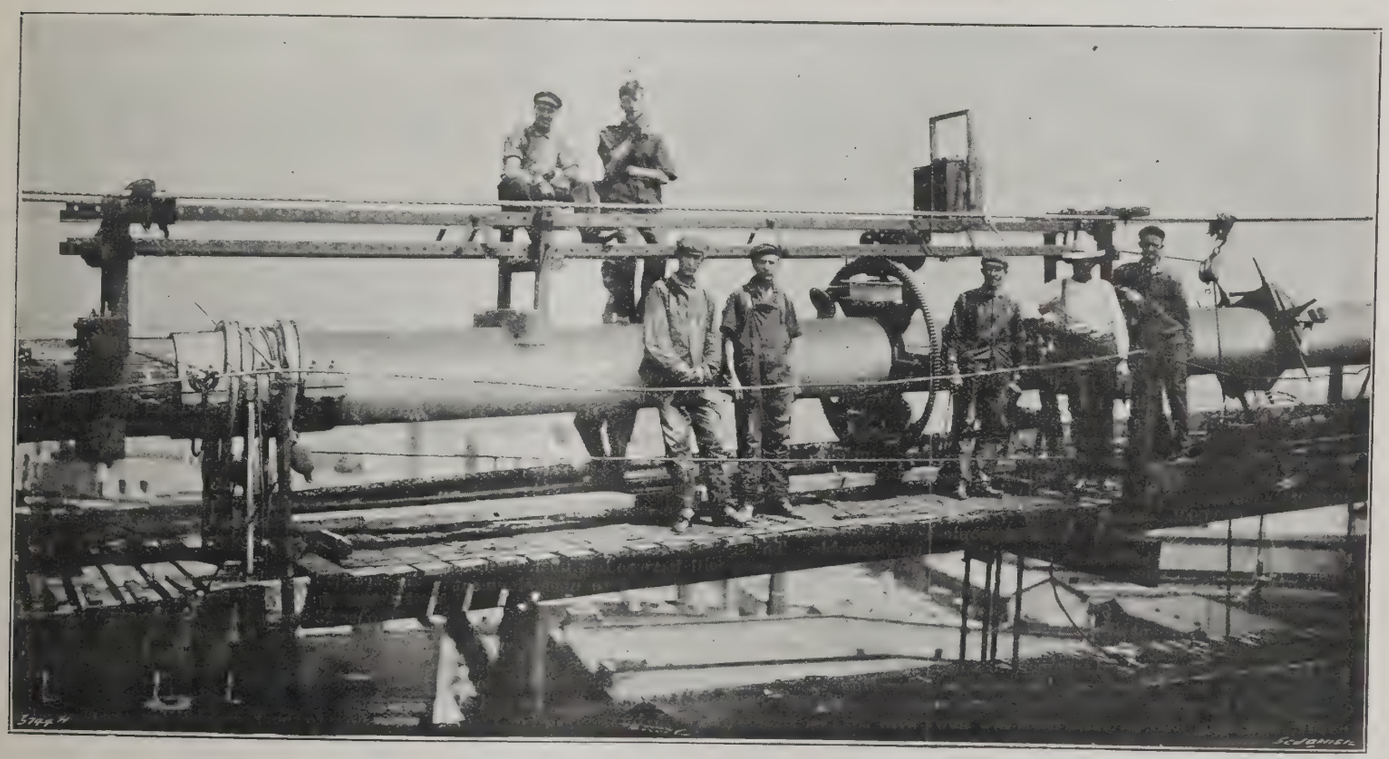


FIG. 98. CABLE WRAPPING.

of shoes, the latter were released from their temporary connections by 35-ton hydraulic jacks with 4-ft. strokes, twisted 90 deg., and connected permanently to the eye-bars (see Fig. 78, page 528), the strand being lowered a few inches from the position in which it was laid to the line of the finished cable. Accurate final length and deflection adjustments of the strands were made by shims inserted between their shoes and pins.

After the strands in the centre and lower part of each cable were completed, seven of these were bunched together in hand-squeezers, making a cylinder about 9 in. in diameter, seized every few feet with several turns of temporary wire wrapping. The remainder of the 37 strands, 3½ in. in diameter, were then completed for each cable, as indicated in Fig. 72, page 528. All seizings were then removed, and the wires compacted into cylinders by the use of flange-connected steel yokes put under very heavy compression by hydraulic presses of about 43,000 lb. capacity. The sixteen yokes, each operated by two men, were moved 2 ft. at each operation, and completed their work in a few weeks. After the cables were compacted, flanged cast-steel collars (Figs. 85 to 88) were bolted to them at panel points about 18 ft. apart, to receive the suspender ropes, and the cables between them were covered with red-lead paste, and protected by a permanent wrapping of No. 9 soft-steel galvanised wire.

The wrapping was accomplished very rapidly and satisfactorily by four 1000-lb. machines, each having an annular flanged cast-steel housing about

5 ft. in diameter, concentric with the cable. It carried two 7000-ft. reels of wire, and was revolved around the axis of the cable, ten times per minute, by a ½-horse-power electric motor, laying two spiral wires close together under a tension adjusted to about 200 lb. by a spring-friction disc. This machine is illustrated in Fig. 98, page 529. The bearing of the machine against the laid wires compacted the latter, and advanced the machine at the rate of about 1½ in. per minute, sliding easily on the cable on six smooth bronze shoes. The wrapping wire was not spliced, but was continuous between suspender bands.

On the main towers and anchorage piers the cable-strands were laid in temporary positions a few inches horizontally eccentric from the cable centres, on sets of guide-sheaves. When completed they were wired between sheaves to a lifting-beam raised a few inches clear of the sheaves, moved transversely, lowered to permanent position in the cast-steel saddles, and the wire lashings cut and pulled out. The cables, which weigh about 12,537,000 lb., and cost, with their suspender ropes, about 1,900,000 dols., were commenced January 15, and finished June 30, 1909. At the floor line of the anchorages the cables pass through castings, as shown in Figs. 79 and 80, page 528. General views representing different stages of progress in the construction of these cables are given in Figs. 99 and 100, on page 536.

(*To be continued.*)

INDUSTRIAL NOTES.

The Board of Trade has recently issued a report on the changes in rates of wages and hours of labour in the United Kingdom during the year 1913. In an introductory review of the year by Mr. F. H. McLeod, the Director of Labour Statistics, it is stated that the year was one in which there was an active demand for labour, especially in the first half, and wages rose in sympathy. The movement of wages, which has been in the upward direction since 1910, reached its culminating point in the first half of 1913, but began to fall off after the month of August in tho e branches of the metal trades in which changes in wages are automatically regulated by fluctuations in the selling prices of pig-iron and manufactured iron and steel; the increases in the coal-mining industry were also checked. In spite of these set-backs the net effect of all the changes in the year was to increase wages by 179,000*l.* a week, an amount which has only twice been exceeded during the last twenty years, in 1900 and 1907, when the figures were 208,500*l.* and 201,000*l.* respectively. From the time the several changes in 1913 took effect until the end of the year the aggregate wages bill was increased by over 6,000,000*l.*; if they had all been in force for the whole year the total increase would have been 9,000,000*l.*

Of the increase of 179,000*l.* per week in 1913, coal-mining accounted for 102,000*l.*, the building trades for 23,000*l.*, and engineering and shipbuilding for 13,500*l.* The increases in the building trades were much greater than those recorded for any previous year, considerably exceeding the total advance in these trades during the preceding thirteen years. In eleven of the last twenty years wages have risen, and in nine they have fallen. The average increase in years of rising wages has been about 97,000*l.* a year, and the average decrease in years of falling wages about 48,000*l.*, with the result that wages show a net increase of over 630,000*l.* during twenty years in the weekly wages of all classes of workpeople, except agricultural labourers, seamen, and railwaymen, covered by these statistics.

The estimated weekly increase in the wages of farm servants during 1913 is given as 9964*l.* This may be compared with 1912, which was also a very good year, the weekly increase for that year being 5291*l.*

Early in 1913 seamen, firemen, and trimmers obtained a general advance of 10s. a month at the principal ports of the United Kingdom. This followed a similar rise in 1911, and altogether average rates are now higher than ten years ago by 30 per cent. on steamships, and by over 40 per cent. on sailing ships.

In the case of railwaymen, average weekly earnings, as distinct from rates of wages, are alone available. According to these figures, the average earnings were 27s. 11½d. in 1913, and 27s. 4½d. in 1912—a rise of over 6d. a week. As compared with 1907, which was also a good year, the rise in the average earnings of nearly half a million railway workers is over 2s. a week.

Complete figures with regard to the first eight months of 1914 are not yet available; but, so far as they go, they indicate that in coal and iron-mining, and the iron and steel industries, the decline already noticed in the later months of 1913 has continued. In the principal other groups of industries, however, there have been further advances.

The works of Messrs. Howard and Bullough, Limited, of Accrington, have been reopened this week, as the 500 members of the Amalgamated Society of Engineers, who came out on strike some three months ago, have decided, by a large majority, to accept the new terms offered by the firm, including an advance from 36s. to 37s. a week. As a result of the strike 4000 other workpeople have been thrown out of employment, and a sum of about 60,000*l.* has been lost in wages.

From the *Yorkshire Post* we learn that the clothing factories of Leeds continue to be busy with orders for army uniforms, the chief difficulty experienced being the comparative shortage of khaki cloth. No further contracts of any size have been distributed among local firms, but considerable interest has been taken in War Office tenders for the supply of 100,000 coats for cavalry, and it is hoped that at least a portion of this contract will be placed in the city.

There is also considerable expectancy among boot manufacturers in Leeds. It is considered likely that the War Office will very shortly give out an order for over one million pairs of army boots, in addition to which orders are expected from the Admiralty and from the Government of Greece.

Arrangements have been made for the formation of a National Union of Scottish Mine-Workers, to take the place of the existing Scottish Miners' Federation. The new scheme, which was approved by a large majority and comes into operation on the 1st prox., will, it is thought, be more effective in dealing with strikes and lock-outs. The present Scottish Federation agents will continue their services.

According to the *Birmingham Daily Post*, the position as regards unemployment in Birmingham is improving, the returns showing that fewer men and women are unemployed and that there is less short time. The building trade, however, continues to be depressed; but little new work has been given out for some weeks, and some of the work in hand has been suspended owing to the scarcity, or prohibitive price, of materials. The labour position is, however, not materially worse than in a normal October, owing to the fact that a large number of men are engaged on the training and concentration camps. Most engineers are still very busy, and the work in hand is spread over a wide field. In the brass trades there is some amount of short time, but very little unemployment. This industry is largely employed in making articles formerly supplied almost exclusively by Germany. Fairly good orders are being received for cabinet brass, and makers of plumbers' brass are moderately well employed. There is still no export demand for bedsteads, but in the home trade sales have been on a rather larger scale. Between 20,000 and 25,000 hospital beds are now in course of manufacture among Birmingham firms, and as far as can be seen at present, future orderings are not likely to be on a very large scale, though rumours of inquiries for large numbers of the cheapest iron beds for the allied armies have been current in trade circles.

In a notice issued to the men employed at the Baddesley Collieries, the Trustees point out that, although the present state of trade affords good employment, short time is certain in the near future. They therefore urge the men not to miss a shift, and to set aside a sum of money each week for use during the anticipated period of depression. It is also pointed out that, owing to the wood-cutters in Russia and other countries having been called to the colours, it is necessary to exercise the most rigid economy in the use of timber, as next year's supply will be almost unobtainable. The stock in hand, although ample for present requirements, will have to last until 1916, so that wastage of timber will lead to unemployment in the future.

From the report of the quarterly meeting of the Amalgamation of Card-Room Operatives, published in the *Manchester Guardian*, we learn that the local associations were strongly recommended to fall in with the new suggestions made by the Board of Trade to qualify themselves for the repayment out of Government funds of a part of their out-of-work expenditure. All the associations, except that of the Accrington district (which for the purposes of card-room organisation includes Blackburn, Burnley, Nelson and Colne) make out-of-work payments, and the additional levies imposed on their members remaining at work would qualify them for a refund of half the amount so spent. The Board of Trade, however, insisted, as a condition of the refund, that all out-of-work members should sign a "vacant-book" at their union office at least twice a week as long as they remained out of work. To this the Card-Room workers' representatives objected, stating that this procedure would be inconvenient and would be difficult to reconcile with the ordinary methods adopted by the various associations to satisfy themselves that their members were really entitled to the benefit. The Board of Trade was asked to accept the existing arrangements, which enabled a district association with a large membership to be worked by a small number of officials without any risk of fraudulent applications for benefit resulting. The Board, however, would not agree to this, and it was afterwards decided to recommend to the districts that unemployed members entitled to benefit should sign an out-of-work book once a week on a given day during working hours, and that, where benefits were paid by collectors, the member's signature should be obtained for the amount received. A letter from the Board dealing with the matter was read at the meeting, the letter stating that the Board considered that proof of unemployment should be obtained by signature in a vacant book, and it could not agree that the obtaining of such a signature twice a week was an unreasonable requirement. It was, however, prepared, in the special circumstances of the present emergency, to accept one signature in respect of a week of unemployment. The letter also stated that this concession must be regarded as only temporary, and if the Board had any reason to think that the arrangement for one signature per week was not working satisfactorily, it reserved the right to impose more stringent conditions for the continuation of the repayment. For the present repayments could only be obtained from the date when the vacant-book procedure was set up, but, subject to special conditions, an emergency grant might be payable as from August 4. As above stated, the meeting recommended the district associations to comply with these conditions, and the recommendation will be considered by special meetings of the members in each district; the new procedure will almost certainly be adopted at once. It is also understood that each district will apply for the special grant in repayment of their out-of-work expenditure as from August 4.

These new conditions under which the Government grant will be made, apply, in the first instance, to the Card-Room Amalgamation only, and the concession will not be made to all trade unions. The requirements of Section 106 of the Insurance Act, under which the Government's offer was originally made, will still be enforced as the general rule, but exceptions will be dealt with on their merits. The Weavers' Amalgamation, for instance, whose case closely resembles that of the Card-Room Operatives, has applied for special treatment, and will almost certainly be granted the same concession.

We learn from the quarterly report of the Oldham Card-Room Association that, since the war began, the average number of members in receipt of unemployment benefit has been 6000 per week, which number is about one-third of the total financial membership. The excessive drain on the reserve funds of the Association occasioned by this unemployment will, it is considered, continue for some time to come, though probably at a somewhat diminishing rate. The Association has, however, been able to meet all the claims the rules provide for. The average number of members in receipt of stoppage pay has been 4418 per week, while an average of 71 members have been granted accident pay. The expenditure, it was stated, has been 23,163*l.*, and the income, 7667*l.*, showing a loss of 15,496*l.*

The Board of Trade announces that in the trades compulsorily insured against unemployment—viz., building, works of construction, engineering, shipbuilding, vehicle-making, &c.—the percentage of unemployment on October 23 was 4.31, as compared with 4.50 a week before and 5.41 a month before. These figures relate to the whole of the United Kingdom, and include all unemployed workmen in the insured trades.

As regards the uninsured trades, the number of men and women on the registers of the Labour Exchanges on October 23 was practically the same as the figures for a week earlier, being 61,525, as compared with 60,402. For men alone the corresponding figures were 25,677 and 25,623, and for women 35,848 and 34,779.

According to the *Yorkshire Post*, the General Union of Textile Workers has asked the Manufacturers' Association in the Huddersfield district for payment of overtime rates, at 1½d. per hour extra over piece rates, to weavers and other piece-workers; for time and a quarter to time-workers not specified in the general agreement of 1913; and for the limitation of overtime working to two hours per night, the abolition of overtime working on Saturdays, and the abolition of Sunday labour. At a joint conference the employers declined to grant the request relating to the weavers and piece-workers, and held that special provision for the other time-workers was unnecessary, as overtime rates were being paid in places where such overtime was worked. The employers also contended that the limitation of overtime was a practical impossibility, as the pressure on the manufacturers to produce to the utmost of their capacity was so persistent that

the working of overtime was a national necessity. The employers added that they had reluctantly resorted to overtime, and that it will naturally come to an end when the pressure caused by Government orders ceases.

LIGHT GUNS OF LARGE BORE AND HIGH-EXPLOSIVE SHELLS.

To the Editor of Engineering.

Sir,—In the *Times* of the 23rd inst. the military correspondent states:—"It is odd how little was known about the heavy guns. Even when the writer some weeks ago described the heaviest German field howitzer known to him—namely, the 11.2-in.—a technical paper called *Arms and Explosives* expressed its frank disbelief in the existence of such a weapon; and after various sarcastic remarks, and much admirable reasoning of a technical kind, rejected the howitzer altogether, and declared that the writer's statement must be dismissed as an unnecessary attack on the confidence of our troops."

Having had the honour of giving a lecture on April 22, 1891, at the Royal United Service Institution, Whitehall, on "Heavy Guns *versus* Light Guns," I hope you will kindly publish a few short extracts from that paper, in which the superior efficiency, economy, and safety from the enemy's fire of heavy ordnance were clearly shown.

First, as regards safety. I showed that guns of various calibres would expose the following areas of surface as a target for the enemy's projectiles:—

	Area in Square Feet.
1000 tons of 16.25-in. guns	590
1000 ,, 13.5-in. ,, ...	716
1000 ,, 12-in. ,, ...	730
1000 ,, 9.2-in. ,, ...	982
1000 ,, 8-in. ,, ...	1200
1000 ,, 6-in. ,, ...	1650

This indicates that any given weight of 16.25-in. guns would offer half the target surface of an equal weight of 8-in. guns.

I then discussed the effects of shells when firing against vessels in harbour, batteries, dockyards, or public works, and stated that: "If the structure be not completely perforated, only very trifling damage can be done by small shells." As the result of many experiments at home and abroad, I showed that the relative destructive effect of the shells of that period would be approximately as follows:—

	Destructive Effect.
6-in. shell	1.00
8-in. ,, ...	3.25
9.2-in. ,, ...	6.00
12-in. ,, ...	17.80
13.5-in. ,, ...	121.40
16.25-in. ,, ...	572.00

I showed also the absolute economy in the money cost of the heavy shell as regards mere weight per pound, economy in transport, and particularly in the money cost for the damage inflicted on the enemy by, say, 1000 tons of shells.

Now that our recently purchased light-draught vessels are bombarding Ostend, I quote the following words from the same lecture:—"I hope it will be remembered that our vessels must not only be able to meet those of the enemy, but that our vessels should be able effectually to attack an enemy's ports and seaboard at long range." I have consistently advocated the principle of *special ships for special purposes*, and therefore I have been in favour of a special class of vessels for coast and harbour defence, because those vessels best adapted for harbour defence are the very best for the attack of enemy harbours. Such vessels would be very economical in first cost and in upkeep, and could be efficiently manned by small crews of local naval volunteers and veteran naval reservists.

Such vessels would be of infinite value in attacking enemy harbours at long range and in defending our shores in case of the defeat of our High Seas Fleets by a coalition of hostile naval Powers, which latter is not an impossible eventuality in the near future, although very improbable apparently at the present moment. However remote such a disaster may appear at present, it ought to be provided against as soon as possible. The large majority of naval experts were opposed to this system of coast attack and defence; but I believe Earl Brassey, the veteran naval reformer, held this view many years ago, when I had some correspondence with him on naval matters.

In the discussion following my lecture in 1891 I proposed battleships of 20,000 tons to carry 15-in. guns, and on June 1, 1895, four years afterwards, I wrote to the Admiralty to suggest once more the adoption of 15-in. guns. We have some afloat now. My proposals of April, 1891, attracted considerable attention abroad, and I received an invitation from the United States War Department to contribute a paper to the Division of Military Engineering of the International Congress of Engineers at Chicago in 1893. I sent a paper on "Heavy Guns and High-Explosive Shells," which was accepted and subsequently published in the official report, issued at Washington in 1894. Recent events in Belgium and France induce me to quote that which I wrote twenty-one years ago:—"Some English writers on the future of naval warfare have expressed the opinion that ships will never again attack coast fortifications, and that humanity will prevent the bombardment of unprotected seaports. Continental writers on this subject have expressed an opposite opinion, and have stated that future wars will be wars of extermination, in which undefended towns and private property will be ruthlessly destroyed to cripple the enemy as much as possible whenever the opportunity offers. . . The writer reiterates his conviction (one of many years' standing) that victory will attend on the guns of large bore and on the shells of great explosive power." That forecast has been completely fulfilled by recent events. The experience of some notable sieges during the last sixty years—Silistria, Kars, Sebastopol, Metz, Strasbourg, Paris, Plevna, Pekin, and Ladysmith—proves how little damage was done by large numbers of shells not exceeding 8 in. in diameter. More recent experience in Belgium and France fairly proves the accuracy of the statement I wrote in 1893, that the relative destructive effect per pound of cost of various shells of the same kind, but of various diameters, would be approximately as follows (for every pound expended):

	Destructive Effect.
1*l.* expended on 12-in. shells	480
1*l.* ,, 9.2-in. ,, ...	294
1*l.* ,, 8-in. ,, ...	254
1*l.* ,, 6-in. ,, ...	62

That paper, written in 1893, contained a proposal which, I believe, preceded by several years Colonel Cuniberti's proposal for the battleships now known as "Dreadnoughts." I quote verbatim from the Official Report, published at Washington in 1894:—"There can be no doubt that a ship of 14,000 to 16,000 tons can carry four turrets, each turret having two 32-cm. guns (12.6-in. guns), the turrets being arranged so that the eight guns can be fired on either broadside, or six of the guns could be fired ahead or astern. Such a ship would carry an auxiliary armament of small quick-firing guns to destroy torpedo-boats, &c., and on the top of each turret two 15-cm. quick-firing guns could be mounted in a shield or small turret, which could be rotated independently of the large turret. Such a ship will surpass in fighting power, and in the safety of its armament, every ship now afloat; the separation of the guns in four independent turrets being of importance to prevent total disablement and to maintain, if necessary, great rapidity of fire on both sides of the ship at the commencement of an engagement at sea."

I think it must be generally admitted that my former proposals have been practically adopted, and I now submit that new weapons as destructive as the largest howitzers of the Germans can be constructed of very light weight, so that they could be transported through swamps, and over sandy plains and mountain passes with much ease and rapidity and at little expense of horse or motor-power; and also carried in coast-attack vessels and river boats of very small draught.

It would not be prudent to say more on the proposed weapons, as I do not desire them to be evolved by our most scientific and enterprising antagonists.

In conclusion, I must express the wish that we may soon have some specially-designed vessels for coast attack, to carry guns of very great calibre, but of comparatively light weight.

I am, Sir, yours faithfully,
George Quick,
Fleet Engineer, Retired.

Rosemead, Maidenhead, October 27, 1914.

"GERMAN SCIENCE."

To the Editor of Engineering.

Sir,—In the article under the above title, published in your issue of October 16, it is stated that Germany has a claim to primacy in the art of music.

It seems a pity to demolish this, the Germans only claim to originality, but so it must be, as "Musicus" stated in his article, "Austria and Music," published in the *Daily Telegraph* some time back: "Nearly all the great musicians, *creative* or interpretative, were emphatically *not* German."

Beethoven's family, for instance, came originally, curiously enough, from Louvain, thence to Antwerp, before passing on to Bonn; "Schubert was purely a Viennese; Mozart as purely an Austrian."

Haydn, Glück, Anton Brückner, Goldmark, Dvorâk, and many others, all were *not* German.

Even though Wagner and Schumann were Saxons, "Saxony for long was more Austrian than German."

Amongst the most distinguished conductors, Richter was born in Hungary and educated in Vienna; Nikisch purely a Hungarian by ancestry, birth, and education.

Of great violinists, Joachim was born and bred at Kittsee, near Pressburg, and studied in Vienna; Fritz Kreisler, again, is as good a Viennese as a man could be.

Popper, a great 'cellist, was a Prager. Amongst great pianists and teachers Liszt was Hungarian through and through; Emil Sauer a genuine Viennese, albeit a native of Hamburg.

The list in the article referred to and enclosed is too long to quote from further, but it is very sad to think that Germany must be prepared to surrender nearly all "the great musicians, *creative* or interpretative," to other nations.

I am, Sir, yours faithfully,
J. H. Jay.

40, Summerfield-avenue, Queen's Park, Brondesbury, London, N.W., October 23, 1914.

THE HEENAN FILTER.

To the Editor of Engineering.

Sir,—We were very interested in an article on the Balcke spray-type filter in your issue of October 23, but there is one point which we do not agree with.

It stated that for turbo-generators below 3000 kw. capacity a dry air-filter was the cheapest to instal, because the cost of washing the cloths would not be as great as the cost of pumping the circulating water for the sprays, which is always necessary in the case of wet-type filters. Might we point out, Sir, that in our type of wet filter this is not the case, as no circulating water is required.

You will no doubt remember that you published a description of our filter and cooler some time ago, and if you refer to this you will see that our machine consists of a large length of galvanised-iron plate, about 8 in. wide, wound spirally round a central drum, like a huge clock-spring. The spaces between the plates are about ⅛ in., and the whole of the air passes through them. The filter has two of these drums mounted on a shaft and rotating slowly in a tank of water, the water-level being about half way up. Consequently the air is brought into intimate contact with an enormous amount of wet surface, which extracts all particles of dust. The length of plate has been decided upon as the result of experiments to find the best proportions to ensure that the scrubbing action caused by eddy currents is a maximum. The air leaves the machine in a natural and cleansed condition, absolutely free from any trace of loose moisture.

The power to rotate the drums is practically negligible, our largest machine absorbing only ½ horse-power.

Yours faithfully,
Heenan and Froude, Limited.

Worcester Engineering Works, Worcester, October 27, 1914.

The Thomas Hawksley Lecture.—The meeting of the Institution of Mechanical Engineers, which was to have been held this evening, and at which the second Thomas Hawksley lecture was to have been delivered, has been cancelled under very sad circumstances, the author of the lecture, Mr. William B. Bryan, the chief engineer to the Metropolitan Water Board, having died suddenly on Wednesday last. We have dealt with Mr. Bryan's career elsewhere in the present issue.

Lantern-Slides for Lectures.—Messrs. Ed. Bennis and Co., Limited, inform us that they have a number of lantern-slides dealing with the development of mechanical stoking, elevating and conveying apparatus, which they will be pleased to loan to any responsible engineer for lecture purposes. A list of the slides and particulars of their subject-matter can be obtained on request. Applications should be made well in advance of the lecture date, and should be addressed to the Publicity Department, 28, Victoria-street, S.W.

The Trent.—On Monday, the 26th inst, the Nottingham Town Council decided, by a large majority, to proceed with Trent improvement works, towards the cost of which the Development Commissioners have promised an advance of 50,000*l.*, the ratepayers of Nottingham contributing 100,000*l.* The idea is to improve the navigation of the Trent between Nottingham and Newark, and it is contended that the effect of the proposal will be to make Nottingham an important inland port. Mr. A. R. Atkey, chairman of a committee having charge of the scheme, traced the attitude of the Town Council on the question since 1884, and explained that, as a result of a conversation with Mr. Ernest Jardine, M.P., the chairman of the Trent Navigation Company, it was borne in upon him that a tantalizing stretch between Nottingham and Newark was the only bar to a great improvement for the city. It was for that reason that he brought the matter forward in the first instance. Some members of the Council pressed for further consideration of the proposal, but only seven voted for delay, and eventually a proposal to proceed at once was carried without dissent.

Carbons for Electric Lighting.—In view of the large quantities of coal annually carbonised in the United Kingdom at gas works and in coke-ovens, there would seem to be very good prospects for the establishment of a large electric carbon industry here. As is generally known, however, foreign competition has in the past proved difficult to meet, and the only considerable carbon factory in this country seems to be that of the General Electric Company. It is to be hoped that the present elimination of German and Austrian competition may do something to assist British manufacturers, and that a more satisfactory home production may grow up. A recent Board of Trade White Paper shows that Germany's annual exports of such goods have a total value of 541,600*l.*, and those of Austria-Hungary a value of 48,175*l.* The annual exports of these countries to the United Kingdom are valued respectively at 90,650*l.* and 9200*l.* The annual exports of the United Kingdom have at present a value of only about 10,000*l.*

New Oil Dépôt at Salt End, Hull.—The Anglo-Mexican Petroleum Products Company, Limited, of Finsbury-court, London, E.C., have taken a site covering about 12 acres of land at Salt End, near Hedon, on the River Humber, about 4 miles from Hull, for an oil-storage installation. The programme of tankage to be erected comprises four 95-ft. storage-tanks, each capable of holding 45,800 barrels, and two 75-ft. tanks holding 26,800 barrels each, making a total of 236,800 barrels, or 33,800 tons, for fuel oil and other heavy products. There will be six 75-ft. tanks for kerosene and motor spirit of "Mex" brand, capable of holding 26,800 barrels each, while storage accommodation for liquid bitumen for road-dressing will also be provided on a large scale. The future programme comprises, further, 95-ft. tanks and 75-ft. tanks for kerosene and "Mex" motor spirit. In connection with the latter, can-filling apparatus and equipment for handling the trade in motor spirit will be developed. Several tanks providing accommodation for lubricating-oil storage on a scale corresponding to the above figures are also arranged for.

COAL-HANDLING PLANT AT SOUTHEND-ON-SEA ELECTRICITY STATION.

CONSTRUCTED BY MESSRS. ED. BENNIS AND CO., LTD., ENGINEERS, LITTLE HULTON, BOLTON.

Fig. 1.

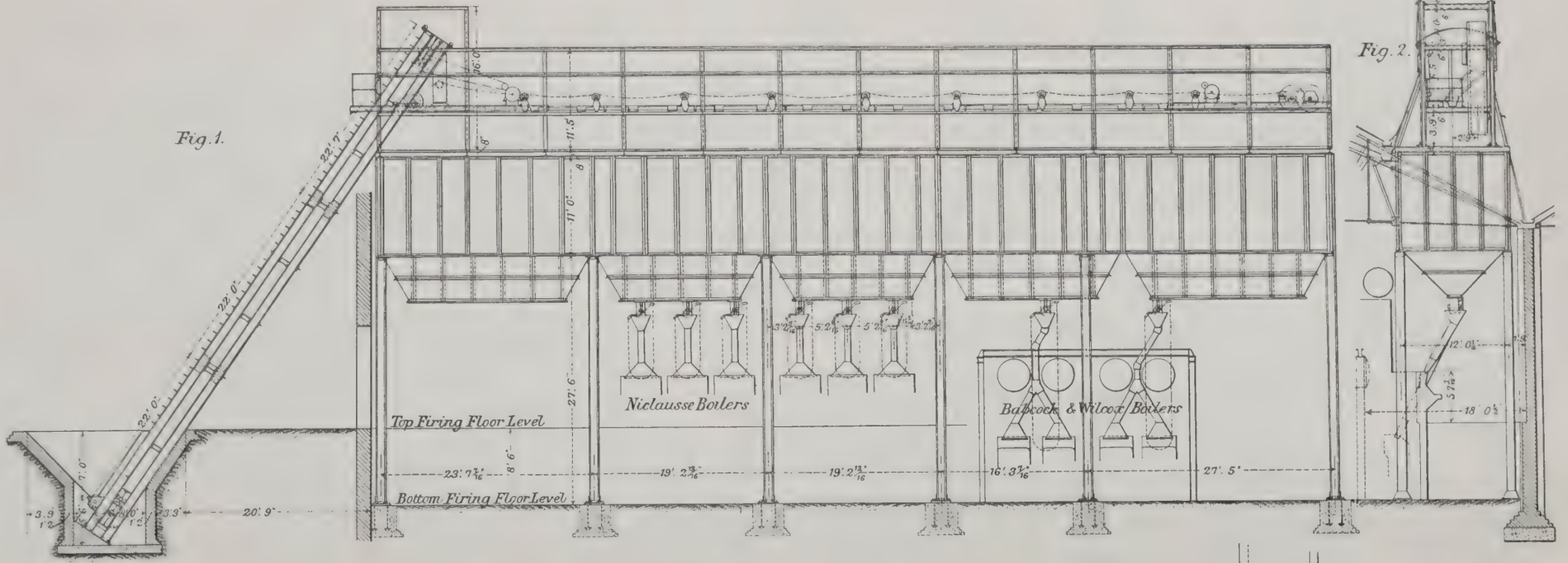


Fig. 2.

Fig. 3.

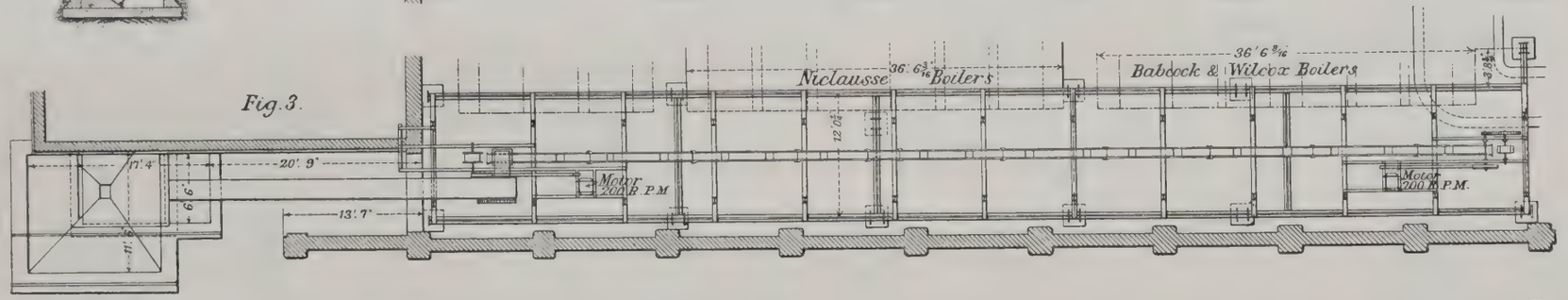
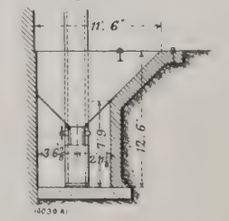


Fig. 4.



An interesting coal-handling plant has recently been installed at the Corporation Electricity Station of the Borough of Southend-on-Sea. This plant forms part of the same extension during which two Niclausse boilers were added to the station. We illustrated and described these boilers some few months ago,* and in the figure we published at that time the coal-handling plant may be partly seen. We now illustrate it in detail. The extension has been carried out under Mr. Robert Birkett, the borough electrical engineer, and the coal-handling plant has been supplied by Messrs. Ed. Bennis and Co., Limited, of Little Hulton, Bolton. It has been built in accordance with one of several schemes which were submitted by Messrs. Bennis and other engineering firms.

The plant, as will be seen from Fig. 1, above, at present feeds four boilers, but has been arranged to cover an additional Niclausse boiler which will be set at the left-hand side of the existing two—*i.e.*, in the left-hand position in Fig. 1. The gear has also been designed so that if the older boilers at the right-hand side are replaced in the future by Niclausse boilers, no structural alterations will be necessary in the coal-handling plant. The arrangement consists of a series of overhead storage-bunkers, of a total capacity of 500 tons of coal; a bucket elevator raising the coal from a dumping hopper; and a horizontal conveyor which distributes the coal to the bunkers. The general lay-out will be clear from Figs. 1 to 4. Before the present extension was carried out the two original water-tube boilers were fired by hand from the bottom firing-floor level, shown in Fig. 1. The coal was drawn from bunkers built at this level, and was brought in by carts which tipped into the bunkers from a raised platform.

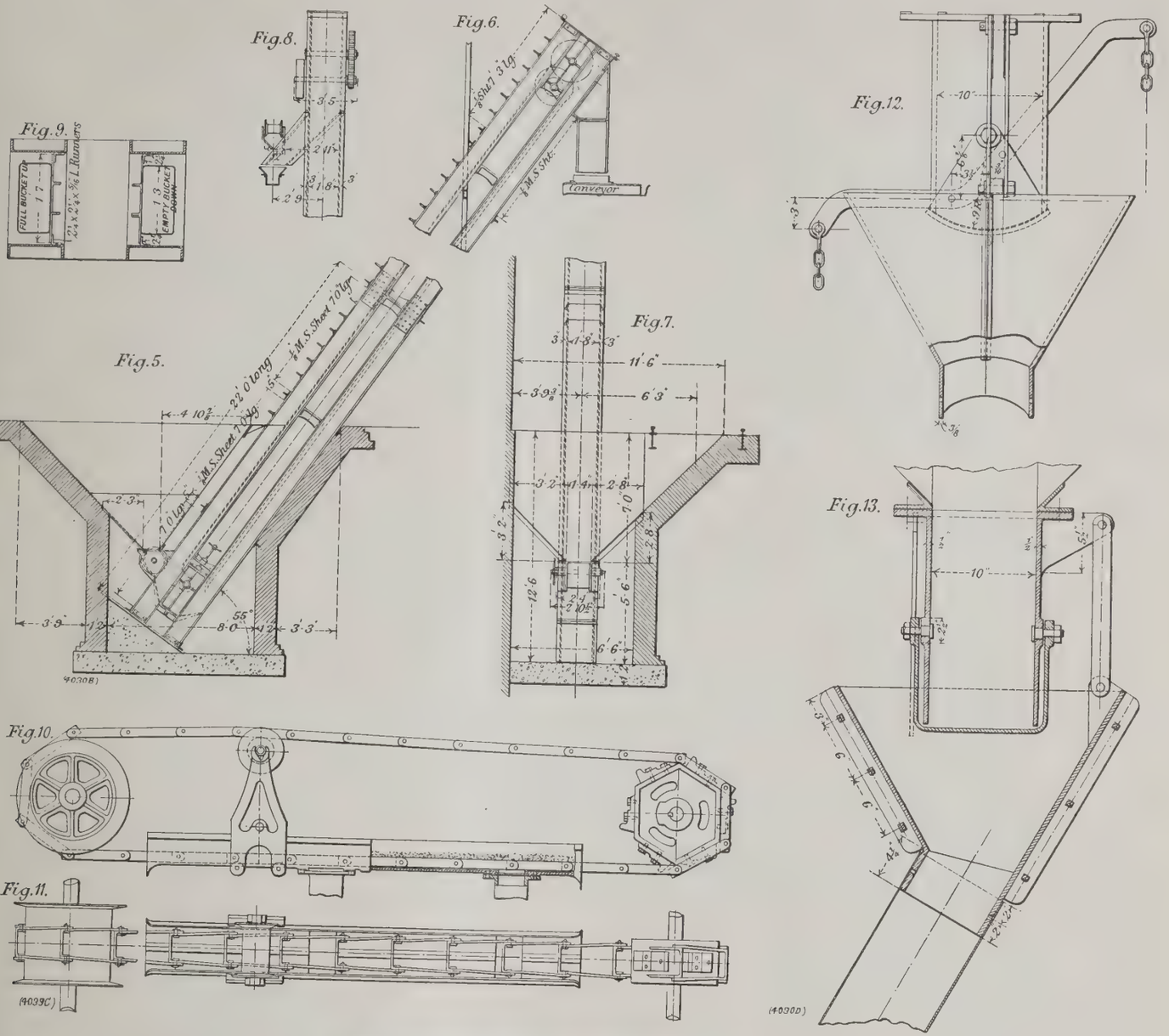
One of the most interesting features of the new installation is that, in order to obtain room for the overhead bunkers, it has been necessary to cut away a considerable portion of the original boiler-house roof. It was not possible to place these bunkers outside the limits of this roof, as a car-shed adjoins the boiler-house, and its roof rests on the party-wall separating the two buildings. The beginning of this roof can be seen at the right-hand side of Fig. 2. Originally the boiler-house roof rested on this same wall, as is shown by broken lines in this figure. It has been necessary to cut off the ends of eight of the roof principals and take the weight on the inner side of the bunker structure. This is shown in Fig. 2. The arrangement was necessitated by a heavier construction for the bunker sides and for the main stanchions carrying the whole structure than would otherwise have been necessary.

Coal is brought to the station in carts and is dumped into the receiving hopper, which is excavated below ground-level and outside the boiler-house, as is shown in Figs. 1 to 4. The bottom end of the bucket-elevator is carried below the hopper, and the coal flows into the buckets by gravity through a Bennis rotary safety feeder, which ensures a regular supply to the buckets and at the same time prevents any sudden rush which would choke the buckets and jam the elevator. The receiving hopper with the elevator in position is shown to a larger scale in Figs. 5 and 7, on page 533. The elevator itself is about 70 ft. long, and will raise the coal at the rate of 20 tons an hour. It is driven by an electric motor from the top end, as can be seen in Fig. 1, the motor being situated above the first bunker. The framework of the elevator is of substantial construction, so that no intermediate supports are required between the top and bottom. A cross-section is given in Fig. 9, while one of the framework joints can be seen in Fig. 5. The full and empty buckets are carried in separate trunks, and the casings are practically dust-proof. The whole of the gearing,

* See Engineering, vol. xcvii., page 680.

COAL-HANDLING PLANT AT SOUTHEND-ON-SEA ELECTRICITY STATION.

CONSTRUCTED BY MESSRS. ED. BENNIS AND CO., LTD., ENGINEERS, LITTLE HULTON, BOLTON.



chutes, &c., is carried by the elevator framework, avoiding all external supports or bearings, and making the whole a self-contained and neat machine, occupying little room.

At the top end, the elevator delivers the coal through a chute, which can be seen in Figs. 6 and 8, to a Bennis U-link steel chain conveyor. This conveyor is of the type illustrated in Figs. 10 and 11. It consists of a series of mild-steel bars pressed into the form of a U, and riveted together to form an endless chain. The lower part of the chain moves along a rectangular trough, and carries the coal with it. Openings are placed in the bottom of the trough at desired intervals, and the coal falls through them into the bunkers beneath. The conveyor is driven through gearing from an electric motor situated near its right-hand end, as can be seen in Figs. 1 and 2. A gangway alongside the conveyor allows of access to all parts of it and to the elevator. This gangway is shown in Fig. 14, annexed, which is a general view of the conveyor. The bunkers are built up of mild-steel plates and sections riveted together to form a series of rectangular bins with hopper bottoms. A number of openings are made at the bottom of each bin, and each opening is provided with an outlet chute and radial cut-off valve. The arrangement is a simple one, and will be clearly understood from Figs. 12 and 13, above. The cut-off valves are operated by chains from the firing-floor. A swing-chute is suspended beneath each outlet, for guiding coal from the bunkers to the stoker-hoppers. These chutes are made to swing back out of the way when boiler-tubes are being cleaned or renewed.

Fig. 14. Chain Conveyor.

The bunkers have a total length of about 106 ft. Their vertical sides are 11 ft. deep, and their top is about 39 ft. above the firing-floor level. They are carried on twelve stanchions formed out of rolled-steel joists, 27 ft. long, resting on concrete pillars built level with the firing-floor. A superstructure is built on top of the bunkers to carry the conveyor, which works in a chamber carried the full length of the bunkers. The sides and roof of the chamber are formed with corrugated sheet, in which continuous windows are set in each side. The appearance of the inside of the chamber can be seen from Fig. 14. Access is obtained to the conveyor-chamber by a ladder on the elevator-frame. The extreme height from the bottom of the stanchions to the top of the superstructure is about 56 ft. The whole plant, consisting of bunkers, stanchions, elevator, conveyor, and superstructure, was supplied and erected by Messrs. Bennis.

The New Army.—The Manchester School of Technology possesses particulars of more than 550 students who were in attendance at the college during the academic year 1913-14 and who are now serving in various branches of His Majesty's Forces. With a view to the completion of a Roll of Honour, which shall also include the names of past students engaged upon military service, the Registrar will be glad to receive any information from such persons themselves or from their relatives or friends.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, October 14.

The iron and steel output of the United States has been still further curtailed under a lessening demand for both crude and finished products. New inquiries and orders for the past week do not represent much more than 25 per cent. of the total capacity. This means a further decline in the average. Nearly all industries are similarly affected; in some, European war orders are imparting great activity. Quite a number of orders from abroad are now being placed, among them a large order for sheet-iron stoves for the French army. Far-seeing steel experts seriously doubt the wisdom of consumers in purchasing only for absolute necessities, especially in pig-iron. Furnace interests are probably as short-sighted in not piling up a reasonable surplus. Foundry work of all kinds drags. Contracts have been placed for two battleships, which means 10,000 tons of plates at least. Awards will be made in a short time for 24,830 tons of armour-plates, special-treatment plates, bolts and nuts. Fair opportunities are offered to sell billets abroad, but price forbids. Eastern sheet-mills are busy; western, slack. Financial conditions have not improved. An undercurrent of apprehension continues. The country at large acts one way and talks another. Much relief is expected as soon as the Federal Reserve Board is in working operation. Apart from all surface reasons, the European war has disarranged conditions seriously. Cotton-planting interests will be helped out with an advance of 150,000,000 dols. A financial readjustment is in the near future, when a general improvement in industrial conditions is assured, both from domestic necessities and foreign requirements.

October 21.

Iron and steel continue quiet. Here and there concessions are made for prompt delivery. The entire situation is most disappointing. It is roundly estimated that, outside of crude material, purchasers and orders absorb about one-fourth the maximum productive capacity. Not the slightest disposition is shown to buy for forward delivery. The financial situation is at the root of the trouble. Some mills are down to 30 per cent. of capacity, but the general average is nearer 50 per cent. Specifications come in slowly. Foreign business has not developed as usual. Even in steel rails, which some of our Eastern makers thought they would get, orders have gone to England. English inquiries covering several thousand tons of steel billets are now before the trade, but prices are too high. Prospects for exporting sheets and wire are quite favourable. The estimate of total stocks of all kinds of pig-iron puts it at 1,200,000 tons, of which 250,000 tons are in the South, 150,000 tons at Virginia, 80,000 tons in Pennsylvania, and 700,000 tons in the Lake district and the West. Within the past two weeks 80,000 tons of barbed wire, plain wire, and nails have been sent abroad, with a great deal more business pending. The Crucible Steel Company, near Pittsburg, booked an order for 5000 tons of bayonet and sabre steel for France. Orders are placed for 2,500,000 horse-shoes, besides nails. There is quite a demand for auto trucks and varied military supplies for export. Wire-mills run from 80 to 95 per cent. of capacity. General construction and bridge work is slow, and structural output meets all necessities at one-third full-capacity output. Nearly all orders run from 100 tons to 900 tons. The railroads are all waiting for more encouragement to lay out money.

The Junior Institution of Engineers.—At a recent informal meeting of the Institution, Mr. Walter T. Dunn, F.C.I.S., gave a lecture on the latest developments in gas-lighting for domestic purposes, illustrating his remarks by an excellent array of modern gas fittings, glassware and appliances, many of the burners being shown in action.

German and Austrian Competition in the Aluminium Trades.—No. 77 of the Board of Trade's White Papers, dealing with German and Austro-Hungarian competition, is concerned with aluminium and aluminium wares. It is stated that the value of the exports from Germany during 1912 amounted to 822,100*l.*, and those from Austria-Hungary to 60,410*l.* No corresponding figure can be given for the United Kingdom. It would appear that for crude and scrap aluminium, Germany's principal markets are the Netherlands, Belgium, and the United States; for sheets, plates, &c., the United Kingdom, India, Belgium, Switzerland, Italy, and Russia; for wire, the United Kingdom, Denmark, and Switzerland; and for other articles, including presumably cooking utensils and general fittings, the United Kingdom, India, Canada, Australia, Norway, Denmark, the Netherlands, Belgium, Italy, Russia, Brazil, and the United States. The Austro-Hungarian exports are much less important, but considerable trade is done with France and the United States. From various Trade Commissioner and Consular reports there should apparently be considerable opening for competition on the Continent, in the Colonies, and in the United States. In many markets the trade in aluminium utensils appears to be almost wholly in German hands.

THE LJUNGSTROM TURBINE.

In our issue of April 12, 1912, we illustrated and described the construction of the Ljungstrom turbine. A machine of this type was recently manufactured by the Brush Electrical Engineering Company, of Falcon Works, Loughborough, and is now at work in the electric supply station of the St. Pancras Borough Council. The following is a report of its performances just presented to the Council by Mr. Sydney W. Baynes, the chief electrical engineer:—

St. Pancras Borough Council.

Electricity and Public Lighting Department,
October 15, 1914.

To the Chairman and Members of the
Electricity, &c., Committee.

Installation of 1000-Kw. Ljungstrom Turbine.

Gentlemen,—I have to report that this set was put into commission on July 30 last, and has been in constant service since. Over the period of its operation it has generated nearly 1,000,000 units out of a total of 1,681,360 units turned out at the King's-road generating-station.

With respect to the steam consumption, it will be gratifying to note the actual practical results come out considerably better than the guarantees at all loads, reaching as high as 10 per cent. less steam at one-fourth load.

Hereunder will be found the guaranteed figures for this 1000-kw. turbine in comparison with the actual figures obtained on the test-bed, showing the gain in economy:—

Steam Consumption.	Full Load.	¾ Load.	½ Load.	¼ Load.
Actual	12.75	13.57	14.67	17.76
Guaranteed	14.0	14.75	16.5	19.75
Pounds of steam less than guaranteed	1.25	1.18	1.83	1.99

Since this turbine has been in use there is a saving in coal equivalent to about 1700*l.* per annum, a result which amply justifies the trouble and small expense of the early investigations into its merits. Notwithstanding the high speed of 3000 revolutions per minute, and 6000 per minute between the two rotating elements, there is almost complete absence of noise or vibration, and the control, both electrically and mechanically, is all that could be desired. It is, indeed, the quietest and smoothest running set ever placed in the works.

Improvements in Steam Economies Since 1891.—I have tabulated the test figures showing the steam consumption per kilowatt of all the sets at our generating-stations, and would call attention to the steady improvement throughout the period covered by the gradual development of the undertaking.

The saving in capital expenditure on boilers and accessories obtained by this improved machinery may be best appreciated by stating that the outlay for boilers and accessories to operate the 5000-kw. Ljungstrom turbo will cost about half that needed for the earlier reciprocating engines of equivalent power.

It is interesting to note that the first engines at the King's-road works required 26.6 lb. of steam to produce a unit of electricity, as compared with the Ljungstrom turbine of to-day only using 12¾ lb. (less than half) to do the same work.

Pounds of Steam per Kilowatt Required by Generating Plant Installed at Various Dates of Progress.

——	Date Installed.	Kilowatts.	Full Load.	¾ Load.	½ Load.	¼ Load.
Reciprocating engines ..	1891	80	25.0	—	—	—
Ditto	1896	130	26.6	—	—	—
Ditto	1899	500	23.1	24.48	27.42	35.5
Ditto	1903	450	19.5	21.0	22.6	27.65
Turbo D.C. ..	1906	1000	17.0	18.0	19.5	24.5
Turbo alternating ..	1909	2200	16.15	17.1	18.85	22.8
Ljungstrom alternating	1914	1000	12.75	13.57	14.67	17.76
Ljungstrom guaranteed	—	5000	11.8	12.38	13.4	15.9*

* It may be anticipated that these figures will be reduced by the test results when this set is installed, as in the case of the present set.

The Ljungstrom turbine shows a marked improvement in steam consumption at the lower loads—viz., quarter, half, and three-quarter loads—in comparison with either of the earlier turbines, and possesses every advantage towards economies, not obtainable in the past, when necessity compels the operation of plant at the lower loads.

Sydney W. Baynes,
Chief Electrical Engineer.

Contracts.—The Hydraulic Engineering Company, Limited, Chester, have received the order for the triple-expansion vertical hydraulic pumping-engine, recently advertised, for the Manchester Corporation, to the requirements of the engineer, Mr. L. Holme Lewis.

University of London, University College.—Professor Ernest R. Matthews, A.M. Inst. C.E., F.R. San. I., Edwin Chadwick Professor of Municipal Engineering, will deliver a public lecture on Monday, November 2, at 5.30 p.m., at University College, on "Reinforced Concrete in Municipal Engineering Works."

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with an easier tone, but there were no dealings. At the close sellers of Cleveland warrants quoted 49s. 6½d. cash, 49s. 10½d. one month, and 50s. 4d. three months. In the afternoon weakness again prevailed, and 1000 tons of Cleveland warrants were done at 49s. 8d. one month and 50s. 1½d. three months, with closing sellers at 49s. 5d. cash, 49s. 8½d. one month, and 50s. 3d. three months. The market was a shade firmer on Friday morning, but no business was done, and sellers quoted Cleveland warrants at 49s. 6d. cash and 49s. 9d. one month. The afternoon session was also idle, but the tone continued firm, and buyers' quotations for Cleveland warrants advanced to 49s. 5d. cash, 49s. 8½d. one month, and 50s. 1½d. three months, with sellers naming 49s. 6d., 49s. 9½d., and 50s. 4d. respectively. On Monday morning business was at a standstill, and although sellers of Cleveland warrants made no change in their quotations, buyers shaded theirs. There was again nothing doing in the afternoon, and prices were only fractionally changed, sellers of Cleveland warrants quoting 49s. 5½d. cash, 49s. 9d. one month, and 50s. 4½d. three months. On Tuesday morning an easier tone prevailed, but buyers continued to hold off, and the session closed with sellers of Cleveland warrants naming 49s. 4½d. cash, 49s. 8d. one month, and 50s. 3d. three months. In the afternoon the market was steady, and the turnover consisted of one lot of Cleveland warrants at 49s. 4d. cash, with sellers over at that figure, and at 49s. 7½d. one month, and 50s. 3d. three months. When the market opened to-day (Wednesday) weakness was manifest, and prices fell away 3d. to 4d. per ton. The turnover was limited to 500 tons of Cleveland warrants at 49s. 1d. cash, with sellers over, and at 49s. 4½d. one month, and 49s. 11d. three months. The afternoon session was quite idle, and no dealings were recorded. Sellers of Cleveland warrants were asking an increase, and quoted 49s. 3d. cash, 49s. 6d. one month, and 50s. three months.

Sulphate of Ammonia.—The market for sulphate of ammonia is somewhat dull, and sales are not yet heavy. There has been little movement in price, which continues round 11*l.* per ton for prompt lots, Glasgow or Leith.

Scotch Steel Trade.—While it cannot be said that business in the Scotch steel trade has improved to any extent, there is, nevertheless, a rather better feeling, and it is thought that the present dullness will soon give place to better conditions. The unsettled state of many of the markets abroad has lessened export orders, but fair quantities of material are being shipped every week. The demand from the various shipyards at home is meantime poor; but, even had we not been at war, it is doubtful if it would have been very much greater, considering the very heavy tonnage output during the past two years. Sectional material is also quiet, and no change can be reported in the condition of the black-sheet trade. Prices, where not under the control of the association, are a shade easier, but buyers continue to hold off in the meantime.

Malleable-Iron Trade.—The demand for finished iron has not broadened out much, and makers in the West of Scotland report little change in the position. Works are being kept running fairly well, as orders of one sort and another are always dropping in. Prices are unchanged.

Scotch Pig-Iron Trade.—In the Scotch pig-iron trade there is a moderate amount of business passing, but makers could undertake to deliver very much more. The shipping trade is certainly quieter than usual, but there is no gloomy feeling on the part of producers, as the demand will come along all right. Hematite iron is dull, and is quoted round 70s. per ton. The following are the current market quotations for makers' (No. 1) iron: Clyde, 68s.; Calder, Gartsherrie, and Summerlee, 68s. 6d; and Langloan, 70s. (all shipped at Glasgow); Eglinton, 62s. 6d.; and Glengarnock, 70s. (both at Ardrossan); Shotts (at Leith), 68s. 6d.; and Carron (at Grangemouth), 69s.

Institute of Marine Engineers.—Mr. E. Kilburn Scott's paper on "Gyroscopic Compasses, with Particular Reference to the 'Sea Star' Type," was discussed at a meeting of the Institute of Marine Engineers held on the 12th inst., when Mr. James Adamson, hon. secretary, presided. In the course of his paper, which had been read the previous week, Mr. Kilburn Scott said the gyro-compass was quite independent of the earth's magnetism. Although Foucault discovered, as long ago as 1852, that, when suitably constructed, the gyroscope tended to point to the true or geographical north, it was only within the last few years that practical instruments had been constructed which would work on board ship. The "Sea Star" type of gyro-compass, designed by Captain V. H. Rozic and the author, was so arranged that the righting momentum did not depend on gravity for its magnitude, but was always determined by the amount of deflecting momentum that had to be counteracted. The means to this end were forcible and automatic. The gyro-wheel was so mounted that it was non-pendular about its horizontal axis, and therefore not subject to ballistic effects. The "Sea Star" differed from the Anschutz and Sperry types in that the direction of rotation of the gyro-wheel was clockwise when looking at the north-pointing end of the gyro-wheel spindle; the other two ran counter-clockwise. Owing to the direction of rotation of the "Sea Star" gyro-wheel being opposite to the rotation of the earth, the gyro-wheel was in a state of permanent unstable equilibrium, and therefore, as soon as it had been deflected in the slightest degree, there was a strong tendency to increase, and the motor was immediately started to correct the deviation.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The general position has undergone very little change during the week, except that a slightly easier tendency is evident in one or two sections. Trade in house coal is slow, except with respect to the highest grades, which are somewhat difficult to obtain. During the week the demand has eased considerably, neither country buyers nor London consumers showing their usual interest in the market. In the circumstances the pits are only moderately employed. Collieries producing for foreign consumption report a further decline in shipments, and both Yorkshire and Derbyshire prices have declined from 6d. to 1s. Fortunately an even tone is maintained in the home demand for hard and locomotive sorts, and this enables the pits to continue at the rate of three days a week. Gas-coal is quiet but steady. Fair tonnages are being sent to inland works on contract account, and shipments, though well below the normal, are a little larger. Norway, Sweden, France, and Italy are good customers. Slacks are uneven. For the best qualities there is an improved demand, and values have hardened; but in the lower grades quotations vary greatly, and low figures are offered where prospects of placing heavy tonnages are presented. The further weakening of the Manchester cotton position is having a correspondingly adverse effect on this section of the South Yorkshire market. Coke is in smaller demand, and prices are weakening. Quotations:—Best branch hand-picked, 16s. to 16s. 6d.; Barnsley best Silkstone, 12s. 6d. to 13s. 6d.; Derbyshire best brights, 12s. 6d. to 13s. 6d.; Derbyshire house, 11s. to 12s.; best large nuts, 11s. to 11s. 9d.; small nuts, 9s. 3d. to 10s. 3d.; Yorkshire hards, 10s. 6d. to 11s. 6d.; Derbyshire hards, 9s. 9d. to 10s. 9d.; best slacks, 7s. to 8s.; seconds, 4s. 9d. to 5s. 9d.; smalls, 1s. 9d. to 2s. 9d.

Iron and Steel.—The deflation of pig-iron quotations has had the desired effect. All classes of buyers are coming forward more freely with orders, and contracting has again been resumed. An additional effect of importance is that makers of finished goods, intent on making the most of the existing commercial conditions, are able to offer better inducements to prospective buyers, and thus to enter into closer competition with those American manufacturers who are doing their utmost to gain an ascendancy in certain sections of the iron and steel trades. There is very little surplus production, and the position of makers is regarded as satisfactory. West Coast hematite is quoted at 81s., East Coast hematite at 73s. 6d., Lincolnshire No. 3 foundry at 51s. 8d., Lincolnshire forge at 58s. 8d., Derbyshire No. 3 foundry at 56s. 9d., and Derbyshire forge at 55s. Bar-iron makers are again complaining of a shortage of work. The mills are running about half time. The South Yorkshire Makers' Association basis price remains at 8*l.* 5s. Sheets are unaltered at 9*l.* 10s. Further evidence of the steady improvement in the steel trades is to hand. The number of State-insured workmen out of employment has been reduced to fewer than one in a hundred, and unemployment in all branches has declined something like 30 per cent. In certain leading branches a serious shortage of skilled labour is reported. Engineers are specially needed, and the demand is being partly met by other districts. Government work increases. The capacity for output is on a record scale, but if it was much larger there would be sufficient contract business to keep all departments fully engaged. Output chiefly consists of guns, shells, and armour, but big quantities of swords are also being made. Light armour for the protection of motor-cars and aircraft is in big demand. Rapid progress is being made with military camp-kitchens. A Rotherham firm has five hundred of these to make. Heavy machinery, marine castings, and railway material are most in request by consumers who have withdrawn their custom from German houses. The lighter trades are receiving encouraging support from Colonial buyers. Big quantities of files, saws, and shears are to be made for Calcutta, Rangoon, Newcastle (New South Wales), and high-speed steel for New York and Montreal. The crucible-steel trades are suffering from the depression of the motor-car industry. Trade in steel billets is steady at unaltered rates.

FRANCE.—The British Chamber of Commerce, 9, Rue des Pyramides, Paris, has a demand for British makers of pyrometers (dial) for steam-heaters.

SIR WILLIAM WHITE MEMORIAL FUND.—The amount subscribed to the above fund has now reached a total of nearly 3000*l.*, and it has been decided to devote the principal portion of the fund to the establishment of a scholarship for research work in naval architecture, particulars of which will be announced in due course. Any further contributions will be gladly received by the Secretary, Institution of Naval Architects, 5, Adelphi Terrace, London, W.C.

FIRE PRECAUTIONS FOR BELGIAN REFUGEES.—The British Fire-Prevention Committee has issued a special fire warning for buildings in which Belgian refugees are being temporarily housed, and this fire warning is obtainable not only in the English language, but in French and Flemish translations. The various dangers are pointed out in concise language, having regard to the fact that many of the refugees are neither used to the open fires or ranges as customary in England, nor to gas lighting or electric lighting. Copies of the warning can be obtained upon written application (giving requirements as to language) addressed to the Registrar, the British Fire-Prevention Committee, 8, Waterloo-place, London, S.W.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The pig-iron market is very quiet. Values show a further downward movement, and what business is passing is still confined to small transactions for early delivery, traders making very little effort just now to enter into forward contracts. There is some further inquiry for pig-iron for Scandinavia, Holland, and Italy, but there are still considerable obstacles to business with those countries. Financial difficulties still stand in the way, and very few vessels are obtainable. In addition, South American firms are keen competitors for the Italian trade. What iron is going abroad is being shipped at high freights. Deliveries to Scotland would be larger if more vessels were available. Stocks of iron at makers' yards are understood to be accumulating rather rapidly, but the additions to the public warrant stores are not large. No. 3 g.m.b. Cleveland pig is on sale at 49s. 6d. f.o.b., No. 1 is said to be rather scarce, and is 52s.; No. 4 foundry is 49s. to 49s. 3d.; No. 4 forge, 48s. 9d.; and mottled and white iron, each 48s. 6d. East Coast hematite pig is very weak. Both makers and merchants are now keen sellers of Nos. 1, 2, and 3 at 62s. 6d., and possibly a firm offer to buy at round about 62s. would receive favourable consideration. No. 1 has been sold at 63s. So far as can be ascertained there are no new features in the foreign ore trade. Business is at a standstill, and definite quotations are not easily fixed. Sellers still base prices on 17s. 6d. for best Rubio, but buyers consider the rate should be nothing above 17s. Some consumers report that they have fairly large stocks. Blast furnace coke continues dear. Sellers still name up to 17s. 6d. for Durham bee-hive of average quality delivered at Tees-side works.

Stocks and Shipments.—The stock of Cleveland pig-iron in the public warrant stores now stands at 106,774 tons. Since the beginning of the month the stock has been increased by 3810 tons. Shipments of pig-iron from the Tees are on only a moderate scale. To date this month they average 1427 tons per working day, the total despatches being returned at 44,263 tons, 39,303 tons of which have gone from Middlesbrough and 4960 tons from Skinningrove. To the same date last month the loadings were given at 46,838 tons, or a daily average of 1951 tons, and for the corresponding part of October a year ago, the clearances reached 96,767 tons, or an average of 4032 tons per working day.

Manufactured Iron and Steel.—Fairly satisfactory accounts are given of the manufactured iron and steel trades. A good deal of work is being turned out, and some producers are being pressed for delivery. One or two branches, however, are showing signs of slackness. Constructional departments and shipbuilding-material branches are not so active as they have been. There are a few inquiries in the market for rails. Principal market quotations stand:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 5s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 8*l.*; iron ship-rivets, 8*l.* 7s. 6d.; iron girder-plates, 7*l.* 5s.; steel bars (basic), 7*l.* 10s.; steel bars (Siemens), 7*l.* 15s.; steel ship-plates, 7*l.* 5s.; steel ship-angles, 7*l.*; steel boiler-plates, 8*l.* 5s.; steel strip, 7*l.* 5s.; steel hoops, 8*l.*; steel joists, 7*l.* 2s. 6d.—all less the customary 2½ per cent. discount; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 7s. 6d.; steel railway sleepers, 7*l.*—all net at works; galvanised corrugated sheets, 24 gauge, in bundles, 14*l.* f.o.b.—less the usual 4 per cent.

THE CHARTERED INSTITUTE OF PATENT AGENTS.—Lord Moulton, an honorary member of the Chartered Institute of Patent Agents, will deliver, in the Hall of the Institute, on Wednesday, November 4, the address opening the session.

THE BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION.—The Council of the British Electrical and Allied Manufacturers' Association decided at the last meeting not to hold the usual annual dinner this session.

INSTITUTION OF CIVIL ENGINEERS.—In addition to the awards announced in April for papers read at the meetings, the Council of the Institution of Civil Engineers have made the following awards for papers published in the Proceedings without discussion during the session 1913-1914:—A Telford Gold Medal to Mr. J. V. Davies (New York); Telford Premiums to Messrs. W. C. Popplewell (Manchester), A. J. Knowles (Cairo), H. Gaskell, Junr. (Widnes), and P. Rothera (Trichinopoly); the Crampton Prize to Mr. H. F. Carew-Gibson (London), and the Manby Premium to Mr. W. M. Griffith (Bareilly, India). The Webb Prize for the best paper on railway machinery published during the past three years has been awarded to Mr. Henry Fowler (Derby); and the Indian Premium for 1914 to Mr. P. Rothera (Trichinopoly). The Council have made the following awards in respect of students' papers read during the session 1913-14:—The James Forrest Medal and a Miller prize to Mr. J. E. Swindlehurst (Birmingham); and Miller prizes to Messrs. T. C. Grisenthwaite (Glasgow), H. J. C. Harper (Bristol), W. P. Nevett (Birmingham), J. M. L. Bogle (Manchester), E. A. Cross (Birmingham), S. Brassey-Edwards (Manchester), G. T. Cotterell (Bristol), D. D. Stanier (Newcastle), W. E. Gurry (London), H. Taylor (Birmingham), and R. C. Rattray (Manchester).

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has been rather inactive, but there has been no relaxation of the firmness observable in superior large, including Admiralty and dry descriptions. Monmouthshire and bituminous large have remained easy, and house coal, patent fuel, and coke have shown no change. The best Admiralty large has made 21s. to 22s.; best secondary qualities, 19s. to 20s.; other secondary descriptions, 18s. 3d. to 18s. 9d.; best bunker smalls, 7s. 9d. to 8s.; and cargo smalls, 5s. to 6s. 6d. per ton. The best household coal has been quoted at 19s. to 20s.; good households have made 17s. to 18s.; No. 2 Rhondda large has been quoted at 12s. 3d. to 13s. 3d; and No. 2 smalls at 6s. 6d. to 7s. 6d. per ton. Special foundry coke has realised 27s. to 30s.; good foundry coke, 20s. to 24s.; and furnace coke, 17s. 6d. to 18s. 6d. per ton. As regards iron ore, Rubio has made 16s. 6d. to 17s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Greater Swansea.—Further consideration has been given by the Swansea Town Council to the question of extending the borough. The Parliamentary Committee explained a provisionally-approved extension scheme and a rearrangement of the Victoria and Landore Wards. Alderman Merrells asked for further information respecting the new division of wards, and moved that the meeting be adjourned for a week for that purpose. This was agreed to. It was also decided that an application should be made to the Local Government Board for authority to borrow 331,894*l.*, the estimated cost of carrying out the first portion of the scheme—viz., the construction of a main intercepting sewer from the present borough boundary at Morriston to the Mumbles Head. The new sewer will provide for the requirements of a population of 250,000.

Pembrey.—It is stated on good authority that the old powder and dynamite works on the Pembrey Burrows will shortly be enlarged for the manufacture of high explosives. Messrs. Nobel, powder and explosives manufacturers, who ran the works on a small scale many years ago, propose to erect a modern establishment.

Tredegar.—Gloom has prevailed at Tredegar, as it is feared that 1000 men will be reduced to idleness. This is due to the fact that the Tredegar Iron and Coal Company has issued notices to terminate contracts to 700 men in its employment at the Whitworth Colliery, and 250 employed in the house-coal seam of the Oakdale Colliery.

Newport.—There has not been much new business in steam coal, and prices have remained about stationary. The best Newport Black Vein large has made 16s. 9d. to 17s.; Western Valleys, 16s. to 16s. 6d.; and Eastern Valleys, 15s. 6d. to 16s. per ton.

PARSONS MARINE TURBINES.—Some details of the progress of the Parsons turbine were given in the report presented at the seventeenth annual general meeting of the Parsons Marine Steam-Turbine Company, Limited, held on Wednesday, the 21st inst. The report stated that up to the present time the total horse-power of marine turbines of the Parsons type, completed and under construction in the works of the company, and of licensees, as well as in the works of the Continental sub-companies and licensees of Parsons Foreign Patents Company, Limited, amounted to about 12,360,000 horse-power, an increase during the year of about 1,760,000 horse-power. Of this total nearly 10,510,000 horse-power was, or would be, employed for the propulsion of warships, and over 1,850,000 horse-power in vessels of the mercantile marine and yachts. The application of geared turbines to marine propulsion continued to be greatly extended both for vessels of the mercantile marine and for vessels of war, and the vessels fitted with this system were giving every satisfaction. Since the issue of the last report vessels had been ordered to be fitted with geared turbines for the Cunard Company, the Federal Steam Navigation Company, the Union Steamship Company of New Zealand, the Canadian Pacific Railway Company, the Oceanic Steam Navigation Company, the Ellerman Line Steamship Company, the Venice-Alexandria Line, &c. The number of war-vessels, passenger and cargo-vessels now built or building, with all-geared or part-geared turbine machinery, included in the above totals is 126, with an aggregate of about 1,000,000 horse-power; 62 such vessels, with a total of 620,000 horse-power, have been ordered since the date of the last report. Experimental investigations on propeller efficiency, carried out in the company's vacuum tank, have given very valuable information, more especially in regard to the most suitable revolutions and pitch ratios for geared turbine installations for attaining the highest efficiency in the various classes of vessels. The sum of 14,608*l.* 16s. 1d. has been expended during the year on further experiments with gearing, blading, &c., the benefit of which has been shown in the satisfactory results obtained. The directors feel that they are carrying out the wishes of the shareholders in subscribing 500*l.* to the Prince of Wales's National Relief Fund, and 500*l.* to the Newcastle War Relief Fund, and in making suitable allowances to the wives and dependants of those employees who have been mobilised or who have enlisted. The profit for the year, after providing for depreciation on buildings, plant, machinery and office furniture, upkeep of patents, &c., transferring 14,608*l.* 16s. 1d. to the experimental and pioneer work account, and writing the company's holding in Consols down to 70*l.* per cent., amounts to 42,723*l.* 4s. The year's dividend is 10 per cent., with a bonus of 10 per cent., both free of income-tax, and the sum carried forward is about the same as a year ago.

THE MANHATTAN BRIDGE OVER THE EAST RIVER, NEW YORK.

(*For Description, see Page* 526.)

Fig. 99. Working Platforms for Erection of the Cables.

Fig. 100. The Erection of the Cables; Wire Reels on Anchorage Pier.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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With a Two-Page Plate of the GRANARY AT GLASGOW HARBOUR

NOTICES OF MEETINGS.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (INCORPORATED).—Friday, October 30, at 7.30 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-upon-Tyne. The Council report and statement of accounts for Session 30, 1913-14, will be read, and will be followed by a paper by Mr. J. W. Hobson, entitled "Industrial Locomotives."

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, October 31, at 7.15 p.m., at the Institute, Wolverhampton-street, Dudley. The President, Mr. James Raybould, will deliver his Presidential Address.

THE SOCIETY OF ENGINEERS.—Monday, November 2, at 7.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. A paper entitled "Uses of the Hydraulic Mining-Cartridge," will be read by Mr. James Tonge, M.I. Mech. E., F.G.S.

THE RÖNTGEN SOCIETY.—Tuesday, November 3, at 8.15 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. The Presidential address will be delivered by Sir Alfred Pearce Gould, K.C.V.O.

THE INSTITUTION OF ELECTRICAL ENGINEERS: MANCHESTER LOCAL SECTION.—Tuesday, November 3, at 7.30 p.m., in the Engineers' Club, Albert-square, Manchester. The Chairman, Mr. P. P. Wheelwright, will deliver his Address, after which there will be an informal smoking concert.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 3, at 8 p.m. Inaugural meeting of the session. Address by Mr. B. Hall Blyth, M.A., the President, and presentation of medals awarded by the Council.

NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to some Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, OCTOBER 30, 1914.

WAR'S DISLOCATION OF SUPPLY AND DEMAND.

IN ancient times whole nations went to war, and they carried their capital with them, because it consisted entirely of their herds and stock, since they were almost exclusively engaged in pastoral life; and these possessions, with the addition of simple implements of war, served for the supply of the nation when under arms. Some races, notably the Tartars, even took their women with them, and utilised their services on what we should term the lines of communication. In the lapse of time all this has been changed. With the development of the factory system, the continuous effort of inventive genius, the improvement of mechanical methods of manufacture, and the specialisation of the worker in particular branches of industry, a nation now has its capital widely distributed, and in large measure immovable. Our demands, too, collectively and individually, have enormously increased, largely owing to the facility of exchange, and still more to the cheapening of the processes of production. The luxuries of yesterday become the necessities of to-day. We had grown to regard this condition of affairs as normal, but we have been suddenly awakened to the fact that the present time is exceptional, and that we are faced with a duty the most stern that can be demanded of a nation or race, and one to which all other requirements must be subservient. To quote the words of the King, "We are fighting for a worthy purpose, and we shall not lay down our arms until that purpose has been achieved." This purpose demands not only the direct personal service of many, but also sacrifices, national and individual. In considering how it is to be achieved we have to decide in the first place what things are indispensable to our welfare, so far as monetary affairs are concerned. It is only by an adequate supply of money, or rather of money's worth, that our fighting force, alike in respect of numbers and equipment, can be maintained thoroughly adequate and efficient. Adam Smith enunciated the principle that not more than one hundredth part of the inhabitants of a European country could be employed as soldiers without ruin to the country which paid for them. He would doubtless increase this proportion under present circumstances; his estimate probably concerned soldiers continuously in training. Nevertheless, an enormous proportion of the active producers of a nation must be maintained in employment to satisfy the immense demands of the fighting force. At the same time there is urgent need for a manufacturing and exporting nation to continue its usual occupations in order to produce the wealth without which a war cannot be satisfactorily waged over a prolonged period

We are therefore beset with a very difficult problem, because, in the ultimate issue, the maintenance of the flow of wealth of a nation becomes the determining factor. We use the term "flow of wealth" advisedly, because capital invested in productive plant, whether buildings or machinery or transport facilities, if not in continuous operation ceases to be wealth. The real measure of wealth is the income of a nation, and it is computed that in this country the total per annum is 2000 millions sterling. Any diminution of this income exercises necessarily a weakening influence even when the nation is at war. A large part of the product of labour, and therefore a considerable proportion of this 2000 million, must be utilised directly in the war (in addition to the 77 million spent normally each year on the Navy and Army), and from a narrow economic and material point of view all this is waste. But mankind, in spite of many a lapse, nurtures ideals higher than food and pleasure, and chief among these is national existence, for which it is ready to pour out its money as if it were water. At the same time it is incumbent on the nation to maintain its income to the fullest extent, and, as far as possible, to compensate for the flow of money to the fighting line. Professor William Smart, in his recent address at the Royal Philosophical Society at Glasgow, did well to direct attention to this phase of the existing situation, and particularly to the dislocation of supply and demand.

There is a tendency to overrate the difficulties in respect to the supply of men and materials, &c., required to maintain the production of the country at as near the normal rate as possible during war. The withdrawal of men for the fighting line is not generally a serious factor. The difficulty rather is the stoppage of supplies of raw and manufactured material from countries which are closed by the operation of the war. This applies particularly to Germany and Austria, and to a less extent to France, Belgium, and perhaps the Baltic countries, owing to periodical interruption in over-sea transport. Dr. Smart enters into a consideration of why we are dependent to any considerable extent upon supplies, particularly from Germany. He gives three reasons:—First, that Germany had a start in making certain productions; second, that in some industries her large production, with its manifold economies, not only give her an immense market within herself, but a great foreign outlet; and third, that more attention had been devoted to the application of science and the acquirement of expert and technical skill than is the case in this country. He considers that her superiority in the chemical industries, dyes and drugs, mathematical and physical apparatus (such as lenses, microscopes, &c.) is directly attributable to this factor. This, however, is only half a statement of the case, and does not include the great and permanent effects that may follow the dislocation of supplies in consequence of the war. There is no reason to controvert the first of the Professor's statements, because it is accurate. He might, however, have utilised the opportunity to point the moral. In many instances—notably in connection with electrical productions—Germany got the start, not because of greater enterprise on her part, but because of interference by our Legislature. The development of electric traction in this country was undoubtedly delayed for many years because of the policy pursued by municipal authorities supported by Parliamentary enactments. The companies owning the tramways were refused extensions of their leases necessary to justify the capital expenditure on the transfer from horse to electric traction, and the municipalities themselves refused to take over the tramways on reasonable terms. The result was that there was no great demand in this country for electric machinery for traction, just as there was no demand for electric-lighting machinery for a somewhat similar reason. The German people, on the other hand, went in for electric traction in a whole-hearted way, and there was at once a great stimulus to the electric industry. It is only within the last few years that we have managed to make up leeway. Professor Smart admits that where a nation comes second into the field they secure the advantage of the pioneer work done by others; but, here again, he has not driven the lesson home, and this is the more to be regretted, not only because he is an economist of the first rank, but because the lesson at the present juncture of affairs is of the most

vital importance to the present and future rearrangement of the sources of supply and demand. He does well to enforce upon manufacturing firms the seriousness of their duty under present conditions, not only to make this country independent of foreign supplies, but to beat competition, and extend the field of demand. The great majority of manufacturers are endowed with enterprise, but they are beset with the grave difficulty that when new appliances are installed the workers, with their false ideas of economics, refuse proportionately to increase the output from the new machines to meet higher capital charges, and lessen the over-all cost of production, while at the same time probably obtaining an increased rate of wage per week. It is, as we have said, one of the most vital problems of the moment, and we should have liked such an authority as Professor Smart to have brought home to the workers, and to their leaders, the advantage which has accrued to Germany from the more liberal encouragement of manufacturers to replace old appliances by new high-speed producing mechanism afforded by the efforts of the worker to make the most of the new mechanism.

As regards the second reason assigned by the Professor for German supplies to this country, we think that he might have pointed to the economic advantage of concentration. The Germans in very many instances have combined in a perfectly legitimate way all the contributory industries which go to the manufacture of a complete product from the raw material to the article as it is presented to the buyer. This has not only reduced intermediary charges, but has involved great economy in the handling of material where the works also are concentrated.

As regards the third reason—namely, the higher regard paid to science—there is much in his contention; but here again the difficulty is largely one of adapting the workers to the new conditions. The objection to dependence on foreign supplies has not come home to us hitherto with any degree of force. To-day, however, we are realising the seriousness of the problem, and we echo the Professor's question: "Why, with all our immense capital, which goes spilling over into foreign investments, do we not make more things here?" We are convinced that the necessity has only to be enforced to result in the fulfilment of the requirements. In the chemical industry, and in all industries where mechanism is used, the cost of power is a serious problem, and one of the first considerations must be the cessation of that immense waste which is involved in the transmission of the heat value of coal from the mine to the motor or electric appliance in the factory. Other countries have snatched from us electrochemical industries, because Nature has endowed them with immense water power; and here again the dislocation of supplies may force us to a scheme, long advocated, whereby the transmission of power from the coal-mine may be tackled with practical earnestness.

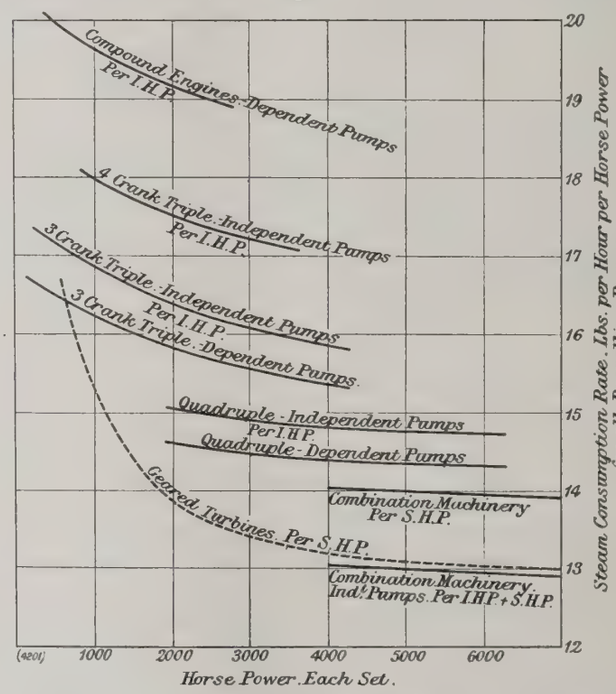
We should be able to overcome the difficulties due to lessened demand at home and in countries where trade has been disturbed directly or indirectly owing to hostilities. There is little need to enforce the necessity of taking steps to find a new permanent demand for our supplies to belligerent countries, or modify our supply to meet the demand which exists. Professor Smart has stated the case here admirably. We have to keep our magnificent industrial organisations intact and as fully as possible in operation, in order that labour may be kept in remunerative employment and that capital may secure its return, so that the income-wealth of the nation may be able to stand the great and prolonged financial strain of war operations. The immediate dislocation of supply must necessarily cause a certain degree of unemployment in various industries and districts, until the workers who have more or less specialised turn their attention to other fields of usefulness. This is one of the disabilities of the modern factory system, and it would be well if temporary employment could be found in other departments of activity. The interruption of demand in some countries must be met by the securing of new markets by enterprise and perseverance.

In this respect Professor Smart's figures are undoubtedly reassuring. He shows in detail, for instance, that our exports to belligerent countries equal over 150 millions sterling. If we add those of the Scandinavian countries, which are partly affected, the total becomes practically 200 millions sterling. A large part of this trade is forfeited, but, on the other hand, it must be remembered that, so long as Germany is isolated from the world by a "ring of steel," she cannot meet the demands which have hitherto come from other countries. Germany's exports of manufactured goods total 300 millions sterling, so that here we have provided for us at once a legitimate field for making up our deficiencies. Again, in our Colonies, who take 188 millions sterling worth, preference will, there is reason to believe, be given to British goods instead of the supplies hitherto taken from Germany. Moreover, other countries, which are not affected by the war, take 194 millions sterling worth of goods from us, and 155 millions sterling from Germany. Here, again, there is a big field open to British enterprise, and we doubt not that a large part of it will be very quickly secured by our manufacturers. It is true that our allies must also be scanning the world for new markets, for the very same laudable reasons as stimulate the British producers, and we must hope that they will also achieve success. That, however, is no reason why we should not do our best, because the cessation of supply from Germany must be met; and if our action be not thoroughly efficient, other countries, notably the United States, may succeed where we fail.

PARSONS MARINE GEARED TURBINES.

H.M.S. Badger, which rammed and sank a German submarine-boat, is the first British warship which was fitted with geared turbines, and this "good service," to quote the Admiralty telegram expressing official pleasure with the crew, as well as the general excellence of her work during the war, is further proof of the efficiency of this latest system of ship propulsion. One of the objections urged against the turbine system generally was that it did not conduce to easy handling or manœuvring of a vessel. Were further proof required to dispose of this idea, it is to be found in the operation of war vessels, not only at the "Fight of the Bight," but in ramming. Another incident of the week, indicative of the increasing favour of the system, is the successful trial of the first Atlantic liner fitted with geared turbines—the Cunard liner Transylvania. This is only another indication of the commendable enterprise shown by our premier steamship company in recent years, for it will be remembered that they were the first to place on the New York express service a turbine-driven ship—the Carmania, which, under the command of Captain Noel Grant, R.N., won such renown as an armed cruiser by sinking the Cap Trafalgar. The success of the Lusitania and Mauretania too has had great influence on ship propulsion. The step to the geared turbines of the Transylvania was not so momentous, since the marine installations in use or in process of construction represent collectively about 1,000,000 shaft horse-power.

The Transylvania, however, is the largest ship completed with the system. She has been built by the Scotts Shipbuilding and Engineering Company, Limited, of Greenock, and is 567 ft. in length, 66 ft. 6 in. in beam, and 45 ft. in depth, and has accommodation for 2475 passengers, including 350 in the first-class and 125 in the second-class rooms. We are concerned here with the machinery, and may dismiss the ship arrangement with the remark that she embodies all those features which distinguish her larger sisters, notably the Aquitania, as the highest ideal of merchant-ship equipment, and demonstrate the experience and enterprise of the management of the Cunard Company. The machinery is arranged to drive twin-screws, there being for each propeller-shaft a high-pressure and low-pressure Parsons reaction ahead turbine, placed side by side, the former on the inner and the latter on the outer line, both engaging with a gear-wheel on the propeller-shaft. The size of the installation is suggested by the diameter of the gear-wheel, 10 ft., and its breadth, 5 ft. At full power the turbines run at 1630 revolutions, while the speed of revolution of the propellers is 130 per minute, the ratio being 12½ to 1. The full power is 9500 shaft horse-power, and the speed 16½ knots. The steam consumption of the turbines is only 11½ lb. per hour per shaft horse-power. These figures represent the maximum power without the use of the by-pass valves. Either the high-pressure or low-pressure turbines can be worked independently, the steam-leads being arranged accordingly, so that the derangement of any one turbine does not interfere with the driving of the ship by twin screws. Incorporated with each low-pressure ahead turbine is an astern turbine, of Parsons impulse reaction type, of adequate power for rapid manœuvring. Later we hope to give fuller details, but may here add that there are six cylindrical boilers, working under natural draught, arranged in two separate water-tight compartments, and supplying steam at a pressure of 210 lb. per sq. in.



Further interest in geared turbines is raised at the moment by a paper read last Tuesday at the Institution of Engineers and Shipbuilders in Scotland, by Mr. W. D. McLaren and Mr. G. M. Welsh. In it they gave outline particulars of the machinery for a number of vessels typical of various classes, and for the same ships designs, weights, &c., of geared-turbine installations were set out for comparison. In dealing with performances, actual and probable, the authors estimated the resistance, plotting curves of effective horse-power on a speed base, along with thrust delivered, shaft and indicated horse-powers, and the estimated steam consumption. The data are more or less empirical, but doubtless assumed from a large mass of material in the possession of the authors.

Without entering into the methods of computation adopted, it is permissible to indicate generally the deductions made as regards comparative steam consumption for different types of machinery. The authors admit the difficulties in setting out precise data, but give in the diagram annexed, Fig. 1, representative performances which may be accepted as correct within reasonable limits. They direct attention to the point that the consumption rates for engines with dependent pumps is less than for engines with independent pumps; but in the latter case the power for these auxiliaries is not recorded, and the heat in their exhausts is generally utilised for feed-heating. Compound engines are assumed to work with a boiler pressure of 130 lb. per sq. in., triple-expansion engines with 180 lb., and quadruple-expansion engines with 220 lb. per sq. in.

As regards the comparative weights, an advantage is proved in all cases. Some of the tabulated particulars in the paper may be summarised; in all cases the boilers are of the cylindrical type.

—	Displacement.	Heating Surface.		Weights.	
		Reciprocating.	Turbines.	Reciprocating Machinery.	Geared-Turbine Machinery.
	tons	sq. ft.	sq. ft.	tons	tons
Channel steamer..	2,030	9,900	7,890	580	470
Cargo coaster ..	2 020	2,130	1,930	145	152
Cargo tramp ..	11,900	8,200	6,610	570	500
Passenger and cargo-steamer ..	11,520	21,520	17,540	1280	1030
T.S.S. liner ..	13,560	30,740	27,670	2120	1560
Q.S.S. liner* ..	35,500	83,850	83,850	5550	4200
Paddle steamer ..	494	4,230	3,550	240	195

* This is combination machinery against geared turbines.

The reduction in heating surface in the case of turbines is indication of the economy in steam consumption, which, of course, influences the total weight of machinery from boilers to engine-tunnel.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. IX.

By FREDERICK WILLIAM LANCHESTER, M. Inst. C.E.

GUN-FIRE. THE ENERGY ACCOUNT.

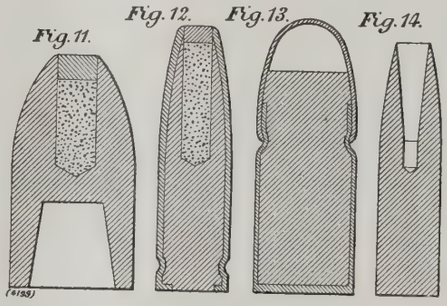
THE kinetic energy of a projectile commonly represents from 10 to 30 per cent. of the total energy of the explosive or powder charge by which it is projected; the lower figure corresponds to the performance of a small-bore low-velocity rifle such as a rook rifle, the latter being that approached under the most favourable conditions by the military or big-game rifle. The British Service rifle with Mark VI. ammunition thus has an efficiency of approximately 28 per cent.; in the ordinary sportsman's "12-bore" the figure is about 11 per cent.

The total energy released on combustion by black powder is the equivalent in round numbers of 500 foot-tons per lb. The corresponding figure in the case of cordite is half as much again, or approximately 750 foot-tons per lb.; and in general it may be taken that most of the explosives in common use have an energy content between 500 and 1000 foot-tons per pound. In the case of the Service rifle the weight of the powder (cordite) is 30 grains (0.0043 lb.), and the bullet 215 grains (0.0307 lb.), and the velocity 2050 ft. per second. Thus the total energy of the charge is $0.0043 \times 750 = 3.2$ foot-tons, and the muzzle (kinetic) energy is 2000 foot-pounds = 0.895 foot-ton; the efficiency, therefore, is $0.895/3.2 = 0.28$, as already given. It is worthy of remark, *en passant*, that there is very close accord between the figures applying to the gun and those which obtain in the gas-engine in all such matters as efficiency, heat lost to barrel (cylinder walls), and heat remaining in gases. The agreement is far closer than one would have ventured to expect in view of the great disparity of the conditions.

It has already been pointed out that under the conditions of attack on aircraft there is very little possibility of utilising the whole of the energy of the bullet on impact. Unless the motor mechanism, or the pilot or gunner, be hit, the character of the structure employed in aircraft is such that the bullet or projectile will pass through with a comparatively insignificant loss of energy and will do little or no damage. With the ordinary military bullet, and more particularly with the spitzer model, nothing less than encounter with a heavy metal part will cause it to break up. Any non-metallic structural material, such as timber, is bored cleanly through, and if initially designed with a reasonable margin of safety, the resulting injury to it is negligible. The position is similar to that which existed, before the adoption of explosive shell, in the attack on the wooden ship by the artillery or cannon of a century ago. At close quarters the cannon ball would go clean through, often with comparatively little injury. It is said that Napoleon, observing this to be the case, himself expressed the opinion that explosive shell (a then well-known expedient in siege operations) could be adopted generally in naval warfare with advantage. The situation is considerably more acute in the case of the attack on aircraft by rifle-fire, and so we are led to consider the possibilities of the explosive or expanding bullet, ignoring, for the purpose of discussion the existence of the Declaration of St. Petersburg.

THE EXPLOSIVE BULLET.

The simplest form of explosive bullet, and one of the most effective, is that devised by Mr. Metford about the middle of the last century; this, as applied to an Enfield bullet of the period 1860, is illustrated in Fig. 11. An explosive charge is inserted in the fore part of the bullet, and consists of equal parts of sulphur and chlorate of potash,* this mixture acting both as detonator and "burster." The hollow-ended form, or "drilled-up" end, has the incidental advantage that it alone will determine the expansion of the bullet on impact, quite apart from the action of the explosive charge. If the Metford system were applied to the modern bullet, the section would be somewhat as shown in Fig. 12, the basis of which is the Service 0.303 Mark VI. Another good form to take as the basis of an explosive bullet is the



capped bullet, Fig. 13, as used in sporting rifles, the space inside the cap being conveniently filled with mixture to Metford's specification.

It is difficult, however the cavity be arranged, to devote more than about one-eighth or one-seventh of the volume of the bullet to receive the charge, and consequently, in view of the relatively low density of the explosive (about 1.6 in the case in point), the weight of the burster cannot be more than some 2 or 3 per cent. of the total. Taking the figure for cordite as representing the energy of the burster explosive, this means, in the case of the Service rifle, about 5 or 8 grains, or 1300 ft.-lb. energy, But the efficiency of the burster is not likely to be higher than that which we associate with the main charge—it is at some advantage, inasmuch as there is no confined barrel to the walls of which heat is lost, but it is at a serious disadvantage, in that the explosion is not with any certainty confined to its work. It is doubtful whether of the 1300-ft.-lb. total more than 300 ft.-lb. on an average will be usefully expended.

We are thus led to appreciate the attributes of the explosive bullet, and more generally the explosive shell, in true perspective. The explosive only adds to an initial energy content of 2000 ft.-lb. as due to velocity, a matter of about 300 ft.-lb. in available explosive energy, a quantity representing an addition of only 15 per cent. It is at once evident that the value of the explosive charge is less due to its direct action than to the fact that by its spreading or scattering effect on the projectile the kinetic energy is used to better advantage. In other words, the explosion is effective as a means of initiating or causing the expansion of the bullet rather than as acting directly by its own destructive power. In the case of large shells the proportion of burster charge to total weight can be increased, and so the direct effect is relatively more important; for armour-piercing projectiles, however, the proportion is no higher than in the example taken—*i.e.*, about 3 per cent. It might be imagined that the employment of some higher explosive would give a capacity of greater direct bursting energy, but the high explosive is not so called by reason of any greater total energy content, but rather on account of the effects of its rapidity of action; in brief, its power of detonation.

It is evident that, for the purpose under contemplation, the destruction of the less substantial structural parts of aeroplanes, &c., if we are able to secure the proper and immediate expansion of the bullet on impact without the use of an explosive charge, every useful purpose will be served. The bullet energy, even reduced to about one-quarter of its initial value by 1000 yards flight, is more than sufficient, if definitely expended in the impact, to destroy any strut or spar or other light constructional part, without any aid from an explosive charge. The question is, whether the expansion of the bullet can be induced to take place with sufficient rapidity by any less drastic device.

THE EXPANDING BULLET.

Any bullet is considered an expanding bullet that is so made as to spread or mushroom on impact with its objective. But it is more usual to restrict the term to bullets having some special provision artificially to assist or facilitate their expansion, and, generally speaking, the objective is assumed to be game or other living quarry of some description. Evidently, if the target be hard enough, every bullet will expand to some degree. The means usually adopted in the case of the solid-lead bullet is to drill or form a hollow in the nose, as familiar to all who have used the sporting rifle. Another well-known method is to split the nose for a short distance by two cuts at right angles. In the case of the nickel-covered bullet the drilled nose again is sometimes adopted, or the nickel sheath at the nose, or point, of the bullet is removed, the lead core being laid bare. All these devices have been practised in connection with sporting ammunition for many years. The art of designing an expanding bullet is so to proportion things that under the average conditions the degree of expansion is that found to be most desirable; thus the depth of the hole, or the extent of the slits, or the amount of the sheath cut away may be varied to whatever extent desired. The object to be attained is that the bullet shall expend its whole energy in inflicting the maximum possible injury, but at the same time it must not go to pieces or spread to such an extent that its penetration is lacking. In stopping big game it is necessary, not only that the energy should be wholly utilised, but also that it should be expended, as far as possible, in injury to the deep-seated vital organs. More recently Messrs. Westley Richards have brought out a modified form of expanding bullet in which the sheath is kept intact, but is not wholly filled by the lead core, there being an air-space in the fore end; this type (already illustrated in Fig. 13), expands to a moderate degree only, and retains a considerable power of penetration.

One of the main factors contributing to the spreading or expansion of a bullet is the centrifugal force of the bullet itself; all that is required of the impact is so to break down the structure of the bullet as *to permit* it to expand. The direction of motion of the peripheral portions of the bullet make at all points an angle with the axis of flight at least equal to the angle of the rifling, which is commonly about 1 in 10 to 1 in 12. This is the state of things when the bullet is discharged, but the actual angle rapidly becomes greater owing to the reduction of velocity, the speed of rotation being comparatively little affected. Thus at 1000 yards range the velocity is reduced by half, and the relative direction of the skin of the bullet becomes about 1 in 6 to the line of flight. If then by a sudden impact or other means the bullet were broken into a number of small fragments at any point in its path, these fragments would immediately spread out after the manner of shrapnel, covering a cone whose base would be approximately one-third of its height; moreover, the distribution of the fragments in space—that is, within the conical surface—will be almost uniform. Such a distribution would be almost ideal from the point of view of the work in hand. A desirable solution to the problem would appear to lie in the direction of a bullet composed

* This mixture being liable to detonate by friction, the ingredients should be separately ground and mixed with due care.

of pellets or shot embedded in a matrix of only just sufficient strength to hold together, so that on comparatively light impact the component pellets will be released, and each will follow its individual direction of motion.

In every case the degree of expansibility requires, finally, to be determined by experiment, though with sufficient previous experience, and a proper comprehension of the conditions, it is usually possible to hit off the right thing without much difficulty. For the destruction of wooden struts, spars, &c., it is clearly necessary to obtain the most rapid expansion possible (corresponding to instant disintegration), since the bullet has to do its work in a distance rarely exceeding some 3 in. or 4 in. Owing to the fact that the "tissue" penetrated is of very low density—about 30 lb. or 40 lb. per cub. ft.—it is probable that good results would be obtained by drilling the nose with a conical aperture of large diameter, at the entrance about half the diameter of the bullet, after the manner illustrated in Fig. 14. The writer is at the present time making a series of experiments with expansive bullets on a target made up of wooden scantlings of cross-section comparable to aeroplane struts or wing members. We may form some estimate of the latent destructive power of the military Service bullet from the fact that it will penetrate some 4 ft. of deal or pine, representing $3\frac{1}{2}$ cub. in. of wood *displaced*. Taking this as a criterion, it is clear that if we can obtain the necessary rapidity of expansion, there is ample energy in a single hit to sever any ordinary wing or similar structural member.

The Light-Weight Shell.

Apart from the question of the explosive or expansible bullet, we have already seen that the 14 oz. limit of projectile weight is an irksome restriction when we are dealing with aeroplane armament. Not only is the gun required weighty and cumbersome, but the weight of the ammunition is, save for machines of exceptional size, almost prohibitive. If we are able to adopt a weight of 6 oz. or 8 oz. in place of 14 oz., it will be possible to use a gun direct-mounted without the elaboration of recoil mechanism, and weighing from 40 lb. to 45 lb. In addition to this, the cartridges would weigh less than 1 lb. apiece, and provision could be made for some 200 rounds in a machine of present-day dimensions. For attack on other aeroplanes, such a shell would be almost as effective as one of twice the weight, and, owing to the recoil limit, the rate of fire can be doubled if the lighter shell be adopted.

It is convenient to make a distinction between the *explosive bullet* and the *shell*, even if the definition be considered somewhat artificial. The former is defined as containing a single charge, impact fuse and "burster" in one; the latter (the shell) contains, as well as the burster charge, an independent cap or detonator, and a fuse or mechanism, time or impact, for determining the instant of explosion. Many writers refer to the explosive bullet equally as a shell.

It is unnecessary to discuss the probability or possibility of the abandonment of the restriction imposed by the Declaration of St. Petersburg. We know that the clause in question was framed from humanitarian motives, and it is fairly evident that any expanding bullet that, from its behaviour, is tantamount to an explosive bullet would be looked upon as infringing the terms of the Declaration, even though it contain no actual explosive; the terms of the Hague Declaration (Article 60) are virtually an admission of this. What is equally clear is that neither at St. Petersburg, in 1868, nor at the Hague, in 1899, did the matter arise that now confronts us; and so it is actually a question to what extent either document will be considered binding under the conditions that have arisen. In any case it behoves us to ascertain definitely all there is to know on the subject.

THE ACTION OF A WEHNELT CATHODE.

Some experiments, made quite recently by Dr. F. Horton at the Cavendish Laboratory, and communicated to the Cambridge Philosophical Society and to the *Philosophical Magazine* of August last, again raise the question of the action of the Wehnelt cathode, which is not yet understood, although the device has been much used for years. It consists of an auxiliary cathode, generally of platinum, which is covered with the oxide of some alkaline earth, the metal calcium or barium generally, and heated by the electric current of a special circuit. Wehnelt himself supported the suggestion that the electrons proceed, not from the glowing oxide, but from the hot platinum underneath. K. Fredenhagen suggested that the hot oxide conducted electrolytically, that the current decomposed the oxide into oxygen and calcium, and that the electron emission was due to the recombination of the metal and oxygen.

Last year A. Gehrts modified this view by suggesting that the dissociation of the oxide was essentially thermal and took place in the absence of a heating current, but that in the presence of the current there was also electrolytic dissociation, some travelling of the oxygen ions to the anode, and an emission of electrons, owing to the recombination of the calcium and oxygen. Gehrts spread the oxide on cathodes of platinum, iridium, tantalum, carbon, and tungsten (to which it adhered badly). Removing the oxide after some use of the cathode he found that platinum and iridium had alloyed with the calcium, and that tantalum and carbon were oxidised.

Neither of the above-named theories is considered satisfactory by Horton. He experimented with Nernst filaments and with platinum cathodes, both coated with lime. The comparison was difficult, because the filament could not easily be kept glowing in a vacuum at sufficiently low temperatures to take measurements in the absence of cathode rays. In most cases he made use of fine platinum tube heated by alternating currents, and he measured the temperatures, up to 1360 deg. Cent., by a Féry optical pyrometer.

During these experiments Horton observed that the gas pressure in the bulb increased more rapidly when the electric discharge was passing through the oxide than when not; after two hours' work there was a decrease of pressure in the absence of the discharge. The liberation of oxygen was, however, only about one-thousandth of what it should have been according to Faraday's law.

The conclusions at which Horton arrives are:—(1) That the emission of electrons has its origin in the lime itself, which does not merely help the electron to escape from the metal; (2) that there is electrolysis, but very little liberation of oxygen, and that it is improbable that the recombination of oxygen and calcium would go on together with the decomposition of the oxide, through a layer of solid lime particles, as the charged oxygen atoms would be liberated on the vacuum side of the lime layer and within a strong electric field, tending to draw them away from the cathode; (3) that the chemical combination of calcium and oxygen does not itself give rise to any detectable emission of electrons. Thus Horton does not support the Fredenhagen-Gehrts hypothesis. In view of the doubt, which the most recent experiments, made both here and on the Continent, have thrown on the supposed emission of electrons and on the existence of the photo-electric effect in cases where the liberation of occluded gases is really prevented, we must, however, consider the question to remain open.

THE LATE MR. WILLIAM B. BRYAN.

It is with very great regret that we announce the death of Mr. W. B. Bryan, Chief Engineer to the Metropolitan Water Board, who died in the Savoy Hotel shortly before midnight on Tuesday evening last. Mr. Bryan had been in good health and good spirits up to the very day of his death, but had a heart seizure in his office at Savoy Court on Tuesday forenoon. Medical assistance was at once obtained, and he was removed later in the day to the Savoy Hotel. He appeared to rally well, and no immediate danger was anticipated, but these hopes of a favourable issue were destined to be disappointed, death occurring, as stated, just before midnight.

Mr. Bryan was born at Nottingham in 1848. He was articled to Mr. M. O. Tarbotton, M. Inst. C.E., of Nottingham, and at the completion of his articles acted for some time as assistant engineer to the Corporation of that borough, and also to the Nottingham and Leen Valley District Sewerage Board. At Nottingham he gained much experience in the execution and design of the large public works carried out under Mr. Tarbotton's direction, between 1863 and 1873. In the latter year Mr. Bryan was appointed engineer to the Burnley Corporation, and for them he designed and carried out a complete sewerage scheme at a cost of 50,000*l*., and other public works executed for the same authority to a value of as much again. In 1875 he became borough and water engineer to the Corporation of Blackburn, though he retained until 1878 the post of engineer to the Sewage Committee of Burnley. It was at one or other of these towns that an incident occurred which throws an interesting light upon the unfair pressure that public bodies sometimes impose upon their technical advisers. In addition to his other duties Mr. Bryan was asked to undertake that of gas examiner, the gas supply being in the hands of a company. During his term of office the Corporation acquired this undertaking without issuing any fresh instructions to their gas examiner. He, as in duty bound, reported shortly after the transfer the supply of bad gas, and was, in consequence, waited upon by a most indignant committee, who instructed him that now the works were in the hands of the Corporation, bad gas was no longer to be reported.

At Blackburn, Mr. Bryan was responsible for the building of viaducts, bridges, and sewerage improvements and other new municipal works to the value of 150,000*l*., and also designed for this borough a new water-supply from the West Riding and Lancashire hills. Before this latter work was completed, he was (in 1882) appointed chief engineer to the East London Water Company. When he took charge, the engineering side of this undertaking was in a far from satisfactory condition. Water waste was very great, and there was a certain carelessness about the quality of the supply to the mains. In fact, a small villa had actually been erected on one of the islands in the company's reservoirs, in spite of the ensuent risk of contamination. Mr. Bryan soon effected extensive improvements. He was an enthusiast on the subject of giving the purest possible supply. His assistants were instructed that the company's interests lay in effecting, whatever the cost, a thorough purification of the water before allowing it to enter the mains, and the low typhoid death rate, in spite of East End squalor, affords ample evidence that this declaration of policy was most effectively embodied in practice. Owing to his retiring disposition, however, and aversion to advertisement, Mr. Bryan was little known to the public he served so effectively, and his name came before them mainly in connection with the discreditable attacks made on the East London Company by the less reputable class of politician who at that date sought publicity as members of the London County Council. The drought of 1895 was wholly unprecedented, yet had Mr. Bryan's plans been sanctioned by Parliament, there would have been no scarcity in his district. In fact, in 1893 the East London Company had promoted a Bill in Parliament to increase their storage and pumping power, and this Bill, at the instance of the London County Council, was rejected. In this connection the action of the late Professor James Stuart was particularly open to censure, as it is difficult to believe that, even with his slight training in practical engineering, he could have failed to realise the futility of his argument that the East London Company (taking water from a small and very variable river such as the Lee), required no more storage than companies drawing on a large and more constant river like the Thames.

In 1903 Mr. Bryan was faced with another emergency of a different kind. In spite of his opposition Parliament had given powers to a Commission to improve the drainage of the Lee Valley, with the result that water passed off the land and into the river much more rapidly than before. In short, a flood that in the old conditions took ten days to pass off, with the improved drainage got away in three, and was correspondingly higher. Mr. Bryan feared that any large increase in the height of the flood-level would endanger his filter-beds, on the efficiency of which the health of the area supplied was dependent. In 1903 this fear was realised. On learning from his office that the water was rising to an unprecedented height at Lea Bridge, he hastened to the scene, collected labourers where or how he could, and set them to raid a neighbouring brickyard; with the bricks thus commandeered his ragged regiment built up line by line a wall just ahead of the rising flood. It was a touch-and-go matter, but finally the rise ceased, and the filters were saved. The cost of the day's work was high, but the company accorded their engineer practically a *carte blanche* in the matter of necessary expenditure, a

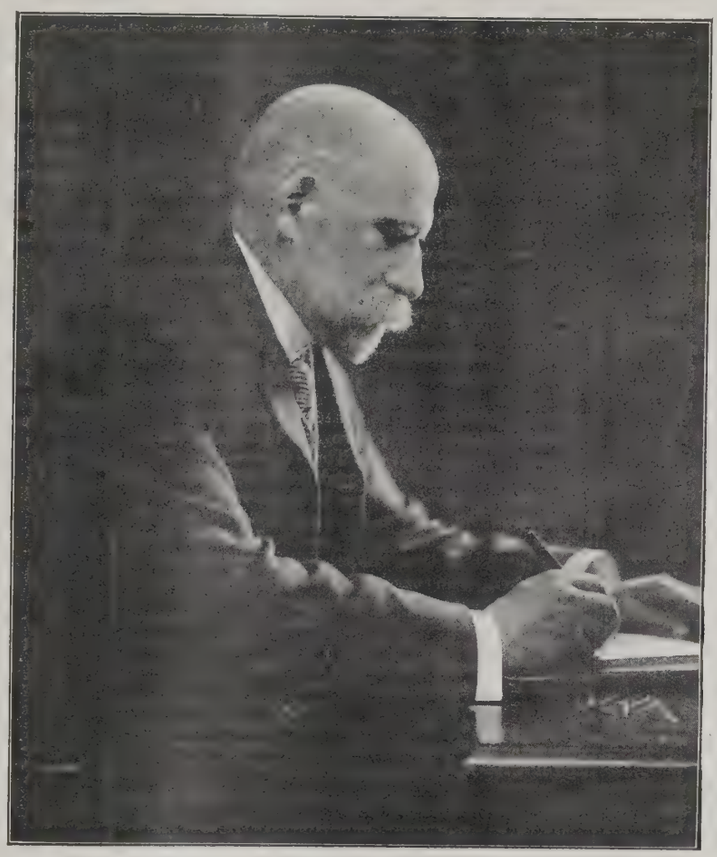
policy which is in striking contrast to that of their successors, since we understand that the utmost the Chief Engineer of the London Water Board is allowed to expend without direct authorisation by a controlling committee is limited to 5*l.*!

When Mr. Bryan took charge of the East London Works, the number of houses connected to the mains was some 132,500, whilst at the transfer of the undertaking in 1904 this figure had risen to 228,742. Owing to the efforts made to check waste, the consumption had, however, increased very much less rapidly, some 12,725 million gallons being supplied in 1882, as against 14,755 million gallons in 1903-4. Of this additional supply, a part was obtained from deep wells, which Mr. Bryan was the first to introduce on the East London system. The sinking of some of these wells involved problems of much difficulty. At Walthamstow, for example, the chalk is overlaid by green sand heavily charged with water, and it was exceedingly difficult to seal into the chalk the cylinders lining the walls of the well. This was finally effected by grouting up the sand with neat cement; but with characteristic reticence, Mr. Bryan would never consent to particulars of this difficult and very interesting operation being published.

Whilst, as stated, the total supply to the East London district increased but little during Mr. Bryan's tenure of the post of chief engineer to the company, a very large expenditure was made with a view to improving the quality and the certainty of the supply. Under his direction vast new reservoirs were built. With the completion of the East and West Warwick reservoirs to his designs the company's storage capacity amounted to some 1200 million gallons, but by adding the Banbury and Lockwood reservoirs this was more than doubled. The old Racecourse reservoir was also greatly enlarged. These extensions were not effected solely with a view to securing a greater certainty of supply, but largely because experience had shown that by permitting the water an interval of rest in a reservoir the load imposed on the filters was greatly reduced. This conclusion has been most adequately confirmed by researches since made in the bacteriological laboratories of the Water Board, and in consequence the enormous reservoirs at Island Barn (900 million gallons) and Chingford (3000 million gallons) have in practice been used for subsidence as well as for storage. The difficulty with storage is to make a non-technical board realise the necessity for its provision. Not long ago Mr. Bryan was reproached by a committeeman for demanding additional storage, on the ground that many existing reservoirs were not half full, the complainant failing to realise that much of the storage is not needed in normal years, but that every decade or so there comes a period of prolonged drought, which will give rise to the greatest inconvenience if not provided for betimes.

One of Mr. Bryan's most notable characteristics was his restraint. The temptation to an engineer in his position to embark on grandiose schemes, such as, for example, the supply of London with water from the Welsh mountains, is obviously very great. Reservoirs forming deep mountain lakes and aqueducts 200 miles long appeal to the imagination and would probably be welcomed by nearly every non-technical member of the Water Board. To the engineer they offer extraordinarily great attractions. The work involved is of the most interesting character, and remains as a permanent monument to his fame. Great as the temptation must have been, Mr. Bryan withstood it, and, without doubt, very much to his personal disadvantage. He fully realised the truth embodied in the aphorism that an engineer is a man who can do well, at a cost of 20s., work which any fool can, in some fashion, do for 40s., and in the whole of the vast contributions he has made to the water works of London he always gave the full weight to considerations of economy. Not merely did he reject the Welsh scheme on such grounds, but more recently abandoned another plan for the construction of a huge reservoir in the valley of the Kennet, because this plan did not lend itself to progressive development. No one knows what the needs of London will be in forty years' time, and, in his opinion, it was best not to commit posterity too far in advance. Hence, in place of the proposed Kennet scheme, he substituted another, which could be executed in stages. The first step in this will be the construction at Shepperton of a reservoir capable of holding 7000 million gallons, which will be lifted from the river against a head of about 40 ft. Mr. Bryan was notably courageous in adopting new devices promising greater economy or greater efficiency in the conduct of the undertakings under his control. A notable example of this was his enterprise in adopting Humphrey pumps for Chingford, in spite of the fact that this involved proceeding at one step from an experimental pump developing 8 horse-power to permanent pumps of some 400 horse-power each.

Mr. Bryan seldom spoke in public, and wrote but little. He was elected an associate member of the Institution of Civil Engineers in 1875, and transferred to the class of member in 1879, amongst his sponsors being the late Mr. G. F. Deacon. Since November, 1908, he has been a member of the Council of the Institution of Civil Engineers. His only contribution to the Proceedings of this society (apart from discussions) seems to have been a very short note on "The Detection of Leaks in Water-Mains," published in 1887. In this he referred specifically to the great difficulty attaching to the localisation of leaks in the case of pipes laid under the concrete beds which support wood or asphalt pavements. In such cases the visible leakage may be many yards away from the actual fracture, and similar difficulties were, he said, met with when the pipes were laid in pervious gravels. The Institution of Junior Engineers was in this respect more fortunate, his presidential address on "Water Supply," delivered in 1906, giving a most interesting historical *résumé* of ancient water systems, as well as many valuable notes on modern practice. He had, moreover, consented to deliver this evening the Thomas Hawksley lecture at the Institution of Mechanical Engineers. His address was to have been "On Pumping and other Machinery for Water Works and Drainage," matters on which his experience was almost unrivalled.



Photograph by Oscar Hardee.

The late Mr. William Booth Bryan.

Mr. Bryan was, it may be added, an enthusiastic volunteer, and was Colonel of the 2nd Tower Hamlets Rifle Volunteers from 1889 to 1903. He was an excellent shot, winning the Queen's and St. George's badges at Wimbledon and the championship badges of the Middlesex Rifle Association and North London Rifle Club.

In conclusion, special mention should be made of Mr. Bryan's extreme kindliness, and his great readiness to recognise and reward good service. One of his former assistants relates that some twelve months after his appointment by Mr. Bryan, the latter called him into his office to tell him that not only had he recommended him for a substantial increase of salary, but that, in addition, he wished

to give a personal recognition of his appreciation, handing him therewith a cheque for 100*l*. The incident is very characteristic, and his staff were devoted to him.

The funeral will take place to-morrow (Saturday), at Chislehurst, where Mr. Bryan resided. It will be preceded by a memorial service at Christchurch, Chislehurst, at 2.15 P.M. Those who intend to take part in this last token of respect and esteem will be able to arrive at 1.43 P.M. by leaving Cannon-street Station at 1.20 P.M , or London Bridge at 1.23 P.M.

THE BRITISH ASSOCIATION IN AUSTRALIA.

(*Continued from page* 516.)

SECTION G.—ENGINEERING.

Section G met at Melbourne, in the lecture-hall of the Engineering Department of the University, and at Sydney in the P. N. Russell theatre of the Engineering building of the University. Punctually at 10 A.M. Professor Coker opened the sectional proceedings at Melbourne on August 14. There were many empty chairs in the hall at that moment, but the hall quickly filled up, and throughout the meeting, both at Melbourne and Sydney, the transactions attracted large audiences, who were thoroughly interested in the proceedings. The number of papers and reports discussed was 37, and in this respect, as well as in the character of the papers, the transactions of Section G will well bear comparison with those of previous meetings. To dispose of the long programme, the section met at Melbourne on the mornings of Friday, Tuesday, and Wednesday; at Sydney only two days, Friday and Tuesday, were available, as the members had to leave for Brisbane at noon on Wednesday; hence the section had to subdivide into subsections for civil engineering and for mechanical engineering on the Tuesday, a somewhat unusual feature for Section G. As a rule, the sections of the Association meet on five days. Saturday has for many years been an excursion day, and in Australia week-end excursions were arranged, so that the Monday could not be utilised for sectional work either. The officers of the section were:—President: Professor E. G. Coker, M.A., D.Sc, who has just entered upon his new duties as Professor of Engineering in University College, London; Vice-Presidents: Professor J. E. Petavel, F.R.S., and George Forbes, F.R.S.; Secretaries: Professors G. W. O. Howe, M.Sc., Imperial College of Science, South Kensington (Recorder), W. M. Thornton, D Sc., of Newcastle, W. H. Payne, M. Inst. C.E. (Professor of Engineering at Melbourne), and W. H. Warren, M. Inst. C.E. (Sydney).

Stress Distribution.

Professor Coker delivered his presidential address on Stress Distribution in Materials at Sydney; we published this address in our issue of August 21. The vote of thanks was proposed by the Vice-Chancellor of the University, and supported by Professor Warren. Professor Coker had, from the first, to insist upon a time limit, and he fully deserved the praise bestowed upon him, at the close of the proceedings, for his courteous and efficient presidency.

In the following report we group the papers irrespective of the order in which they were read; some questions, like material-testing, irrigation, &c., came up at both the centres.

The Stress Distribution in Short Compression Members.

A further contribution to this subject, by Professors Coker and Filon, "The Stress Distribution in Short Compression Members," was read by Professor Coker. He said that the distribution of stress in a rectangular block, due to forces applied to its boundaries, was a fundamental problem which was much influenced by the manner in which the load was applied to the end faces. In order to obtain consistent results, the end faces of small specimens were sometimes fitted with surface-plates; as this was laborious in large specimens, the specimens were faced with plaster-of-Paris, or plates of mill-board were interposed. But it was then difficult to determine within the elastic range the stress at any point, unless optical methods were used. In most testing-machines the mechanical arrangements for applying a pure compression load were defective. In order to overcome this trouble the authors had constructed a special testing-machine, in which they used two substantial blocks worked to true planes at their opposite faces. One of these blocks was fixed or capable only of a small movement along the normal to the working faces. The other block was secured to a block carried by two sets of flexible diaphragms of steel, spaced at a considerable interval and clamped at their outer edges in the framing of the machine in such a way that the motion of the pressure-plate had only one degree of freedom, and was limited by the elastic deformation of the diaphragms. The applied load was weighed by a lever system, and as the work done in deforming the diaphragm was stored therein and tended to bring the moving system back to its initial position, frictional errors were avoided, and the load could accurately be measured.

The optical stress produced was proportional to the difference of the principal stresses at any point; in order to determine the magnitude of each separately, an independent measure was hence required. The change in thickness was most convenient for this purpose; it was proportional to the sum of the principal stresses, and could be measured by the aid of a lateral extensometer; thus optical and mechanical measurements were combined. The slides exhibited concerned square blocks of $1\frac{1}{2}$ in. by $1\frac{1}{2}$ in., of different lengths. They showed that the stress was much smaller at the plane of separation than at the centre of the block; there was a considerable end effect tending to reduce the compression stress at the end faces. This want of uniformity was due to the way in which the pressure was applied, the brass pressure-plates in the experiment in question preventing the free lateral displacement of the loaded material. When a more extensible material was interposed to transmit the pressure, a greater pressure should be observed at the centre, and that was so. The stress distribution changed considerably when a thin sheet of India-rubber was interposed, the stress at the centre line then becoming greater, and being, moreover, increased by about 20 per cent. of the total load. The effect was, further, not merely confined to a small area at the ends, but was exerted over the greater part of the block. Other diagrams and tables exhibited showed the injurious effect of a lead plate. Uniform stress conditions should, on the other hand, be secured by making use of an intermediate layer of the material under test; and when experiments were made with a block of xylonite between two similar blocks of xylonite, the stress distribution became indeed nearly uniform; only the corners were slightly irregular, because the corners of the freshly-cut xylonite shrunk a little. It was thus demonstrated that in compression tests the load should be applied through an intermediate layer of the same material, and not through hard-steel face-plates.

Stress Distributions in Engineering Materials.

The Report of the Committee on "Stress Distributions in Engineering Materials" was printed in our issue of September 4. Professor J. Perry is the chairman, and Professors E. G. Coker and J. E. Petavel are the secretaries of this Committee.

Dynamic Increment of a Rolling Load.

A paper, sent by Professor Herbert Chatley, M. Inst. C.E., D.Eng., of Tang Shan, North China, on "The Dynamic Increment of a Single Rolling Load on a Supported Beam," was published on page 327 of our issue of September 11.

The Testing of Materials.

Professor W. E. Dalby, F.R.S., read two papers on this branch of engineering. The one on "The Testing of Materials" was printed in our issue of August 28. The second paper was a description of the "Laboratories of the City and Guilds Engineering College, London," of which we gave an illustrated account a few years ago.

A Theory of Work Speeds in Grinding.

Mr. J. J. Guest sent a paper on "A Theory of Work Speeds in Grinding," which was taken as read in the absence of the author.

Change of Elasticity with Temperature.

The paper by Professor F. C. Lea and Mr. Crowther, of Birmingham, on "Change of Elasticity with Temperature," was published on page 487 of our issue of October 16.

Behaviour of Metals under Strain.

In his contribution to the problem of "The Behaviour of Metals under Strain," Dr. W. Rosenhain, F.R.S., insisted that for a rational understanding of the behaviour of metals and alloys, their truly crystalline character in the normal state was of fundamental importance. Evidence of this character, he demonstrated, was readily obtained by the microscope in a variety of ways, including the development of etched figures, negative crystals, oriented crystals, &c. The typical manner in which a crystalline aggregate was formed when a metal was solidifying by a process of dendritic crystallisation was illustrated with the aid of the kinematograph, by the building up of aggregates of cubical blocks. The illustrations further elucidated the behaviour of crystals and aggregates under plastic deformation, and deformation by a process of slip on the cleavage or gliding planes of a crystal; the phenomena of fatigue, testing by shock and fracture under shock or repeated impact, the phenomenon of semi-plasticity and elastic recovery, and the effect of thermal treatment were likewise rendered visible to the audience—not only to the individual observer—and explained by the theory of an amorphous phase in metals; our readers are aware that Dr. Rosenhain has recently extended this theory of Dr. Beilby.

The Distribution of Phosphorus in Steel.

In his second paper, Dr. Rosenhain pointed out that the marked effects of phosphorus on steel, which, according to the specifications for tyres, axles, &c., should not contain more than 0.035 per cent. of phosphorus, could not be understood if the phosphorus were evenly distributed through the steel. J. E. Stead had shown by the method of heat-tinting that such steel had a banded structure. The recent use of a new etching agent (ferric chloride, hydrochloric acid, and small quantities of copper and tin chlorides) by Dr. Rosenhain and Mr. J. L. Houghton brought this structure out more clearly. This reagent deposited copper first on the nearly pure ferrite area, and only after some time on the regions richest in phosphorus. When the etching was long continued, the produced appearance was the same as with the heat-tinting. But when the treatment was interrupted at an early stage, additional peculiarities became discernible in the steel. From the study of these etching patterns Dr. Rosenhain concluded that the origin of the banded structure had to be traced back to processes occurring during the first solidification of the solid-solution alloy. Thus the coarser or finer banding of the finished steel depended upon the scale of crystallisation which took place in the original ingot, in spite of the fact that the crystalline structure might entirely have been changed by the subsequent mechanical or thermal treatment. The great persistence of this "geographical" distribution of phosphorus was to be ascribed to the low velocity of the diffusion of iron phosphide when in solid solution in iron.

Gaseous Explosions.

Passing to papers on engines and explosions, we notice the report of the Committee on Gaseous Explosions in the first instance. This important report, which we published in our issue of August 28, was presented by Professor Dalby, the Secretary of the Committee, of which Dr. Dugald Clerk is chairman.

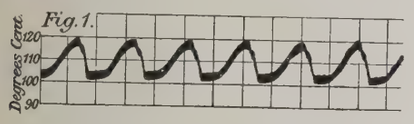
Temperature Cycles in Heat-Engines.

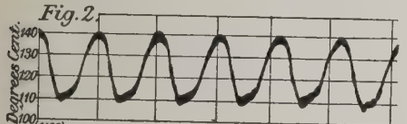
Professor Coker also briefly described the continued experiments, which he has been conducting in the Finsbury Technical College in conjunction with Mr. Walter A. Scoble, on "The Cyclical Changes in the Temperature of the Working Fluid of Gas-Engines." The measurements were made, he explained, with the aid of thermo-couples, which were inserted either in the cylinder and in the exhaust-pipe or at the centre of the inlet and exhaust-valves and at three points of a vertical diameter of the piston. The couples for the first two measurements consisted of platinum and its alloy with iridium or rhodium; they were fixed in the cylinder-wall or freely suspended near the wall. In measuring surface temperatures, the metal was thinned at the respective points, and wrought-iron wires were riveted into suitable holes leading through the thinned wall to the surface exposed to the gas; the couple was then wrought iron-cast iron.

When Professor Coker brought these researches

before the Institution of Civil Engineers last year, he had made measurements by taking a number of readings throughout a cycle, making use of a Dalby contact-breaker, which allowed the couple instantaneously to be connected to the galvanometer of the balance device at any predetermined point of the cycle. Since then they had successfully tried to obtain automatic photographic records with the aid of the most recent type of the Einthoven galvanometer kindly supplied by the Cambridge Scientific Instrument Company. The image of the deflected string (silver wire) was focussed on a plate which dropped at a constant rate when released by forcing a special mixture of oils through a needle-valve. A vibrating invar bar closed the circuit of a small battery, whose current energised a small electric motor revolving at 5 revolutions per second; the spindle of this motor was provided with teeth, through which the light leaving the microscope was allowed to pass so as to produce a time-scale. The couples were made of thin wire rolled down, fused together electrically, and then re-rolled to the order of 0.005 in. For taking measurements in a hollow cylinder the wires were threaded through a two-way fire-clay tube and embedded in plaster-of-Paris within a metal sheath which was screwed into the thinned cylinder-wall, the junction being exposed to the gases, into which it projected by about $\frac{1}{2}$ in. Many hundreds of cycles could be recorded in this way. In order to ensure true values the engine should run very steadily at constant maximum pressure, and for that purpose rich gas mixtures were preferable.

The Einthoven galvanometer, Professor Coker explained, undoubtedly offered great advantages; but no thermo-couple or resistance-wire was sufficiently sensitive instantaneously to respond to the extremely rapid changes in temperature caused by the explosions in an internal-combustion engine. The maximum temperatures of high explosions recorded would also appear to be too low, while the suction temperatures were in fair agreement with those obtained by other means. Real estimates of the discrepancies could be made in the case of steam-engines, for which the temperatures could be deduced from the indicator diagrams by the $p\,v = \mathrm{R\,T}$ relation, and where the temperature range was comparatively small. The following figures referred to a steam-engine, governed by throttling, and driving a dynamo; the couple was fitted into the cylinder :—





In the first test, no load was put on the engine, and the maximum temperatures deduced from the pressure and from the couple were respectively 123.4 deg. and 121.5 deg. Cent.; the exhaust temperatures were 103.1 deg. and 104 deg. Cent. In the second test, on load, the maxima were 146.6 deg. (pressure) and 142 deg. Cent. (couple), while the exhaust temperatures were 107.7 deg. (pressure) and 111 deg. Cent. These figures showed a very fair correspondence, and the accuracy could no doubt be improved. The couples used in this instance were nichrome-constantan, as there was no danger of fusion; they give high electromotive forces. Figs. 1 and 2 illustrate the thermo-couple records of the two cases; on other diagrams exhibited, but not reproduced, the temperature range exceeded 1000 deg. Cent. The records from surface-metal couples, taken at the centre of the inlet and the exhaust-valves, were also satisfactory, and the author certainly succeeded in demonstrating the usefulness of this new method of obtaining reliable cyclic temperature records.

Petrol-Motor Fire-Engines.

Professor T. Hudson Beare, M. Inst. C.E., contributed "Notes on Some Tests of Petrol-Motor Fire-Engines and the Frictional and other Resistances to the Flow of Water through Canvas Fire-Hose." An article on these trials appeared in our issue of April 24, 1914.

The Lost Pressure in Gaseous Explosions.

Professor W. M. Thornton, D.Sc., D.Eng., in a paper on "The Lost Pressure in Gaseous Explosions," pointed out that when the maximum pressure of an explosion was calculated from the heat of combustion of the elements of the gaseous mixtures, the values obtained were about twice as large as those found experimentally, so that the efficiency of explosions for different gases seemed to approach the value one-half. Four suggestions had been made to account for this discrepancy: that there was dissociation of the gaseous products; that the specific heats of the gases at explosion temperature were much higher than assumed; that the products were rapidly cooled by radiation to the walls of the vessel; and that the combustion was not complete at the momentum of the maximum gas-pressure, a suggestion made by Dr. Clerk, because the pressure seemed to keep constant for a long interval. As these suggestions could not account for the considerable loss in gas-pressure, Mr. Thornton suggested that the loss was caused by the forces of cohesion which came suddenly into play at the moment of the formation of a molecule; these forces would check the translational energy, to which pressure and temperature were alone due, and raise for the moment the rotational energy of the combining bodies.

The Humphrey Pump.

In the absence of Mr. Herbert A. Humphrey, M. Inst. C.E., an abstract of his paper on "The Humphrey Pump" was given by Professor Petavel. The paper explained the principle, theory, and construction of these remarkable pumps, and concluded with descriptions of the two most notable plants—the plant at the King George V. Reservoir at Chingford, Essex, where five pumps can each lift 40 million gallons of water per day 30 ft. high; and the big scheme now being carried out for the Egyptian Government at Mex, near Alexandria, where 10 (18 finally) pumps, each capable of delivering 100 million gallons of water per day through a lift of 20 ft., are to be installed, in order to drain Lake Mareotis. We have kept our readers fully acquainted with the characteristic features of the Humphrey pumps and plants.

Aviation Research.

A paper by Professor J. E. Petavel, F.R.S., of Manchester, on "Aviation Research," was the first brought before the section, and well deserved the first place; that we have not noticed it earlier in this report is because it did not well fit into any other spot, and because the time did not allow Professor Petavel to give what he had intended to give. Professor Petavel had prepared a long paper and many diagrams and tables. But he said, when called upon, he had been obliged to tear up his paper a few days ago, since the information it had contained could not now be made public. Under these circumstances, he confined himself to general remarks—a masterly exposition of the principles of aviation, which was listened to with the keenest interest; but naturally it was much in the nature of an abstract. When a surface was moved through the air, he pointed out, a certain pressure was to be overcome, and the propelling power required was smaller when the surface was curved than when plane. The distribution of the pressure over the wing was very irregular both for the upper and lower surfaces, as the three-dimensional models showed, and it changed with any change in the angle of flying; in the curved wing there was a forward reaction on the front part, whilst on the plane wing that component was small. The wing resistance was, however, only a part of the total resistance. In a badly-designed model the resistance at right angles to the stream was equal to the projected area of the part. Professor Petavel exhibited a stout wire, a cylindrical rod, about a foot long, a flat board, a disc, and a cigar-shaped model, which all offered the same total resistance. Struts, he said, should be made deep, and wires rather double than in loops; planes should not project at right angles to the motion. The strength of aircraft had much been increased of late, but quite abnormal stresses were set up when a machine was allowed to dive and suddenly turned into a horizontal path. As regards stability, all good modern machines were longitudinally stable, and would glide when the motor was stopped, because the centre of gravity was lying forward. Lateral stability was much more difficult to realise; but they had been very successful at Farnborough, and a machine could be left to itself at a speed of 50 miles per hour. At present aircraft was chiefly wanted by the Army and Navy; but a big country like Australia, where there was usually plenty of space for landing, should make a large use of flying-machines.

Professor Coker did not invite discussion; the subject would have been almost too vast, even if circumstances had permitted its discussion, he remarked.

Railways and Motive Power. Heavy Internal-Combustion Locomotives.

Turning to papers on mechanical propulsion, we first mention two papers, already published in our columns, by Professor W. E. Dalby, on "Railways and Motive Power" (see Engineering, September 4, page 317 *ante*)—compiled, he said, for the purpose of instituting a discussion—and by Mr. Hedley J. Thomson, of London, on "Transmission Systems for Heavy Internal-Combustion Engines" (see page 329 *ante*, September 11).

Metropolitan Electric Railways for Sydney.

Mr. J. J. C. Bradfield, M. Inst. C.E., chief engineer for metropolitan railway construction in the Public Works Department of Sydney, had prepared a comprehensive paper on the "Metropolitan Electric Railways Proposed for Sydney," a subject which has been dealt with by us in our issues of December 12 and May 16, 1913. As he was in England at the time of the Sydney meeting, Mr. Percy Allan, M. Inst. C.E., assistant to the Director-General, Public Works, Sydney, read his paper. The scheme, for which sanction is to be sought in this year's Parliamentary session, involves the construction of underground railways, the electrification of the suburban lines, and the construction of one or two bridges to link up the city, which is situated south of the magnificent bay, with the North Shore, where populous suburbs have risen, and also with the industrial western suburb of Balmain.

The outlay for the whole project, comprising the erection of a large electric power-station (already in the course of erection) is estimated at 17,000,000*l*. We should at once remark that the electric tramways, on which Sydney relies at present, are the property of the State of New South Wales, which is thus directly interested.

The first question which Mr. Bradfield discussed in his memoir was "bridges or subways?" Sydney, he pointed out, was already the fifth port of the Empire. During the year ended May, 1914, 20,214 vessels, aggregating 18,743,420 tons, entered and left the harbour. Not to obstruct the shipping, the bridges would have to cross on one clear span. Adopting gradients of 1 in 40 to the North side and of 1 in 30 to Balmain, a junction of the bridge railways to the underground system could be effected by giving the bridge a headway of 170 ft. at high water. The Australian Wireless Company and the Marconi Company of Australia considered this headway sufficient for radio-telegraphic installations on shipboard; in extreme cases telescopic masts could be adopted. The biggest steamer trading with Sydney, the Ceramic, had masts of 162 ft. above the load-line; the masts of the Imperator and the Aquitania rose to 210 ft. above water. The navigable depth in Sydney harbour was 40 ft., and could easily be increased to 60 ft.; the draught of the largest vessels now afloat was 35 ft., and 60 ft. would have to be provided above the tops of the subways if they were to be built; that would mean a road-level of the subway at 90 ft. below low-water line. The rocky shore favoured bridge construction, however, whilst the approaches to subways would be very difficult. There would not be any ventilation and drainage trouble with bridges, moreover, and bridge construction had indeed been decided upon by the Parliamentary Committee.

Mr. Bradfield then passed to the existing traffic. The Sydney Central Railway Station, completed in 1906, had been considered adequate for at least fifteen years; but 40,000 people had to be dealt with per hour during the busy time of the day, and the system already threatened to become unworkable. The number of tramway passengers carried in the years ended June, 1910 and 1913, had steadily increased from 201,000,000 to 294,455,452, at the rate of 14 per cent. annually. The area of Sydney had grown to 118,299 acres, and the popu-

lation to 725,400. The author then described in detail how the new underground railways would relieve the tram-lines, which were to serve as feeders for the underground. From Redfern (which is the first railway-station in Sydney on the main line to Melbourne) six parallel tracks were to run to the central station; there they were to divide into an eastern and a western branch, forming a loop round the city, to be equipped with six stations; some of these would be two-level stations. A speed of 25 miles per hour would enable the department to maintain a service of a minute and a-half on each of the three tracks. The eastern and western suburbs were to be served by an outer circle of double-track lines, mostly with open-air stations.

Four lines of track were to lead to the North Shore Bridge, starting underground and proceeding on steel viaducts and two-hinged braced arch spans. This point brought the author back to the bridges. The westerly bridge, he said, might start from Dawes Point to McMahon's Point; the distance would be 2250 ft., and it had yet to be demonstrated that it was practicable to build a heavy railway bridge of 2250 ft. clear span. The route Dawes Point to Milson's Point had hence been given preference; the length would be 1600 ft., and the cost only one-third of that of the longer bridge. As regards type, suspension or cantilever construction came into question. Assuming that the bridge was manufactured outside the State, a suspension bridge would be slightly cheaper, chiefly on account of the Federal tariff; all metal-work manufactured in the United Kingdom was subject to an import duty of 25 per cent. (from elsewhere of 30 per cent.), but the high-grade steel wire for the cables was exempt from duty. On the other hand, a cantilever bridge was more rigid and more suitable for heavy railway traffic, and the Committee had decided in its favour. Mr. Bradfield had submitted two designs of cantilever bridge; in design B the lower chord was curved, and the top chord sloping from the tower on straight lines, as in the Forth Bridge; in A the lower chord was almost horizontal, and the top chord curved; the former type was to cost 2,600,000*l.*, the latter 2,750,000*l.* Mr. Bradfield gave particulars of his scheme. Nickel steel was to be the chief material. The anchor arms were to be constructed on false-work, and the cantilever arms were then to be erected, the suspended span being also built from both sides by the cantilever method. A wind pressure of 50 lb. per sq. ft. was allowed for. The greatest wind velocity recorded at Sydney was 120 miles per hour (September 23, 1892), which corresponded to 72 lb. per sq. ft. on Trautwine's formula, whilst Eiffel's coefficient would give 43.2 lb. per sq. in.; at the new Quebec Bridge a wind pressure of 30 lb. per sq. ft. had been allowed for. Dealing with the difficulties of columns for large bridges and of subdivided panels, Mr. Bradfield proposed multiple intersection trusses, fairly common in Great Britain (but not in America), combined with a K bracing. The temperature range was large, the extreme temperatures observed at Sydney being 173.3 deg. and 24.0 deg. Fahr. The new power-house for the tramway-lines at White Bay, Balmain, would develop 100,000 horse-power and 120,000 horse-power for short periods; turbo-alternators were being installed, and the railways were to be worked on overhead circuits at 1500 volts continuous current.

During the discussion Professor W. H. Warren drew attention to the relative advantages of nickel steel and carbon steel, as to which Mr. Bradfield had remarked that the cost of the bridge construction might be reduced by 15 per cent. if carbon steel were preferred to nickel steel. These considerations, Professor Warren stated, had not been in the minds of the members of the Royal Commission who had reported that the tunnels were more suitable than the bridges. The Minister for Works, Mr. A. Griffith, added some complimentary remarks.

(*To be continued.*)

"The Magnet of Commerce."—We have received from the Great Central Railway a copy of a booklet having the above title. It contains illustrated information on the British coalfields, the figures of coal exports, the output and value of coal in 1912, data on coke manufacture, and the types of coke-ovens in use in this country. Particulars are also given concerning the facilities for dealing with coal supplies on the Great Central Railway system and at the Immingham Dock. These data, and information on the latter dock, will be found most useful for reference purposes.

LEAD, TIN, AND THE WAR.

There has been, in consequence of the war, considerable disturbance in the markets of these metals. The world's production of lead and tin during recent years has been as follows, in tons:—

—	1910.	1911.	1912.	1913.
Lead	1,127,000	1,136,000	1,181,800	1,186,700
Tin	114,800	117,600	124,700	128,900

During the last four years the increased production of lead has been 59,700 tons, and of tin 14,100 tons. There have been very marked fluctuations in the value of tin, and a tendency to decline from the very high prices of 1912. The prices of lead and tin during recent years have been as follow:—

—	Average, 1903-1913.	1912.	1913.
	£ s. d.	£ s. d.	£ s. d.
Lead, per ton	15 3 5	17 15 10	18 6 2½
Tin ,, ...	165 0 5	209 8 6	201 13 6

The world's production of raw lead has been obtained from the following sources:—487,000 tons were contributed by the United States, Mexico, and Canada; 116,000 tons came from Australia; and 574,000 tons from Europe. The European countries producing lead are Spain, with 203,000 tons; Germany, 181,000 tons; Austria, 24,000 tons; Belgium, 50,800 tons; Great Britain, 30,500 tons; France, 28,000 tons; and Italy, 21,700 tons. The consumption has been as follows:—

	Tons.
United States	401,300
Germany and Austria	259,000
Great Britain	191,400
France	107,600

The German-Austrian production is 54,000 tons less than their consumption, and there may consequently be a lead famine in those countries during the war, which may, however, be neutralised by Germany acquiring the Belgian output of 50,000 tons; the Italian output may also be sent into Germany. Of tin, half the world's production is obtained from the Straits Settlements, 65,640 tons; the tin produced in Europe is essentially derived from imported ores, the bulk of which is exported from Bolivia, and is smelted in England and Germany. The direct shipment of tin ore to Germany is, of course, now impossible. One-sixth of the world's output of tin is produced in Great Britain, a larger proportion than that of any other European country.

All exports of lead have been forbidden by the British Government, which has requisitioned all visible supplies, so that English consumers may be inconvenienced, until the demand may be supplied from, possibly, America. It is possible that the war may curtail the world's output by more than 200,000 tons. As the output of the countries affected by the war will probably be entirely consumed in the countries themselves, and as they are not now in a position to use much of the metal in arts and manufactures, it appears to be likely that the market value of lead will not be much affected by the probable curtailment of production. The export of lead from the United States is an important factor; it would appear from the following figures that unless the output there can be increased, we cannot expect to receive much larger supplies from America, as the home consumption there is steadily increasing:—

	Tons.
1913	54,300
1912	76,200
1911	113,300
1910	78,500

These figures show a remarkable falling-off in the quantities available for export. British imports of lead ore have been as follow during recent years:—

	Tons.	£
1909	15,542	120,540
1911	17,259	135,010
1913	18,453	184,930

and of pig and sheet lead:—

1909	207,660	2,705,000
1911	213,707	2,902,009
1913	204,136	3,718,000

The pig lead during 1913 was imported from Spain to the value of 1,424,000*l.*, from the United States to 443,000*l.*, and from Australia to the value of 1,308,000*l.* The value per ton, according to the above figures, was 13*l.* 0s. 6d. in 1909, and 18*l.* 7s. 2d. during 1913—an increase of 5*l.* 6s. 8d. Our imports of tin ore have during recent years been as follow:—

	Tons.	£
1909	24,086	1,621,000
1911	28,837	2,306,000
1913	34,592	3,308,000

About two-thirds came from Bolivia. The Bolivian output has increased from 29,400 tons in 1908 to 37,700 tons last year. The value per ton during 1909 was 67*l.* 6s. 5d., and during 1913, 95*l.* 13s. 2d., an increase in value of 28*l.* 6s. 9d. Our imports of tin in blocks, ingots, bars, and slabs have been as follow:—

	Tons.	£
1909	41,725	5,603,000
1911	45,906	8,739,000
1913	45,682	9,252,000

These came mainly from the United States, Russia, and the Straits Settlements. The value per ton during 1909 was 134*l.* 6s. 4d., and during 1913, 202*l.* 10s. 9d., an increase of 68*l.* 4s. 5d.

Argentine Prospects.—The grave political events which are affecting Europe are having their inevitable reflex on Argentine affairs. The altered economic conditions have had the result of causing all classes in the Republic to exercise rigid economy, and to adjust their means to prevailing circumstances. The prospects for the new harvest are considered to be good. In view of difficulties attending the export of coal from England, the Central Argentine Railway Company has considered it desirable to approach the Argentine Government, which has sanctioned, with a view to economy in the use of fuel, a modified passenger train service, as well as an augmentation of the time allowed for the transportation of merchandise. As a further economy, wood is being obtained at convenient points and used for fuel.

Aluminium-Foil.—According to a recent American Consular report from Switzerland, aluminium-foil is coming into considerable use to replace tin-foil for wrapping tobacco, confectionery, &c. The aluminium-foil, costing about 1s. 9½d. per lb., is about twice the price of tin-foil, but, being lighter, works out at about the same price for wrapping purposes, and is said to stand transport and handling without marking the goods. It is made by painting sheets of pure aluminium with a solution of oil, placing them one on another, or folding them, and then rolling them out to double their length. These are then folded and rolled again, and the process is continually repeated until the desired thinness is obtained. The rolls are water-heated to 113 deg. Fahr. The sheets are finally rolled cold, and annealed by heating in vacuum and cooling gradually.

Engineering Openings in Russia.—H.M. Consul-General at Moscow has forwarded a report received from a reliable source in regard to the machinery import trade of Russia, which contains a list of various classes of machinery which have hitherto been imported from various Continental countries, but which it is considered might now be replaced by British manufactures. It is stated that about fifteen years ago German machinery makers sent to Russia representatives who noted what had been supplied by English firms, copied some of the advantages, and proceeded to remedy defects which were pointed out by users, with the result that in a short time machinery was delivered from Germany which met users' requirements, and was delivered at Moscow at lower prices than English machines. All classes of machinery entering Russia have to pay duty by weight, and whilst English makers, with few exceptions, have practically ignored the *rôle* that weight plays when duty is imposed upon it, the Germans have attached importance to it. In many machines there are heavy, rough cast-iron and other parts which could be made in Russia at a price which would considerably reduce the total cost of the machine to the purchaser delivered at his mill or works. This is a phase in the machinery trade worthy of consideration by English producers of heavy, rough machinery who are desirous of entering the Russian market. With the development of municipal institutions in Russia it is asserted that there is a great field for contractors capable of installing water-works, gas-works, electric-light, and tramway plant, &c., but recently German firms have invariably obtained such contracts. One of the causes contributing to their success in this direction has been the ready way in which the German business houses have met purchasers in regard to terms of payment, &c.; this has been possible owing to the fact that the interests of various German makers have been so interwoven that they could obtain financial support where an isolated English supplier would fail. Moreover, whenever a big scheme has been under consideration, the German combines have had their representatives continually in touch with those who have had the placing of the orders, and by constantly assisting them, free of charge, to draw up specifications, these representatives have succeeded in getting specified just those classes, designs, models, and sizes which could only be obtained from German firms. British machinery manufacturers, who wish to obtain a share of the Russian orders hitherto placed in Germany, are urged to commence the necessary propaganda at once, and not to wait until the war has terminated. They should prepare their circulars in the Russian language, and cause them to be distributed to likely customers through reliable agents. The distribution of circulars in a haphazard way will do little good; they should be sent out by firms or individuals on the spot who know exactly who are the users of the machines described. The report in question may be inspected by United Kingdom machinery manufacturers at the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C.

A STANDARD IN REFRIGERATION.

*Report of the Refrigeration Research Committee of the Institution of Mechanical Engineers.**

(*Concluded from page* 520.)

APPENDIX II.

On the Quantities Involved in the Process of Refrigeration, and on the Analysis of the Process by Means of Diagrams, with Examples.

By Sir J. Alfred Ewing, K.C.B., F.R.S., Member.

1. A refrigerating process is carried out by certain changes of state on the part of a fluid which forms the working substance and acts as a vehicle for the conveyance of heat.

In general these changes are cyclic—that is to say, they bring the substance periodically to the same state. They include an alternate taking in of heat at a low temperature and giving out of heat at a higher temperature. In calculations relating to them it is convenient to deal with unit quantity of the substance (1 lb. or 1 kg.).

2. In any particular state of the substance there are certain definite functions of the state with which we are concerned—namely :—

The pressure, P
The temperature,* τ
The volume, V
The internal energy, E
The total heat, I
The entropy, ϕ

} These four are reckoned per unit quantity of the substance.

* In what follows τ is to be understood as the temperature on the absolute scale, the zero of which is taken as − 273 deg. Cent.

3. The total heat and the entropy are important because they supply very convenient means of representing the physical properties of the substance and the changes of state on which refrigeration depends, and of determining the refrigerating effect and the work which has to be expended in producing it. The internal energy is important because it is required as a step in understanding what is meant by the total heat.

4. The working substance may be in the condition of a liquid, or of a mixture of liquid and vapour, or of a saturated or superheated vapour. To specify completely its particular state at any instant it is sufficient to give either the pressure or the temperature, and one of the other four quantities named in this list. Thus if P and V are given, the state of the substance is fully defined, and the other quantities can be found, assuming that we have a sufficient experimental knowledge of its properties. Or we may specify the state by giving τ and ϕ or P and I. Or, again, it is sufficient to give ϕ and I: with these as data the corresponding pressure temperature and volume can be inferred, the properties of the substance being known. More generally, any two of the six quantities will serve as data for determining the state, except that the pressure and temperature do not suffice in cases where the substance may be partly in the condition of liquid and partly in that of vapour.

5. The working substance may change its state in various ways: thus it may take in heat either at constant volume or while expanding; it may expand or be compressed without taking in heat; the expansion may take place through a throttle-valve or under a piston. But in any change of state whatever the amount by which each of these six quantities is altered depends only on what the initial and final states are, and not on the particular process by which the change of state has been effected. In other words, all these quantities are functions of the actual state of the substance: they have definite values depending only on the state, and do not depend on the way in which that state has been reached.

6. There are other quantities, such as the heat taken in, or the work done, which depend on how the change of state has taken place. In dealing with them we have to distinguish between one process of change and another, even in cases where both processes may bring the substance from the same initial to the same final condition.

7. A broad distinction, which is of great importance, has to be drawn between processes which are reversible and those which are irreversible. If a substance expands quietly under a piston, the process is reversible, because, by reversing the motion of the piston, we can expend upon the substance the same work as it does on the piston while expanding and cause the heat (if any) which enters the substance during the expansion to leave it during the compression. In every respect, as regards work done and heat transferred, the process can be reversed. But if a substance expands by passing through a throttle-valve to a region of lower pressure where the kinetic energy of the stream and eddies is dissipated through internal friction, the process is irreversible. The motion of the stream and eddies cannot be reversed. To get the substance back again to the region of higher pressure would require an expenditure of more work than was done by the substance in its expansion; and if we were to force it back again, we should not restore it to its original state; we should find it warmer than at first in consequence of the heat that has been produced in the subsidence of the streaming and eddying motions.

8. No process of compression or expansion in a real cylinder is strictly reversible, but the condition of reversibility, which is approximated to in actual compressors, is to be taken as fulfilled in the ideal machine which we postulate for comparison with real machines.

9. Adiabatic expansion or compression means expansion or compression carried out reversibly and without allowing any heat to enter or leave the substance.

* Paper read before the Institution of Mechanical Engineers, October 16, 1914.

Isothermal expansion or compression means expansion or compression carried out reversibly and at constant temperature.

Expansion through a throttle-valve is not adiabatic, because it is not reversible, though it may be (and generally is) carried out without letting heat enter or leave the substance.

10. We now proceed to consider the meaning of the three quantities E, I, and ϕ. Think of a substance expanding in any manner, whether reversibly or irreversibly, taking in heat as it expands, and doing work in overcoming pressure which resists its expansion. It has a certain stock of internal energy to begin with, and this will change by the difference, if any, between the heat it takes in and the work it does. Thus, internal energy gained = heat taken in − work done, the words "by the substance" being understood throughout. This applies to any change of state whatever. It furnishes a means of measuring the change of internal energy due to the change of state, in whatever manner the change of state takes place.

11. We have no means of measuring the total stock of internal energy of a substance, and can deal only with changes in the stock. But it is convenient to assume some arbitrary starting point for the reckoning of E; and the convention adopted is to write E = 0 when the substance is in the liquid condition at a temperature of 0 deg. Cent. and a pressure equal to the vapour pressure corresponding to that temperature. We shall call this for brevity the zero state of the substance. Under this convention the values of E are negative at temperatures below 0 deg. Cent.

We have then for any other state :—

$$E = Q - A W,$$

where Q is the heat taken in while the substance is caused to pass by any process from the zero state to the state in question, W is the work done by it in the process, and A is the factor required to convert W into heat units. A is the reciprocal of "Joule's equivalent." E, for any state of the substance, is a definite number of thermal units, and its value is the same whatever stages the substance passes through on its way from the zero state. It is not directly used in calculations of the performance of refrigerating-machines, and we are therefore not concerned with the numerical values of E. But it is necessary to know the meaning of E in order to understand the definition which follows of the total heat I.

12. The total heat I is defined for any state of the substance by the equation :—

$$I = E + A P V,$$

where I, E, P, and V all relate to the same state.

It should be noticed that, in the zero state of the substance, I is not equal to zero, but to a small positive quantity depending on the volume of the liquid and the vapour pressure at that state. E is then zero, and I for the zero state is therefore equal to A P V, where P is the vapour pressure at 0 deg. Cent., and V is the volume of the liquid at 0 deg. Cent. and pressure P. In carbonic acid the value of I for the zero state is about 1 thermal unit; in ammonia and sulphurous acid it is much less.

13. When a substance is heated under constant pressure the change of I is equal to the heat taken in. For we have under all conditions, for any small change of state :—

$$d Q = d E + A P d V.$$

Hence, for a change during which P is constant,

$$Q = E_2 - E_1 + A P (V_2 - V_1),$$

where the suffix (1) refers to the initial state, and the suffix (2) to the final state.

This may be written :—

$$Q = E_2 + A P V_2 - (E_1 + A P V_1),$$

or

$$Q = I_2 - I_1.$$

14. It follows that while a liquid is being converted into vapour at constant pressure, I increases in proportion to the amount of vapour that is formed. If we write I′ for the total heat of the liquid before vapour begins to form, but at the temperature at which it will form under any given pressure, and I″ for the total heat of saturated vapour at that pressure, the heat taken in during the change from liquid to vapour (or what is commonly called the latent heat of the vapour) is I″ − I′. At any stage when the fraction vaporised is x, and the fraction still liquid is $1 - x$, the total heat of the mixture is :—

$$x I'' + (1 - x) I'.$$

After passing the expansion-valve of a refrigerating-machine the working substance is in the condition of a mixture of liquid with saturated vapour, to which this expression applies. It then evaporates in the refrigerator without alteration of pressure, and the rise of I during the process measures the heat taken in; the substance at the end of this evaporation is, in general, still a mixture of liquid and vapour, but with a much larger value of x.

15. It follows also that when a substance is being condensed under constant pressure, the change of I measures the heat given out. This applies to the whole cooling process which goes on in the condenser of a refrigerating-machine. Thus the whole heat which is given out as the substance passes, under constant pressure, from the condition of a superheated vapour to that of a liquid cooled below its temperature of condensation, is measured by the drop in the value of I from the condition on discharge from the compressor to the condition of the liquid just before the expansion-valve.

16. A further important property of the quantity I is that the change of I during adiabatic compression is equal to the work expended on the substance in the compression cylinder. To prove this, take the equation defining I and differentiate it :—

$$I = E + A P V,$$
$$d I = d E + A d (P V),$$
$$= d E + A P d V + A V d P.$$

But in any small change of state,

$$d E + A P d V = d Q,$$

where $d Q$ is the heat taken in.

Hence, in any small change of state,

$$d I = d Q + A V d P.$$

In an adiabatic operation $d Q = 0$, and

$$d I = A V d P,$$

from which

$$I_2 - I_1 = A \int_{V_1}^{V_2} V \, d P.$$

But the quantity under the sign of integration is the work expended in the compressor in taking in the substance when its volume is V_1, compressing it till its volume is V_2, and discharging it. It is the area of the indicator diagram (Fig. 1) for the complete compression process.

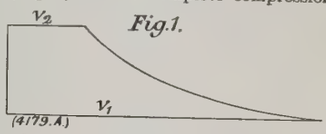


Fig.1.

Thus the change in I from the condition at suction to the condition at discharge measures the work of the compressor in the ideal process which is assumed to be adiabatic.

17. A third important property of I is this, that when a substance undergoes a throttling process, such as by passing an expansion-valve, there is no change in the value of I. To prove this we may think of what happens while a unit quantity of the substance passes through the valve, and to make the matter clear, imagine this unit quantity to be separated from the rest of the substance by two frictionless pistons, one of which (A) slides in the pipe that leads to the valve, and the other (B) in the pipe that leads away from it. On one side, as the substance comes up towards the valve, let its pressure be P_1, volume V_1, and internal energy E_1. On the other side, after passing the valve, let its pressure be P_2, its volume V_2, and its internal energy E_2. As each portion approaches the valve, work is done upon it by the substance behind pressing on the piston (A), and the amount of that work done while unit quantity is passing is $P_1 V_1$. After each portion has passed the valve it does work upon the substance in front by pressing on the piston (B), and the amount of that work is $P_2 V_2$ for the whole unit quantity. Since by assumption no heat is taken in or given out, any excess of the work done by the gas over the work done upon it must be supplied by a reduction in its stock of internal energy.* Hence :

$$A P_2 V_2 - A P_1 V_1 = E_1 - E_2,$$

from which

$$E_2 + A P_2 V_2 = E_1 + A P_1 V_1,$$

or

$$I_2 = I_1.$$

Thus the total heat I does not change as the substance passes the expansion-valve. The imaginary pistons were introduced only to make the reasoning more intelligible; the argument holds good whether they are there or not. Hence we might describe the quantity I as that property of a substance which does not change in a throttling process.

18. These three facts about I make it a particularly useful quantity in calculations of the theoretical performance of a refrigerating-machine. In the ideal cycle we have the working substance pass successively through the following states :—

Before compression it consists of saturated vapour at the low pressure of the evaporator, or more commonly it is a mixture of saturated vapour with a little liquid. Call this state *a*. The substance is compressed adiabatically to the pressure of the condenser, and the substance generally becomes somewhat superheated in the process. We then have a superheated vapour at the pressure of the condenser being discharged from the compressor (state *b*). This is now cooled till it begins to condense (state *c*) and is condensed in the condenser till it is completely liquid (state *d*). It is then cooled further to the temperature at which it reaches the expansion-valve, the whole operation going on at constant pressure. This brings it to state *e*, which is that of a liquid still at the pressure of the condenser, but cooled below the temperature of condensation. The substance next passes the expansion-valve, thereby reaching state *f*, in which it is a mixture of liquid and vapour at the pressure of the evaporator. It is then about to take up heat from the brine, or other thing that is to be cooled, by evaporation at that pressure. That evaporation completes the cycle, bringing the substance again to the initial state (*a*).

The change from (*f*) to (*a*) is the effective part of the whole process, when heat is being taken in by the working substance at the lower limit of temperature. The amount of that heat measures the refrigerating effect.

19. By considering the successive values of I in these stages, we can express very simply the quantities of heat and work involved in each part of the operation. For it follows from the properties of I, which have just been explained, that $I_b - I_a$ measures the work spent in the compressor, $I_b - I_e$ measures the heat rejected to the condenser and cooler. This is made up in general of

* It is assumed here that the velocity in the pipes is so small that no account need be taken of the kinetic energy of the substance as it approaches the valve or as it passes away.

three parts—namely, $I_b - I_c$, which is heat taken out of the superheated vapour before it begins to condense, $I_c - I_d$, which is the latent heat taken out during condensation, and $I_d - I_e$, which is the heat taken out of the liquid by cooling it after condensation. $I_f = I_e$, because there is no change of I in passing the expansion valve. $I_a - I_f$ measures the refrigerating effect.

The coefficient of performance, which is the ratio of the refrigerating effect to the work spent in the compressor, is :—

$$\frac{I_a - I_f}{I_b - I_a}.$$

20. The whole problem, therefore, of calculating the performance resolves itself into finding the total heat I at the various stages of the operation. For this purpose it is exceedingly convenient to have a chart exhibiting the properties of the substance, by means of which I at each stage can be readily found.

21. In order to draw such a chart we make use of another property of the substance—namely, its entropy ϕ.

For the present purpose it will suffice to define the entropy as follows: Imagine the substance to be taking in heat while it changes its state in a reversible manner. Let its absolute temperature be τ while a quantity of heat d Q is taken in. Then $\frac{d\,Q}{\tau}$ measures the increase of entropy. This increase of entropy is caused by taking in the heat d Q. Similarly, when the substance passes in a reversible manner from any one state to another, the whole increase of entropy :—

$$\phi_2 - \phi_1 = \int \frac{d\,Q}{\tau},$$

the integration being taken to include all the heat it receives in passing from the first state to the second.

22. It can be shown that the change of entropy as thus defined is the same whatever be the reversible process by which the substance passes from the first to the second state. The proof of this proposition will be found in any treatise on the thermodynamics of heat-engines, and need not be reproduced here. The proposition follows as an obvious conclusion from the fact, that in any reversible cycle, such as Carnot's, $\int \frac{d\,Q}{\tau}$ is equal to zero when taken throughout the complete cycle.

Thus the entropy ϕ is a definite function of the state of the substance. The numerical values of the entropy are reckoned from a standard state—namely, the zero state as already described in speaking of E (Art. 11), and the value of ϕ at that state is taken as zero.

23. In any reversible operation we have :—

$$d\,\phi = \frac{d\,Q}{\tau},$$

and therefore the heat taken in

$$Q = \int \tau\, d\phi.$$

Hence, if the operation be carried out at constant temperature, as in evaporation or condensation at constant pressure,

$$Q = \tau\,(\phi_2 - \phi_1).$$

24. In an adiabatic operation ϕ does not change. The entropy of a substance might therefore be defined as that property which does not change when the substance is compressed or expanded reversibly without taking in or giving out heat.

25. When a substance expands irreversibly, say by passing through a throttle-valve, its entropy is increased, although no heat is taken in. This applies to the expansion stage in the ordinary refrigerating process.

26. With regard to the numerical statement of the quantities E, I, and ϕ, it is to be noted that E and I both express a number of units of heat per unit quantity of the substance. The unit of heat itself involves the unit of mass. Consequently it makes no difference in the numbers which express E and I whether we use the kilogram or the pound as our unit of mass, provided in both cases we use the same scale of temperature. When heat is expressed in pound-degree-centigrade units we have the same numbers for E or I as when it is expressed in calories. But if British thermal units (based on the Fahrenheit degree) are used, the unit of heat is less for the same unit of mass, and the numbers expressing E or I are consequently increased in the ratio of 9 to 5.

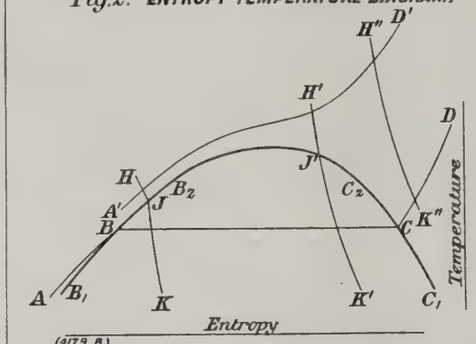
The numerical values of entropy are not affected by changing either the unit of mass or the size of the degree on which the unit of heat is based, for the size of the degree affects equally the numerator and the denominator in the expression for ϕ.

27. We are now in a position to consider how the properties of a working substance may be represented by means of a chart. This is done by taking as co-ordinates two of the six quantities named in Article 2, and drawing lines to show the relation between these during various imaginary operations involving changes of state. In general, the lines on the chart are drawn so that they show what occurs when the substance changes its state in such a manner as to keep another of the six quantities constant.

A familiar example is the chart which uses the entropy and the absolute temperature as co-ordinates. This chart has the valuable property that the area under any line which represents a reversible process measures the heat taken in or given out during that process (since $Q = \int \tau\, d\,\phi$, Art. 23), the area being measured down to the absolute zero of temperature. It follows that when any completely reversible cycle is represented on the chart, the area enclosed by lines representing the process will be a measure of the work done. But it is important to bear in mind that this is true only of reversible operations; if any part of the cycle is irreversible, as it is in the action of a refrigerating machine, the enclosed area is no longer a measure of the work done, nor is the area under any line that represents an irreversible operation a measure of the heat taken in.

The entropy temperature chart is usually formed by drawing lines which show the relation of entropy to temperature as the substance changes its state by taking in heat at constant pressure. These are called lines of constant pressure. Thus in the diagram, Fig. 2, if we start from any condition A, in which the substance is in the liquid state, and take in heat while the pressure is kept constant (as might be done by heating the substance in a vertical cylinder under a piston loaded with a constant weight), the entropy increases and the temperature rises till a point B is reached, at which vapour begins to form. Then heat continues to be taken in, but without further rise of temperature, till a point C is reached, at which all the substance is turned into saturated vapour. If the heating be continued, still at the same pressure, the vapour becomes superheated; the temperature and entropy increase together in the manner represented by the line C D. The whole heat taken in from the beginning of the operation is the area under the line A B C D, measured down to the absolute zero of temperature. The line A B C D is a line of constant pressure. If we carry out this experiment at various pressures, keeping the pressure constant in each case throughout the operation, we find that the locus of B is a curve such as $B_1\,B_2$, which marks the boundary between the liquid state and the state of mixed liquid and vapour. Similarly we find that the locus of C is a curve such as

Fig. 2. ENTROPY-TEMPERATURE DIAGRAM.



$C_1\,C_2$, which is the boundary separating the state of mixed liquid and vapour from the state in which the vapour is superheated. If these boundary curves are extended upwards by using higher and higher values of the pressure, they come together in a rounded top at what is called the critical temperature of the substance. The pressure at which this occurs is called the critical pressure. If we use a still higher pressure the whole operation of heating at constant pressure will occur outside of the boundary curves. It is represented in that case by a line such as A′ D′ in Fig. 2, which is a curve with no straight portion. The substance passes from the condition of liquid at A′ to that of gas at D′ in a continuous manner, and there is no stage at which it is made up of a mixture of liquid and vapour.

The sketch relates to carbonic acid. In the other substances used in refrigeration the working pressures lie much below the critical pressure, and we are consequently not concerned with the region above or near the critical point.

28. For practical purposes it is convenient to have an entropy-temperature chart with lines of constant pressure drawn upon it corresponding to a series of pressures differing from one another by definite amounts, and extending over the range in actual refrigeration. In a chart for carbonic acid this range extends from about 15 or 20 atmospheres up to 100 or 120, and as the critical pressure is about 75 atmospheres a large part of the diagram lies above that.

The value of the chart is much enhanced if a series of lines are also drawn on it corresponding to constant values of the total heat I. The form taken by such lines is illustrated in Fig. 2, where H J K is a line of constant total heat starting from a point H at which the substance is in the liquid condition. It is discontinuous at J, where it crosses the boundary curve. H′ J′ K′ is a line of constant total heat, part of which lies in the region of superheated vapour, and H″ K″ is one lying wholly in that region.

29. Lines of constant volume may also be drawn on the chart if desired. An example is sketched in Fig. 3, where M M, N N are lines of constant volume, extending from the region of mixed liquid and vapour into that of superheated vapour.

The same figure illustrates another useful addition to the chart. If the horizontal distances from one side to the other of the boundary curve (such as B C), each of which corresponds to the process of evaporation at some constant pressure, are all divided into a number of equal parts (say ten) and curves are drawn through the divisions, these curves represent lines of equal dryness: they indicate, where they cut each line of constant pressure, what fraction x of the mixture consists of vapour, for in the process of evaporation the entropy increases in direct proportion to the fraction evaporated, its increase being proportional to the heat taken in.

30. We may now consider how to represent on the entropy-temperature chart the complete operation of an ideal refrigerating machine, in the successive stages already mentioned in Article 18. The cycle may be considered to begin at a, Fig. 4, where we have a mixture of saturated vapour and liquid passing from the evaporator into the compressor. In this example the dryness of the mixture is taken as 0.9. The line $a\,b$ represents the process of adiabatic compression, the height of the point b being determined by drawing $a\,b$ vertically upwards till it meets the constant-pressure line corresponding to the pressure in the condenser. The substance is somewhat superheated at b. The next process consists in cooling at constant pressure; this is represented by the line $b\,e$, and is made up of three stages, in the first of which ($b\,c$) the superheated vapour is cooled

Fig. 3. ENTROPY-TEMPERATURE DIAGRAM WITH LINES OF EQUAL DRYNESS.

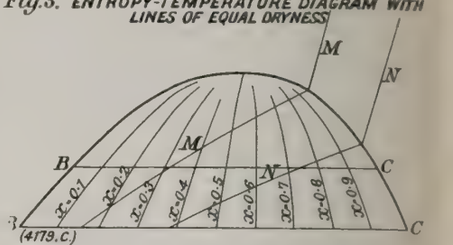
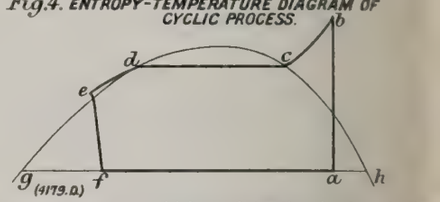


Fig. 4. ENTROPY-TEMPERATURE DIAGRAM OF CYCLIC PROCESS.



to the temperature at which condensation begins; in the second stage ($c\,d$) condensation takes place; and in the third stage ($d\,e$) the liquid is cooled before reaching the expansion-valve. In the next process the substance passes the expansion-valve. This is represented by the line $e\,f$, which is a line of constant total heat. It brings the substance into the condition of a mixture, consisting mainly of liquid. The proportion which is converted into vapour by passing the valve is determined by the position of f on the line $g\,h$, x_f being equal to $\frac{g\,f}{g\,h}$. Lastly, we have the process of effective evaporation, when the substance is extracting heat from the brine or other cold body by evaporating in the refrigerator; this is represented by the line $f\,a$, during which the dryness changes from x_f to x_a.

31. The heat taken in from the cold body is the area under the line $f\,a$, measured down to a base-line corresponding to the absolute zero of temperature. This may also be expressed as $(\phi_a - \phi_f)\,\tau$, or as $I_a - I_f$.

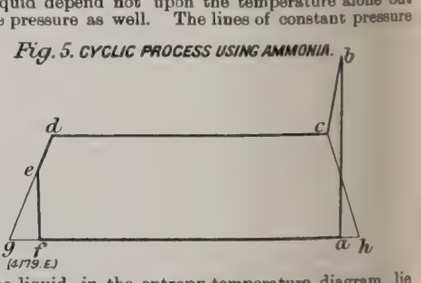
The heat rejected to the condenser and cooler is $I_b - I_e$. It is also equal to the area under the line $b\,c\,d\,e$ measured down to the absolute zero.

The work spent in the compressor is not the area of the closed figure $a\,b\,c\,d\,e\,f$ representing the complete cycle, for the step $e\,f$ is irreversible. The most convenient way to find it, when lines of constant total heat are drawn on the chart, is to read off the values of I at a and at b, and take the difference, the work spent being $I_b - I_a$. It may also be found as the difference between the heat rejected and the heat taken in—namely, the area under $b\,c\,d\,e$ minus the area under $f\,a$—both areas being measured down to the absolute zero.

It is essential in reckoning the heat taken in to know the position of the point f, and the only accurate way to determine that is to infer it from the fact that $I_f = I_e$. The proportion of vapour at f has to be such that the total heat of the mixture there, at the lower pressure (the pressure of the evaporator), is equal to the total heat of the liquid at the higher pressure, and at the temperature to which the substance has been cooled at e, before passing the expansion-valve.

32. In carbonic acid the volume of the liquid changes considerably with changes of pressure or temperature under such conditions as occur in refrigeration, because the substance is not far from its critical condition. In consequence of this the total heat and the entropy of the liquid depend not upon the temperature alone but on the pressure as well. The lines of constant pressure

Fig. 5. CYCLIC PROCESS USING AMMONIA.



for the liquid, in the entropy-temperature diagram, lie apart from one another, and from the boundary curve. But in the other substances employed in refrigeration, the volume of the liquid is so nearly constant for such pressures and temperatures as occur in practice that its variations need not be taken into account, and there is practically no difference in the heat required to warm

the liquid from one temperature to another whatever be the pressure or in the change of entropy produced by the operation. Hence the lines of constant pressure for the liquid practically coincide with one another and with the boundary line of the liquid state. The operation of heating or cooling the liquid, under any pressure, is accordingly represented by a movement up or down the boundary line. This applies to the diagrams for ammonia and sulphurous acid. A diagram for ammonia is sketched in Fig. 5, where the successive stages of the refrigerating cycle are distinguished by the same letters as before. The line $g\,d$ is part of the boundary line of the liquid, and the point e lies practically upon it. Thus though the actual pressure of the liquid at e is P_2, which is the pressure corresponding to the line $c\,d$, the total heat there is substantially the same as that which the liquid would have if it were at the same temperature and at a pressure equal to the vapour pressure for that temperature.

Call that I'_e. The total heat of the mixture at f may be written—

$$I' + x\,L,$$

where I' is the total heat of the liquid, and L the latent heat, at the lower limit of temperature corresponding to the line $g\,h$. Since there is no change of total heat in passing from e to f we may write—

$$I' + x\,L = I'_e,$$

from which

$$x = \frac{I'_e - I'}{L}.$$

Thus x may be found, and consequently the position of f, provided we have a table of values of the total heat of the liquid at various temperatures, and of the latent heat. This method can be resorted to in cases where lines of total heat are not drawn on the chart. But it applies only to substances in which e lies practically on the boundary line of the liquid, and therefore it does not apply to carbonic acid.

33. It will be clear that there is a very great advantage in having the values of I available for directly determining the quantities involved in a refrigerating process. For this purpose it is convenient to have them represented on a chart for all the conditions which the substance assumes during its operation. This consideration has led Dr. Mollier to invent another kind of chart* better suited than the entropy temperature chart for exhibiting the changes of I. He uses I itself as one of the two co-ordinates of the diagram, with the result that the heat taken in, the work spent, and the heat rejected are all three read off as lengths on the scale used in drawing the set of ordinates which represent I. For the other co-ordinate he uses the entropy, so that the process of adiabatic compression is still represented by a straight line parallel to one set of ordinates. The Mollier diagram, as it is commonly called, or ϕ I chart, is now recognised as an extraordinarily effective instrument for the study of problems in technical thermodynamics relating to heat-engines and to refrigeration.

Compared with the entropy-temperature chart, it possesses advantages which are especially conspicuous when it is applied to examine the action of an ideal refrigerating machine. Dr. Mollier, besides describing the method, has published a complete ϕ I chart for carbonic acid. This was reproduced in the author's book on "The Mechanical Production of Cold" (Cambridge University Press, 1908).

* R. Mollier, "Neue Diagramme zur technischen Wärmelehre," *Zeitschrift des Vereins Deutscher Ingenieure*, 1904.

34. To bring the diagram into a suitably compact form, Mollier uses co-ordinates for I and ϕ which, instead of being at right angles, are inclined to one another at a small angle, in the manner illustrated in Fig. 6. This gives lines of constant total heat running horizontally, and lines of constant entropy crossing them as shown. In Mollier's diagram for carbonic acid, the co-ordinates are inclined at an angle whose sine is one-fifth, with the

Fig.6. USE OF INCLINED CO-ORDINATES IN THE φI DIAGRAM (MOLLIER).

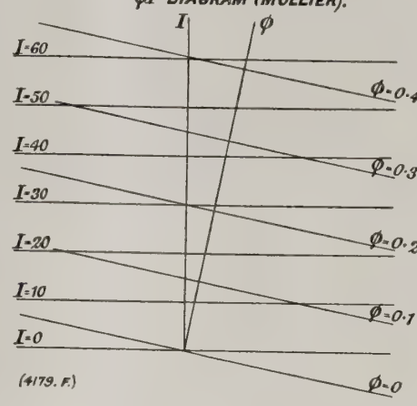
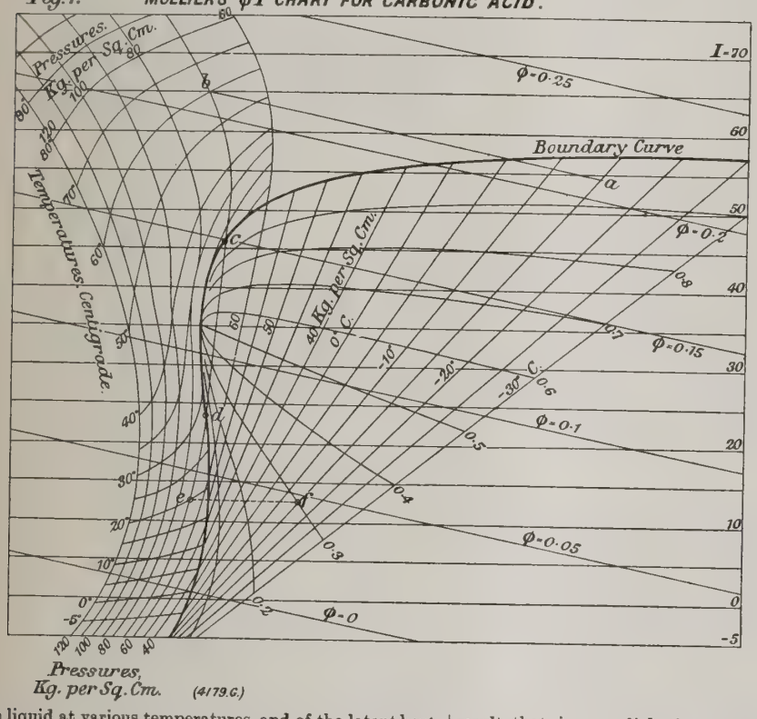


Fig.7. MOLLIER'S φI CHART FOR CARBONIC ACID.



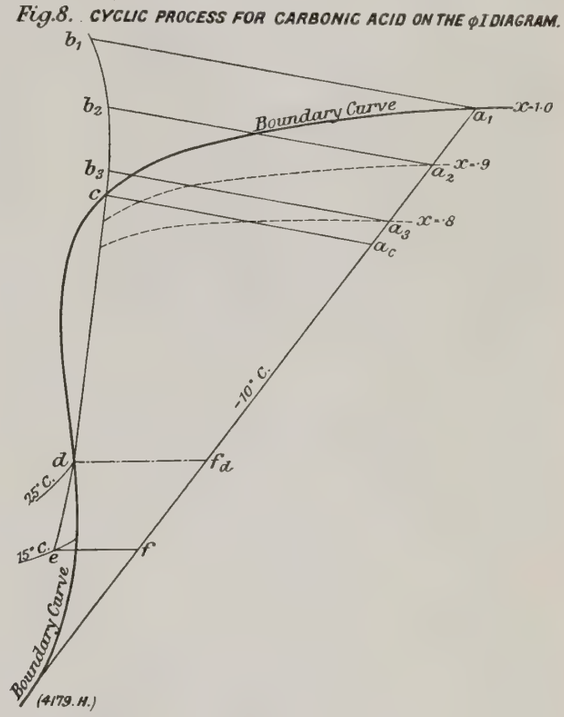
35. Any line which represents evaporation under constant pressure is straight, with a slope proportional to the absolute temperature, for in that process $d\,I = \tau\,d\,\phi$, and therefore the slope $\frac{d\,I}{d\,\phi}$ is equal to τ. Further, any point on such a line represents a mixture of vapour and liquid in the proportion of the segments measured from the beginning and end of the process of evaporation, just as in the entropy-temperature diagram, for the whole change of I which the line represents is the latent heat L, and the length from the beginning of the line up to any point corresponds to a proportional change of I, equal to x L. Hence lines of equal dryness can be drawn in the same manner as the entropy-temperature chart — by dividing the whole length of each evaporation line from one side to the other of the boundary, into a number of equal parts (say ten), and joining the points of division by curves.

36. To trace a refrigerating cycle on the Mollier chart, begin, as before, at a point a which represents the state of the substance when it is about to enter the compressor. The straight line $a\,b$ parallel to the lines of constant ϕ is the process of adiabatic compression. The position of b is determined by its intersecting a line of constant pressure corresponding to the known upper limit of pressure. The temperature reached in the process is seen from the position of b among the lines of constant temperature. Next we have the constant pressure process of cooling and condensation and further cooling, $b\,c\,d\,e$, e being fixed by the temperature to which the substance is known to be cooled before reaching the expansion-valve. Then a horizontal straight line through e (a line of constant total heat) represents the process of passing through the expansion-valve, and determines a point f on the evaporation line which exhibits the condition in which the substance enters the evaporator. The process of evaporation $f\,a$ completes the cycle. I_a, I_b, I_c, and I_f (which is the same as I_e) are read directly from the diagram. As already stated, the work done is $I_b - I_a$, and the refrigerating effect is $I_a - I_f$.

37. We may illustrate the use of the chart by some examples. Take, first, a case in which the working substance is carbonic acid, with −10 deg. Cent. as the temperature of evaporation, 25 deg. Cent. as the temperature of condensation, and 15 deg. Cent. as the temperature to which the substance is cooled before passing the expansion-valve. The diagram for the performance of an ideal machine under these conditions is sketched in Fig. 8, assuming various degrees of dryness at the beginning of the compression. If the substance is then entirely dry, the operation starts at a_1; namely, the end of the evaporation line for −10 deg. Cent., and compression brings it to b_1 which is on a line of constant pressure equal to the pressure of saturated vapour at 25 deg. Cent.; namely, 930 lb. per sq. in. But the vapour is considerably superheated at b_1, its temperature there (as the lines of constant temperature show) being 63 deg. Cent. The work spent in compression is most accurately found by reading off the length of the line $a_1\,b_1$ on a scale which makes that length a direct measure of the change of I. It is found to be 8.72.

We next trace the process of condensing and cooling

Fig.8. CYCLIC PROCESS FOR CARBONIC ACID ON THE φI DIAGRAM.



under the constant pressure of the condenser. From b_1 to c the gas is losing its superheat, from c to d it is being condensed, and from d to e it is being cooled as a liquid. The point e is found by the intersection of the line of constant pressure, under which the process is carried out, with the line of constant temperature for 15 deg. Cent. Next draw $e\,f$ parallel to the lines of constant total heat to meet the evaporation line for −10 deg. Cent. I_e or I_f is found to be 9 25. The refrigerating effect $I_{a1} - I_f$ is 47.92. The coefficient of performance is therefore 5.50. This cycle corresponds to completely dry compression.

38. Suppose, on the other hand, that the compression is just wet enough to avoid any superheating. In that case it must commence at a_c in order that the adiabatic line representing the compression may pass through c on the boundary curve. Then the work done in compression is smaller than before, for $a_c\,c$ is smaller than $a_1\,b_1$. The refrigerating effect is also smaller, for $f\,a_c$ is smaller than $f\,a_1$. The coefficient of performance is now found to be 5.54.

39. Between these two there is a certain degree of dryness which gives a slightly higher coefficient of performance than either. This may be shown by taking a succession of points for various degrees of dryness, such as a_1, a_2, a_3 as the starting-point of the cycle, and working out the coefficient of performance for each. But we may reach the same conclusion more directly thus:—

The refrigerating effect for these various degrees of dryness is proportional (on some scale) to the length $f\,a$. The work done is proportional (on another scale) to the length $a\,b$. Hence the position of b which will give the best coefficient of performance is that which gives the smallest ratio of $a\,b$ to $f\,a$. This is found by drawing a tangent from f to the line of constant pressure on which b lies. By applying this method in the present case it will be seen that the best coefficient is got by making x about 0.9; its value is 5.72. The vapour is then superheated at the end of compression to 33 deg. Cent.

40. Below are tabulated results for various values of x, the dryness at the beginning of compression :—

x.	Refrigerating Effect. $I_a - I_f$.	Work of Compression. $I_b - I_a$.	Coefficient of Performance.
1.0	47.92	8.72	5.50
0.95	44.86	7.97	5.63
0.9	41.80	7.31	5.72
0.85	38.74	6.79	5.71
0.8	35.68	6.32	5.65
0.76	33.24	6.00	5.54

By taking x equal to 0.76 we have the case shown by $a_c\, c$, when the vapour is just saturated at the end of the compression.

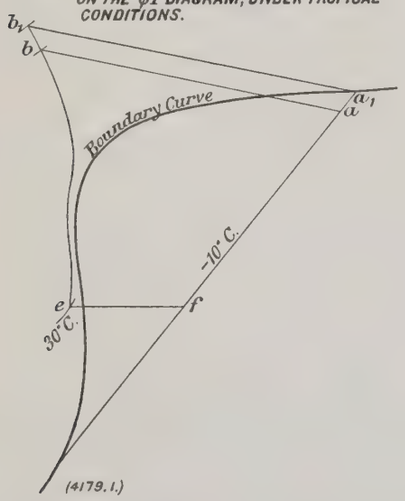
41. As another example take the same conditions as before, except that the condensed liquid, instead of being cooled to 15 deg. Cent. before expansion, reaches the valve at the temperature of condensation—namely, 25 deg. Cent. In that case, the process of expansion is $d\, f_d$, Fig. 8 (page 35), the rest of the cycle remaining as before. The following results are then found for various values of x :—

x.	Refrigerating Effect. $I_a - I_{f_d}$.	Work of Compression. $I_b - I_a$.	Coefficient of Performance.
1.0	38.07	8.72	4.37
0.95	35.01	7.97	4.39
0.9	31.95	7.31	4.37
0.85	28.89	6.79	4.26
0.8	25.83	6.32	4.09
0.76	23.39	6.00	3.90

The maximum coefficient of performance is got by making x about 0.95, as may also be seen by drawing a tangent from f_d to the line of constant pressure. Comparing its value, which is 4.39, with that in the previous example (5.72), we see what is lost by omitting to cool the condensed liquid before it passes the valve.

42. A further example will serve to illustrate the application of the Mollier diagram to carbonic acid working under tropical conditions, so that the higher limit of pressure is above the critical pressure of the substance. Still taking − 10 deg. Cent. as the temperature of evaporation, we shall suppose the pressure in the condenser to be 80 kg. per sq. cm. (or 1138 lb. per sq. in.), and the temperature to which the liquid is cooled before expansion to be 30 deg. Cent. With these data the diagram takes the form shown in Fig. 9, where $a_1\, b_1$ represents a process

Fig. 9. CYCLIC PROCESS FOR CARBONIC ACID ON THE φI DIAGRAM, UNDER TROPICAL CONDITIONS.



of completely dry compression, and $a\, b$ a process of compression in which the position of a has been so chosen as to give the maximum coefficient of performance. The line $a\, b$ consequently cuts the curve of constant pressure (for 80 kg. per sq. cm.) at the place where a tangent from f would meet that curve. The point e is determined by following the line of constant pressure till it cuts the line of temperature 30 deg. Cent. The maximum coefficient is obtained when x is about 0.95. Its value is 3.21, and under these conditions the vapour is superheated to 66 deg. Cent. at the end of compression. The following are the results in this case of varying the initial dryness :—

x.	Refrigerating Effect $I_a - I_f$.	Work of Compression $I_b - I_a$.	Coefficient of Performance.
1.0	36.67	11.16	3.20
0.95	32.61	10.17	3.21
0.9	29.55	9.26	3.19
0.85	26.49	8.45	3.14
0.8	23.43	7.72	3.04

In all these examples it is interesting, and practically important, to notice how little the coefficient of performance in the theoretical cycle is affected even by considerable changes in the dryness x.

43. The application of the Mollier diagram to ammonia is illustrated in Fig. 10 by an example referring to tropical conditions.* There, as in former examples, the temperature of evaporation is taken as − 10 deg. Cent. The substance is supposed to be condensed at 35 deg. Cent. (pressure, 197.3 lb. per sq. in.), and to remain at that temperature until it reaches the expansion-valve. The cycle is $a\, b\, c\, d\, f\, a$.

The following are results for various values of x :—

x.	Refrigerating Effect. $I_a - I_f$.	Work of Compression. $I_b - I_a$.	Coefficient of Performance.
1.0	261.6	54.5	4.80
0.95	246.0	49.0	5.02
0.9	230.4	45.4	5.07
0.85	214.9	42.5	5.06
0.8	199.3	39.8	5.01

Fig. 10. CYCLIC PROCESS FOR AMMONIA ON THE φI DIAGRAM.

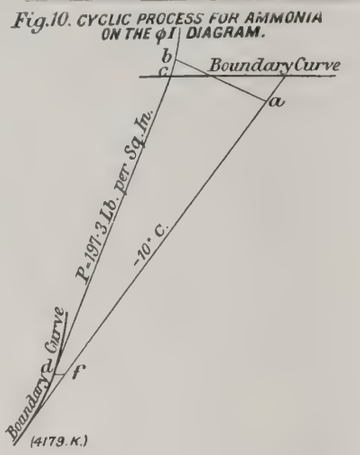


Fig. 11.

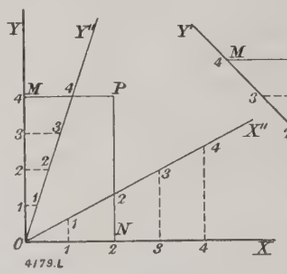


Fig. 12.

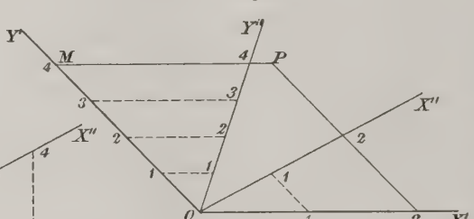


Fig. 13.

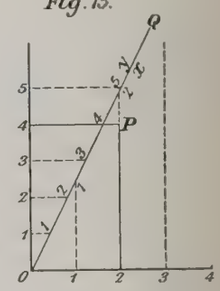


Fig. 14.

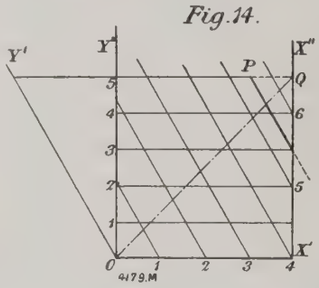


Fig. 15.

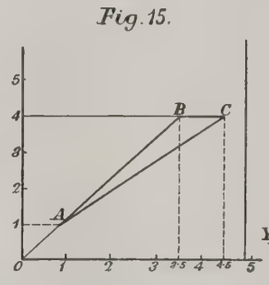
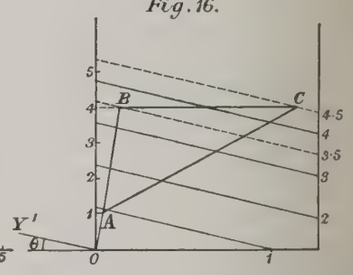


Fig. 16.



Here the maximum coefficient of performance (5.07) is reached with a value of x only very slightly greater than that which just gives wet compression. We may take the coefficient got by using wet compression, with b on the boundary curve, as practically equal to that maximum.

44. As a final example, take ammonia working in the same conditions as those that were assumed for carbonic acid in the first example—namely, an evaporation temperature of − 10 deg. Cent., a condensation temperature of 25 deg., and the liquid cooled to 15 deg. Cent. before passing the valve. We then have for various values of x :

x.	Refrigerating Effect.	Work of Compression.	Coefficient of Performance.
1.0	284.6	42.2	6.74
0.95	269.1	38.4	7.01
0.9	253.5	35.8	7.08
0.85	237.9	33.6	7.08
0.8	222.3	31.5	7.06

Here, again, we have very nearly the maximum coefficient with completely wet compression, for which $x = 0.91$.

45. These examples will serve to show that for ammonia (and the same thing is true of sulphurous acid) the maximum coefficient of ideal performance is found with all necessary accuracy by taking as the ideal cycle one in which the substance is just saturated at the end of compression. In other words, it suffices to take completely wet compression—namely, compression represented by an adiabatic line through c—for the purpose of finding the maximum coefficient.

Only for carbonic acid does any material improvement in the coefficient take place by taking a higher value of the initial dryness x in the ideal cycle. It is because carbonic acid is used under pressures not far removed from the critical pressure that it differs in this respect from the other two substances.

46. The method of finding x for the maximum coefficient has been explained in Article 39. It may be expressed in terms of the following rule, which is applicable to any substance :—

Mark a point f on the evaporation line to show the state of the substance on entering the evaporator. From f draw $f\, b$ tangent to the line of constant pressure for the condenser, meeting that line in b. Then the compression line $a\, b$ passing through b is the one which gives the maximum coefficient of performance in the ideal cycle.

This rule holds universally provided that a falls within the boundary curve, as it does under all such conditions as are met with in practice.

APPENDIX III.

A Note on Skew Co-ordinates and the Choice of Scales for φI Charts.

By Professor C. Frewen Jenkin, Member, of the University of Oxford.

Engineers who are not familiar with the use of skew co-ordinates may feel some doubt as to the interpretation of the three φI charts issued with this Report (see pages 517, 518, and 519 *ante*). The construction of diagrams with skew co-ordinates is explained in the following note, but it is not necessary for the user of the charts to understand their construction, because in all the ordinary calculations on refrigerating cycles the only quantities taken from the charts are values of the total heat I; these are read on the vertical I scale exactly as if the chart were drawn on ordinary squared paper.

The co-ordinates of the point P, Fig. 11, referred to the axes O X, O Y, are $x = P M$, $y = P N$, where P M and P N are drawn parallel to the axes O X and O Y. The magnitudes of the co-ordinates may be read conveniently on scales marked along the axes; thus $x = P M = O N = 2$; $y = P N = M O = 4$.

Exactly the same remarks apply to Fig. 12, where P is referred to the skew axes O X′ and O Y′. The co-ordinates P M and P N are drawn, as before, parallel to the axes.

The scales on which the magnitudes of the co-ordinates are read need not lie along the axes; for example, the y scale might be marked along any line O Y″, Figs. 11 and 12. If the scale along O Y″ be made the proper size, the intercept on it by the co-ordinate P M will give the same reading as the intercept on the axis O Y, Fig. 11, or O Y′, Fig. 12. Similarly, the scale for the x co-ordinate might be set off in any direction, such as O X″, Figs. 11 and 12. As a special case, both scales might be marked along the same line, as is done in Fig. 13, where the y scale is marked above and the x scale below the line O Q. A similar pair of scales along a single line might be used in the same way with skew co-ordinates.

Finally, it is not necessary that the scales should be marked along a straight line. For example, in Fig. 14 the x scale is marked partly along the axis O X′ and partly along a perpendicular to it, X′ X″. If this were not done in this figure, the x co-ordinate of such a point as P could not be read, because the foot N of the co-ordinate falls off the paper.

Generally the most convenient positions for the scales when skew co-ordinates are used are, one vertically on the left and one along the bottom and right-hand side, as in Fig. 14. Another position for the x scale which will extend to all points on the paper is along a diagonal, O Q,

* The data taken for the properties of ammonia are those given by Goodenough and Mosher, Bulletin No. 66, of the University of Illinois, 1913.

Fig. 14, but this position may interfere with other lines on the diagram.

It is necessary to remember, when the co-ordinates of any point on the diagram are being measured, that they are to be found by drawing parallels to the axes through the point to cut the scales, and that the axes are not necessarily the lines along which the scales are marked. For example, the co-ordinates of B in Fig. 16 are found by drawing a horizontal line through B to cut the vertical scale and an inclined line parallel to O Y′ to cut the right-hand scale ($y = 4$, $x = 3.5$).

The axis O Y′ need not be shown, if any line or lines are shown to indicate the direction in which the co-ordinate P N must be drawn; such lines are drawn in Fig. 14 through the x scale divisions 1, 2, 3, &c. If horizontal lines are also drawn through the y scale divisions 1, 2, 3, &c., the whole paper will be divided into a skew graticule, or network of parallels, corresponding to the squares on ordinary squared paper, Fig. 14.

The advantage of skew co-ordinates is that they enable the shape of curves or figures to be altered by shearing them sideways in a manner which is impossible with rectangular co-ordinates, whatever be the choice of scales. Such an alteration of shape may be used either to reduce the size of paper required to contain a given figure or to increase the scale to which the figure may be drawn in a given size of paper. For example, the triangle A B C, which is plotted as large as is possible with rectangular co-ordinates in Fig. 15, can be enlarged to the form shown in Fig. 16 by using skew co-ordinates, though the outside dimensions of the paper on which it is drawn are no larger. The line B C in Fig. 16 is made four times as long as in Fig. 15 by choosing the axis O Y′ inclined at an angle θ, such that

$$\tan\theta = \frac{1}{4-1}\frac{y}{x} = \frac{1}{3}\frac{y}{x},$$

where x and y are the co-ordinates of C. If the y scale is drawn vertically, as in Fig. 16, it remains the same size as in Fig. 15, but the x scale is four times as large in Fig. 16 as in Fig. 15.

For plotting ϕ I charts, which are more or less of the form of the triangle A B C, the advantages of skew co-ordinates are considerable, since the various curves are spread over a larger area (four times as large in Fig. 16 as in Fig. 15), so that they are more easily distinguished. The increase in the ϕ scale is not of much use, because the values of ϕ are not needed in any of the ordinary refrigeration problems.

The angle between the axes of skew co-ordinates should be chosen so as to keep the diagram as compact as possible when convenient scales are used vertically and horizontally. There is no advantage in choosing an angle containing a round number of degrees, or one having simple trigonometrical functions; the user of the chart is not concerned with the angle, but only with the scales.

The scales chosen for the three ϕ I charts issued with the Refrigeration Committee's Report are all simple multiples of inches, so that a rule divided in decimals of inches may be used to measure the co-ordinates vertically and horizontally. The co-ordinates of any point on a chart may be read to the nearest scale divisions by means of the graticule. To obtain the exact values it is necessary to measure in what proportion the point divides the distance between the two graticule lines on each side of it. To do this the direction in which the distances are measured is immaterial, so that any rule divided in decimals may be used by holding it at a suitable angle.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Canada: The Imperial Trade Correspondent at Toronto reports that a company has been formed in Ontario with a capital of 1,000,000 dols. (about 205,500*l*.) for the purpose of searching for and working deposits of natural gas, oil, salt, and minerals. With reference to the notice on page 7 of the *Board of Trade Journal* of October 1 last, relative to the construction of a concrete roadway between the cities of Toronto and Hamilton, the Imperial Trade Correspondent at Toronto has now forwarded the names of the members of the Toronto and Hamilton Highway Commission, as well as the name of the chief engineer.

New Zealand: The office of H.M. Trade Commissioner for New Zealand reports that the Westport Harbour Board has adopted a schedule of works which it is proposed to carry out within the next eighteen months at an estimated cost of 98,225*l*. These comprise extension of the western breakwater, 30,000*l*.; building new wharf, 30,000*l*.; wharf at floating-basin entrance to enable large vessels to swing, 10,800*l*.; dredging, 13,500*l*.; additional machines and tools for railway workshops at Westport, 1500*l*. United Kingdom firms interested should address any communications in this connection direct to the Secretary, Westport Harbour Board, Westport, N.Z.

Argentina: The *Boletin Oficial*, Buenos Aires, of September 11, contains a notice, issued by the Ministerio de Agricultura, authorising the Compañia Unida de Irrigacion del Chubut to carry out the necessary works for the utilisation of the waters of the Rio Chubut, up to 80,000 litres per second, for irrigation purposes. The *Boletin* of September 14 contains a decree approving the estimate of 131,385 pesos currency (about 11,500*l*.) submitted by the firm of Orenstein and Koppel (Arthur Koppel) for the provision of the metal work for a bridge over the Rio Dulce at Santiago del Estero. The material is to be delivered f.o.b. Buenos Aires within a period of twelve months from the date of the contract.

Netherlands: The *Nederlandsche Staatscourant* of October 9 publishes the text of an agreement between the Ministerie van Waterstaat and the steam-tramway company Oostelijk Groningen for the construction of light railways from Ter Apel to Delfzijl, *via* Winschoten, and from Blijham to Bellingwolde, under a system of subsidies from communal and provincial authorities.

Uruguay: The *Diario Oficial*, Montevideo, of September 22, reports that tenders are invited by the Montevideo Port Authorities for the supply of 50 wagons for the Port railway. Sealed tenders will be received, up to 3 p.m. on January 19, 1915, at the Secretariá del Consejo de Administración del Puerto, Calle Piedras 385, Montevideo, to which address application for further particulars should be made.

Japan: His Majesty's Commercial Attaché at Yokohama reports that there will probably be a considerable diminution in the number of new machinery orders placed by Japanese firms, as, owing to the war, the majority of plans for new companies and for the enlargement of existing companies have been postponed. Hitherto most of the pumping machinery in use in the Japanese mines has been of German make, and the mine-owners have not been able to judge the merits of British pumping machinery of this class. Consequently United Kingdom makers may now be able to benefit themselves in this direction.

Spain: The *Gaceta de Madrid* of October 15 contains a notice, issued by the Ministerio de Fomento, authorising Don Alejandro Arriola to carry out the necessary works for the utilisation of the waters of the Rio Bornoba, district of Villares de Jadraque, up to 2500 litres per second, for industrial purposes. Work is to be commenced within a period of six months from the date of the approval of the plans, and must be completed within three years.

CATALOGUES.

Oil-Cans, &c.—From Messrs. Joseph Kaye and Sons, Limited, of 93, High Holborn, W.C., we have received a copy of their latest catalogue of oil-cans, fillers, oil-bottles, torch-lamps, &c.

Artesian Wells and Pumping Plant.—Messrs. C. Isler and Co., Limited, of Artesian Works, Bear-lane, Southwark-street, S.E., have sent us a set of their catalogues, which have recently been revised and brought up to date. The catalogues deal respectively with driven tube-wells, well-boring plant, air-lift pumping plants, and deep-well pumps. An interesting pamphlet on water-supply and boring work in general was also included among them.

Drop-Forgings.—We have received from the Carron Company, of Carron, Stirlingshire, a catalogue illustrating a selection of their drop and hand forgings. The forgings include a great variety of spanners, crane-hooks, eye-bolts, swivel-eyes, eye-plates, ring-plates, crank-shafts, connecting-rods, hand-rail stanchions, bridges for manhole covers, turn-buckles, horn-cleats, &c., all of which are illustrated by reproductions of dimensioned sketches.

Turbine-Pumps.—We have received from Messrs. Mather and Platt, Limited, of Park Works, Newton Heath, Manchester, a copy of their latest catalogue of high-lift turbine-pumps. The catalogue describes the construction of these pumps, and then deals with the different types made. These include horizontal high-lift pumps, colliery and mining-pumps, sinking-pumps, single-chamber pumps, fire-pumps, hydraulic and boiler-feed pumps, automatically-operated pumps, well-pumps, and pumps for bore-holes. The catalogue is well printed and fully illustrated, and is altogether a very attractive and useful publication.

Rotary Pumps.—We have received from Mr. W. Carnegie, of 33 and 35, Charterhouse-square, E.C., a catalogue of Arnesen's patent rotary pumps, which are manufactured by M. Clausen, of Copenhagen. These pumps have no valves or springs, and can be used for heads up to 200 ft. and suction lifts up to 20 ft. They will pump all kinds of clean or dirty liquids, and have even been used to pump soft soap. The pumps consist of a cylindrical chamber containing an eccentric rotor with four radial vanes which are guided in circular slots concentric with the chamber; the tips of the vanes are thus kept close up to the inner surface of the chamber without being in actual contact. Several types and sizes are made with capacities ranging from 5 to 200 tons per hour. They are arranged either for belt driving or for direct coupling to electric motors or steam-engines.

Iron Cement.—The Smooth-On Manufacturing Company, of 572 to 574, Communipaw-avenue, Jersey City, N.J., U.S.A., have sent us a pamphlet giving instructions for the use of their well-known iron cements and compounds, and illustrating examples of their many applications. These include the repair of cracked and imperfect castings of all kinds, repairs to tanks and boilers, making flanged joints steam and water-tight, and other work of this description. Several different qualities are made, one of which is specially suitable for making tight joints in structural iron and steel-work, and setting glass in metal skylights and pavement lights. Another kind is used, either alone or mixed with Portland cement and sand, for making hard floorings, waterproofing walls, and other purposes. Other products of the company are a cement for setting and coating fire-bricks, and corrugated sheet-iron gaskets coated with Smooth-on cement for making all kinds of flanged joints. The London office of the company is at 8, White-street, Moorfields, E.C.

Producer-Gas.—The Power-Gas Corporation, Limited, of Parkfield Works, Stockton-on-Tees, have sent us two catalogues dealing respectively with Mond-gas plants and suction-gas plants. The Mond-gas plants are made, either with or without apparatus for the recovery of by-products, in units up to 30,000 horse-power or more. Non-recovery plants are made with capacities of from 100 horse-power, and by-product recovery plants from 500 horse-power upwards. As is well known, these plants are used for gasifying cheap bituminous coal, peat, lignite, brown coal, colliery refuse, wood, and other similar fuels, the gas being used either for power production or heating purposes. The pamphlet points out the essential features of a good producer, explains the advantages of the Mond producer, and mentions some of the applications of Mond gas. A long list of installations, several of which are illustrated, is also included. The other pamphlet deals in a similar manner with suction-producers and suction-pressure producers using anthracite, coke, or charcoal, as well as with special plants for use with semi-bituminous fuels.

Boiler Mountings and Valves.—A very comprehensive catalogue of boiler mountings and valves has lately been issued by Messrs. J. Hopkinson and Co., Limited, of Britannia Works, Huddersfield. The catalogue, which contains 341 pages bound in paper-covered boards with cloth back, is divided into thirteen sections. The first section contains general information relating to the firm's products, and deals particularly with the effect of superheated steam on various metals. Cast iron, it points out, "grows" and cracks when subjected to high temperatures, so that for high-pressure and superheated steam the firm make their valve-bodies and covers of cast steel; a new steel foundry has, we understand, recently been built for the purpose of making these castings. For the construction of valve-discs and seats, a specially hard, non-corrodible, and heat-resisting alloy, known as "Platnam" metal, is used. This metal has a coefficient of friction considerably lower than that of bronze, so that it is especially suitable for the purpose for which it is employed. The second section is occupied by standard specifications of mountings for Lancashire, dryback, Babcock and Wilcox, Stirling, and other boilers, while Section III. deals with safety-valves and relief-valves, giving particulars of low-water and high-pressure safety-valves, as well as of ordinary safety-valves of the dead-weight, spring, and weighted-lever types. The next section, relating to stop-valves, is especially complete. It deals with many types and patterns of valves for high and low-pressure service, with steam, air, and water, among them being included the well-known Hopkinson-Ferranti stop-valves, illustrated and described in Engineering, vol. lxxx,, page 851. We understand that about 15,000 valves of this type have been made up to the present time. Later sections give particulars of check-valves, injectors, water-lifters, blow-off valves, scum-valves, water-gauges and water-level recording accessories, pressure-gauges, syphons, gauge-cocks, isolating-valves, reducing and surplus-pressure valves, expansion-joints, steam-dryers, steam-traps, automatic exhaust-valves, plug-cocks, whistles, unions, thermometers, and many other fittings and accessories. It concludes with a general index to its contents, a code-word index, and an index of illustrations. The catalogue, which is very fully illustrated and most conveniently arranged, gives all necessary particulars except prices; it is, however, very fully coded to facilitate inquiries. The firm, in fact, seem to have spared neither trouble nor expense to make the catalogue as serviceable as possible to engineers, and we have no doubt that their clients will appreciate the result.

Oil in Palestine.—According to a correspondent in Jerusalem, quoted by the *Morning Post*, the American Standard Oil Company are constructing at great expense a road from Hebron to the Dead Sea. Two thousand men are said to be employed on the work, which is being carried out in connection with oil prospecting. The company are evidently satisfied that oil will be found. They are bringing out a large quantity of machinery and eight motor-trucks and automobiles by special steamer. The staff of the Pierson Company are prospecting on the east side of the Dead Sea, and appear equally hopeful of success.

The Prices of Scotch Steel and the War.—The last issue of the Madrid Journal *Revista Minera, Metalurgica y de Ingenieria* contains a paragraph reproduced from *Stahl und Eisen*, Düsseldorf, which says that "the Scotch steel works have increased the prices of their products from 7*l*. to 9*l*., there being at the present time no competition on the part of Germany." The paragraph in the German journal adds that "anxiety is felt in British shipping circles owing to the rise in price of ship-plates." The word "products" in the German journal has a certain saving vagueness, but it no doubt means ship-plates, judging from the context. Three pages further on, our Spanish contemporary gives the following quotations:—

	Oct. 1, 1914.	Sept. 24, 1914.	Oct. 2, 1913.
	£ s. d.	£ s. d.	£ s. d.
Ship-plates, Glasgow ..	7 2 6	7 2 6	7 7 6
Ship-plates, Middlesbrough	7 5 0	7 5 0	7 5 0

These quotations from our Spanish contemporary show that the prices have remained practically stationary. They agree in the main with the information we give every week in our Notes from the North and from Cleveland and the Northern Counties, and also with the diagrams of prices we publish monthly and quarterly. The paragraph in the German journal referred to calls to our mind the French saying: *Voilá comment on écrit l'histoire.* We have not received *Stahl und Eisen* and other German journals since the commencement of hostilities.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

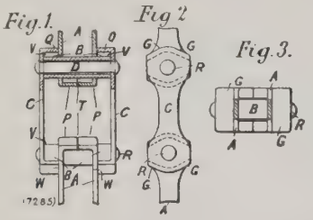
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

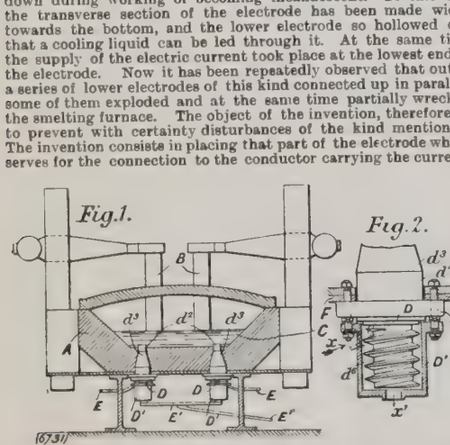
7285/14. C. G. Eden, and Hans Renold, Limited, Manchester. Internal-Combustion Engines. [15 *Figs.*] March 23, 1914.—This invention relates to driving-chains of the kind usually called "silent chains," particularly to comparatively narrow chains such as are used for driving the cam-shafts of internal-combustion engines. According to the present invention, a chain of the silent type, capable of gearing on one face only or on both faces, is built of inner and outer combinations, of which the inner combinations each consist of a pair of half-I links held together at each end by a single cylindrical bush, the said bushes extending outwards beyond the link-webs on each side thereof, whilst the outer combinations each consist of a pair of half-I links, one on each side of the inner combinations, held together by a couple of studs, one at each end of the links, the said studs passing through the bushes of the inner combinations and being riveted to the outer combinations. A, A are the half-I or channel-section links of the inner combination, which are held together by the bushes B, B, on to which they are forced until



they touch, as shown at T, either with their end projections P, P pointing towards one another or away from one another. The bushes extend outwards beyond the link side-faces on both sides of the inner combination, as shown at B, B. These elements are connected to form a chain by outer combinations consisting of half-I links C, C, placed one on each side of the inner combinations, with their end-projections Q, Q pointing inwards, as shown, and by the studs D, D, which may be riveted to the connecting-links, as shown at R. It is of great importance that the studs D, D should be firmly held where they are riveted. Either the edges of the end-projections Q, Q are suitably formed to work against the side-faces of the adjacent links, as shown at W, Fig. 1, or the edges of the bushes B, B are so formed, as shown at V, or both the edges of the end-projections Q, Q and of the bushes B, B are so formed, wherever relative motion of the edges and the side-faces can take place. It will be seen that practically the full width of the chain is available for providing bearing surface for the studs. The gearing faces are formed on the end-projections of the links, as shown at G. (*Accepted July* 22, 1914.)

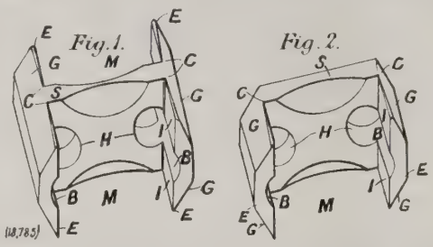
MINING, METALLURGY, & METAL-WORKING.

6731/14. Fried. Krupp Actiengesellschaft, Essen, Germany. Electrical Smelting Furnace. [2 *Figs.*] December 13, 1913.—In electrical smelting furnaces it is necessary, by artificial cooling, to prevent the lower electrodes melting down during working or becoming incandescent. To this end the transverse section of the electrode has been made wider towards the bottom, and the lower electrode so hollowed out that a cooling liquid can be led through it. At the same time the supply of the electric current took place at the lowest end of the electrode. Now it has been repeatedly observed that out of a series of lower electrodes of this kind connected up in parallel, some of them exploded and at the same time partially wrecked the smelting furnace. The object of the invention, therefore, is to prevent with certainty disturbances of the kind mentioned. The invention consists in placing that part of the electrode which serves for the connection to the conductor carrying the current,



between the part containing the cooling liquid and the head-piece of the electrode. In Fig. 1, A denotes the hearth of the smelting furnace; B the main electrodes which are suspended above the furnace and consist of carbon; C the charge; and D the lower electrodes of malleable iron which are built into the base of the smelting furnace and are arranged in a circle. Each of these electrodes is provided below the bottom of the furnace with a cooling-pot D^1. The corresponding inlet-pipes are denoted by E, the outlet-pipes by E^1. The body of the electrode has at its upper end a cylindrical head-piece d^2; next follows a conically widened out portion d^3, a cylindrical portion d^4, and a collar d^5. To this collar d^5 is connected the cooling-pot D^1 already mentioned. The cooling-pot surrounds, with a slight amount of clearance, the screw-threaded lower end d^6 (see Fig. 2) of the body of the electrode. The cooling liquid, which flows through the turns of the screw-thread in the direction indicated by the arrow *x*, comes into contact with a comparatively large part of the outer surface of the end d^6 of the electrode which is to be cooled down. Above the collar d^5 are bolted thereto bronze clamps F, through which the supply of the current is effected. The conical enlargement of the body of the electrode serves, in the subject matter of the invention, not only, as in the known electrodes, for the purpose of providing the necessary space for the cooling liquid, but it ensures at the same time that the current density in the body of the electrode becomes less and less towards the lower end. (*Accepted July* 15, 1914.)

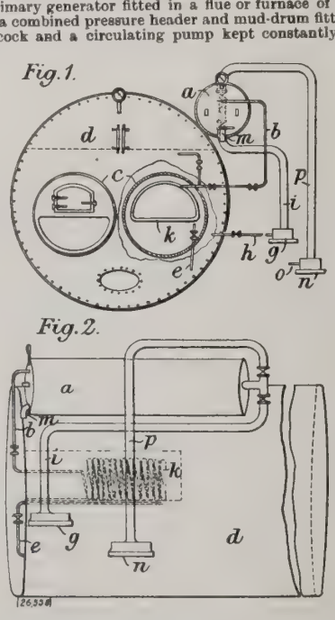
18,785/13. C. G. Renold, and Hans Renold, Limited, Manchester. Manufacture of Block-Links. [2 *Figs.*] August 19, 1913.—This invention relates to the manufacture of block-links, such as are described in the specification of application, No. 15,157, of 1913. These block-links are of I or half-I (channel) section in plan view, the stem of the I or half-I representing the web of the link, and the rest of the letter the lateral end-projections which provide the bearing surfaces for the stud and the gearing-faces for the teeth. All such I or half-I links are very conveniently made by the local case-hardening processes described in the specification of application No. 26,815, of 1912, and the present invention consists in the application of those local case-hardening processes to the manufacture of such links. This invention may be carried out in many ways. For example, one may begin by producing a block of steel of rectangular outline in plan-view and of almost the finished outline in side elevation, with the stud-holes in the proper places, as shown at H in the drawings, carbonise it all over, machine out the middle parts to leave the spaces marked M on each side of the I-links, or on one side of the half-I links, to change the outline in plan-view from a rectangle to an I or half I, as the case may be. Next, the inner



faces I of the lateral end-projections E may be brought to shape, and the carbonised parts that remain may be hardened by the usual heating and quenching or cooling. Finally, the gearing-faces G of the teeth may be ground to the proper size, shape, and position, this final grinding being, of course, very light, as it is necessary, probably, merely to correct the distortion due to hardening, and will remove so little metal that the finished surfaces are still thoroughly case-hardened. This would leave a hardened skin on the edges S of the links, as well as on the gearing-faces G, and on the bearing surfaces B of the stud-holes and grooves. In some cases it might be advisable to remove the carbonised metal, before the hardening operation, from the corners C, formed where the carbonised surfaces on the top and bottom of the gearing-faces of the tooth meet the carbonised skin at the top and bottom of the link, to prevent the possibility of a crack starting to form there. Another way of carrying out the invention would be to shape the links almost to finished size, then electro-plate or otherwise protect from the action of the carbonising means employed all parts of the link except the gearing-faces and the stud-holes, next carbonise and harden the link, and finally grind it slightly, as described in connection with the other process of manufacture, to bring it to a finished size and shape. (*Accepted July* 22, 1914.)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

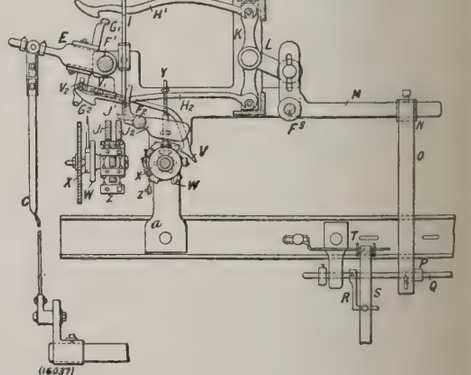
26,558/13. Edward Makin, Manchester. Steam-Generators. [2 *Figs.*] November 19, 1913.—This invention relates to steam generators of the type in which a primary generator is employed in the internally-fired flue or other flue or furnace of the boiler. The invention consists in the combination with a primary generator fitted in a flue or furnace of the main boiler, of a combined pressure header and mud-drum fitted with a blow-off cock and a circulating pump kept constantly working



to circulate the water from the boiler through the combined pressure header and mud-drum to the primary generator and back to the boiler, except when the circulation is reversed. *a* designates the pressure header or reservoir containing feed water maintained at any required degree of pressure, but always at a sufficient pressure in substantial excess of the boiler pressure, the feed-water reservoir supplying through the pipe *b* and similar pipes any number of D-coiled or similar primary generators *k* fixed in the flue *c* of a battery of boilers, of which the boiler *d* is one, and being placed in the most convenient position relatively to the boilers. In this arrangement each D coil *k* is supplied through the pipe *b* connected to one end, preferably the front end, of the coil, and the circuit of circulation of steam and water is completed by a connection through the pipe *e* from the D-coil to the water-space of the boiler, the pressure header or reservoir *a* being fitted with a pressure gauge, and the necessary valves and taps being supplied to regulate the feed and circulation. The primary generator *k* is fed with water taken from the bottom of the boiler through the pipe *h* by the circulating pump *g* or equivalent, and supplied through the pipe *i* and back-pressure valve to the pressure header *a*, and then by the pipe *b* to the generator *k* and back to the boiler by the pipe *e*, as already described. By this arrangement one circulating pump *g*, or equivalent, is able to supply feed water from the pressure header *a* for the battery of boilers, and the circulating pump is kept constantly working to circulate the water from the boiler through the combined pressure header and mud-drum to each primary generator and back to the boiler, except when fires are banked and the circulation is reversed. A second pump *n* or its equivalent is also provided which draws feed water through a pipe *o* from the source of supply. The water is pumped up as required through a pipe *p* and back-pressure valve, and so to the pressure header or reservoir *a*, where it mixes with the water circulated from the boiler. The pressure header *a* is converted into a mud-drum by providing it with a blow-off cock *m*, and in practice it is found that by having a continued and uninterrupted circulation of water from the boiler up into the pressure header *a* and back to the boiler through the generator *k*, that the formation of scale in the boiler and connections is prevented, and that the mud is deposited in the mud-drum and pressure header *a* in a very finely-divided or pulverulent condition, so much so that the sludge dries into a fine silky powder. This sludge is blown out through the blow-off cock *m* in the well-known manner when it is desired to clear the pressure header *a* of the mud. (*Accepted July* 8, 1914.)

TEXTILE MACHINERY.

16,037/13. I. Walton, Nelson. Looms. [1 *Fig.*] July 11, 1913.—This invention comprises a selvedge motion that will weave any kind of selvedge or lockstitch without any consideration of the weave in the body of the fabric. According to this invention, a lag-chain acts through feeler devices on hooks adapted to be engaged by draw-lugs to control the selvedge warps through suitable means. Fixed to the bottom shaft of the loom is an eccentric which gives motion to the rocking-lever E through the medium of the connecting-rod C. The small cross-head and bracket form a suitable means of fixing the rod C to the lever E. The lever E is fulcrumed at F^1. The two draw-lugs G^1 and G^2 are cast along with the L-shaped arms that are fixed to the lever E by set screws. A short slot permits adjustment if desired. The two hooks H^1 and H^2 are connected at one end to the baulk K by means of a stud which forms a joint. The loose ends of the hooks are designed to form catches to allow the hook H^1 to engage with the draw-lug G^1 when the feeler J^1 is lifted and the needle I lowered by a peg in the second-row holes in the pattern chain; also to allow the hook H^2 to engage with the draw-lug G^2 when the feeler J^2 is lifted by a peg in the first row of holes. When in their normal position, the hooks H^1 and H^2 are clear of the draw-lugs, the hook H^1 being held or supported at the loose end by the needle I which rests upon the feeler J^1 that is fulcrumed at F^2 and so balanced to support the weight of hook H^1. An extension of the feeler J^2 supports the hook H^2. The pattern is formed by small wood lags Z that are connected together by links and rings. Each lag is perforated by two holes, pegs being arranged to any given pattern in these holes to actuate



the feelers J^1 and J^2. The chain is passed round the cylinder, which has eight partitions. Cast along with the cylinder are the rack-wheel W and the star-wheel X. A spring-hammer Y rests upon the star-wheel and assists in keeping the cylinder in its correct position whilst the selection of hooks takes place. The cylinder receives its motion from the turning catch V, which is fixed to G^2 by the stud V^2 and the extension arm V^1. At each upward stroke of the lever E and outward stroke of the draw-lug G^2 the catch V draws the cylinder one-eighth of a revolution and presents a fresh lag to the feelers every two picks of the loom, and since the draw-lug G^1 is the first to act on each lag, this must always take the first pick when arranging the pegs in the lags. Blanks or no pegs on the pattern lags allow the hooks to remain in their normal position. Pegs placed in the lags actuate the feelers and allow the hooks to engage with the draw-lugs; thus a connection is made with the draw-lugs and the baulk K through the medium of the hooks H^1 and H^2. The link L connects the baulk to the bell-crank lifting-lever M which has its fulcrum at F^3. The bracket N can be adjusted along the lifting-lever M to give any desired leverage, whilst the slot in the short-arm of lever M provides another range of varied setting to suit the leverage desired. Fixed to the bracket N is a leather band O that is also connected to the finger P. This finger is fixed by means of a set screw to the rod Q that extends a short distance past each selvedge. Fixed also to the rod Q is a lifter R that is attached to the tape S, to which the selvedge harness is made fast. The small bobbin T, over which the tape S passes, prevents any excessive wear on the tape. A second tape is connected to the opposite ends of the harness. There are duplicate parts of R, S, and T for controlling the opposite selvedge. A spiral spring connected to the finger P draws back the selvedge healds to their normal position as the lever M is released. The mechanism being double-acting, an "open shed" is formed, and since the crank of lever E permits an equal movement of the draw-lugs, this gives an equal lift on both picks. (*Sealed October* 1, 1914.)

THE BRITISH ASSOCIATION IN AUSTRALIA.

(*Continued from page* 544.)

SECTION G.—ENGINEERING.

Australian Ports and Modern Shipping.

Mr. W. E. Adams, A.M. Inst. C.E., Principal Assistant Engineer to the Sydney Harbour Trust, presented a paper on "Australian Ports in Relation to Modern Ships and Shipping," of which we published a long abstract in our issue of September 18, page 356.

Mr. W. Reid Bell, of the Tasmanian Harbour Trust, had announced a paper on "Harbours," to be read at Melbourne, but was prevented from attending the meeting.

The Port of London.

Professor Dalby gave an abstract of a paper by Mr. C. R. S. Kirkpatrick, M. Inst. C.E., Chief Engineer to the Port of London Authority, on "The Port of London." With the aid of an excellent chart of the Thames below London Bridge, which Professor Dalby had sketched on the board, he was able to explain the main features of the big scheme in the few minutes at his disposal. Having emphasised the importance of the Port of London for Australia, and mentioned the most recent additions to the service, the new White Star liner Ceramic (18,600 tons) and the Aberdeen liner Euripides (15,050 tons)—which was praised by the members of the British Association whom it had brought over to Australia on its maiden trip—the author pointed out that, prior to the inauguration of the Port Authority, the docks had been in the hands of three independent companies: the London and India, the Millwall, and the Surrey Commercial, whilst the river had been administered by the Thames Conservancy Board. The fusion of these bodies had resulted in a more efficient and economical working, a general unification of policy, and a concentration of efforts on measures of supreme importance to the port. At the beginning of 1910, Mr. F. Palmer, then chief engineer, had drawn up a report on port improvements. The cost of the whole working was estimated at 14,500,000*l.*, and the project was subdivided into three heads or programmes, according to the degree of the urgency of the work. The primary or urgent programme, now being carried out, involved an expenditure of more than 5 million pounds.

This primary programme concerned mainly the river and the docks. The Thames was beset with shoals, but was free from anything of the nature of a bar. From the Nore up to Crayfordness the navigable channel was to be widened and deepened to 1000 ft. and 30 ft at low water; this work was practically completed up to Gravesend, opposite the Tilbury Docks. Up to the Albert Docks, 7 miles further up, the same depth was to be maintained, but the width was only to be 600 ft. The widths and depths further above were to be 600 ft., 500 ft., 450 ft., and 26 ft., 16 ft., and finally 14 ft, the last-mentioned figures referring to the reach Tower Bridge to London Bridge. This work would involve the removal of 20,000,000 cub. ft. of gravel, sand, chalk, and mud; the dredging plant comprised the suction-dredger Lord Desborough, raising 3500 tons of sand per hour, six bucket-dredgers (maximum bucket capacity 1 cubic yard), and 21 steam-hoppers for taking the spoil down to sea.

The docks consisted of five groups. The first, the Tilbury Docks, covered, with their three branches for the Bombay, Australian, and Atlantic passenger services, 54 acres; 138 acres were to be added; the main dock was to be extended to 3230 ft. by 600 ft., and involved an addition of 1600 ft. to the South Quay, and of three large transit sheds, 550 ft., 600 ft., and 650 ft. long and 120 ft. wide. The new quay-walls were founded on monoliths sunk to the ballast at a depth of 60 ft. below coping level. The ultimate extension would require a new entrance-lock, 1350 ft. by 130 ft., with 55 ft. of water over sills; the depth at high water of spring tides in the main and transit docks was 38 ft. Two new dry docks and a deep-water jetty for cargo-steamers were also under construction. The latter was designed as a double-decked structure, 1000 ft. by 50 ft., built of reinforced concrete, and was to be equipped with 3-ton electric cranes; the new river-side landing-stage for passengers was to be 1500 ft. by 80 ft.

At the Victoria and Albert Docks, the heart-centre of the docks, a very large development scheme was in progress. The water area, of 184 acres, was to be increased by 64 acres; the depth was to be 35 ft. (ultimately 38 ft.); access was to be afforded by an entrance-lock, 800 ft. by 100 ft., with 45 ft. of water below Trinity high water, over the sills. The new and old docks were to be connected by a passage, 100 ft. wide, spanned by a swing-bridge; but ultimately a still larger dock would be built north of the present site. An important feature of the present scheme was the provision on the south side of seven jetties for the transference of goods between ship and barge, without interfering with the direct discharge on to the dock quay. A graving-dock, 650 ft. long (ultimately to be 800 ft.), was being provided at the extreme inner end.

Similar improvements were planned for the next groups of docks, the East India system, which closely adjoined the West India, the Millwall and Surrey groups. New pumping plants, to give additional depth, were being installed at several of these docks. The improvements of the West India Docks, the pioneers of modern dock accommodation, dating from 1802, involved the re-opening of the old Limehouse Basin and Lock. No large dock works were projected for the Millwall Docks, where grain was chiefly handled, nor for the St. Katharine Docks, except for the wool storage. At the Surrey Docks there was ample area for further development; at the London Docks the chief urgent improvement was the enlargement of the entrance channels; a two-storey jetty, 783 ft. by 192 ft., was also being constructed there, the upper part to serve as a warehouse, the lower for transit. As regards other improvements in which Australia would particularly be interested, Mr. Kirkpatrick referred to cold storage, to grain in bulk, and to wool. The cold storage at Charterhouse-street, Smithfield, for a further 78,000 carcases of mutton, was nearly completed; the electric conveyors had a capacity of 650 carcases per hour. At the Albert Dock large new stores, a sorting-shed, and a refrigerating station were in course of construction. The sorting-shed formed the upper storey of a transit-shed, 1100 ft. by 123½ ft.; frozen produce was to be discharged directly into the insulated chamber on the upper floor, which was to be maintained at 15 deg. Fahr.; the different consignments were to be arranged either for immediate despatch or for transfer, by means of conveyor bridges, to the cold-storage warehouse behind. The cold store would be a building of six storeys, 300 ft. by 100 ft., 64 ft. high; the refrigerating station was to be equipped with ammonia machines; within two years the accommodation for frozen meat at the docks would be increased to 1,350,000 carcases. The additions to the means of dealing with grain in bulk comprised pneumatic elevators (capacity 100 tons per hour), fitted with turbo-exhausters instead of reciprocating engines, and suction-pipes to ships of any size. With respect to wool, the Port of London had last season handled more than 1½ million bales, considerably more than all the other ports of the United Kingdom put together. The floor space of the new warehouses at St. Katharine's Docks would amount to 26 acres, there being accommodation for exhibiting 40,000 bales of wool at a time.

During the discussion of this paper Professor Luigi Luiggi, of Rome, remarked that the London docks had remained behind; another speaker expressed this by saying that he had, some years ago, gone on board like Noah going on his Ark.

The Canberra Plan.

Mr. Walter B. Griffin, of Melbourne, read a paper entitled "The Canberra Plan," on the projected capital of the Commonwealth, Canberra, which is situated in the south-eastern portion of New South Wales, the site having been presented by that State to the Commonwealth. The paper dealt with economic rather than with engineering features, and might, perhaps, have been presented to Section F, Economics and Statistics, where two discussions on town-planning were held. When the Commonwealth decided upon building a special capital, competitive designs were invited, and Mr. Griffin, of Chicago, now living in Melbourne, was awarded the prize, and was appointed Federal Capital Director of Design and Construction. Mr. Griffin pointed out that architecture had failed in effecting co-ordination in town construction, and that the creation of an altogether new city in a new country like Australia enabled them to go back to homogeneity and to project a whole town on the lines on which new buildings and works were projected. The site offered many advantages. The general country level was 2000 ft. above sea-level; the Australian Alps formed a sunlit background; three local mounts, rising 700 ft. above the plain, afforded objective points of prospect to terminate great garden and water vistas; the hills of 200 ft. were appropriate for public buildings, and the Molonglo River and low grounds allowed of maintaining a water surface of 5 square miles. In classifying the purposes of the city he had proceeded from generals to particulars, and from the ends desired to the means for obtaining them. The scheme, which he outlined after having made extensive studies specially in America and Europe, looked very elaborate. It distinguished occupation and communication as main divisions of functions. The public groups of buildings, forming centres joined by avenues, were to comprise Government buildings (Capitol, courts), a recreation group (stadium, theatres), university, military, and municipal groups. The university buildings were to be arranged in concentric circles or arcs to house natural science, theoretical science and applied science, and derivative experimental sciences. Private groups of buildings were not to be designed on the gridiron plan, though some streets would intersect at right angles; the junction of the different centres would involve curved streets and radiating roads, but would avoid acute angles. Much industry was not desired in the capital. The circulation system was to be kept apart from the distribution system, the latter streets and lines to cut the former at right angles. Mr. Griffin explained his project by many views. Little had been done so far, and under the present conditions progress will probably be slow. Temporary arrangements would, of course, have to be adopted to a certain extent, and it is doubtful whether so detailed a project will admit of being carried out; some parts of a town, and departments of a university, *e g*, may develop strongly, and others languish. But Canberra certainly promises to become a picturesque, healthy, and pleasant city, which will be visited as demonstrating an instructive attempt of solving æsthetic and practical town-planning.

Irrigation.

The problems of irrigation were discussed in two meetings of Section G, at Melbourne and at Sydney, the latter being a joint meeting with Section M (Agriculture). The question is far less acute in Victoria and New South Wales, of course, than it is in West and South Australia and in Queensland; yet the subject is one of supreme importance for all Australia. Arriving in West Australia and South Australia, the visitors heard complaints about the drought, and when they returned, four weeks or more later, having meanwhile had rain in the Eastern States, the drought had not yet been broken, and the situation was very serious. Water is everywhere the property of the State, and as many rivers are common to several States, water rights are, or are to be, settled by the Commonwealth. Apart from a few big installations, not much has so far been done in large irrigation plants from rivers and lakes, and this is, perhaps, not altogether to be regretted, at any rate not in those districts where irrigation is less resorted to for the purpose of obviating drought and famine than for raising the value of land. The expense of the big schemes has so far been too high. But in many districts a water famine is an ever-threatening danger, and there sufficient water should be provided to keep man and beast alive. That can often be done by the aid of artesian wells; but the well water is not always palatable and suitable even for superior irrigation, and artesian wells can only be sunk under special geological conditions, where rainfall and hydraulic pressure can be made to force the water, which has perolated through the soil of a large area, out again at certain spots.

We do not abstract the papers quite in the order in which they were read, and we embody in the Australian papers also some notes from the guide-books and official publications presented to the visitors. The lengths of the communications generally limited the discussions to complimentary remarks.

Irrigation in Italy and Lybia.

The first of these papers, read by Professor Luigi Luiggi, of the University of Rome, M. Inst.

C.E., President of the Italian Society of Civil Engineers, on "Irrigation in Italy," was published *in extenso* in our issue of September 18, on pages 371 to 375. The communication was discussed by the Melbourne Professor of Engineering and local organising secretary, Mr. H. Payne, M. Inst. C.E., and by Dr. Elwood Mead and Mr. Dethridge, of the Irrigation Commission of Victoria, who agreed that the outlay for irrigation benefited the country; it was also to be regarded as an insurance against failures of crops.

Irrigation in Lybia.

In a second paper on "Irrigation in Lybia," Professor Luiggi referred to a country which, once famous for its fertility, had by neglect become almost desert-land. The neglect was not only due to Turkish misrule, to which Professor Luiggi alluded in his introduction; it began long before the advent of the Turks, in Roman days. The term "Lybia" was used in the official Italian sense, in order to designate Tripoli, Bengasi and Cyrenaica, countries in which the Italians, when they began the war against Turkey three years ago, practically found neither harbours, nor lighthouses, railways, or modern roads. Professor Luiggi briefly dwelt on these features and the general improvements adopted, and spoke especially of those concerning agriculture, as to which he had himself been consulted.

Tripolitania was for the most part a flat country, slightly elevated above the sea-level; all the rain fell during the winter, 20 in. near the coast, 10 in. near the table land, hardly any further inland. Yet owing to the abundance of sunshine, even in winter, good crops could be raised in March and April. Cyrenaica was an undulated plateau, 2500 ft. above sea-level, with a rainfall of from 15 in. to 30 in.; fruit trees, olives, cereals, &c., throve, provided they could be protected from the summer drought; matters hardly appear to have been as bad as painted.

Thus the future of Lybia, Professor Luiggi continued, largely depended on irrigation; the soil was very permeable; all the water passed rapidly into the subsoil, and had to be raised by wells. A very clever method, probably of Roman origin, was adopted to minimise evaporation. On the area to be irrigated palm trees were first grown, to serve as sun-shades for fruit trees planted underneath, which, in their turn, sheltered the lucerne, vegetables, &c., which were directly irrigated; the same plot hence yielded three crops. But the method was only applicable to limited zones, in which the underground water-level was not more than 20 ft. or 30 ft. below the ground. In other spots the rainfall had to be collected in reservoirs, and ruins of ancient Roman dams and cisterns were found in many places, and were now being restored. The new reservoirs were provided with rock-fill dams, which were simple to build and to repair, and which, with slopes of 1 in 2, would resist earthquake shocks.

A novel feature of these dams consisted in the automatic syphon spillways introduced by Mr. Gregotti. The syphon was generally a square tube of ferro-concrete, capable of discharging from 1 to 15 cub. m. per second. If larger discharges were required, up to ten syphons were placed side by side. The syphon was automatically primed as soon as the water-level exceeded the normal by 2 in. or 3 in., thanks to the shape of the lip; the velocity of discharge was due to the difference of level from the reservoir level down to the outlet, whilst in the ordinary spillway the head was limited below by the sill. The syphons were, moreover, less expensive in construction. In the Lago Lungo reservoir, near Genova, *e.g.*, the old overflow spillway required a head of 1.40 metres, and some 15 million cub. ft. had run to waste over the spillway after a storm. There a battery of ten syphons, with an internal cross-section of 1.90 m. square (6 ft. 4 in. square) and a working head of 5.75 m. (18⅞ ft.) had been provided, and at the same time the sill had been raised by 0.95 m. (3 ft.), so that an additional volume of 300,000 cub. m. (10½ million cub. ft.) could be impounded; that was a very important advantage. It was, moreover, proved that the syphons gave a discharge of 150 cub. m. per second when the water rose to 4 in. over the lip, which was 14 in. less than formerly with the spillway. A diagram of this type of syphon appeared on page 373 (Fig. 9), of our issue of September 18, where we published Professor Luiggi's first paper. The paper was illustrated by many diagrams, and when it was repeated before the Victorian Institute of Engineers' meeting, together with the Chambers of Commerce and Agriculture, Professor Luiggi also showed kinematograph films. In proposing a vote of thanks, Mr. L. A. Wade, Chairman of the Irrigation Commission of New South Wales, particularly dwelt upon the ingenious device adopted in Lybia for preventing evaporation; that device should more widely be known.

Nile River Floods, A.D. 641 to 1451

Mr. T. W. Keele, M. Inst. C.E., in presenting a paper on "An Investigation of Nile River Flood Records from A.D. 641 to 1451 for Traces of Periodicity," explained that his diagrams were interesting because they represented the longest continuous record in the world. The Egyptian records, which had recently become available, and which were trustworthy, after eliminating certain clerical errors in the Arabic, had been continued, apart from two breaks (a long one of 285 years and a shorter break of 25 years) up to the present year.

When taking up the study of the rainfall in the Commonwealth in a paper on "The Great Weather Cycle," published in 1910, Mr. Keele had suggested a period of 19 years. Subsequent analysis pointed to multiples of 19, $76 = 4 \times 19$, or $114 = 6 \times 19$, and $171 = 9 \times 19$ years, and these periods were obtained by plotting, not the rises and falls above or below an arithmetical mean, as was usually done, but by adopting a system which would show the cumulative effects of departures from the mean. When he had first brought this matter up, he had connected Halley's comet with the weather, and had been severely criticised for doing that. But from Mr. C. I. Merfield's investigation of the positions of the comet at the times of its perihelion, it would appear that in almost every one of the fourteen instances the comet had made its appearance during periods of great drought in Egypt.

Fertility of Lower Egypt and Cotton Growth.

We mention here two papers by Mr. H. T. Ferrar, M.A., F.G.S., of the Egyptian Survey Department, also read at this joint meeting. The first concerned "Two Maps Illustrating the Fertility of Lower Egypt," and it emphasised the important lesson that it is an economy to spend money on detailed mapping of a new country before launching on canalisation and drainage projects, which, if lacking in finality, might entail a greater outlay on remodelling than would have been needed for the original survey. The fine maps exhibited had been prepared by Mr. F. E. Frith and Mr. Ferrar to record the present condition of the land. The fertility of the soil in arid countries, Mr. Ferrar stated, depended chiefly on water supply and drainage; but with injudicious irrigation much salt might accumulate owing to evaporation, and thus a good deal of harm had been done in some parts of the United States, for instance. In Egypt the salt content of good land was only 0.3 per cent.; in barren, uncultivated land it might rise up to 20 per cent. The fertility also depended upon the relative level; the high ground was, on the whole, much more fertile than the low ground, as sea-level was approached. The level differences were generally small in Egypt; but there were drainage canals which were inefficient, because they did not closely follow the lowest parts of depressions between opposing elevations, and some ancient water channels had hence to be re-modelled.

The second paper, on "Some Factors Controlling the Growth of Cotton," dealt with temperature, water supply, soil, and labour as the chief factors. Sub-tropical climates were best suited for cotton-growing. At sowing time the temperature in Egypt was about 65 deg. Fahr.; it rose to 82 deg. and 83 deg. Fahr. as the plants attained maturity. The crops required an equivalent of an annual rainfall of 46 in., which was met by irrigation from perennial canals and by other means. The volume (or depth) of the soil was of more importance than its composition; cotton was grown on almost pure sand and on unctuous clay, and a high-water level might actually reduce the yield, because it limited the volume of available soil. Where the price of labour was high, the cultivation of the most valuable types of cotton proved most profitable. The East Coast of Australia, Mr. Ferrar concluded, seemed to provide the temperature and rainfall necessary for cotton cultivation; but widespread experiments would be required in the first instance.

Irrigation Dams and Hydro-Electric Power.

Mr. E. Kilburn Scott, in his paper on "Irrigation Dams and Hydro-Electric Power," which in the author's absence was read by Professor Petavel, dealt with another aspect of the irrigation problem. He described various plants, and he pointed out how the energy of the impounded water could best be utilised. The plants described comprised the San Roque Dam of the Cordova Light, Power and Traction Company, in Argentina, where 253,000,000 cubic metres of water were impounded in a lake basin larger than any in Europe; the drainage area was 520 square miles. Fifteen years ago a tunnel, 83 metres long, 8.5 square metres cross-section, was cut through granite at Bamba to connect two ends of a loop of the River Primero, flowing from this lake, and a fall of 31 metres was thus rendered available, driving seven McCormick turbines totalling 4000 kw. at 60 cycles and 700 volts. Two years ago a second power-house was built lower down the river, at Calera, where four turbines of Escher Wyss, each developing 1870 horse-power, were installed; a third power-house was projected. In California many hydro-electric power-stations were linked by an enormous network of bus-bars, and the irrigation water was gained by pumping, centrifugal pumps being installed in wells, 60 ft. deep, 1 mile apart, a 30-horse-power motor being able to irrigate 1 square mile of land.

Mr. Scott further referred to the Assouan Dam project, where alternators were to be installed, for which purpose he would recommend the project which Bláthy, of Messrs. Ganz and Co., Budapest, had worked out for an installation on the Danube, and also to suit Australian conditions, in particular the Trawool Dam scheme on the Goulburn River, 70 miles from Melbourne. In conjunction with Messrs. Crane, of Melbourne, he had schemed a plant eight years ago; a dam, 1800 ft. long and 180 ft. high, was to impound 70,000 million cub. ft. of water in a lake 60 ft. deep. Mr. Scott then passed to the utilisation of the hydraulic energy for the manufacture of nitric acid, nitrates, calcium carbide, cyanamide for electrolysis, making carborundum and graphite, melting concentrates, and other purposes. Phosphate rock could be ground, mixed with water, and furnace-gas passed through the mixture to render the phosphoric acid and also the lime soluble. In basic Bessemer slag the phosphorus was in the soluble state; in open-hearth slag (Talbot furnace) it could be made soluble by treatment with nitric acid. For countries like Australia the direct method of making fertilisers seemed on the whole preferable to the indirect cyanamide process.

Irrigation in Victoria.

Mr. J. H. Dethridge, already referred to, in a discourse on "Irrigation in Victoria," mentioned that irrigation had in their State been commenced in 1884, thirty years ago, in Mildura, where Messrs. Chaffey Brothers had obtained a concession for water from the River Murray; in 1887 the First Mildura Irrigation Trust had been founded. Other works had followed slowly on the Murray River, and artesian wells had also been started. The great difficulty of supply from rivers was the extreme irregularity of the available water. The snowfall in the Australian Alps (which rise above 7000 ft.) was unimportant; the rainfall fluctuated very much, as twenty-five years of careful observations taught them; it varied in different districts from 60 in. to 11 in. per year, and even in the case of the most regular of the rivers, the Goulburn, which joined the Murray, the fluctuations were very large. On that river the Goulburn scheme, the largest of the State works, was commenced in 1887; the weir had a length of 925 ft. and a height of 50 ft. The main western channel thence to the Waranga basin (which had an area of 20 sq. miles) had a length of 23 miles, widths of 131 ft. and 100 ft. (level and bottom), and a depth of 7 ft., the grade being 6 in. per mile. The wall of the Waranga basin had a thickness of 137 ft. at the base, and a width of crest of 8 ft., the water depth being 28 ft. The channel from Waranga to Serpentine Creek had a length of 92 miles. The recent Werribee scheme in the central southern part of the State provided water from the Bacchus Marsh to the Werribee Research Farm; there the walls had to be founded on tubular reinforced-concrete piling in alluvial soil. A new great scheme, probably the largest in

the world, was connected with Lake Victoria, situated across the border in New South Wales; there water would have to be raised 100 ft. by pumps. The custom was to supply water to users through water-meters, which, however, were not yet so accurate as gas-meters. The farmers were not very willing to take the water, as they had to pay whether they actually used the water or not. Since 1906 all State water works were vested in the State Rivers and Water Supply Commission, which had also taken over the control of irrigation lands previously vested in the Closer Settlement Board; under that Board a number of irrigable estates were bought from private owners, subdivided and settled, mainly from over-seas.

Irrigation in New South Wales.

Mr. L. A. Wade, M. Inst. C.E., in his paper on "Irrigation in New South Wales," said that the history of irrigation to the present time was the history of the evolution of the small farm unit from the large pastoral holding. Australia had, in its early years, been subject to the common law of Great Britain in regard to riparian rights; that law provided rather for drainage than for irrigation. The State of New South Wales had been the first to pass a Water Act, defining the rights of the Crown to the control of river and like water and irrigation. As the great river of Australia, the Murray, received its tributaries from Queensland (the Darling), New South Wales, and Victoria, and formed the boundary between the latter two States, finally to enter South Australia, all questions of water rights affected four States, and an inter-State agreement had not yet been arrived at, especially because the rainfalls of different parts were either monsoonal or antarctic, and the rains came in different seasons. Some big schemes had, however, been carried out. The biggest of these was the Murrumbidgee River scheme, which a committee had recommended in 1887. The task was, as in other cases, to take the water from the coastal district and table-land, which had a sufficient rainfall, to the plains which were less fortunate in that respect. A dam was constructed below the junction of the Murrumbidgee and Goodradigbee Rivers (tributaries of the Murray) across a narrow gorge near Burrinjuck; this dam hemmed in the water of a catchment area of 5000 square miles. It was one of the largest dams in existence. Completed, the wall, of cyclopean concrete, would be 236 ft. high; the present height was 200 ft.; the wall was 160 ft. thick at its base, and the water depth was 80 ft. The wall rested on an intrusion of red granite; the storage ground consisted of limestone and sandstone. The water liberated was taking twelve days to reach the irrigation area, 100 miles further west, at Berembed, through a winding channel (the Murrumbidgee river-bed) 200 miles long. The State development work had not proceeded very far yet; provision was being made for 7000 farmers possessing from two up to fifty acres each, and for a population of 100,000; the area of a farm might be 200 acres, but only fifty acres would be irrigated. At present 700 farmers had settled. The lessee had to be a *bonâ fide* resident on the farm, and rentals were at the rate of 2½ per cent. The State assisted the settlers in various ways, by charging half water rates for the first year, by building houses to be paid for within twelve years, &c.

One of the most notable features of the Australian Continent was the existence of the great artesian basin which covered a total area of 500,000 sq. miles, 327,000 sq. miles of which were within Queensland —the basin there had a width of 700 miles—and 102,400 sq. miles in South Australia. The water given by artesian wells was almost entirely rainfall, as the Government astronomer, H. C Russell, had first tried to prove in 1879 by showing that only 1.46 per cent. of the rainfall on the Darling River flowed down that river; this figure was wrong, but the idea was right. The deepest artesian well at Boronga had a depth of 4335 ft.; several hundred feet was the usual depth, and hence the water was warm. One bore had in 1893 given 1,900,000 gals. of water per day; but the yield had everywhere decreased, in the course of time, owing to the increase in the number of bores; the diminution was mostly over 70 per cent. in ten years. Nearly 400 bores had ceased to flow in six years, so that pumping had to be resorted to. Of 512 wells sunk in New South Wales, 44 had been failures. The water was distributed by systems of inexpensive drains, of which more than 5000 miles had been laid. Some 3000 bores were in existence, both public and private, by licence. The water was, as stated, warm; it was also strongly alkaline, containing carbonates (chiefly Na_2CO_3), and altogether 0.6 or 0.7 solid parts in 1000 parts; sometimes sodium chloride predominated. The salinity was not too strong for potable water, although occasionally sulphuretted hydrogen was likewise present; but the accumulation of alkali compounds was injurious to plant-growth, though it did not interfere with the soil merely wanted for stock-raising. A very peculiar feature was the corrosion of the steel casings and iron pipe linings of some artesian wells, notably at Coonamble. This corrosion, once set in, proceeded very rapidly, so that the casings collapsed. The destruction had been ascribed to the free carbonic acid (and oxygen) in the water; a remedy had not yet been found.

Professor Fawsitt, of Sydney, read a paper on this subject—"The Corrosion of Iron and Steel by Artesian Waters in New South Wales"—before Section B, Chemistry. We should add that some of our notes on artesian wells were taken from a contribution by Mr. E. F. Pittman, under this heading, to the "Hand-Book for New South Wales."

Turning to electrical papers, we should first notice the discussion on "Radiotelegraphy;" as this discussion was held in conjuction with Section A, in the rooms of A, we shall abstract when dealing with the proceedings of that section.

Electrification of the Atmosphere.

Sir Oliver Lodge, who opened this discussion, contributed to Section G notes on "The Artificial Electrification of the Atmosphere." He dwelt on the suggestions he had made in his Kelvin lecture before the Institution of Electrical Engineers last winter, on which we commented at the time; but he was not able to state that he had been offered any financial aid for starting the experiments on a very large scale, which the investigation of these, no doubt, very important problems would require.

The Capacity of Radiotelegraphic Antennæ

Professor G. W. O. Howe presented a mathematical paper "On the Capacity of Radiotelegraphic Antennæ," a subject which has not so far received much attention; the *Jahrbuch der Radiotelegraphie* contains a valuable contribution to the subject by Pedersen, who is associated with Poulsen in so many researches. When a straight wire was supported horizontally or vertically at a great distance from the earth, Professor Howe pointed out, and brought to a potential, the charge would not be uniformly distributed all over the wire, the density being greatest near the ends of the wire. The calculation of the capacity might greatly be facilitated, however, by the assumption of a uniform distribution which would not be possible in a continuous wire, but possible in a wire made up of short sections of, say, 1 cm. length, stuck end to end, but insulated from one another. The potential in such a wire would vary from point to point in a manner which could be calculated. If the sections were then assumed to be interconnected, electricity would flow from points of high potential to points of low potential until the potential was everywhere the same, and the assumption was made that the final uniform potential was equal to the average potential. This was not strictly correct, of course, but sufficiently correct for practical purposes. Applying this method to antennæ of various types, Professor Howe deduced formulæ and compiled tables from which the capacity of any antenna could be read off directly from its dimensions. He fully considered the corrections due to the leading-down wires and to the proximity of the earth; the effect of the latter was much greater in multiple-wire antennæ than in simple antennæ. Numerous examples had been worked out; the capacity of a single horizontal wire with vertical leading-down wires, *e.g.*, length 200 ft., radius 0.048 in., 100 ft. above the ground, was 483 microfarads, and if the proximity of the earth were neglected, 467 microfarads; ten parallel wires, of same radius, 600 ft. long, 4 ft. apart, at an elevation of 200 ft., would give a total capacity of 3.14 millifarads. Professor Howe did not mention measurements of his own. Referring to some measurements made by Louis Cohen last year, he pointed out that his formula was in better agreement with the measured value than Cohen's own formula.

Electricity in Coal-Mining.

Professor W. M. Thornton, D.Sc., D.Eng., gave a *résumé* of his recent researches on "The Limiting Conditions for the Safe Use of Electricity in Coal-Mining." The lower limit of inflammability of methane-air mixtures was 5.6 per cent. (by volume) of methane, or 5.1 per cent. at 200 deg. Cent.; the most inflammable mixtures were 8 per cent. for continuous-current break-sparks, and 10.2 per cent. mixtures for alternating-current sparks. The higher the frequency, the smaller the danger, 7 amperes at 40 periods, 16 at 60, 20 at 80, and 29 at 100 periods being equivalent to 1 ampere at 100 volts continuous. When the inductance was varied, the energy of an igniting break-spark was constant at 0.1 joule. Electric signal-bells, having inductances up to 0.5 henry, ignited gases. All electric lamps and fuses should be encased. Oscillations in a cable sheath, caused by short-circuits on the conductor, would not ignite gas, but maintained leakage arcs from armouring were slightly more active than break-sparks. Capacity sparks from cables left insulated after being charged were very active, 0.002 joule causing ignition. Static discharges from 6-in. belting at high speed would not ignite gas, nor would the blue brush discharge from high-tension conductors. Dust clouds in movements called forth electrification and sparks, but under experimental conditions at any rate the energy was too small to cause danger. Radio-telegraphic operations above ground did not induce sparking potentials below. The influence of the presence of gas in forwarding coal-dust explosions was noticeable when 0.5 per cent. of gas was present. Coal-dust alone could be ignited by break-flashes, requiring 3.5 to 6 amperes continuous at 480 volts in non-inductive circuits, and 14 amperes at 40 periods on a power factor of 0.8. As regards faults, continuous-current cables were rapidly disintegrated in the presence of moisture, while alternating-current faults were self-healing, and mechanical faults did not increase electrically on alternating-current cables. Armouring or protection of lighting and signalling circuits was necessary to prevent sparking; and though the limits of safety were electrically low, the risks of ignition were at present not greater than those attending the use of flame-safety lamps, and could be entirely prevented.

Australian Timber.

Professor W. H. Warren presented a long memoir on "Australian Timbers," which was taken as read owing to the stress of time. Professor Warren is an acknowledged authority on this subject, on which he lectured before the Society of Arts two years ago.

(*To be continued.*)

THE MANHATTAN BRIDGE, NEW YORK.

By Frank W. Skinner, Member of the American Society of Civil Engineers.

(*Concluded from page* 530.)

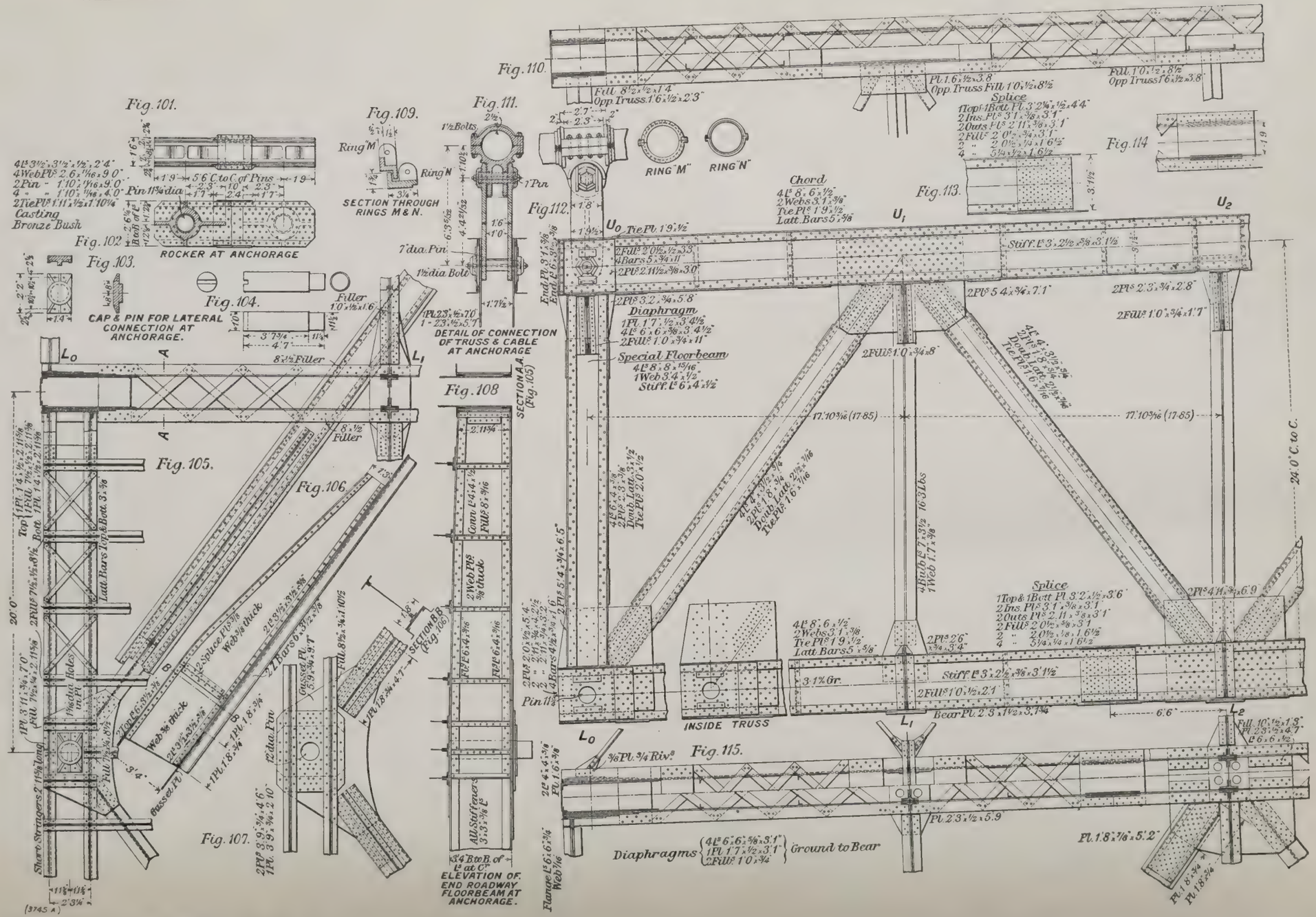
Design of Main Cables—(*concluded*).

Stiffening Trusses and Floors.—The stiffening trusses, of which a good general view is given in Fig. 5, Plate XXVIII., published with our issue of September 25 last, are 24 ft. deep on centres, are divided into 18 ft. 1-in. panels by I-shape verticals, made with a solid web-plate and four flange angles, and each panel is braced by a single diagonal member with a rectangular cross-section made of two built channels with 20-in. web-plates and 3½-in. by 3½-in. flange-angles, turned in and latticed. The chords are made of two built channels, 37-in. deep, with reinforced webs, and 8-in. by 6-in. flange-angles, latticed. The chords were shop-riveted in two-panel lengths, with all splices fully field-riveted. All joints at panel points, as well as all lateral, floor-beam, and stringer connections, were field-riveted. Details showing the construction of these girders are given in Figs. 101 to 115, on page 554, which show specifically the end bay of the girders, whilst a general section through them is illustrated in Fig. 116, page 555, further details being given in Figs. 117 to 123.

The trusses are suspended from the main cables at each panel-point by four parts of the suspender-rope, which pass symmetrically on both sides of the floor-beams, and terminate at their lower ends with sockets, 5¼ in. in diameter, threaded on their exterior surfaces to engage nuts with spherical bearings on thick concaved plates on the bottom flanges of the lower chords and end vertical posts.

The trusses are built chiefly of nickel steel with

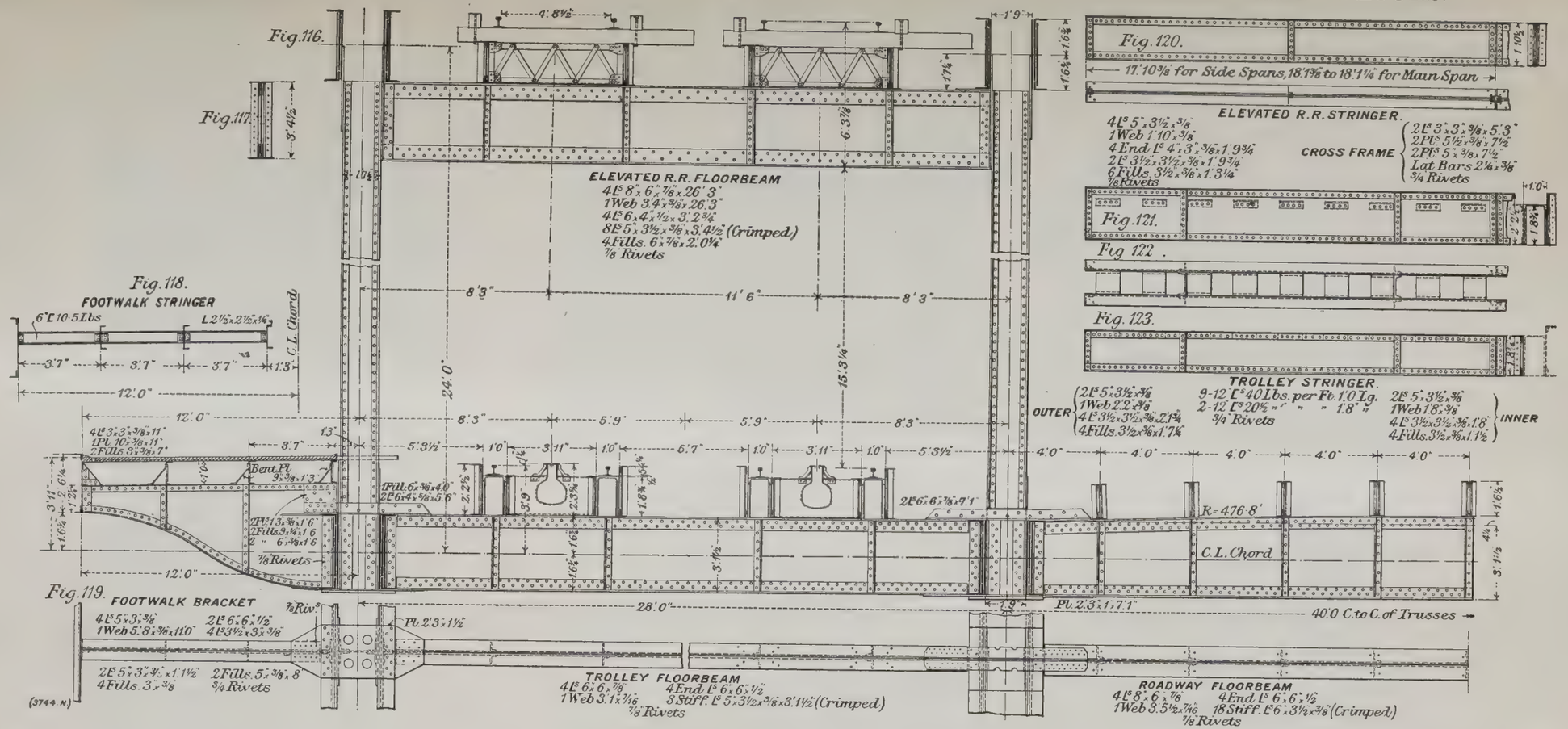
THE MANHATTAN BRIDGE, NEW YORK; DETAILS OF STIFFENING TRUSSES AND FLOORS.



nickel-steel rivets. The ultimate strength was specified to be 85,000 lb. to 95,000 lb., and the elastic limit 55,000 lb., whilst the elongation in 8 in. was required to be numerically equal to 1,600,000 lb. divided by the ultimate strength, and the reduction in area at point of fracture to be 40 per cent. The maximum tensile stress, 40,000 lb. per sq. in. : maximum compressive stress, 40,000 lb. $-(150\ L \div R)$; shear on rivets and bolts, 16,000 lb.

The trusses were proportioned to carry a congested live load of 16,000 lb. per lineal foot of bridge. The floor system was proportioned for live

THE MANHATTAN BRIDGE, NEW YORK; DETAILS OF STIFFENING TRUSSES AND FLOORS.



loads of two 52-ton motor-cars on 22-ft. wheel-bases on each elevated railroad track; a 26-ton load on a 10-ft. wheel-base, or a uniform load of 1800 lb. per lineal ft. on each street-car track; a 24-ton concentrated load and a uniform load of 100 lb. per sq. ft. on the roadway platform; and a distributed load of 100 lb. per sq. ft. on the side walks. A horizontal wind pressure of 2000 lb. per lineal foot of bridge was allowed.

The cross-section of the main and side spans is the same, and is symmetrical about the bridge axis. All four lines of trusses are connected by the lower floor beams, which are plate-girders 3 ft. 1½ in. deep, with the stringers seated on their top flanges. They were erected in three main sections spliced across the lower chords of the inner trusses. The ends are extended 12 ft. beyond centres of the outside trusses by plate-girder cantilevers (see Fig. 116, above) similarly spliced across the bottom chords of the outside trusses to carry the side walks. Each rail of the four street-car tracks on the lower deck is carried between two plate-girder stringers, 20 in. and 26 in. deep, and the roadway is carried on 18-in. stringers 4 ft. apart. The pair of trusses on each side of the bridge axis are connected, at panel points, by plate-girder floor-beams 40 in. deep, web-connected to the vertical posts, with their top flanges flush with the bottom flanges of the top chords. They carry on their top flanges four lines of elevated railroad plate-girder stringers 22 in. deep. The heaviest members in the suspended superstructure are the bottom chords, 36 ft. long, weighing 30,000 lb. each. The total weights of the suspended centre span and of both side spans are 9000 tons and 9700 tons respectively, and their total contract cost was about 2,000,000 dols.

Erection of Suspended Superstructure.—Three panels of the lower deck at each tower were erected by derrick-booms temporarily seated on the towers, which, also erected on the platform, thus provided, four movable and two stationary stiff-leg derricks at each tower and were themselves then removed. The stationary derricks hoisted the materials from lighters through holes left in the floor for that purpose, and delivered them to two lines of service cars running on the railroad beams in both directions from both towers on permanent tracks between the inner and outer trusses. The cars were pulled out away from the towers by cables operated by the hoisting-engines serving the stationary derricks and returned by gravity down the grade due to camber. At the towers the empty cars were hoisted 6 ft. clear of the tracks to clear the full cars going out on the same tracks.

The derricks were all installed on the lower floor, and erected it and the bottom chords, attaching the latter to the suspenders with temporary connections at alternate panel points as they advanced to the centre of the main spans and to the anchorage piers at their first trips. The derricks returned idle to the towers, and commencing their second round trip, completed the erection of the trusses going out, and erected the upper floors and transverse bracing, completing the structure as they returned.

After the derricks completed their first trips the permanent suspender connections were made at intermediate panel points and the adjacent temporary connections removed; after the erection of the top chords the connections at the alternate panel points were restored, permanently, and the camber accurately adjusted. Each derrick was operated by an independent steam hoisting-engine connected to the distribution mains from the central boiler plant. The erection was accomplished at the rate of about 300 tons per day by an average force of about 230 men. Riveting, on the web-splices of the bottom chords, was not commenced until the camber was adjusted, and was done with thirty gangs using pneumatic hammers, or by a pneumatic jaw-machine operated by air at 100 lb. pressure from a compressor plant at the Manhattan end. The four-men gangs drove each from 200 to 600 1-in. rivets in an eight-hour day, little or no field reaming or fitting being required.

Approach-Viaducts.—The approach-viaducts are essentially alike on both sides of the river, varying only in height and length of spans, and have the same dimensions and arrangement of floors as on the main spans. Their total lengths are about 1293 ft. and 1212 ft., on the Manhattan and Brooklyn sides respectively. Each has seven riveted spans from 126 ft. to 189 ft. long on centres. They have clearances of 16 ft. to 85 ft. above the ground, and are supported on masonry piers with arched openings in them. The viaduct steelwork cost erected 1,300,000 dols., the contract price for

THE MANHATTAN BRIDGE, NEW YORK.

Fig. 124. Approach-Girders with Tower Traveller for Erection.

the viaduct piers was about 900,000 dols. Each of the piers has two pairs of pyramidal granite towers connected by transverse arches and walls, and having separate concrete footings on the sandy soil above ground water level. The principal quantities involved in the completed viaducts on both sides of the river include 56,000 yards of excavation, 61,000 yards of fill, 20,000 yards of concrete masonry, 11,800 yards of granite masonry and 18,000 tons of steel.

On the Manhattan side the materials excavated from the pier foundation pits were shovelled into 1-yard steel buckets, hoisted, and dumped between the piers by derricks with 80-ft. 15-ton booms. Broken stone and sand were unloaded from barges by a 1-yard clam-shell bucket operated by a derrick boom, and dumped in hopper-bottom storage-bins, which delivered by gravity to 1½-yard bottom-dump steel buckets on wagons. The buckets and cement were drawn to the travelling concrete tower, which moved from pier to pier as the work progressed. They were hoisted by the spoil-derricks, and dumped into the charging-hopper in the top of the tower, whence they were fed to the mixing-machine, which, in turn, delivered the concrete to buckets, handled by the adjacent derricks to the piers.

On the Brooklyn side broken stone and sand were delivered by a clam-shell bucket from barges to a belt-conveyor, 200 ft. long, discharging into 500-yard storage-bins. The bins delivered by gravity to special side-dump measuring-cars on the surface of the ground, which were pushed a few feet by hand, and discharged their contents to a skip set in a pit, and also received the cement emptied by hand from bags. The skip was taken to the charging-hopper of the concrete-mixer by a trolley-hoist operated by the mixer engine, and moving about 35 ft. horizontally on an overhead Howe truss-bridge. The concrete was transferred about 1500 ft. from the mixer to the piers by wagons, which dumped it into scale-boxes handled by derricks, as much as 210 yards being thus handled in 10 hours. The superstructure of the viaducts on both sides of the river was erected by a 34-ft. by 40-ft. steel tower traveller (shown in Fig. 124, above), 53 ft. high, with four 50-ft. 20-ton booms, moving on the lower deck of the viaduct. The weight of the traveller and equipment, including four hoisting-engines, was about 80 tons; it was operated by a force of about 40 men, and erected a maximum amount of 217 tons of steel in one eight-hour day, usually unloading the pieces, weighing up to 29,000 lb. each, from wagons, and assembling them in position in a single operation. After erecting most of the viaduct on one side of the river, the traveller was moved to the opposite side, and erected the superstructure there.

The falsework consisted of vertical four-post bents calculated for 200-ton loads at every panel point, and framed together to make alternate towers and open panels. It was of novel design, made of interchangeable members with wooden compression pieces and steel tension pieces. The 14-in. by 14-in. vertical posts, and 8-in. by 8-in. and 6-in. by 8-in. horizontal struts were connected together, and to the ⅞-in. pin-connected sleeve-nut diagonal rods with pairs of steel angles bolted on. The falsework contained only about 350,000 ft. b.m. of timber, and after being used on one side of the river was re-erected on the opposite side, and after the completion of the job was in excellent condition for use on other work.

The bridge was designed and the construction supervised by the Department of Bridges of the City of New York. The original designs were made under Mr. J. L. Shea, commissioner, Mr. S. R. Probasco, chief engineer, and Mr. R. S Buck, engineer-in-charge. Afterwards Mr. Gustav Lindenthal, Mr. George E. Best, Mr. J. W. Stevenson, and Mr. K. L. Martin successively served as commissioner; Mr. O. F. Nichols, Mr. R. S. Buck, and Mr. Alexander Johnson served as consulting engineers; Mr. C. M. Ingersoll and Mr. Alexander Johnson served as chief engineers; Mr. H. A. Lachicotte, Mr. Holton D. Robinson, Mr. J. A. Knighton, Mr. D. E. Baxter and Mr. A. I. Perry were principal assistant engineers; and Messrs. Canère and Hastings were consulting architects.

The principal contracts were awarded to Mr. J. C. Rodgers for the tower piers and caissons, to the Kosmos Engineering Company and to the Williams Contracting Company for the anchorage piers; to Ryan and Parker for the steel superstructure; to Mr. J. C. Rodgers for the viaduct substructures; and sub-contracts to the Glyndon Contracting Company for the cable-making; to the Terry and Tench Company for the erection of the steel towers and main spans; and to Oscar Daniels for the erection of the approaches. After the main spans had reached an advanced stage of construction an expert report was made on them by Mr. Ralph Modjeski, who found that the entire structure was well designed and well made of good materials. The foundations of the tower piers show total settlements of about ¼ in. and ½ in., and those of the anchorage piers of $1\frac{13}{16}$ in., and a horizontal displacement of 1 in. maximum at the top. The foundation ordinary pressures are about 7 tons per square foot, and 6.7 tons to 8.7 tons per pile. The towers and cables have a large margin of safety. The stresses in the stiffening trusses were found by Mr. Modjeski to correspond with the designer's computations, the floors and lateral systems were of ample strength, and the details and connections were in accordance with practice and in good harmony with the structure.

2-10-2 TYPE LOCOMOTIVES FOR HEAVY FREIGHT SERVICE.

The single expansion, non-articulated locomotive, has reached its highest development in weight and hauling capacity, in the 2-10-2 type. Locomotives with this wheel arrangement are now being intro-

RECENT 2–10–2 TYPE LOCOMOTIVES FOR HEAVY FREIGHT SERVICE.

CONSTRUCTED BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA., U.S.A.

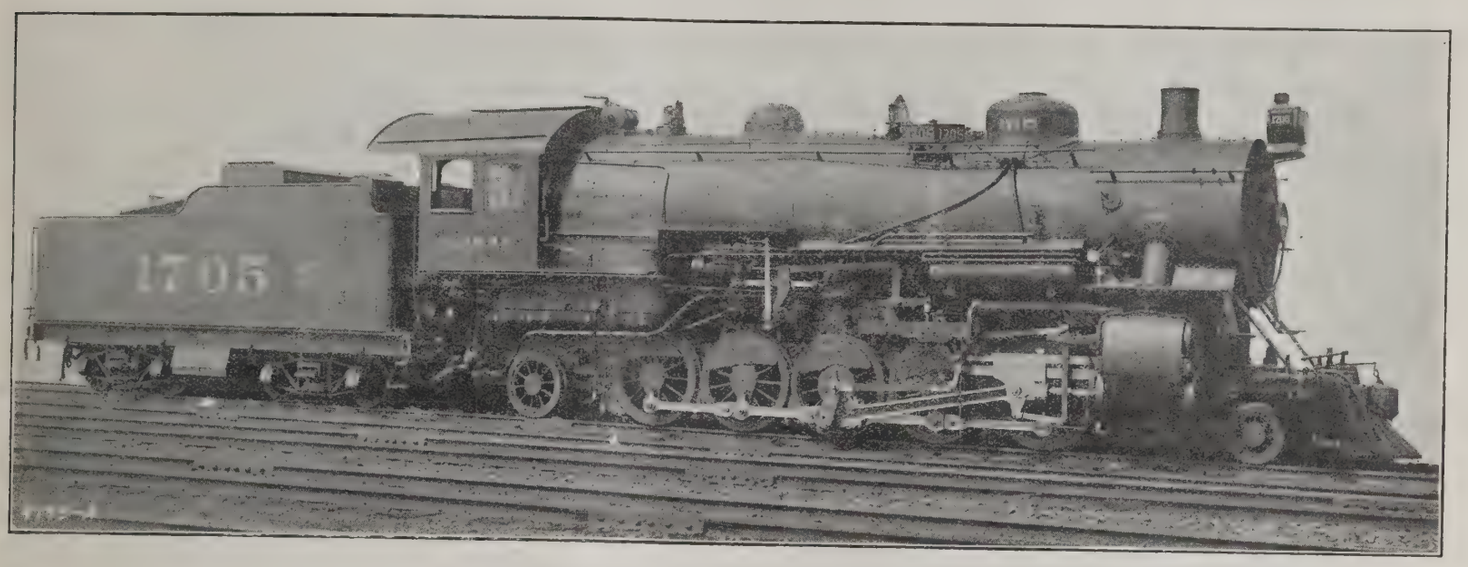


FIG. 1. LOCOMOTIVE ON THE ATCHISON, TOPEKA AND SANTE FE RAILROAD.

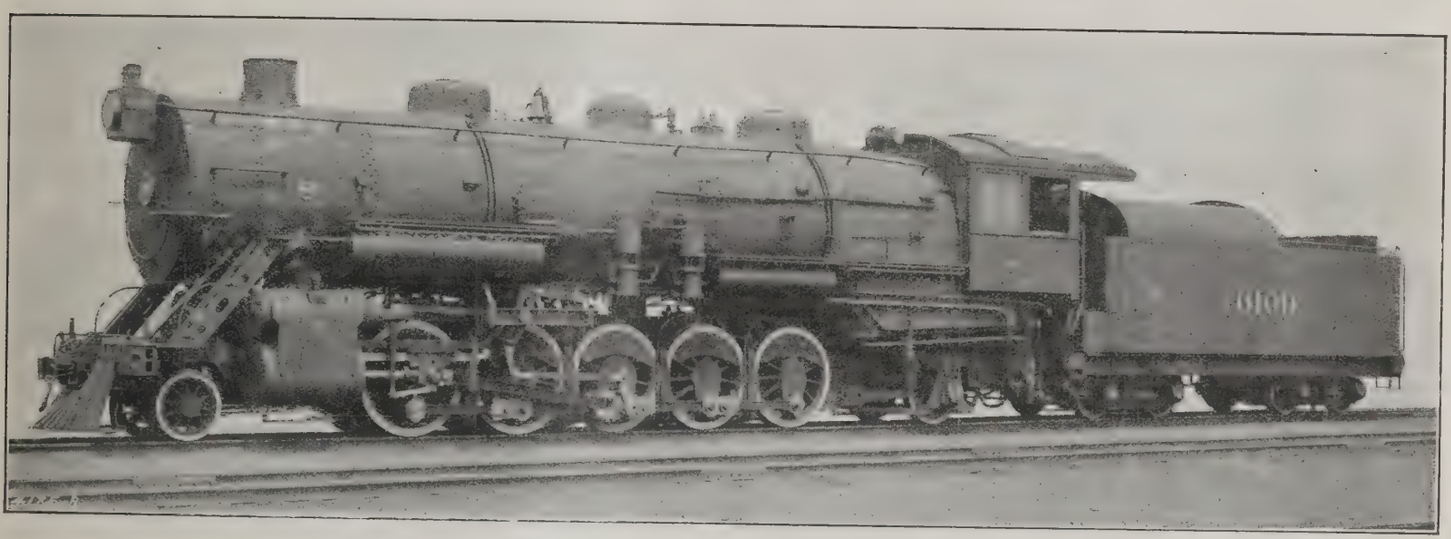


FIG. 2. LOCOMOTIVE ON THE CHICAGO, BURLINGTON AND QUINCY RAILROAD.

FIG. 3. LOCOMOTIVE FOR THE BALTIMORE AND OHIO RAILROAD.

duced in the United States for heavy freight service on steep grades. On the majority of roads, the largest locomotives (excluding those of the articulated type) are of the eight-coupled type; and where track conditions permit of heavy wheel-loads such engines have sufficient adhesion to develop tractive forces of from 50,000 lb. to 60,000 lb. Where grades are comparatively light, locomotives of either the 2-8-0 or 2-8-2 type are hauling the heaviest trains of practicable size. With the same load per pair of driving-wheels, a ten-coupled locomotive can, of course, develop a tractive force 25 per cent. greater than an

eight-coupled engine. Although the rigid wheel-base is necessarily long, ten-coupled locomotives can be built capable of taking the sharpest curves encountered on trunk lines. These engines are well suited to heavy road-service, and are doing excellent work on divisions where long runs must be made over difficult profiles, and where the nature of the business is such that heavy trains can be economically handled at comparatively slow speeds. This is particularly true when handling mineral traffic. We illustrate three recent examples of this type on page 557 of this issue.

The first road to adopt the 2-10-2 type was the Atchison, Topeka and Santa Fe in 1903. The Santa Fe had previously tried locomotives of the 2-10-0 type, but difficulty was experienced with these engines on account of derailments when backing them on sharp curves. Conditions on this road are unusually severe, as the maximum grades on the mountain districts are 185 ft. per mile, and all locomotives must be able to take curves of 16 deg. (358 ft. radius). In order to prevent derailments, the 2-10-0 type was modified by the addition of a rear truck. The new design met the requirements successfully.

During the years 1903-7, 160 locomotives of the 2-10-2 type were built by the Baldwin Locomotive Works for the Santa Fe system. With two exceptions, all these were equipped with tandem compound cylinders. The two engines referred to had single expansion cylinders, and one of them was fitted with a smoke-box superheater. Many of the compound locomotives subsequently underwent modifications, and ten of them were converted into Mallet locomotives by the addition of forward units. In the years 1912 and 1913 additional locomotives of the 2-10-2 type were built by the same firm, the new engines being fitted with single-expansion cylinders and fire-tube superheaters. Fig. 1, page 557, represents one of these engines built in 1913.

As has been explained, the rear trucks are used on these locomotives to enable them safely to enter sharp curves and switches when running backward. The forward end of the fire-box is immediately over the fifth (or rear) pair of coupled wheels, and the weight carried by the rear truck is therefore considerably less than it would be if the fire-box were placed entirely behind the coupled wheels over the truck. The height from the grate of the bottom row of tubes is sufficient to allow of a brick arch, which is supported on four water-tubes. The fire-door and grate-shaker are both operated by power. The superheater is of the Schmidt type, with thirty-six elements, and the superheating surface is 20.7 per cent. of the water-evaporating surface. The boiler is designed for a pressure of 210 lb. per sq. in., but in service the safety-valves are set at 170 lb. The circumferential seams in the boiler barrel are lap-jointed and double-riveted, while the longitudinal seams are butt-jointed with inside and outside covering strips and six rows of rivets. These seams are welded at the ends, and their strength is equal to 90 per cent. of the solid plate. The frames are annealed-steel castings, with a carbon percentage of 0.40. They are of the bar form, 5 in. in width, and are strongly braced transversely between adjacent pairs of driving-wheels. Each frame is in one piece, with a single front section, to which the cylinders are secured. This form of construction is, in large locomotives, generally replacing the former pattern, in which the front frame sections were separate from the main frames, and were bolted and keyed in place. With the new design the frame castings are increased in weight, but are better able to resist the severe stresses to which they are subjected.

The front truck is of the radial centre-bearing type, with a swing bolster, which is hung on three-point suspension links. The springs of this truck are equalised with those of the first and second pairs of coupled wheels, while the three remaining pairs are independently equalised with the rear truck. The latter is a side-bearing radial truck, with inside journals. The load is transferred to it through swing links which connect the boxes with yokes that form part of the equalising gear. The wheels of the third, or main, coupled pair have plain tyres without flanges. On the first and fifth pairs of coupled wheels the total lateral play between the rails and flanges is $\frac{3}{4}$ in., while on the second and fourth pairs it is $\frac{5}{8}$ in. The play on both the front and back truck wheels is also $\frac{5}{8}$ in. Provision is made for lubricating the flanges of the leading pair of coupled wheels for the purpose of reducing flange wear.

The steam distribution is controlled by inside admission piston-valves, which are 16 in. in diameter. As these locomotives are required to drift down long grades, the cylinders are fitted with vacuum relief-valves, and also with by-pass valves. The valve motion is of the Walschaert type, controlled by the Ragonnet power-reversing gear, operated by compressed air. In a locomotive of such size, fitted with coupled wheels of comparatively small diameter, it is a difficult matter to counterbalance the reciprocating and revolving parts properly. The locomotive now under notice has counterweights, keyed to the main driving axle between the frames, in addition to the usual counterweights in the wheel-centres. A satisfactory arrangement of balance is provided in this way. In accordance with the usual American practice, the tender is carried on two four-wheeled trucks. It is equipped with a power-operated device for pushing the coal forward as the supply becomes depleted, so that the fuel is always within easy reach of the fireman.

Fig. 2, page 557, represents one of thirty engines of the 2-10-2 type operating on the Chicago, Burlington and Quincy Railroad. Five of these 2-10-2-type engines were built by the Baldwin Locomotive Works in 1912, and the remainder, of which that illustrated is one, in 1914. The two lots are similar in general dimensions, and as they exert a tractive force of 71,500 lb., they constitute a notable group of unusually large units. They have a large number of interchangeable detail parts.

The particular locomotive illustrated is one of two, in which a material reduction in the weight of the reciprocating and revolving parts has been effected by the use of special alloy steels. The piston-rods, main connecting-rods, coupling-rods, rod-end straps, and main crank-pins are of nickel-chrome steel annealed; while the pistons and crossheads are annealed-steel castings, with a carbon percentage of 0.40. The piston-rods and main crank-pins are hollow. A saving in weight of the reciprocating parts, on each side, amounting to 379 lb., or 16 per cent., has thus been effected. This has avoided the necessity of using inside counterweights on the main driving-axle.

These locomotives are required to traverse curves having a radius of 21 deg., or 273 ft.; and the following provisions have been made to secure a sufficiently flexible wheel-base: The first and fifth pairs of coupled wheels have a lateral play of $\frac{3}{4}$ in. between the wheel-hubs and boxes; for the remaining pairs the play is $\frac{1}{8}$ in., while to compensate for this difference the knuckle-pins of the coupling-rod ends on the second and fourth pairs of coupled wheels are fitted into spherical bushings of case-hardened steel, thus allowing the rods a limited amount of lateral flexibility. The tyres of the third or main pair of coupled wheels are flangeless; while the lateral play between rails and flanges is $\frac{5}{8}$ in. on the second and fourth pairs, and $\frac{3}{4}$ in. on the first and fifth pairs. The front and rear trucks are of the radial-swing type, the front truck being equalised with the first three pairs of coupled wheels, and the rear truck with the fourth and fifth pairs. The rear truck is of the Hodges pattern, with outside journals. It has a long, half-elliptic spring over each box, and the side swing is taken by the spring hangers, which are jointed for the purpose.

The steam distribution is by inside-admission 15-in.-piston-valves, driven by Walschaert motion. As in the case of Santa Fe locomotives, reversing is effected by the Ragonnet power-mechanism. The cylinders are fitted with vacuum relief-valves, but no by-pass valves are applied. The boiler has a long barrel of large diameter, with a deep, wide fire-box placed back of the coupled-wheels and over the trailing truck. In a long boiler of this type, extending over five pairs of wheels, it is advisable to use a combustion-chamber, not only to increase the fire-box volume, but also to keep the length of the tubes within reasonable limits. This combustion-chamber extends forward into the boiler-barrel, and has a length of 28½ in. The boiler-barrel is straight on top, but the third course has a slope on the under-side, in order to provide a sufficiently deep water-space under the combustion-chamber to ensure free circulation. In this way the shell diameter is increased from 88½ in. to 100 in. The fire-box is equipped with a brick arch supported on four tubes, each 3½ in. in diameter. A Street mechanical stoker is applied. This device transfers the coal from the tender to a point under the foot-plate, where it is picked up by a bucket conveyor. The fuel is raised by the conveyor to a sufficient height to be dropped, through suitable pipes, to three distributing points, which are placed in the rear of the fire-box above the level of the fire. From these distributing points the coal is blown into the fire-box by means of steam-jets. With the aid of a stoker these large locomotives can be worked at full theoretical capacity, and the maximum steam pressure can be maintained in the most difficult kind of service. The success of these unusually powerful units is unquestionably largely due to the application of fuel and labour-saving devices.

The Baltimore and Ohio Railroad locomotive illustrated in Fig. 3 was also recently built by the Baldwin Locomotive Works. It exerts a tractive force of 84,500 lb., and exceeds in hauling capacity any other non-articulated locomotive thus far constructed. The ratio of adhesion is practically 4, and the load carried per pair of coupled wheels exceeds 67,000 lb. A locomotive with such wheel-loading is, of course, suitable only for work on roads where tracks and bridges are of the heaviest description. A large part of the traffic handled by the Baltimore and Ohio Railroad consists of coal, which is moved in heavy train-loads at comparatively slow speeds, a class of service for which the locomotive now under notice is particularly well fitted.

In this engine all the coupled wheels have lateral play in the boxes of ¼ in., while the play between the rail and flanges is 1 in. on the first and fifth pairs of wheels, and ¾ in. on the second and fourth pairs. The side-rod ends, as in the case of the Burlington locomotives, are fitted with spherical joints. This arrangement has been successfully used for some time on heavy 2-8-2 type locomotives in service on the Baltimore and Ohio Railroad.

The cylinders of this 2-10-2 type locomotive are bushed, and are fitted with by-pass valves, but no vacuum relief-valves are applied. The piston-valves are of the inside admission type, 16 in. in diameter, operated by Walschaert valve-gear. The Ragonnet power reverse mechanism is applied. The reciprocating and revolving weights are counterbalanced by keying supplementary counterweights to the main coupled axle, as was done in the case of the Santa Fe locomotive previously described. The boiler, although somewhat larger than that used on the locomotive for the Chicago, Burlington and Quincy Railroad, is similar to it in general design. The superheater is composed of forty-eight elements, and the superheating surface amounts to 1329 sq. ft. A combustion-chamber, brick arch, and Street mechanical stoker are applied.

TABLE I.

Railway	A. T. & S. F.	C. B. & Q.	B. & O.
Cylinders	28 in. × 32 in.	30 in. × 32 in.	30 in. × 32 in.
Valves, piston, diameter	16 in.	15 in.	16 in.
Coupled wheel ,,	57 in.	60 in.	58 in.
Truck wheels, front ,,	29½ in.	33 in.	33 in.
,, back ,,	40 in.	42½ in.	44 in.
Boiler, diameter	80¾ in.	88½ in.	90 in.
Thickness of sheets	⅜ in., 27/32 in., ⅝ in.	⅝ in.	⅞ in., 1⅛ in.
Firebox length	108 in.	132 in.	132 in.
,, width	78 in.	96 in.	96 in.
Thickness, side, crown, and back sheets	⅜ in.	⅜ in.	⅜ in.
Thickness, tube-plate	7/16 in.	⅝ in.	⅝ in.
Water spaces	6 in.	6 in. & 4 in.	6 in.
Tubes, 2¼ in., number	251	264	269
,, 5½ ,, ,,	36	45	48
,, length	21 ft.	22 ft. 7½ in.	23 ft.
Heating surface:—			
Fire-box .. .. sq. ft.	193	272	258
Combustion chamber ,,	—	68	65
Tubes ,,	4174	4966	5215
Arch tubes ,,	23	43	35
Total ,,	4390	5349	5573
Superheater ,,	910	1232	1329
Grate area ,,	58.5	88	88
Working pressure lb. per sq. in	170	175	200
Wheel base, driving	19 ft. 9 in.	20 ft. 9 in.	21 ft.
,, total engine	35 ft. 10 in.	40 ft. 1 in.	40 ft. 3 in.
Weight on coupled wheels lb.	248,900	293,000	336,800
,, total engine ,,	296,700	370,000	406,000
Tender tank capacity gals.	9,000	10,000	10,000
,, fuel ,, tons	12	15	16
Wheel base, engine and tender	66 ft. 4 in.	74 ft. 9½ in.	76 ft. 6 in.
Weight, total, engine and tender lb.	470,000	555,000	584,080

The over-all dimensions of this locomotive are as great as the clearance limits on the line will permit, and some ingenuity had to be exercised to keep them within the maximum. The whistle is tapped into the side of the steam-dome and placed in a horizontal position, and the safety-valves are screwed directly into the boiler-shell. The bell is mounted on the right-hand side of the smoke-box front, on a level with the head-light. The sand-boxes are four in number, two for use when going ahead and two for backing up. They are mounted right and left, on the top of the boiler; and the corners are rounded to keep within the tunnel clearances. For the same reason the cab-roof is rounded with a comparatively short radius. The tender is of the Vanderbilt type, with a cylindrical water-tank. The truck-bolsters are composed of I beams, and the side frames are of the arch-bar type. The wheels are of forged and rolled steel, each made complete in one piece.

In the accompanying Table I. we give the leading dimensions of the locomotives described above.

THE IRON AND STEEL INSTITUTE.—As previously announced (see page 300 *ante*), the autumn meeting of the Institute, which had been arranged to be held in Paris, had, unfortunately, to be abandoned, and the Council decided, as a matter of courtesy to the prospective hosts of the Institute, that no alternative meeting should be held in this country for the reading and discussion of the papers offered for the Paris meeting. A general meeting is, nevertheless, required by the rules for dealing with certain business of a purely formal character, and the Council now give notice that a statutory autumn meeting will be held for that purpose on Thursday, November 19, at 11 a.m. As a numerous attendance is not expected, it has been decided to hold the meeting at the rooms of the Iron and Steel Institute, 28, Victoria-street, London, S.W. The agenda is as follows:—Scrutineers will be appointed for the examination of voting-papers for the election of new members. Announcement of the names of Vice-Presidents and Members of Council due to retire in rotation at the annual meeting, 1915. Announcement, as far as possible, of the arrangements for meetings in 1915.

INDUSTRIAL NOTES.

A CONFERENCE of miners' representatives in the English Conciliation Board area was held on October 29, in London, Mr. Stephen Walsh, M.P., occupying the chair. The following were elected as the men's representatives on the Board :—Messrs. Stephen Walsh, M.P., Lancashire (President); T. Ashton, Manchester (secretary); J. Hoskin, Yorkshire (treasurer); Herbert Smith and Fred Hall, M.P., Yorkshire; H. Roughley and H. Twist, Lancashire; Frank Hall and F. Lee, Derbyshire; W. Johnson, M.P., and W. Latham, Midland Counties; W. Carter and C. Bemfield, Nottingham; E. Hughes, North Wales; and W. Buckley, South Derbyshire.

The annual meeting of the Half-time Council (Lancashire, Yorkshire, Cheshire, and Derbyshire) was held on Saturday, October 31, at the Grosvenor Hotel, Manchester. Mr. J. Bond (Chorley) was appointed President, and Mr. A. Lee (Rochdale) Vice-President for the coming year. In his address, the President stated that nearly 100,000 children under thirteen years of age were at the present time in employment in England, and in competition with adults in the labour market. The majority of these young people are engaged in the mills of Lancashire and Yorkshire, where wages are admittedly higher than in other parts of the country. Mr. Bond referred to the condemnation of the half-time system by the Inter-Departmental Committee appointed by the Government. We had recently gone to war, he said, for the sake of "a scrap of paper" bearing the pledge of the British Government, but England had failed to redeem another pledge given at the Berlin Conference in 1890 by Lord Salisbury and Sir John Gorst, who then said :—"We can pledge ourselves for Great Britain that our Government, faithful to its actions in the past, will conform resolutely in the future (if it does not even go beyond them) to the benevolent principles of the Conference." This pledge was to raise the age for child workers to thirteen years. Germany kept faith and raised the age to fourteen years; Great Britain kept the age to eleven years until 1899, and then only raised it to twelve years, at which it was still kept in spite of public remonstrances.

The meeting discussed the serious position created by the large number of "young persons" in their teens who are now in the streets unemployed, and the policy of local authorities in permitting children still to leave the schools at twelve and thirteen years of age to swell the numbers. The following resolution was passed unanimously :—"Seeing that, owing to the war, many children who are now leaving, or have recently left, school cannot find employment, or have lost their positions, all children should at present be retained in school. No child should leave school to seek employment whilst those who have already left are unemployed."

A claim for a living wage of 30s. a week was made at a meeting of temporary Post Office workers, which was held a few days ago at Chandos Hall, Maiden-lane, London. The men in question, who work as sorters, postmen, and porters, in the place of those who have gone to the war, are paid 24s. per week. A number of speakers supported the claim, and a resolution was passed calling upon the Government to grant a minimum wage of 30s. for temporary postmen and others.

The War Office has placed contracts in Sheffield for a million table-knives for soldiers. They are to be all-steel, both blade and handle. The Admiralty and War Office have also ordered from Sheffield works one million table-spoons of a non-ferrous alloy.

The docks controlled by the Mersey Board reported a great shortage of labour at the weekly meeting of the Board held on Thursday, October 29. The situation led to a letter being addressed by Mr. A. Chandler, general manager and secretary to the Board, to Sir Norman Hill, secretary of the Liverpool Steamship Owners' Association, stating that from information which had reached the Board the position had become very serious, and while the matter was one which at the present moment affected shipowners more immediately, it was felt that the existing state of affairs must cause serious injury to the port and greatly discredit it.

The letter also stated that :—"The present condition of affairs arises mainly through a shortage of men or a disinclination on the part of men to work regularly, or from the restrictions which the Dock Labourers' Union is imposing on labour. I am to ask that your special attention should be given to the question of obtaining more men, or in impressing the Labour authorities with the need of relaxing their present methods. If any deputation is proposed to be formed, either by the Steamship Owners' Association alone, or in conjunction with the mercantile associations of the port, to wait upon the Board of Trade in London, my Board would wish me to represent them thereon."

In the course of the meeting Mr. J. W. Hughes stated that the records did not show that the shortage of labour had been brought about by increased imports to Liverpool. The imports for October were very much down, the importation of cotton being between 100,000 and 150,000 bales less than in the corresponding month of last year.

Mr. Thomas Rome, who followed, said the shortage of labour had become so bad that the greatest difficulty was experienced in keeping to fixed sailings, and many cases had occurred of vessels being seriously delayed. If this should continue, they would lose the tonnage which had accrued to the Mersey through Southampton being closed. During the week preceding the meeting the company he represented were never less than 400 men short each day. Such a condition of affairs could only have one result, which was that the vessels would have to be diverted to Glasgow or other ports.

Sir Helenus R. Robertson, chairman, said no doubt consideration would be given to the question whether those who were unemployed in other parts of the country might be brought to Liverpool.

The Conference of the Miners' Federation of Great Britain met in the Westminster Palace Hotel on Wednesday, October 28, when the resolutions submitted were unanimously agreed to. They read as follows :—

"That all war relief funds be merged together and taken over by the Government, to be administered by the Government, and that there be a general or uniform scale of relief, modifications or exceptions to be made to suit exceptional districts, the national revenue to be made responsible for raising the funds necessary.

"That this Conference accepts the resolutions of the War Emergency Workers' National Committee, and demands that the following should be the minimum scale of relief :—One adult, 12s. 6d.; two adults, 17s. 6d.; one adult and one child, 15s.; two adults and one child, 20s.; two adults and two children, 22s. 6d.; and 2s. 6d. for each child, and an additional 3s. 6d. for adoption in London boroughs.

"That this Conference presses upon the War Office and on His Majesty's Government that an allowance of 1*l.* per week should be paid to the wives of soldiers and sailors now serving with His Majesty's forces, without any deduction from the pay of those persons serving at the front, and to the widows or other dependants whose husbands, brothers, sons, &c., may be killed in the war, or who may die from wounds received or disease contracted in the war; also 1*l.* per week to those who may be disabled for life, or partially disabled, until they are fully recovered from their injuries. In addition to the above allowance, a payment of 3s. 6d. per week should be made to each child under working age.

"That the Government be called upon to find employment for persons thrown out of employment through the war."

Following upon the paragraph we gave on page 486 *ante*, dealing with the present situation of the cotton-spinners in Switzerland, we now learn that the International Federation of Master Cotton-Spinners' and Manufacturers' Associations has received information concerning the situation of the cotton industry in Italy. In that country the spinning-mills are working generally four days a week, in consequence of the greatly reduced demand by manufacturers. The supply of cotton is said to be regular, but difficulties are being experienced in financing the cotton bought in America. At the outbreak of the war sellers insisted upon cash payments, but now they are coming back to the old terms—bills at ninety days' sight. Manufacturers have had some demand from the Italian home trade, but the exports generally are stopped on account of the impossibility of getting payments from abroad, especially from the Balkan States. Manufacturers are working four to five days a week. The cost of coal, war risks, the high rate of exchange, and reduced output materially increase the cost of production. In Switzerland there is a decrease in production of from 25 to 50 per cent. in the spinning-mills and about 50 per cent. in the weaving-mills. According to statistics compiled in the Swiss textile industry, the wages earned are 57.8 per cent. of the normal (excluding the silk industry, where they are 80 per cent. of the normal).

In their report for September last, recently issued, the General Federation of Trade Unions state the following :—

"At last one of the ideals of the General Federation has been reached; its affiliated membership has passed the million. In spite of the hostility it has had to face, both from employers and others, its total membership now stands at 1,006,904; a magnificent result when all the circumstances are considered. At the moment the Federation reaches such an important point in its existence it is, together with every other trade union organisation, faced with the most serious crisis of a hundred years. It will require loyalty, foresight, and ability to bring trade union organisations, including the Federation, out of the crisis without serious loss.

"Realising the strain to which trade unions, whether they pay unemployment benefits or not, must be put, the management committee early pressed forward the increase of the subsidies under Part II. of the National Insurance Act. It also pressed the Government to extend its help to those unions, who have safe, but not easily realisable, securities, by taking up these securities at their face value and paying to the unions who required it the equivalent value in cash. Part II. of the Act has already been dealt with, and it is certain that the Government is prepared to extend the operation of the Act to unions at present outside its operation. The management committee is anxious that the mistakes of 1911 and 1912 should not be repeated. To stand outside and destructively criticise is not sufficient; the leaders of the movement must come inside and help to create and construct. Neither personal nor political prejudices must be allowed to militate against the construction of the best scheme or the practical association of the trade unions with its administration. The Act should be made to apply to all trades or occupations capable of organisation; immediate benefit should be granted in all cases of *bonâ-fide* unemployment; the benefit period of fifteen weeks should be extended, and simple facilities should be offered for the immediate creation of unemployment benefit schemes by trade unions not at present paying unemployment benefits. The management committee has from the beginning pressed for a really national scheme and for the equal treatment of all workpeople. At present the operation of the Act is partial, only a portion of the workers benefit, though all share in the provision of the Government subsidies. . . .

"When the war became an accomplished fact the management committee strongly advised all its affiliated societies to avoid, as far as possible, all industrial disputes. That they have loyally sought to act upon the advice is shown by the number of claims during the quarter. These only number 108, and 92 of these relate to pre-war disputes. The trade-union movement has given very practical proof of its loyalty to national interests, and has shown how rapidly it can set aside its own particular affairs when the general interests of the State rise paramount. It is gratifying to report that, with few exceptions, organised employers have loyally kept the truce. Those who have taken advantage of the crisis should be noted by each union and punishment meted out when times are favourable. . . ."

In concluding the report in question, the General Federation of Trade Unions make the following statement :—

"The war cannot last for ever, and after the war will come reaction and the rediscovery of the fact that working-class interests are common and not divisible by geographical frontiers or languages, and that international effort to further these interests is imperative. Our conduct to-day will affect our opportunities to-morrow, and it behoves us therefore to carefully guard all our utterances and actions in order that we may not needlessly create additional obstacles and further retard the renewal of international and democratic friendships."

We have nothing to say against the sentiment *per se* which has inspired the above statement of the General Federation. This country as a whole has always greatly desired to live on amicable terms with every country of the world, and an earnest of this, as we have stated before, is afforded by the efforts which were made up to the very last moment by Sir Edward Grey to secure general peace on the present occasion. We think, however, that the General Federation should proceed with the greatest possible caution in their future efforts at internationalism. Their committee should certainly read "A Bavarian's Views on the War," given in the *Times* for last Tuesday, the 3rd inst. Among this Bavarian's "views" are the following declarations :—"We were at one moment somewhat afraid that the Socialists would be lukewarm, but happily it was not so. Our Social Democrats have let go all their international theories and give not a fig for the foreign Labour party. They think only about the profit they may secure for German workmen. I am even told that some labour unions have come forward with the claim that all Belgian factories should be confiscated and given to co-operative unions of German workmen alone. Belgium is now a corpse, and in some weeks the North of France must also become a corpse . . ." If Germany gained the upper hand in the war now raging, Great Britain would probably become a corpse too. It should not take the General Federation long to realise clearly the view of internationalism taken by German labour.

SEMI-PORTABLE SUPERHEATED-STEAM ENGINE.

CONSTRUCTED BY MESSRS. MARSHALL, SONS AND CO., LIMITED, ENGINEERS, GAINSBOROUGH.

Fig. 1.

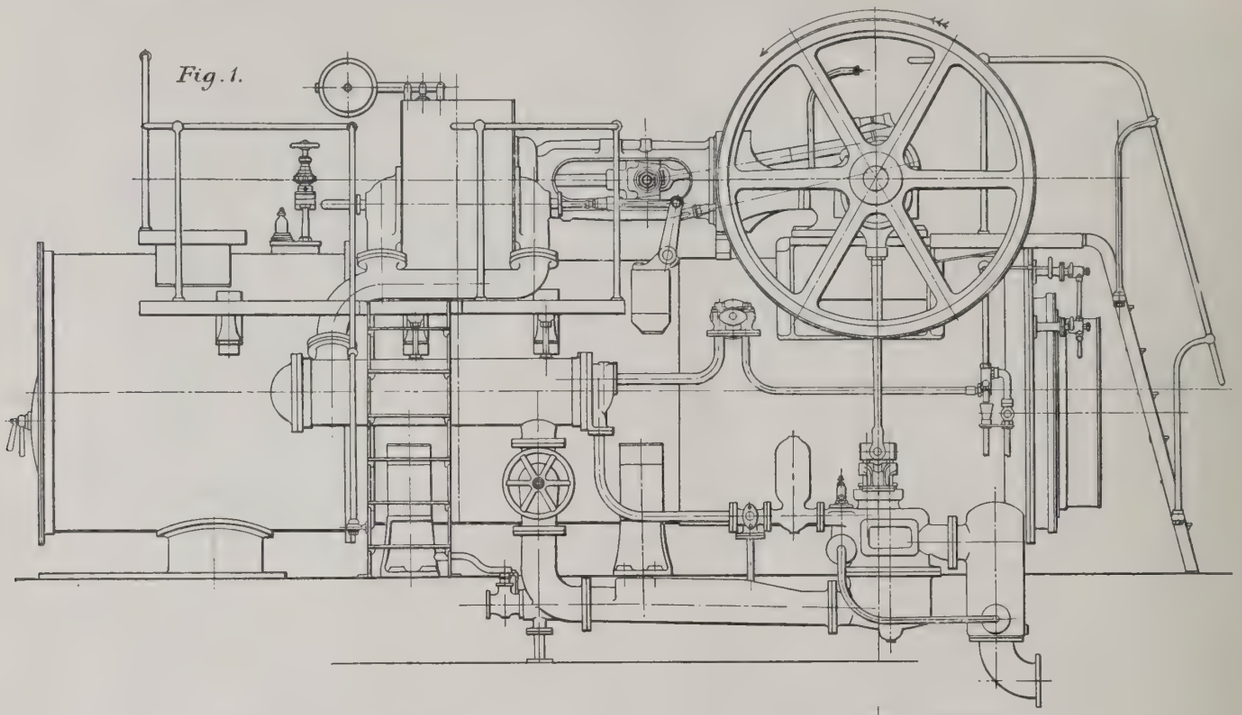


Fig. 2.

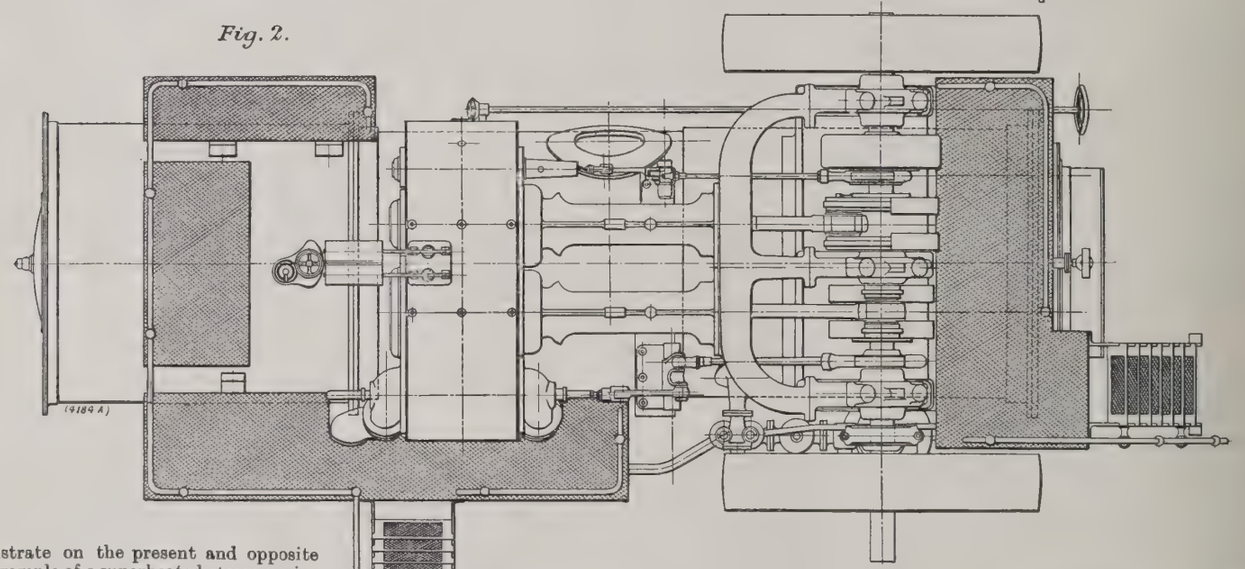
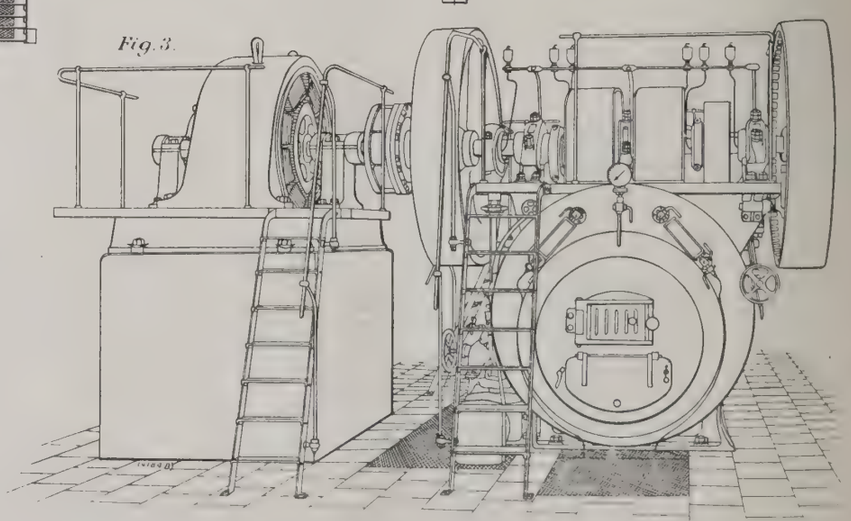


Fig. 3.



We illustrate on the present and opposite pages an example of a superheated-steam engine of the "Locomobile" type, constructed by Messrs. Marshall, Sons and Co., Limited, of Gainsborough. Power plants of this description are now finding considerable favour for driving factories, electric lighting, and other industrial work, owing to their many obvious advantages, of which perhaps the most important is their very low fuel consumption. Several other desirable features, such as low first cost, economy of floor space, inexpensive foundations, absence of condensation losses in steam-pipes, and the fact that they can be housed in small and cheaply-constructed buildings, all tend to render them preferable in certain cases to independent engine and boiler units for plants with capacities up to 200 or 300 horse-power.

The plant illustrated herewith is rated at 100 brake horse-power, but is capable of sustaining an overload up to 125 brake horse-power for long periods. Figs. 1 and 2, on the present page, are respectively an elevation from the condenser side and a plan of the plant, while Fig. 6, on the opposite page, serves to show its general appearance. Fig. 3 is an outline sketch illustrating the engine direct-coupled to a dynamo, and Figs. 4 and 5 show details of the superheater, which we shall describe later.

The engine is of the side-by-side compound type, and is mounted on top of the boiler, as is best shown in Figs. 1 and 2. The high and low-pressure cylinders are combined in a single casting, fitted with separate liners, and bolted directly to the boiler. Steam distribution to both cylinders is effected by balanced piston-valves, fitted with specially-designed spring-rings, and driven from the crank-shaft by eccentrics and rocking-levers, which can be seen in Figs. 1 and 2. A centrifugal crank-shaft governor controls the piston-valve on the high-pressure cylinder, and automatically varies the cut-off to suit the load. The crank-shaft, which is a steel forging, turned, polished, and fitted with balance-weights, is supported on three adjustable car-

SEMI-PORTABLE SUPERHEATED-STEAM ENGINE.

CONSTRUCTED BY MESSRS. MARSHALL, SONS AND CO., LIMITED, ENGINEERS, GAINSBOROUGH.

Fig. 4.

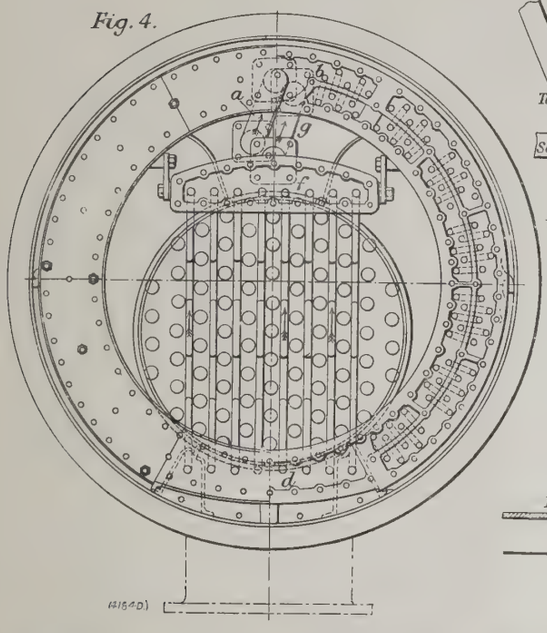
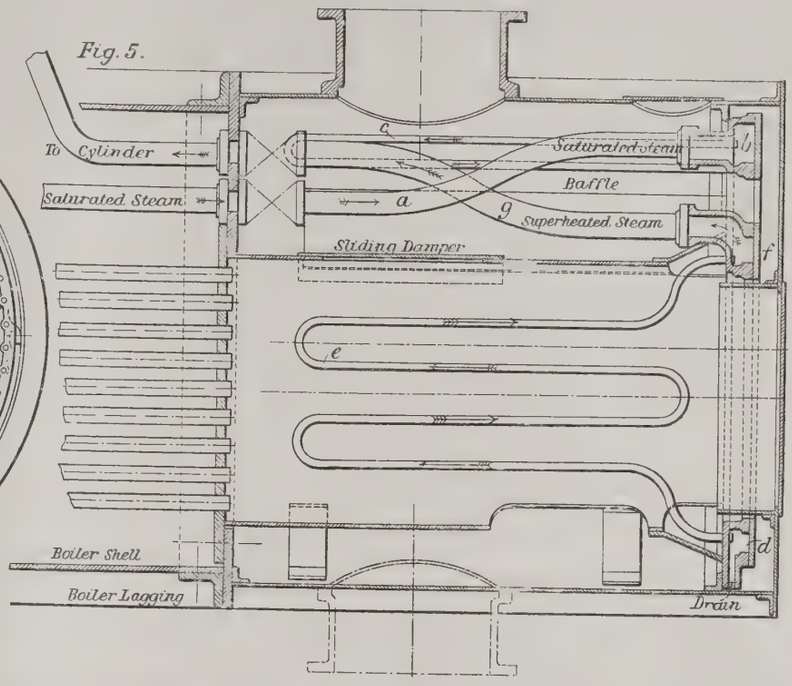


Fig. 5.



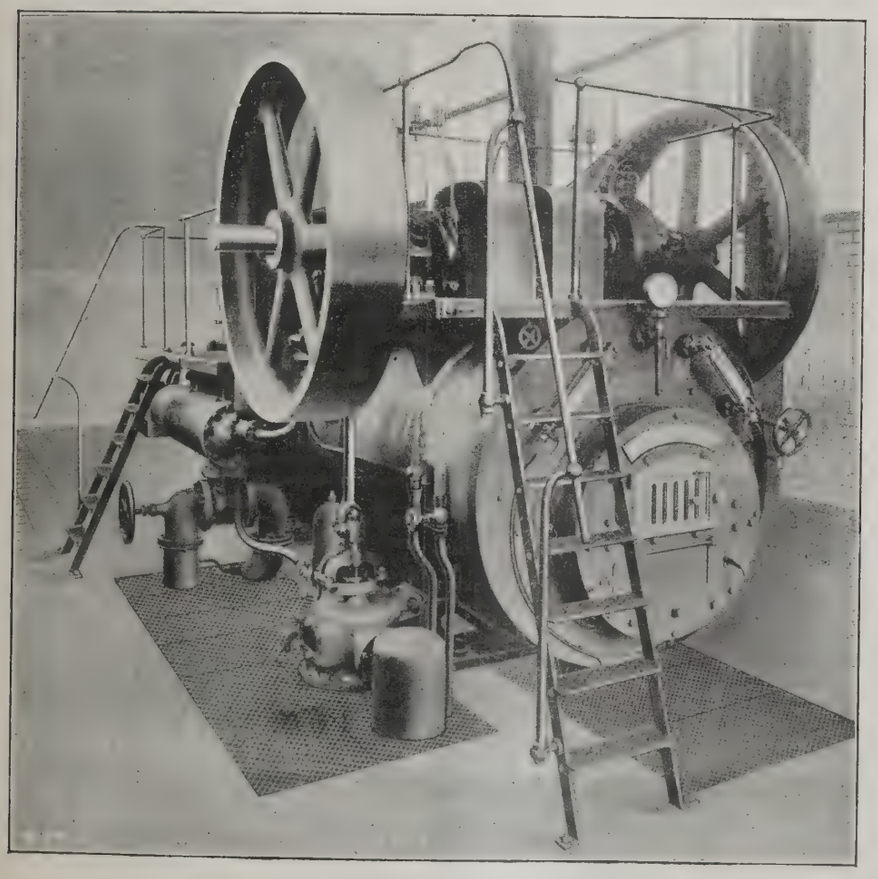


FIG. 6.

riages, with ring-oiled bearings. The carriages are supported on a steel saddle, riveted to the boiler, and attached to the cylinder casting by a distance-piece; suitable provision is made for the expansion and contraction of the boiler. Mechanical oil-pumps are provided for cylinder lubrication, and drop sight-feed lubricators are fitted to all other working parts, except the crank-shaft bearings, which are ring-oiled, as previously mentioned.

Exhaust steam from the low-pressure cylinder passes through a tubular feed-water heater to a jet condenser, both of which are shown in Figs. 1 and 6. The condensed steam and injection water are dealt with by a vertical air-pump of the Edwards type, driven from the crank-shaft by an eccentric. Incorporated with the air-pump is a feed-pump, which draws from the hot-well and discharges through the feed-heater; the whole arrangement will be quite clear from an inspection of Fig. 1.

The boiler, which is of the Cornish multitubular type, is constructed throughout of Siemens-Martin steel plates, and is designed for a working pressure of 180 lb. per sq. in. The fire-box and tubes are arranged so that they can be removed bodily for the purpose of cleaning and examining the internal surfaces. This feature is of considerable importance in factories where stoppages can only be made for short periods, as the whole of the heating surface can be thoroughly freed from deposit in a few hours.

The following results were obtained in a test recently carried out on one of these engines at Messrs. Marshall's works:—

Duration of test	4 hours
Temperature of feed	120 deg. Fahr.
Steam pressure (gauge)	188.7 lb. per sq. in
,, temperature	541 deg. Fahr.
Superheat	158 deg. Fahr
Vacuum	27 in. mercury
Revolutions per minute	206
Brake horse-power	124
Coal consumption	1.47 lb. per B.H.P. hour
Calorific value of coal	11,500 B.Th.U. per lb.
Coal burnt per square foot of grate per hour	23.7 lb.
Percentage of CO_2 in flue gases	10.9
Coal analysis:—	
Carbon	77.30 per cent.
Volatile hydrocarbons	7.75 ,,
Ash	13.0 ,,
Sulphur	0.5 ,,
Moisture	1.5 ,,

It will be observed that the engine was tested at about its maximum continuous output, and that the coal used was of low calorific value. With good Welsh coal having a calorific value of 14,250 B.Th.U. per lb. the consumption would have been 1.185 lb. per brake-horse-power hour, a result on which we think the firm may be congratulated. Similar plants are made with capacities ranging from 50 to 300 horse-power.

One of the most important features of the plant under notice is the superheater, the details of which are illustrated in Figs. 4 and 5, annexed. It will be interesting to compare Messrs. Marshall's design with those previously illustrated in ENGINEERING.* Referring to the illustrations, it will be seen that the saturated steam from the boiler passes through the pipe *a* to the top of a circular cast-steel header which extends round the circumference of the smoke-box. The steam divides on entering the header, and is directed by a series of baffles through a number of U-shaped superheater tubes *c*. In this way the two streams travel round both sides of the header, and eventually recombine in a compartment *d* at the bottom of the smoke-box. The steam then travels upwards through a bank of zig-zag-shaped tubes *e* to a separate header *f*, whence it passes through the pipe *g* to the cylinders. It should be noticed that in passing through the tubes *c* the steam travels in the opposite

* See ENGINEERING, vol. lxxxviii., page 478, and vol. xcii., page 364.

direction to the flow of the gases, and that the final superheating tubes *e* are placed directly in the path of the gases from the boiler tubes. As the temperature of the steam increases, it therefore reaches hotter parts of the superheater, and thus the maximum efficiency of heat transmission is obtained. The actual amount of superheat added to the steam under ordinary working conditions is about 160 deg. Fahr. A sliding damper is provided to enable the gases to be passed into the chimney without circulating round the superheater tubes, and a special double shut-off valve is fitted, so that the engine can be run on saturated steam if necessary. Ample provision is made for sweeping both superheater and boiler tubes.

SPEEDOMETER AND CARBURETTOR WORKS OF MESSRS. S. SMITH AND SON.

On the whole, recent years have probably seen a tendency for the manufacture of engineering and scientific instruments to increase in this country. This is, no doubt, partly to be explained by the growing adoption of such appliances for industrial and other processes. At the same time we think there are distinct signs that an increasing proportion, at any rate of the instruments we use ourselves, are of home build. The value of many scientific instruments in the workshop, and in other industrial fields, was earlier perceived on the Continent than in these islands, and as a natural consequence their manufacture was first taken up there. This gave foreign makers a start, and, to a large extent, our earlier supplies came from them. Recently, however, as we have suggested, manufacture has been started on a considerable scale in this country. The present international situation should assist us in further improving our position, and many of the well-laid-out shops we possess should be enabled either to increase their output or enlarge their range. It is probable that there are many users finding difficulty in obtaining various instruments or instrument parts at the present time owing to failure of ordinary supplies, and it would clearly benefit the country in two ways if such material could be made in some of our works equipped to deal with the smaller class of apparatus.

An interesting example of a works specially laid out for the manufacture of small parts is furnished by those of Messrs. S. Smith and Son, Limited, of 179 to 185, Great Portland-street, London, W. This firm, as is well known, has built up a large business in speedometers, carburettors, and other motor accessories, and it would appear likely that their equipment and trained staff might be of assistance at the present juncture in supplying small parts for other purposes and spheres of work. We had an opportunity of visiting Messrs. Smith's works a few days ago, and found an interesting collection of machine-tools of the smaller class, this remark applying particularly to the speedometer-shop. The works are situated in the basement and on the fourth and fifth floors of a fine modern building, the whole of which is devoted to Messrs. Smith's business. The ground floor forms a large show-room, while the first floor contains the dispatching department and the various offices. The second and third floors are used as stock-rooms, which have a total floor space of about 100,000 sq. ft.

The manufacturing departments, in which we are naturally chiefly interested, are, as we have said, situated in the basement and on the fourth and fifth floors. The basement contains the garage and carburettor-shops, while the speedometer-shops, demanding a lighter type of machinery, are situated upstairs. Views of the speedometer-shops are given in Figs. 1 to 3 on page 564. In them speedometers and distance-recorders are manufactured throughout. As our present purpose is to give a brief description of works rather than the material produced in them, we need not say much of the details of these instruments. To assist in the understanding of the machine-tool equipment, we may, however, mention that the speedometer is of the governor type, and, in addition to the centrifugal parts, contains a sensitive balance-spring arrangement and a train of wheels connecting to the pointer. This train contains spur, bevel, and worm-wheels. In addition, there is a spur and pinion transmitting the drive from the axle, or Cardan shaft, of the car to the centrifugal gear. The distance-recorders contain counting-wheels of the usual type. The brass or aluminium cases for the instruments are made in the shops. Although speed and distance-indicators are the main manufacture, tachometers, chart-recorders, clocks, and various other forms of mechanism are also turned out. An idea of the tool equipment is given by Figs. 1 and 2. It consists essentially of a number of automatic and semi-automatic machines for the production of worm and gear-wheels and small parts in quantity. There are a number of wheel-cutting machines, small automatic lathes, shapers, and hobbing-machines. There are also some grinding-machines and an equipment of light drills. Hardening is carried out in a gas-furnace fitted with a distant-reading pyrometer.

Assembling is carried out in an independent shop, which is illustrated in Fig. 3. In the foreground to the right-hand side of this view can be seen the simple and ingenious machine on which speedometers are calibrated. The instruments are assembled with blank dials, and are run in parallel with a master-indicator, which is checked against an electrical device every few days. The calibrating-machine consists of a rotating disc, with a machined face, against which a small wheel bears. The wheel is mounted on a carriage, which can be moved across the face of the disc. The wheel is connected to two flexible shafts, one at each side of it, which are connected respectively to the instrument to be calibrated and to the master. The wheel being in contact with the disc, is driven by it, and by moving the carriage towards or away from the centre, any required speed can be obtained at the indicators. The speedometer dials are marked by pencil on the calibrating-machines, and are then removed and permanently marked on a series of Taylor, Taylor and Hobson engraving-machines in a special shop. The dials are made of metal or one of the cellulose products, as may be required.

The carburettor-shops in the basement contain in general a heavier type of machine, as will be clear from Fig. 4. The equipment consists of capstan and engine-lathes, milling-machines, drills, &c. This department also contains a garage having accommodation for between twenty and thirty cars. The garage is reached from the street-level by a car-lift. The garage is provided solely for the fitting of the specialities made by the firm to customers' cars. It is obviously a great convenience to be able to fit the various accessories directly in the shops, such a procedure enabling the work to be carried out directly by the staff having most knowledge of the different pieces of apparatus. In addition to speedometers and carburettors, lamps, horns, and electric and acetylene lighting installations are fitted to cars in the shops. Messrs. Smith have the sole agency for the Trier and Martin electric lighting equipment, and are, we believe, the owners of the patents. The whole of the various shops are driven by electric motors, the power being obtained from the town mains.

Contracts.—The Local Government Board has recently approved the scheme of sewerage and sewage disposal for Pencoed prepared by Mr. T. J. Moss-Flower, Westminster and Bristol. The work involves the construction of about five miles of sewers, with railway and stream crossings, detritus, balancing, sedimentation, humus, storm and other tanks, percolating filters, sludge and filter-beds, engine-house, engines, pumps, pump-well and other incidental work. Tenders are to be immediately invited for the work.

The Faraday Society.—A general discussion on "The Hardening of Metals" will take place on Monday, November 23, at the Chemical Society, Burlington House, London, W. The President, Sir Robert Hadfield, F.R.S., will preside over the discussion, and among those who will take part therein are Professor Ernest Cohen, of Utrecht, Dr. G. T. Beilby, F.R.S., Professor J. O. Arnold, Professor H. C. H. Carpenter, Dr. C. H. Desch, Professor C. A. Edwards, Mr. H. L. Heathcote, Mr. J. C. W. Humfrey, Dr. T. M. Lowry, F.R.S., Mr. Andrew McCance, Dr. W. Rosenhain, F.R.S., and others. Further particulars will be announced in due course.

"The Flying Book."—This book, 1914 edition, is issued at the price of 2s. 6d. net by Messrs. Longmans, Green and Co., 39, Paternoster-row, London, E.C. It opens with a short history, entitled "A Hundred Years of Aeroplane Construction," followed by a section on "Military Aeronautics." It gives the names of the various international aero clubs and societies, their officers, and addresses; illustrated information on the world's modern aeroplanes, arranged alphabetically; similar data on the world's modern aero-motors; short biographies of well-known aviators; an industrial directory, and data on the status of military and naval aviation in different countries. The book is a useful reference guide for the the subject dealt with.

Motor Oil-Tank Vessel "Hermes."—The motor-vessel Hermes, built by Palmers Shipbuilding and Iron Company, Limited, to the order of the Anglo-Saxon Petroleum Company, Limited, of London, for carrying oil in bulk, has just been delivered to her owners after running a successful trial trip off the Dutch coast. The vessel, which is about 350 ft. long, has a dead-weight carrying capacity of over 5000 tons, and is built on the transverse system of framing to Class 100 A 1 Lloyd's under special survey, and designed to meet Suez Canal requirements. The vessel has seven pairs of oil-tanks arranged below the main deck, with expansion trunk running the whole length between the main and upper deck, and summer tanks at the sides of the trunks. The deep tank below the cargo hold forward is constructed for the carriage of oil fuel, as is also the double bottom below the boilers. The machinery for the vessel, which has been constructed by the Werkspoor Company, Amsterdam, consists of two Diesel reversible four-cycle six-cylinder engines, working on six cranks and coupled direct to the screw-shafts. A donkey boiler, working with a steam pressure of 120 lb. per sq. in., for heating and other auxiliary purposes, has been supplied by Palmers Company, and is arranged to burn oil. On the trials, reversing from ahead to astern, and *vice versâ*, only occupied six seconds.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was quiet but firm, and 500 tons of Cleveland warrants changed hands at 49s. 4½d. one month, and at the close sellers quoted 49s. 3d. cash, 49s. 6d. one month, and 50s. 1d. three months. One lot of hematite was also done, and realised 62s. seven days. In the afternoon the market was idle, and sellers of Cleveland warrants quoted 49s. 3d. cash and 49s. 6d. one month. On Friday morning a steady tone prevailed, but dealing was confied to one lot of Cleveland warrants at 49s. 6d. one month, and closing sellers named 49s. 3d. cash and 49s. 6½d. one month. Quietness ruled in the afternoon, when no business was transacted, and the quotations of the morning for Cleveland warrants were unchanged. For the three months position sellers quoted 50s. 0½d. On Monday morning the market was again quite idle, and Cleveland warrants were called 49s. 3d. cash and 49s. 6d. one month sellers. In the afternoon there was little change, but Cleveland warrants amounting to 1500 tons were put through at 49s. 2d. cash and 49s. 4½d. one month, with buyers over at the latter figure, and sellers at 1d. more for that position, and at 49s. 2½d. cash. Idleness again prevailed on Tuesday morning, and sellers of Cleveland warrants quoted 49s. 2d. cash and 49s. 5½d. one month. The afternoon session was also idle, and sellers' quotations were unchanged, but buyers named 49s. 1½d. cash and 49s. 5d. one month. When the market opened to-day (Wednesday) the tone was firmer, but no transactions took place. Closing quotations for Cleveland warrants were 49s. 2½d. cash and 49s. 6d. one month sellers, with buyers at 1½d. less in each case. In the afternoon there was little change in Cleveland warrants and no business was done. At the close sellers quoted 49s. 3d. cash and 49s. 6d. one month, and buyers named 49s. 1½d. and 49s. 4½d. respectively.

Sulphate of Ammonia.—The demand for sulphate of ammonia is still slow, and there is little life visible. The price continues round 11*l.* per ton for prompt lots, Glasgow or Leith, and about 11*l.* 5s. per ton for forward parcels.

Scotch Steel Trade.—No change of any moment has taken place in the Scotch steel trade since the last report, and while makers are managing to keep plant running fairly well, they are nevertheless very short of specifications. This is the case for nearly all classes of material for home consumption, as quite a number of new schemes have been temporarily delayed owing to the war. Many of these are likely to be put into being as soon as the outlook becomes more satisfactory. Some of the establishments doing Government work are very busy, and will be so for some time to come. The export trade is still rather quiet, and the dangers attendant on shipping at the present time, coupled with the higher freights and insurance, are keeping back business which would otherwise come through. Prices show little change, but have a slightly easier tendency.

Malleable-Iron Trade.—The malleable-iron makers in the West of Scotland report the state of the trade as still rather quiet. Specifications are scarce, and some weeks it is difficult to secure even nine shifts; but it is freely anticipated that things will improve in the near future. Prices are still based on 7*l.* 12s. 6d. per ton for "crown" bars.

Blastfurnacemen's Wages.—Mr. John M. MacLeod, C.A., Glasgow, has reported to Messrs. James C. Bishop and James Gavin, joint secretaries of the Board of Conciliation between the owners of blastfurnaces in Scotland and the blastfurnacemen, that as to the price of Scotch pig-iron warrants in the Glasgow market for the months of August, September, and October, 1914, there is no change in the wages of the workmen.

Scotch Pig-Iron Trade.—The past week has not brought forth any improvement in the demand for the ordinary qualities of Scotch pig-iron, and business continues on the small side. The easier quotations of late have not even induced consumers to increase their orders beyond actual requirements, and it is doubtful if further shading will take place in the meantime. Hematite is also slow of sale. The following are the market quotations for makers' (No. 1) iron: Clyde, 68s.; Calder, Gartsherrie, and Summerlee, 68s. 6d.; and Langloan, 70s. (all shipped at Glasgow); Eglinton, 62s. 6d.; and Glengarnock, 70s. (both at Ardrossan); Shotts (at Leith), 68s. 6d.; and Carron (at Grangemouth), 69s.

Scotch Shipbuilding.—The Scotch shipbuilding returns for the past month are fairly satisfactory, but are, nevertheless, a long way behind the fine figures for the corresponding month of last year. The following are the totals for the various districts:—

	Vessels.	Tons.
The Clyde	21	45,508
The Forth	1	200
The Tay	1	3,180
The Dee	4	820
Total	27	49,708

The Clyde total is a good average for the year to date, and brings the output for the ten months up to 191 vessels, of 401,869 tons, which is almost 158,000 tons less than for the same period of last year. Of course, it must not be forgotten that both 1913 and 1912 were exceptionally good years in the shipbuilding industry and that nothing like the same returns were expected from this year, so that the above total cannot be considered otherwise than fairly satisfactory. Bookings during recent months have been very small, and October was no exception to the others, and was, indeed, one of the leanest of the lot. Inquiries point to the fact that there is a

fair amount of work under consideration, but much of it will depend upon the course of the war and the prospects of improvement in some of the overseas markets. Most of the shipyards have lost many of their workmen, who are now serving in the Navy or Army, with the result that there is plenty of work left for those remaining. Admiralty work is being pushed ahead with all speed, and the progress being made is extremely good.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The hard-steam section, which has been remarkably steady under trying circumstances, is now beginning to show signs of strain. Though the industrial demand keeps up well, the weakness of the export section cannot be disguised, and with stocks on the increase, forced sales are being made at reduced rates. On the week, Yorkshire hards have declined 6d., and Derbyshire hards, which are a little easier, have dropped 3d. With the continuance of mild weather, house coal sales remain at a low level, values being steady and unaltered. The advent of cold, frosty weather would cause a general improvement. More gas fuel is being produced than is necessary to meet the current demand, and special lots are obtainable at low rates. Export business, though maintained at a fairly even level, is well below the average for this time of year. Owing to a collapse of the Lincolnshire demand, slacks are still on the downward grade. Output has been further curtailed, but stocks are accumulating, and inferior sorts are selling at varying reductions. Coke is easier and prices are on the weak side. Coking fuel is very plentiful. Quotations:—Best branch hand-picked, 16s. to 16s. 6d.; Barnsley best Silkstone, 12s. 6d. to 13s. 6d.; Derbyshire best brights, 12s. 6d. to 13s. 6d.; Derbyshire house, 11s. to 12s.; best large nuts, 11s.; small nuts, 9s. 3d. to 10s. 3d.; Yorkshire hards, 10s. to 11s.; Derbyshire hards, 9s. 6d. to 10s. 6d.; best slacks, 7s. to 8s.; seconds, 4s. 9d. to 5s. 9d.; smalls, 1s. 9d. to 2s. 9d.

Iron and Steel.—Business in the metal market shows a considerable falling off, and values are weakening. Now that the downward movement has set in, consumers, after a spurt of activity, are content to await events, and with that end in view are making such purchases as will carry them over current requirements. The decline is confined very largely to common irons, and there is a good deal of selling below official rates. In hematites, though buying is certainly more restricted, values are for the most part steadily maintained, consumption being as great as ever. Special brands used in the manufacture of armaments show no decline. Only in the commoner East Coast brands is weakness evident. There is no improvement in the finished-iron trade. The bar mills are still short of work, and the revival in general business is slow. There is no scarcity of Swedish iron, but users are having to pay higher prices to compensate for the extra charges of shippers. Satisfactory progress is being made in the steel trades. The alloys difficulty, which has been brought into prominence in the present crisis, is being tackled in a business-like manner. When German supplies of tungsten ceased, high-speed-steel makers had to fall back on supplies from the United States at from two to three times the German price. At a conference of users it was decided that the only way out of the difficulty was to commence the manufacture of the necessary alloys in this country. The leading South Yorkshire manufacturers have accordingly combined in the formation of a private limited company called "High-Speed Alloys, Limited," with a capital of 50,000*l.* The company has taken offices in Sheffield, and its purpose is "to carry on the business of manufacturers of and dealers in tungsten, molybdenum, vanadium, chrome, and other metals or substances used in connection with the manufacture of steel, general merchants, miners, iron-masters, smelters, engineers, manufacturers of chemicals, iron-founders, &c." Unemployment in the steel trades has undergone a further decline, only one in every 130 insured workers being unemployed. The armament houses are engaged unceasingly in the production of armour, guns, and shells. A special shift system has been adopted which enables production to continue day and night throughout the week. Orders for railway steel, castings, and all kinds of tools are plentiful. Deliveries are becoming more regular, and less difficulty is experienced in regard to payments. Special steel has been ordered by South Africa, India, and Australia, and files, saws, twist-drills, and mining implements by Calcutta, Rangoon, Capetown, Durban, Natal, Montreal, and Delagoa Bay. Business in crucible steel continues poor, but Siemens steel cannot be made fast enough, and high prices are asked for acid billets, Bessemer acid being quoted at 7*l.* 15s. to 8*l.* and Siemens acid at 8*l.* 5s.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—A very quiet feeling prevails. The action of the Admiralty in practically closing the North Sea by declaring it a military area is generally approved, though it is fully realised that the drastic step will, for the time being, cripple trading. Producers of pig-iron are very anxious to keep furnaces in blast over the winter months, and are prepared to do so at some sacrifice. The position as regards cost of output may become such as to render it impossible to keep all the furnaces in operation, for fuel continues very dear, and the declaration with regard to the North Sea is stiffening prices of foreign ore. Makers, however, it would seem, have confidence in matters righting themselves, for, since our last report, Messrs. Bolckow, Vaughan have re-started a furnace on Cleveland pig, and the Acklam Iron Company have relighted one to produce special iron. This increases the number in blast on the North-East Coast from 71 to 73, of which 36 are running on Cleveland pig, 25 are making hematite, and 12 are producing special kinds of iron. No. 3 g.m.b. Cleveland pig is 49s. 6d. f.o.b.; No. 1 is 51s. 9d.; No. 4 foundry 49s.; No. 4 forge 48s. 6d.; and mottled and white iron each 48s. East Coast hematite pig is weak, with demand practically at a standstill. Home consumers are said to be well stocked, and trade with oversea customers is cut off. Nos. 1, 2, and 3 are on sale at 62s. Sellers of foreign ore base quotations on fully 17s. 6d. ex-ship Tees for Rubio of 50 per cent. quality, and some firms intimate that they would not make contracts for delivery over periods next year except at a much higher rate. Freights Bilbao-Middlesbrough have advanced 1s., and are now 5s. 6d. Up to 17s. 6d. is still asked for Durham beehive blast-furnace coke of average quality delivered at Tees-side works.

Stocks of Pig-Iron.—According to the official returns issued by Messrs. Connal and Co., the public warrant storekeepers, the stock of Cleveland pig-iron during the month of October was increased by 1097 tons. There are warrants in circulation for 100,800 tons of No. 3 Cleveland pig-iron, and the quantity of iron in store now stands at 103,925 tons.

Iron and Steel Shipments.—The shipments of iron and steel from the Tees during the month of October were on only a moderate scale, and fell considerably below those of October a year ago. Those of pig-iron averaged 2089 tons per working day, the total despatches being returned at 56,406 tons, 48,757 tons of which went from Middlesbrough, and 7649 tons from Skinningrove. In September the loadings totalled 58,923 tons, or a daily average of 2266 tons, and for the corresponding month a year ago the clearances amounted to 125,190 tons, or an average of 4636 tons per working day. All the iron cleared at Skinningrove last month went to Scotland. Of the pig-iron loaded at Middlesbrough, 24,834 tons went abroad, and 23,923 tons coastwise. Scotland, as usual, was the largest buyer, importing 15,645 tons, whilst Sweden received 10,840 tons; Wales, 4400 tons; Japan, 3325 tons; United States of America, 2932 tons; Holland, 2365 tons; Norway, 1726 tons; Portugal, 1250 tons; Italy, 1200 tons; and Denmark, 1020 tons. Tees loadings of manufactured iron during October amounted to 12,425 tons, 5472 tons of which went foreign and 6953 tons coastwise, and those of steel to 23,227 tons, of which 19,741 tons went abroad, and 3486 tons to home customers. India was the largest buyer of both, taking 3042 tons of manufactured iron and 8721 tons of steel.

Manufactured Iron and Steel.—In the manufactured iron and steel trade works are fairly well employed. New business, however, is slack, and specifications are only coming in slowly. Prices all round are unaltered. Principal market quotations stand:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 5s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 8*l.*; iron ship-rivets, 8*l.* 7s. 6d.; iron girder-plates, 7*l.* 5s.; steel bars (basic), 7*l.* 10s.; steel bars (Siemens), 7*l.* 15s.; steel ship-plates, 7*l.* 5s.; steel ship-angles, 7*l.*; steel boiler-plates, 8*l.* 5s.; steel strip, 7*l.* 5s.; steel hoops, 8*l.*; steel joists, 7*l.* 2s. 6d.; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 7s. 6d.; steel railway sleepers, 7*l.*—railway material net at works, and all other descriptions less 2½ per cent. discount; galvanised corrugated sheets, 24-gauge, in bundles, 14*l.* f.o.b.—less 4 per cent.

Northern Shipbuilding Orders.—Shipbuilders and engineers on the North-East Coast have a good deal of work on hand. Besides being busy with work for the Government, they have received orders for the construction of a considerable amount of tonnage. The following firms have just received orders:—Messrs. Sir Raylton Dixon and Co., Middlesbrough, a large cargo-boat for the Colonial Sugar Refining Company of Australia; Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle, a high-class liner, about 447 ft., for the Shaw-Saville-Albion Company; Messrs. Palmer's Shipbuilding and Iron Company, Limited, Jarrow, a large cargo steamer for the Ellerman Line; Messrs. Swan, Hunter and Wigham Richardson, Limited, Wallsend, two large oil-tankers for the Anglo-Saxon Oil Company; Messrs. Wood, Skinner and Co., Bill Quay-on-Tyne, a handy-sized steamer for Messrs. Lysberg, of Cardiff.

UNITED STATES ORDNANCE.—We read in the *Iron Trade Review*, Cleveland, Ohio, that the United States Navy Department opened on the 15th ult. bids for a new type of 14-in. gun. The Midvale Steel Company quoted 97,875 dols. (19,575*l.*) each for not less than ten guns, and the Bethlehem Steel Company 98,500 dols. (19,700*l.*) each for twenty guns—the number to be purchased. Bids were also opened for twenty sets of 14-in. rough-bored and turned forgings; for these the Bethlehem Company quoted 33½ cents (16¾d.) per lb., and the Midvale Company 34 cents (17d.) for twenty sets. The other bids were for forty-five sets of 14-in. rough-bored and turned breech-mechanism forgings, the prices for which ranged from 25 to 34 cents (12½d. to 17d.) per lb., the lowest price being that offered by the Pennsylvania Company. The Erie Forge Company quoted 32 cents (16d.), the Bethlehem Company 33½ cents (16¾d.), and the Midvale Company 34 cents (17d.) per lb. The total of the lowest bid on finished guns is 1,957,500 dols. (391,500*l.*), whilst the total of the lowest bid on forgings, involving 1600 tons, is 1,172,000 dols. (234,400*l.*), and the total of the lowest figure on breech-mechanism forgings, involving 112 tons, is 56,250 dols. (11,250*l.*). The gun material in question is for the battleships California, Idaho, and Mississippi.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Buyers have continued to pursue a waiting policy. The best Admiralty descriptions have been only in limited supply in consequence of short outputs and large recent requirements of the British and allied navies. House coal has been supported by a good demand; patent fuel and coke have shown little change. The best Admiralty large steam-coal has made 21s. to 22s.; best secondary qualities have brought 19s. to 20s. 6d.; other secondary descriptions, 18s. 3d. to 18s. 9d.; best bunker smalls, 7s. 9d. to 8s.; and cargo smalls, 5s. 6d. to 6s. 6d. per ton. The best household coal has been quoted at 19s. to 20s.; good households have made 17s. to 18s.; No. 2 Rhondda large has brought 12s. 3d. to 13s. 3d.; and No. 2 smalls have realised 6s. 6d. to 7s. 6d. per ton. Special foundry coke has been quoted at 27s. to 30s.; good foundry coke at 20s. to 24s.; and furnace coke at 17s. 6d. to 18s. 6d. per ton. As regards iron ore, Rubio has made 16s. 6d. to 17s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Welsh Coal Exports.—The war is telling heavily upon the Welsh export coal trade, apart, at any rate, from shipments to the Admiralty, which may be regarded as exceptional. The general shipments from Cardiff in September, exclusive of deliveries to the Admiralty, were as follow:—Foreign, 898,098 tons; coastwise, 75,911 tons; bunkers, 227,314 tons; coke, 1831 tons; and patent fuel, 30,889 tons. The corresponding shipments in September, 1913, were:—Foreign, 1,675,361 tons; coastwise, 279,199 tons; bunkers, 284,827 tons; coke, 7991 tons; and patent fuel, 65,526 tons. There were, accordingly, decreases all along the line—viz.:—Foreign 777,263 tons; coastwise, 203,288 tons; bunkers, 57,513 tons; coke, 6160 tons; and patent fuel, 34,637 tons. Similar decreases were noted at Newport, the shipments foreign having fallen off, in September, 81,805 tons; coastwise, 17,565 tons; bunkers, 15,759 tons; and patent fuel, 2681 tons. Coke deliveries, however, showed an increase of 1361 tons. Swansea decreases for the month were:—Foreign, 148,940 tons; coastwise, 11,545 tons; bunkers, 6652 tons; coke, 906 tons; and patent fuel, 22,913 tons. There were also decreases at Port Talbot, viz.:—Foreign, 96,759 tons; coastwise, 4209 tons; bunkers, 5520 tons; and patent fuel, 13,414 tons. The general outlook was slightly relieved by an increase of 1055 tons in coke shipments.

Wales and Algeria.—Welsh makers of patent fuel have been invited to tender for the supply of 102,000 tons of such fuel for the Algerian State Railways, deliveries to be made from January to October next year. A small quantity of coke was also required for the same system.

Newport.—The steam-coal trade has shown no great activity. Supplies have been plentiful and prices have been slightly unsteady. House coal, patent fuel, and coke have remained without quotable change. Best Newport Black Vein large has made 16s. 9d. to 17s.; Western Valleys have brought 16s. to 16s. 6d.; and Eastern Valleys, 15s. 6d. to 16s. per ton.

The South Wales Coal-Field.—A Peace Committee, appointed by the Conciliation Board some time since, has disposed of a large number of disputes; and the settlements effected have been accepted by both employers and workmen with one or two exceptions. A banksmen's committee has also made settlements at nearly all the collieries in the coal-field. The terms agreed upon by the committee are not compulsory, and in a few cases the men have elected to continue on the old system, where a reduction of hours is considered to mean a reduction in wages.

THE LATE MR. ALEXANDER AULD.—The death took place, on Friday morning, the 30th ult., at his residence in Kilmarnock, of Mr. Alexander Auld, who for about fifty years was in the employment of Messrs. Andrew Barclay, Sons and Co., Limited, Caledonia Works, Kilmarnock, and for many years acted as their outside representative. His business took him over the whole of the industrial districts of Scotland and the larger part of England. Mr. Auld was widely known and much respected, and his loss will be keenly felt by a large circle of friends.

MOTOR AMBULANCES FOR THE FRONT.—Messrs. Babcock and Wilcox, Limited, have presented two standard motor ambulances to the British Red Cross Society for service at the front. One of the ambulances has been given by the company, and the other has been paid for by subscriptions from the directors and staff. The response from the staff has been so satisfactory that there will be a surplus of between 40*l.* and 50*l.* beyond the 400*l.* required for the ambulance, and it is proposed that this should be handed to the Red Cross Society to go to the cost of another ambulance.

BRITISH TRADE WITH THE STRAITS SETTLEMENTS.—Mr. A. Stuart, Registrar of Imports and Exports at Singapore, the correspondent of the Board of Trade for the Straits Settlements, who is now on a visit to England, will attend at the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C., on Tuesday, Wednesday, and Thursday, November 17, 18, and 19, between the hours of 10 a.m. and 5 p.m., and will be pleased to see by appointment British manufacturers and traders, not represented in the Straits Settlements, who may desire to consult him regarding trade conditions and openings in that Colony. Applications for appointments with Mr. Stuart should be made promptly to the Director of the Commercial Intelligence Branch, 73, Basinghall-street, London, E.C.

THE SPEEDOMETER AND CARBURETTOR WORKS OF MESSRS. S. SMITH AND SON, LTD., LONDON.

(*For Description, see Page* 562)

FIG. 1. AUTOMATIC MACHINES IN SPEEDOMETER-SHOP.

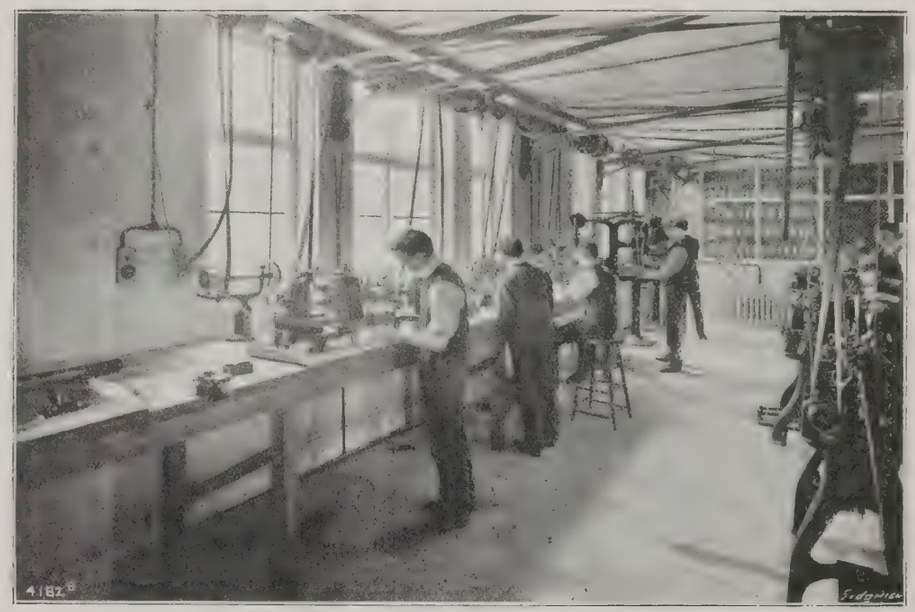


FIG. 2. SMALL MACHINE SECTION OF SPEEDOMETER-SHOP.

FIG. 3. SPEEDOMETER ASSEMBLY DEPARTMENT.

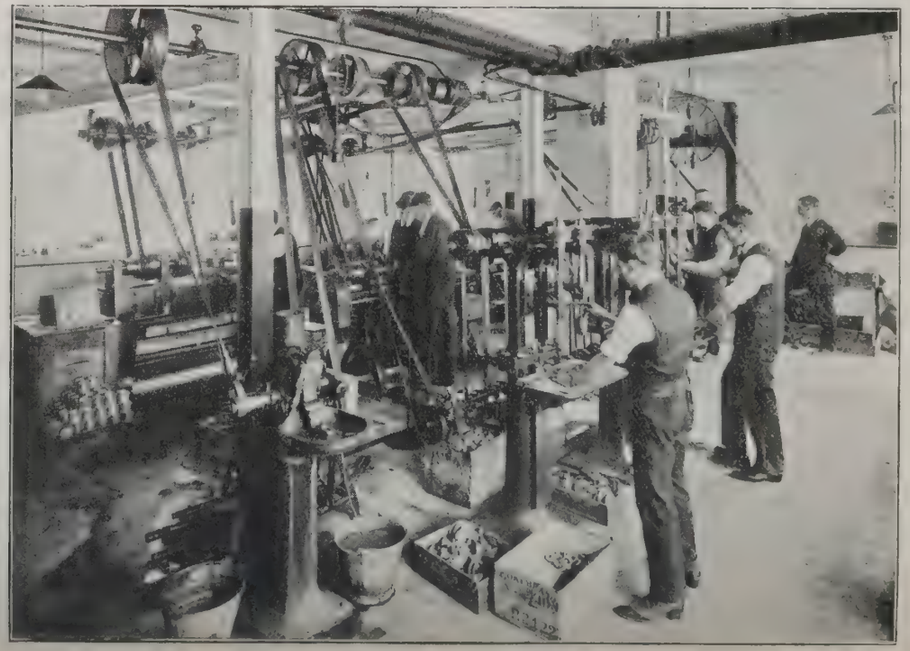


FIG. 4. CARBURETTOR MACHINE-SHOP.

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CANADA, Toronto, Ont.: Wm. Dawson & Sons, Manning Chambers. Montreal: Sells, Limited, 302, Shaugnessy Building, McGill-street.
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TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.
UNITED STATES, New York: W. H. Wiley, 432, Fourth Avenue. Chicago: H. V. Holmes, 957-958, Monadnock Block.

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The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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NOTICES OF MEETINGS.

BRITISH FOUNDRYMEN'S ASSOCIATION: LANCASHIRE BRANCH.—Saturday, November 7, at 4 p.m., at the School of Technology, Manchester. Open discussion on Foundry Problems.

THE INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.—Monday, November 9, at 8 p.m., a paper entitled "Some Notes on the Wear and Tear of Boilers" will be read by Mr. E. B. W. Maitland, B.Sc., Graduate, of London. Chairman: Mr. C. E. Stromeyer.

THE INSTITUTE OF MARINE ENGINEERS.—Monday, November 9, at 8 p.m. "The Circulation of the Scotch Boiler, and How It May be Improved," by Mr. John Tait. Sir James Mills is expected to preside.

THE SURVEYORS' INSTITUTION.—Monday, November 9, at 8 p.m., the first ordinary general meeting of the session 1914-15 will be held, when the President, Mr. Howard Chatfeild Clarke, will deliver an opening address.

THE INSTITUTION OF RAILWAY-SIGNAL ENGINEERS. — Tuesday, November 10, at 2.30 p.m., in the Lecture Theatre, at the Institution of Electrical Engineers, Victoria Embankment, London. Mr. A. H. Rudd's reply to the discussion on his paper, "American Signal Practice as Compared with British Practice."

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH LOCAL SECTION.—Tuesday, November 10, at 8 p.m., in the Rooms, 207, Bath-street, Glasgow, when the Chairman, Mr. James Lowson, will deliver his inaugural address.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, November 11, at 8 p.m., in the Hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, Westminster, S.W. Mr. A. Ludlow Clayden and Mr. Harold Burchall will read a paper entitled "Retail Transport."

THE OPTICAL SOCIETY.—Thursday, November 12, at 8 p.m., at the Rooms of the Chemical Society, Burlington House, Piccadilly. A paper on "The Possible Effects of the War on British Optics," by Mr. T. H. Blakesley, M.A.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 12, at 8 p.m. "Cables," by Mr. C. J. Beaver, Member.

THE PHYSICAL SOCIETY OF LONDON.—Friday, November 13, at 8 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. Agenda: "A Bridge for the Measurement of Self-Induction," by Mr. D. Owen, B.A., B.Sc.; "On the Coefficient of Diffusion in Dilute Solutions," by Mr. B. W. Clack, B.Sc.

NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to some Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, NOVEMBER 6, 1914.

THE FUNCTIONS OF A TECHNICAL INSTITUTION.

ENGINEERING is at bottom a commercial matter. Any new project or new operation, no matter what its success from a technical standpoint, must ultimately stand or fall by its ability, or lack of it, to make out a case for itself in business competition with other projects and operations. The commercial test is in every case the final test. To realise this, however, is not to admit that engineering and engineers have no other interest than to produce or sell more cheaply than their neighbour—that their business is one with that of the Saturday night coster bawling his apples and bananas. With many engineers—probably with most—the underlying commercial aim is hardly present in the foreground as they carry out their work. It more probably occupies a convenient place in the middle distance, and slightly out of focus. A draughtsman engaged in redesigning a machine, in such a way as to conserve its valuable features and yet reduce its manufacturing cost, fixes his attention and interest on the mechanical problem involved rather than on the selling necessity, which is the basis of that problem. He is an engineer, not a salesman, and although his work must ultimately be judged by commercial standards, his actual designing is not commercial work. It is engineering, and as such carries interests and claims which belong only to engineering.

At one time and another a good deal has been talked and written about engineers and business men, and the supposed superiority of the former and the finer nature of their calling. Most of it has been rather silly. Essentially all successful engineers are good business men. Their professional duties are, of course, not the same as those of the men who organise and operate the commercial sides of a business; but in the long run, unless their technical proposals and actions are commercially sound, they cannot be successful, and are, in fact, not good engineering. If we admit all this, as we do admit it, it opens the way for an attack on some of the professional proceedings of engineers. It may be asked, and it has been asked, why, if the interests and aims of the engineering and commercial sides of a business are one, do engineers insist on forming themselves into a caste apart, and, for instance, refuse to admit any commercial element into their technical institutions. The idea is not that they should admit purely commercial members. Clearly no case could be made out for such a claim. The contention is that, since successful engineering must be based on successful business, it would be well frankly to recognise the fact, and not only admit, but encourage the discussion and handling of, commercial matters by the Institutions.

A very important instance of this class of claim has been in evidence for the past year or so in connection with the Institution of Electrical Engineers. A party—we think a strong party—in that Institution felt that its proceedings and activities were of too purely a technical character, and that if it was to take its place as the head in every sense of the electrical profession, it was necessary that it should interfere more directly in the many non-technical or semi-technical questions which affected the interests of its members. Whether as a result of the agitation of this party or not, we do not know, but certainly, in furtherance of its ideas, an Industrial Committee was formed by the Institution to deal with matters of the class in question. The Committee, which was formed in November, 1912, consisted of various members of Council and ordinary members of the Institution, with some representatives of such bodies as the Tramways and Light Railways Association, the Association of Electric Power Companies, the British Electrical and Allied Manufacturers' Association, &c. The Committee held fourteen meetings, and then reported to the Council of the Institution that its constitution had proved not such as to enable it to perform useful work, and suggested that the Council should decide if its powers should be enlarged, or, alternatively, if the consideration of industrial questions was properly within the province of the Institution. In the end the Committee was dissolved in the early part of this year.

The brief history of this Industrial Committee was referred to by Sir John Snell, the new President, in his address to the Institution on the 29th ult. Sir John appeared to think that the non-success of the Committee was inherent in the nature of things, since its proceedings had largely to do with controversial matters, in which the interests of one body of members of the Institution might be, and usually were, directly opposed by those of another body. For the Institution to attempt to deal with questions of this class was to divide it against itself. He stated that, in his opinion, there must be other bodies, apart from the Institution, whose duty it would be to deal with the immediate and special interests of various classes of electrical workers. The majority or all of the members of these classes might also be members of the Institution, but their special sectional interests could not be directly safeguarded by the Institution without the possibility of injuring those of another class of members. The particular interests must be cared for outside. Thus the Incorporated Municipal Electrical Association watched over municipal interests, the British Electrical and Allied Manufacturers' Association dealt with commercial and industrial details of manufacturing, the Electrical Contractors' Association made it its business to protect the interests of wiring contractors, &c. Alongside all these bodies, above them if one wished, the Institution of Electrical Engineers would stand untrammelled by any sectional interest and desirous of advancing electrical interests generally, maintaining a broad and impartial outlook over the whole profession and electrical industry.

With the whole position thus presented by Sir John Snell we are in complete agreement, but we would carry the case much further than he did. We have no wish to criticise the stand he took—those who are not against us are for us—but we do wish to take our stand in a more definite and precise way than he appeared to do. The objections to a technical institution handling commercial matters go much further than the fact that such questions are likely to divide the institution against itself. They go down to the basis of the constitution and aims of the institution and threaten to undermine its whole position. We have said that engineering is based on commerce, but we have not said that engineering is merely commerce. Engineering is an important and leading profession, and its own interests and duties require

the existence of institutions which shall represent it, and it alone, and such have no secondary aims or intentions. If the Institution of Electrical Engineers or any other such institution is to properly represent the engineering profession, it must be independent of all commercial and business factors.

We do not know that there is anything in the Articles of Association of the Institution of Electrical Engineers, or of any other of the leading engineering institutions, to prevent it from dealing with commercial matters if it wishes; but if it is to do so, it must inevitably give up the idea of occupying the position that an important technical institution should occupy. The two things cannot go together. We do not mean to say that an institution cannot deal at one and the same time with technical and commercial interests; but if it does, it cannot occupy a leading position on the technical side. It is precisely inasmuch as they do not deal in commercial matters that the strength of the leading technical societies lies. It is not merely that the introduction of business interests may cause the Council to favour one part of the members against another. This division is not the essence of the matter at all. The technical interests of all the members of an institution are by no means necessarily similar. The point is that the authority of an institution in its own branch of work must be weakened by introducing elements in which there can be no authority.

An important technical institution rightly should be regarded as the final arbiter in its own special sphere. We do not say that all, or any, of our institutions have reached this position, but that is the aim. If, now, an institution of this class is to interfere in commercial matters, it must lose some of its influence in its own province. In commercial matters there are no authorities in the present sense, and if a technical institution is to dabble in them, its standing can only be that of frankly commercial associations. We know very little of the Electrical Contractors' Association, but have no doubt it is an enterprising and valuable body; but no one, least of all, we imagine, the Association itself, would suggest that it has, or can have, any independent authority as far as the general public and the engineering profession as a whole is concerned. Its actions and judgments are naturally and rightly coloured by its constitution and duties. Its affair is to look after the business interests of its members. The same thing applies to other commercial or semi-commercial institutions.

The duties and privileges of the Institution of Electrical Engineers and similar bodies should be quite other than this. Their business in the best sense is to stand as independent authorities on technical matters. Their proceedings, their papers, and their published views should represent the best they are able to give and the best the country is able to give in the way of advice and information on strictly technical matters divorced from all consideration of the commercial value or otherwise of those views to their members or anyone else. If an institution has commercial interests, its opinions must be coloured by those interests. It is impossible that they should not be. And, as a consequence, it cannot attain to or hold an authoritative position in a purely technical sphere. It may attain a semi-authoritative position in the sphere of its commercial interests. If it does or not depends on many things. But it cannot take the position which, in our opinion, it should be the aim of the Institution of Electrical Engineers to take. It is not the business of the Institution of Electrical Engineers to look after all the electrical interests of its members. It is not its business to have anything whatever to say or do with disputes between wiring contractors and municipal supply departments. It is not its business to assist its manufacturing members in meeting foreign competition, except in so far as helping them to learn the best that is being done in other countries is such assistance. Its business is to stand aloof from commerce, so that its opinion and words, and the opinions and words of its members, when speaking as members, may represent technical opinion only, and not technical opinion coloured by even the smallest ulterior motive.

THE PANAMA CANAL.

It is perhaps just as well that the American love of demonstrations and celebrations was given little opportunity of displaying itself on the occasion of the opening of the Panama Canal to commercial vessels, on August 15 last. On page 256 *ante* we chronicled the passage of the Ancon through the Canal. The event passed off without incident, and practically no ceremony. A number of guests were on board the ship, but Colonel G. W. Goethals, although the chief figure of the occasion, was to be seen superintending the various operations in the most informal manner. Quite forgetful of the elaborate programme arranged for next year, the American Press has adopted an attitude conforming with the official decision, and has tried to make out that a quiet and unostentatious opening best befitted the grand scale of the work at Panama. In the light of subsequent events, any other form of inauguration at so early a stage would have been unfortunate. Indeed, it is a question whether the postponement of the opening of the Canal to commerce would not ultimately have been better.

There has been a great desire to bring the work to a conclusion, but for so large a task some extra weeks or months would have been no serious matter. Some delay would probably have proved preferable to the dislocation of traffic once it has been started. Twice recently the Canal has been blocked. Once, on October 15, material slid into the Canal and blocked it for five days. On this occasion fifteen ships were detained in the Canal, and have demurrage claims against the Government. Again, on the 2nd inst., the Canal became blocked by a slide which, it was announced, would take three days to clear. The first of these two slides occurred just north of Gold Hill. It is not clear whether it formed part of a large slide which has given trouble in this vicinity for many years, and which has extended over an area of over 50 acres on that side of the Canal. It appears, however, that one of the characteristics of the old slide was noticed in that of a fortnight ago—namely, the upheaval of the Canal bottom by the pressure of the mass sliding down the bank. Upheavals of this kind are, of course, particularly dangerous to navigation. When they have happened in the past, the earth movement has sometimes been so rapid that there would seem to be considerable risk of vessels being grounded in the canal at such places, and it is difficult to see how the danger can be removed even with constant patrolling.

There was some question before the excavation was completed whether or not, on water being let into the canal, there would be a greater tendency for the banks to slide in. One of Colonel Goethal's chief arguments in favour of admitting water as early as possible last year was that if such things were likely to happen, the sooner they occurred the better, so that they could have done with them. Whether the saturation of the banks has increased their tendency to give way or not, it is fairly clear that the slide trouble is not yet over. The first few passages of large boats even at slow speed must bring down a good deal of unstable material on the banks. The rainy season, which is now at its height, will probably bring down more. Having regard to the magnitude of the slides in the past, it will be surprising if they do not give trouble for some time to come. In fact, it is a question whether it would not have been better, rather than throw the waterway open, to subject it to some moderately severe tests for some months yet. From the official reports, the test passages made have mostly been for the purpose of demonstrating the correctness of alignment and the working of the mechanical equipment. Where there has been trouble from slides, the material might even have been tempted to come down, and if it had done so it could have been cleared away, while greater provision for drainage at the weak spots could have been introduced.

In the end, even if the use of the Canal by commercial vessels were deferred for some months, the result would have been more satisfactory. Shipping will be rather shy of placing reliance upon a route liable to sudden interruption in this way, to say nothing of the risk to the vessels themselves. It will take some time to attract regular services to the new route if, after their making arrangements, they are forced by this reason to depart from them. Much of the merchant shipping is run nowadays to such clockwork schedules that the risk of being detained for an unknown length of time in the Canal would put that route out of the question for the present, and once frightened away, such services may prove difficult to bring back. The success of a good many engineering works has at one time and another been jeopardised by putting them to practical use just a trifle too soon. We trust that the troubles ahead of the Canal may prove slight, but the price of some further delay, if it would assure ultimate security, would be trifling on so big a work, and we cannot help thinking that the authorities would have been well advised not to announce the waterway as open for some time yet. The date for the official celebrations seems to have been better chosen.

THE BREAK OF GAUGE ON AUSTRALIAN RAILWAYS.

With everybody discussing war and invasions, it is natural that it should recur to the Australian mind how the defence of that continent is inconvenienced by the multiplicity of the railway gauges in the various States. No military expert who has given this matter attention has, so far as we know, done other than condemn this diversity. We have frequently referred to the complications this lack of uniformity introduces, even in times of peace. The breaks of gauge at the various borders form barriers which impede intercourse and interchange between the States to an extent which might amount to a veritable danger in time of war, if war entailed the risk of an invasion of the continent. There must be coupled, we think, with any reflection on the matter some regret at the procrastination which has postponed, year after year, the final settlement of this vexed question.

The *Melbourne Age*, which has always urged the importance of a decision, recently returned to the subject in its columns. We cannot help thinking, however, that in this instance its argument in favour of promptly undertaking unification is a little strained. It presupposes the possibility of an invasion of the Continent of Australia during the present upheaval. Now, though events have developed in the last few weeks so rapidly that any hazard at an exact forecast borders on rashness, we can hardly believe that the time has come for Australia's defence policy to be put to the test in that way. The enemies with which our nation is concerned have so far shown themselves unable to prosecute any over-sea expedition of importance, and the whole complexion of affairs will have to undergo a thorough change before anything of the kind can be attempted against our colony. Sporadic raids on ports and shipping, such as those already executed in various seas by Germany's fast cruisers, might be attended by some success. The overland transport of troops could do nothing to put a stop to such actions. The vessel would be away again practically before the troops had entrained, and only heavy artillery on the spot would be of service in such an event. It seems likely that so far as the transport of troops during the present war is concerned, the Australian railways will be employed mainly with the movement of the contingents dispatched to support the arms of the Mother Country in Europe. Even a few hours extra in that case really matters little. The delay would be a minute percentage only on the time occupied in training and in the voyage to Europe.

Not only does the work of unification not appear to be urgent at the moment, but it can easily be shown that quite reasonable arguments can be adduced in favour of its temporary postponement. If we suppose that the course of events might so turn against us that the invasion of Australia by large hostile forces became likely, it would clearly be greatly to the disadvantage of our colony to be caught in the middle of all the disorganisation which must almost inevitably accompany the act of unification. If the defence authorities had to contend with numerous temporary expedients and arrangements, the nature of which would depend upon the exact phase at which the work was interrupted, they would be much harder put to it than if they had to deal merely with what are, by now, known inconveniences, for which provision has doubtless been made in any plans for mobilisation. It may quite reasonably be argued, therefore, that a little further delay is advisable at the present juncture. The reply that this will still further increase the cost of the work when it comes to be undertaken is met by the fact that a hasty decision now would entail a lasting expense on the continent, probably of a much larger order. It is all very well to adopt an heroic strain; to say that now is the time for great works; that the confidence felt in the country should be translated into acts calculated to be of future value on a continental scale, and of present use

in improving employment, &c.; but, before such work is put in hand on the railways, we should like to see some broad-minded attempt made to secure an irrefragable verdict on the gauge and loading-gauge questions so often discussed in these columns. It has been pointed out to us that the present need for postponement furnishes just the opportunity for a reference of the whole matter to a commission of experts of world-wide standing, such as we have consistently advocated. It is to be hoped that this opportunity will be seized. Hitherto when any attempt has been made by politicians to force a decision in favour of one gauge or another, the plea has always been that the time for argument is past and that for action has come. Present conditions are clearly favourable to a deliberate survey of the whole position by first-class and independent judges.

It has often been argued that the 4-ft. 8½-in. gauge is best for the defence of Australia, because it would enable her to purchase stock easily and at short notice. On the other hand, we have shown that it would be better for the country to have an exceptional gauge, since it would then be more difficult for an invading force to utilise the railways. It has long been known, of course, that Russia's railways were made of a different gauge from those of Germany for military reasons. A German invasion of Russia is greatly hindered by the break of gauge. The same, of course, applies in the case of the prospective Russian invasion of Germany. In fact, an unique gauge is incontestibly advantageous for defence. The invader not only has to repair damage done by the forces retreating before him, but he has to supply his own rolling-stock; for naturally, except in a few accidental instances, all stock belonging to the railways would be withdrawn. This very fact, which should carry some weight at the present time, is an argument in favour of a departure, in Australia, from the so-called standard gauge.

NOTES.

The War and the Extension of Trade.

The Manufacturers' Section of the London Chamber of Commerce has just issued a report on the subject of the trade hitherto in the hands of German and Austro-Hungarian firms. Since the outbreak of hostilities the Chamber has been engaged in collecting information relating to the trade done by our enemies, and has been the means of bringing together manufacturers willing to make goods of some particular character, but not of their usual line, and merchants whose sources of supply have been cut off. The report just issued shows that, on the whole, business has been interfered with to a considerable extent, but only in a few instances has it been altogether suspended. The chief points relate perhaps to the financing of new enterprise. Prominent among these is the expression of the need for banks to give greater financial facilities to employers in financing the development of existing, or the establishment of new, enterprises, so that the advantages of present conditions may be secured. No business can, of course, be pushed ahead on to new ground without adequate capital. There appears to be some reluctance to invest in new industries or in plant, &c., needed for expansion, unless, to quote the report, there is given "some assurance on the part of the Government that manufacturers will be enabled to carry on freshly-established industries after the war, in the face of renewed foreign competition." With the prospect of having ultimately to compete with countries assisted by low wages, subsidies, &c., it is uncertain how far new investments would be assured of reasonable returns. The Emergency Committee has been instructed to give effect to several suggestions contained in the report. One of these is that the Government should be approached with regard to the Excise duties on alcohol; another suggests the Government assistance of firms having large uncollectable assets due from belligerent or neutral countries; a third asks for the relaxation of the Factory Acts, so that the hours of working may be made to suit the changes in the demands of business better.

International Atomic Weights.

The annual report for 1915 of the International Committee on Atomic Weights is published in the November number of the Journal of the Chemical Society of London. The members of the Committee—Messrs. F. W. Clarke, W. Ostwald, T. E. Thorpe, G. Urbain—do not propose any change in the now accepted weights. This is in accordance with the resolutions of the Eighth International Congress of Applied Chemistry—that no alterations should be made until after the meeting of the next Congress. The new analytical work dealt with in the report is, on the whole, moreover, not of a kind to press alterations. The accounts of the recent work of Oechsner de Coninck on calcium, barium, and copper are, for instance, not sufficiently detailed to justify recognition. Engaged in the study of standard cadmium cells, Hulett has, in conjunction with Quinn and Taylor, redetermined the atomic weights of cadmium and mercury; the values found for both these metals are lower than those accepted, and the Committee suggest the possibility of some methodical error. The repeatedly made suggestion that tellurium might not be a simple element, but contain a constituent "dvitellurium" of higher atomic weight than tellurium, is not supported by Dennis and Anderson. By reducing the iridium-ammonium chloride by means of hydrogen, Holzmann finds Ir = 193.42 instead of 193.1; a confirmation is to be awaited. On the other hand, the discrepancies between the recent and the old accepted values of the atomic weights of yttrium (Meyer and Weinheber), ytterbium (Auer von Welsbach), helium (Heuse), and neon (Leduc) seem sufficiently well established almost to justify a change; but the matter will stand over till the next Congress, as mentioned. As regards the last-mentioned two rare gases—helium and neon—the determinations rest on density measurements; the discrepancies found are not large (helium = 4.002 instead of 3.99, the accepted value, and neon = 20 instead of 20.2), but they are important in view of the speculations which have recently been based upon differences in the atomic weights of radioactive and other elements. The atomic weights of nickel (Ni = 58.68) and cobalt (Co = 58.97), about which there is so much controversy, have not been redetermined by chemists within the most recent years. We might add that the international atomic weights are based upon the assumption that oxygen has the atomic weight 16, which makes hydrogen = 1.008.

Steam and Electric Traction.

In a recent address to the Railway Students' Association, at the London School of Economics, Mr. R. H. Selbie, general manager of the Metropolitan Railway, discussed the relative advantages of steam and electric traction on railways. It was, he said, impossible to give a direct answer to the question as to whether electric working were cheaper than steam. Taking a six-car train, weighing 200 tons, and accommodating 400 passengers, which was, he said, a convenient size, the cost of operation by electricity would be 22½d. per train-mile. The energy required to drive such a train averaged, he said, about 18 Board of Trade units per mile, the cost of which, inclusive of all generating, maintenance, and interest charges, would be about 9d., since in a station generating, say, 50 million units per year the cost per unit, inclusive of all charges, did not exceed ½d. per unit. The cost of staffing such a train, the interest and maintenance charges on it, would average, he said, about 2¼d. per car-mile, or 13.5d. per train-mile, which, with the generating charges, made up the total cost to 22½d., as already mentioned. A steam-train of equal seating capacity could, Mr. Selbie said, be run at an inclusive cost of 17d. per train-mile, thus showing a very substantial saving. With steam-trains, however, it was not usually practicable to run over one set of metals more than fifteen trains per hour as a maximum, whilst with electric working thirty trains could easily be worked, and in special cases as many as forty to forty-five. Hence, if the traffic required thirty trains per hour, it would be necessary in the case of steam working to double the number of tracks, and the interest charges involved would then much more than offset the greater working cost per train-mile of the electric service. The six-car train adopted as the standard of comparison in the foregoing formed, Mr. Selbie said, a very convenient unit. It was 320 ft. long and seated 400 passengers, and during the slack hours of the day could be broken up into two trains, thus reducing running costs, whilst maintaining frequency of service. Longer electrical trains could, however, be run, and, in fact, nine-car trains were, in certain cases, in service during rush hours. Steam-trains could not be economically broken up into smaller units, since haulage charges with steam were not even approximately proportionate to the number of cars behind the engine. Hence the only practicable way of suiting the service to the slack-hour requirements was by reducing the number of trains, a procedure which tended to drive passengers to the motor-bus and tram. Up to distances of about three miles the motor-bus could, Mr. Selbie said, successfully compete with even electrically-worked trains, but for longer distances the advantage lay with the latter. As at present constructed, higher maximum speeds could be attained with steam than with electrically-operated trains, but in the case of suburban traffic, where the stops were frequent, this was no advantage, being much more than offset by the fact that the electric train attained a speed of 30 miles per hour in 29 seconds from the instant of starting, whilst the steam train took 97 seconds. In spite of the fact that during the slack hours of the day steam-locomotives might be used in other than passenger service, the electric system had in practice a better load-factor than its rival. This Mr. Selbie illustrated by the statement that in one power-station equipped with five 5000-kw. units the load-factor based on the machines actually in operation was 75.6 per cent., which was, he said, far in excess of any corresponding figure possible with steam-locomotives engaged in working suburban traffic.

Inodorous Sewage Treatment.

According to Dr. Rudolf Hering, there are over 100 Imhof sewage-treatment plants in Germany, and from none of them which is properly operated is there an offensive odour. The principle of the process lies in effecting the decomposition of the solids by means of bacteria which do not give rise to the evolution of sulphuretted hydrogen. Fermentation has to take place, of course, but it does so under conditions which give rise to marsh gas and carbonic dioxide, both of which are inoffensive. In the septic tank there is another form of fermentation—that is, putrefaction—and the result is, among other things, sulphuretted hydrogen. If the solids can be separated from sewage, and be protected from contact with further liquid sewage, then the controlling bacteria in the sludge are confined substantially to two classes producing the two gases named. To effect this the sewage is passed very slowly through a tank. This tank has a V-shaped bottom, with a narrow slot at the point of the V, affording communication with a lower, closed tank. The solids drop through this slot and lie quiescent in the lower tank, which has an escape for gases and appliances for the removal of scum. Such sulphur bacteria as find their way into the lower tank rapidly die, and in some three to five months the deposit attains a condition in which it can be exposed to the air without nuisance. The sludge laid in well-drained beds rapidly dries, and then can be used as a fertiliser. Before the sewage reaches the settling-tank it needs to go through a catch-pit to remove the grit and sand. This will take place at a velocity of 12 in. per second, and, after this, a coagulant may be added to ensure the precipitation of the fine suspended matter which would not otherwise be deposited even at so slow a speed as one-tenth of an inch per second. The liquid sewage which escapes can be treated on filter-beds of some kind, and then discharged into a stream, or passed over land, according to circumstances. The great advantage of this process is that the sludge lies at the bottom of the tank until it has lost its objectionable features. The portion at the bottom can then be pumped out from time to time, and be exposed to the air without giving rise to a stench or making its presence known at a distance. The sludge, too, appears to have some manurial value, a feature which is not usually found in this product, although it is more than probable that the chief value of the sewage passes away with the liquid portions to be nitrified in the filters or contact-beds. However, the managers of sewage works have long abandoned the idea of making a profit out of the process, and are quite content if they can carry it out without creating a nuisance.

The Institution of Naval Architects.—The ordinary dates for the next annual meetings of the Institution will fall on Wednesday, March 24, 1915, and the two following days.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. X.

By Frederick William Lanchester, M. Inst. C.E.

Other Weapons of Offence.

For the fighting aeroplane there is no doubt that the gun will prove to be the most useful all-round weapon; however, several other means of offence have been suggested and to some extent have proved themselves of value. Bombs and hand-grenades, both explosive and incendiary, have been found to be of considerable service under appropriate conditions. Other means of attack have been proposed, such as rockets, air-borne torpedoes, &c.; so far, neither of these latter appears to have been successfully utilised.

The difference between a bomb and a hand-grenade is mainly a matter of size and weight, and a corresponding difference in the arrangements made for its release. Ordinarily, a hand-grenade is a small bomb of some 5 lb. or 6 lb. weight or less, containing a high explosive or inflammable charge, and is, as its name implies, thrown by hand. Requiring no particular provision for its storage or discharge, it is a weapon particularly suited to employment by scouting and other machines not primarily intended for fighting. The judicious employment of a few hand-grenades for the scattering of cavalry or the stampeding of led horses, or against troops on the march or massed in reserve, may by its effect amply justify the use of such a device. The bomb is commonly of considerably larger dimensions than the hand-grenade, and is stored or mounted in a magazine of some kind beneath the fuselage of the machine, with some mechanical device for its release, arranged either to let go a single bomb or to empty the magazine as required. It may be said that whereas the hand-grenade is only suitable for injuring *personnel*, the legitimate objective of the bomb is *matériel*. Thus the dépôts, magazines, arsenals, oil stores, &c., of the enemy cannot be effectively destroyed by gun-fire, at least from present-day aircraft; but if attacked by a few squadrons of aeroplanes, each dropping some eight or ten 30-lb. or 40-lb. bombs, irreparable mischief might be effected in a very short space of time. We may take it that in the future any such points will be duly protected by the fighting aeroplanes of the enemy. Consequently the bomb-dropping machine will need to be also a fighting machine itself, with a capacity for rapid fire sufficient to enable it to hold its own with the enemy. Or it will have to act in conjunction with a supporting fleet of fighting machines of sufficient strength to overpower, or at least hold, the enemy during the operation. It is thus clear that the bomb differs from the hand-grenade in not being a weapon suitable for casual employment by the non fighting machine. Further than this, it is a weapon that will in future warfare probably be found to possess little or no value, except when used in considerable numbers by machines acting in squadrons, or fleets several squadrons strong. The use of the incendiary bomb, or petrol bomb, as it is sometimes termed, is indicated where the objective is of a sufficiently inflammable character. But it is probable that in all cases in which an attack is made upon buildings of permanent character, such as in the destruction of an arms or ammunition factory, or of a dockyard, the petrol bomb will be used to complete the job by firing the wreckage remaining after high explosives have done their work.

The Bomb: Difficulties in Connection with Aiming.

The accurate directing or aiming of bombs or hand-grenades, or of any gravitationally-propelled missile, in fact, is one of great difficulty, and many suggestions for the improvement of the degree of precision attainable have been made. The problem, in a sense, is the inverse of that of firing at an aeroplane at high altitude. The period during which the projectile is at the top of its trajectory (the beginning of its fall in the case of the bomb), and in which its velocity is low, introduces considerable uncertainty into the question of direction; it has been proposed to minimise this difficulty by giving the bomb an initial velocity, or "send off," by some form of spring or pneumatic gun. The factor affecting the aim definitely known to the pilot is the velocity of flight (relatively to the air); the factors less exactly known are the height, the direction and velocity of the wind, or, as it must be reckoned by the aeronaut, the *earth drift*, and the direction of the vertical. Previous observation may have given the approximate wind allowance, and the barometric reading (the aneroid) will give the altitude, which, in conjunction with a contour map, will give the pilot the figure for his height. The determination of the vertical, or "plumb," is far less simple or certain than would at first sight appear, since any pendulum device is affected by acceleration just as much as by gravity, and the reading of a damped pendulum or a spirit-level gives the *apparent* plumb, which may be anywhere.

In the case of a machine "looping the loop," for example, the apparent plumb is, in fact, at one instant diametrically opposite to the true plumb, and during the whole evolution it "boxes the compass" in a vertical plane. The lateral deviations of the apparent from the the true plumb, are no less serious, and, in fact, whenever a machine is turning, and correctly banked, the spirit-level records the machine as being on an even keel. In other words, an error in the reading under these conditions is equal to the angle of banking, and is quite commonly as much as 30 deg. or 40 deg. It is precisely on this point—the confusion of the true with the apparent plumb—that many of the suggestions offered for the direction of bomb-dropping are found to fail; and it is quite useless for those having no knowledge of the principles involved to attempt to deal with the problem. No better way of obtaining a clear conception of the difficulty exists than a study of the pendulum accelerometer.*

In the case of a modern aeroplane which virtually "flies itself" it is possible to determine the true plumb with considerable exactitude under calm atmospheric conditions. Such a machine will, just like a gliding model, settle down to a definite flight velocity, known as its natural velocity, and to a known gliding angle, and will maintain a tolerably straight path; under these circumstances the apparent plumb *is* the true plumb. When, however, atmospheric disturbances are present, the difficulty once more makes its appearance.

In view of the above, it is doubtful whether bomb-dropping from aeroplanes will ever be found to compete with gun-fire on the score of accuracy, and it may be anticipated that the utility of this mode of offence will be confined mainly to attack on positions or objects that present a mark either of sufficient area or size to be easily hit or of sufficient importance to justify a prodigious expenditure of missiles.

The Steel Dart.

A form of gravitational projectile or missile introduced during the present war is the steel dart; this commonly consists of a piece of steel wire or rod some 5 in. or 6 in. long by $\frac{5}{16}$ in. in diameter, pointed at the one end and "feathered" at the other. In size and shape the missile resembles an ordinary well-sharpened graphite pencil, the feathering being done in some cases by the milling away of the tail portion to a cruciform section. Alternatively the rear two-thirds of the missile may be made of thin-gauge tube; the weight is about 1 oz. This "pencil dart" is used against the *personnel* of the enemy—*i.e.*, encampments, men or cavalry on the march, &c.; the rate of fall, if dropped from a few thousand feet altitude, would be little short of the limiting velocity, say some 400 ft. or 500 ft. per second. The penetration at this velocity should be about $1\frac{1}{2}$ in. to 2 in. of spruce planking. Steel darts are either allowed to fall out of a hopper or may be simply thrown out or "sown" by hand. They appear to be quite effective when they find their mark, but their discharge and direction are subject to the same limitations as to accuracy that apply to the throwing of the hand-grenade or bomb, with much greater uncertainty as due to wind resistance. Beyond this the steel dart, to be effective, *must* be dropped from a height—a very considerable height—and so it is not possible to make a sudden descent for the purpose of bringing off an attack, as is the case when the bomb is the weapon chosen. For these reasons the writer does not believe that the dart will have a very great vogue. Once the aeroplane has been satisfactorily adapted to the carrying of a machine-gun, it is quite clear that the steel dart, weighing, as it does, as much as the ordinary Service cartridge, must become a thing of derision.

* *Philosophical Magazine*, August, 1905; also Proceedings of the Institution of Automobile Engineers, vol. iv., page 124.

The Rocket and the Air-Borne Torpedo.

A suggestion that has made its appearance over and over again is that of the employment of the rocket in some shape or form; the objective is usually presumed to be a dirigible or airship, and the rocket is to be fired from a rocket-tube or gun of some kind from an attacking aeroplane. There are two replies to this suggestion: firstly, no weapon can be contemplated as forming part of an aeroplane armament that is *confined in its purpose* to the attacking of the airship. The airship is already becoming regarded as a prospective *bonne bouche* for the aeroplane squadron that is fortunate enough to encounter it in the open, and, as the recent exploit at Düsseldorf has shown, it is not in a much happier condition when at home. It is already recognised that the airship may not expose itself to the attentions of hostile aeroplanes, and when the latter are able to attack by one-pounder shell fire, in addition to bombs (explosive and incendiary), the airship, already little more than a name in active hostilities, will cease to have any, even verbal, interest. Apart from the above, the supposed effectiveness of the rocket, or of other spit-fire projectile, is based to a great extent upon a misconception. The modern airship is not so easily set on fire as is commonly supposed; in the rigid type, as exemplified in the Zeppelin, it is reported that the space between the gas-bags and the outer envelope is charged with a non-flammable gas, and it may be penetrated by any ordinary rocket through and through without the smallest chance of ignition.*

The aerial torpedo (proposed by the writer in 1897) at first sight appears promising. Such a torpedo would consist of a gliding model of high velocity adapted to be launched from a gun or pneumatic projector of some kind, and carrying a charge of explosive and an impact fuse actuated by the striking of the aerofoil member on some part of the enemy's craft. Again, we are confronted with the fact that any such weapon would be of little service apart from attack on an airship, and so may be looked upon as useless lumber.

The Supremacy of the Gun.

The real fact at the bottom of the whole question is the vital importance of high velocity in any projectile directed against a rapidly-moving target, and its doubly vital importance when the craft from which it is projected is also in rapid motion. This is universally recognised wherever the gun is to be found, and it is nowhere more important than in the attack on aircraft by aircraft, and in particular aeroplane on aeroplane. Any lapse of time whilst the projectile is in its flight introduces a corresponding uncertainty owing to the relative difference of motion between gun and mark. Thus any projectile travelling at 200 ft. or 300 ft. per second, such as a rocket or aerial torpedo, would require to be directed at a point so far removed from the aircraft it is intended to hit that, in the case of an aeroplane, the chances of success would be remote in the extreme. In brief, nothing but gun-fire gives the necessary rapidity to ensure a reasonable degree of accuracy and useful percentage of hits, and it is probable that for some time to come the demand will be for higher and higher velocity in order that the effective range may be increased. This, however, is looking into the future; at present, the problem of mounting a gun in a satisfactory manner, and getting the highest possible rate of discharge—*i.e.*, rounds per minute—are the more immediate concern of the aeroplane constructor. The relation of the ordinary flight velocity to the mean velocity of the projectile is round about 12 to 1, and this gives the angle of lead necessary to aim in front of the objective from a fixed mounting. When firing from another aeroplane moving in the opposite direction, the angle of lead will be six to one, more or less, a considerably greater allowance than is known in any other branch of gunnery. With the highest muzzle velocity and slow-moving aircraft the angle of lead under these conditions is about 1 in 15. The angle of lead given by a pigeon-shot when the bird is flying fast across the line-of-sight is about

* This feature was actually proposed some years ago to the authorities in this country, and was understood to be a matter of secrecy. However, according to *Navy and Army Illustrated* (September 12, 1914), it now appears to be an established feature of some of the later German Zeppelins.

1 in 20, and even here the demand, under the stress of competition, is for higher and higher velocity. This may be taken as a sure indication of what may be expected in the eventual future of aeronautical gunnery.

LITERATURE.

Compressed Air: A Treatise on the Production, Transmission, and Use of Compressed Air. By THEODORE SIMONS, E.M., C.E. New York: McGraw-Hill Book Co., Inc.

THIS is an eminently practical book, written by one who is well equipped for the task he has undertaken. It is evident that he has had experience of the working of compressed-air plant at the rock face, and is equally familiar with the training of a class of students acquiring a knowledge of the principles underlying the construction of machinery. When the ambition of the professor is tempered by the necessities of the workshop, and practice controls theory, a helpful achievement is likely to result. That is certainly true in this case, and those who are interested in the production, transmission, and employment of compressed air should get from this treatise a clear insight into the operation of the various appliances concerned in the several processes. With the explanation provided it should be easy to master those general principles of physics and thermodynamics that enter into the practical problem, and enable an engineer not only to understand the working of his installation, improve its efficiency, or trace its defects, but, if he will, to pursue independent researches into those wide-reaching possibilities of compressed air that have not yet been exploited.

After reference to such elementary subjects as the composition of air, the difference between isothermal and adiabatic compression and expansion, and the application of the laws of Boyle and Charles, we are introduced to the working of a single-stage reciprocating compressor, its mode of action, and the work accomplished under theoretical and practical conditions, a subject that is pursued till a satisfactory relation is established between the final pressure of a given quantity of air and the power required to compress to that pressure. We may trace a cubic foot of free air through all the changes of temperature and pressure to which it is submitted, and measure the causes that make for and against economic efficiency. That is the goal that the author keeps always in sight, and methodically and with great nicety he tracks the several causes that are operating and carries each to its proper place in the profit and loss account. There are some terms that refuse to submit to exact classification in the final balance-sheet. They can only be settled by a compromise between first cost, operating cost, and effect. The general problem becomes more complicated and the opportunities for the exercise of discretion more varied when the next step is considered, the attainment of the desired pressure in two or more stages. Obviously, there is an advantage if, after partial compression has been effected, with consequent rise in temperature, the air is led into an intercooler, where the heat generated during the first compression is absorbed by running water, and the cooled air subjected to a final pressure in a second cylinder. In such an arrangement we have also on the credit side a reduced strain on the machinery, better steam economy, dryer air, with consequently less trouble from condensation in the discharge-pipe, and less danger of freezing the exhaust-ports. On the other hand, the stage compressor is a more expensive piece of machinery, and its employment is only warranted when the reduction in operating costs more than compensates for the original investment, so that again the selection must be the result of compromise. As a practical rule, the author gives 60 lb. to 70 lb. terminal pressure as the limit at which it is economical to use a single-stage compressor. Between 60 lb. and 100 lb., the choice will be determined by the price and amount of fuel available, though altitude above sea-level, which has the effect of diminishing the weight of free air taken in at each revolution, will have to be considered. "Above 100 lb. both safety and economy speak for two-stage, and above 500 lb. for multi-stage compressors."

When a decision has been made to compress either by one or by more stages, the design and construction of the plant offering for selection are still bewilderingly varied. The problem of mechanical design is handled only so far as it serves to illustrate the theoretical principles discussed. Leaving on one side all details concerning the method of driving the engine, whether direct driven or belted, whether operated by electricity or other motor power, it is sufficient to note that the two main types on the market, known as "straight-line" and "duplex" compressors, have fundamental defects that are not easily eliminated. In the air-cylinder the resistance to the advance of the piston increases from zero to that maximum at which the discharge-valves open. In the steam-cylinder the development of power is precisely the reverse, so that in compressors of the "straight-line" type the steam power is in excess of the work at the beginning, but in defect at the end of the stroke. A fly-wheel is the natural expedient to overcome this inconvenience; but even with this aid the running is not smooth, and a severe strain on the moving parts is inevitable. The "duplex" compressor is designed to meet these manifest defects. It is essentially a combination of two "straight-line" machines so far as the steam and air-cylinders are concerned, with a single crank-shaft, a single fly-wheel serving both. The essential and valuable feature consists in the arrangement of the movements of the pistons on the two sides of the machine, which are so adjusted that by setting the cranks a quarter of a circle in advance of each other, one will be nearly in the middle, while the other is at the beginning or end of its stroke. With less assistance from the fly-wheel, the rotation is much more uniform, but, on the other hand, in addition to the greater initial outlay, the increased floor space occupied, and the more costly foundations required, there are double the chances of delays, for either side may be accidentally stopped, and then all the air is shut off until the necessary repairs are made to both machines. "A heated journal on either side will stop both." We can never escape the choice of compromise. The balancing of the advantages and disadvantages in forms of construction is rendered very evident. Every engineer in the course of his experience has met with plenty of similar cases, but here the defects are worked out quantitatively on the efficiency, with as much precision as the nature of the case permits, and we are made to see how our 100 per cent. at start dwindles down to 20 per cent. or less.

The device of re-heating in order to increase efficiency, the most judicious construction of the pipe-line, the economic use of compressed air in operating the engine, and many other practical details are amply discussed, and carefully constructed problems are designed to illustrate the working of each. These problems are made to contribute very successfully in enforcing generic principles, and in urging the necessity of strict supervision at every stage of the process. The author is justified in stating that "such problems make the student familiar with actual quantities never revealed by mere formulæ, quantities which are often startling to the uninitiated, and impress him with the practical value of such formulæ more forcibly than the mere text can do." In confirmation of this remark, we would ask anyone to work out the quantity of free air that will escape per minute from a pipe-line carrying air under pressure of 80 lb. gauge when the combined area of leakage in the total length amounts to half a square inch. He will find that it is no less than 824 cub. ft., and that to compress this amount of air in two stages to 80 lb. gauge would require 116 horse-power. This result should appeal more powerfully than any formula, and emphasise, in a way not to be forgotten, the importance of attending to comparative trifles.

The Petrology of the Igneous Rocks: A Summary of the Modern Theories of Petro-Genesis, a Description of the Rock-Forming Minerals, and a Synopsis of the Chief Types of the Igneous Rocks and their Distribution as Illustrated by the British Isles. By F. H. HATCH, Ph.D. Seventh Edition, revised. London: George Allen and Co., Limited. [Price 7s. 6d. net.]

FOR more than twenty years the author has been justly regarded as an authority on petrology, and this seventh edition of a well-known text-book marks his deserved success, and attests the popularity of his work. This is only one portion of a more complete treatise, for Dr. Hatch has endeavoured to systematise our knowledge of the composition and structure of sedimentary rocks, and the principal feature of this edition is the adjustment of the plan so as to bring the whole subject of the science of rocks under uniform and adequate discussion. This re-arrangement has necessitated new chapters on the pyroclastic rocks and the metamorphic derivatives of the igneous rocks. The primary classification of igneous rocks into plutonic, hypabyssal, and volcanic may not be satisfactory or scientific, but it is convenient, and having the sanction of almost universal usage, must be accepted. Similarly, the separation of each class of rocks into families and types can be justified, though among authorities there may exist differences of opinion in doubtful cases. We cannot say that we are prepared to accept with complete confidence the author's conclusion drawn from the eutectic theory of the process of crystallisation of igneous rocks, and his review of the formation of porphyritic crystals. To trust to the method of thermal analysis or the equilibrium diagram alone can hardly be regarded as sufficient in the presence of much recent work on metallic compounds. Just as the chemist has had to review some hasty and doubtful conclusions, so the geologist will find himself obliged to adopt other tests for the establishment of his conjectures.

Little alteration seems to have been made in the section exhibiting the distribution of the igneous rocks in the British Isles. This was a specially valuable feature in the earlier editions and would alone have warranted one in commending the work as a text-book to students. The amendments and extensions that have been made to this edition will give to this excellent manual a wider reputation and a longer life.

BOOKS RECEIVED.

The "Mechanical World" Year-Book and Pocket-Diary for 1915. Manchester and London: Emmott and Co., Limited. [Price 6d. net.]

Engineering Problems. Part I. By W. M. WALLACE, Wh. Sc., A.R.C.Sc., Assoc. M.Inst. C.E. London: The Technical Publishing Company, Limited. [Price 3s.]

Assaying in Theory and Practice. By E. A. WRAIGHT, A.R.S.M. London: Edward Arnold [Price 10s. 6d. net.]

The Flying Book. 1914 Edition. London, New York, Bombay, and Madras: Longmans, Green and Co., Bournemouth; The Aviation World Publishing Company, Limited. [Price 2s. 6d. net.]

Electric Cooking, Heating, Cleaning, &c. By "HOUSEWIFE" (MAUD LANCASTER). Edited by E. W. LANCASTER, A.M. Inst. C.E., M. Inst. E.E. London: Constable and Co., Limited. [Price 3s. 6d. net.]

Surveying and Levelling Instruments Theoretically and Practically Described. By WILLIAM FORD STANLEY. Fourth Edition, Revised by H. T. TALLACK. London: E. and F. N. Spon, Limited, and W. F. Stanley and Co., Limited. [Price 7s. 6d., post free.]

United States Geological Survey: Department of the Interior. Bulletins. No. 498. *Head-Water Regions of Gulkana and Susitna Rivers, with Accounts of the Valdez Creek and Chistochina Placer Districts.* By FRED H. MOFFIT. No. 507. *The Mining Districts of the Western United States.* By JAMES M. HILL. *With a Geologic Introduction by* WALDEMAR LINDGREN. No. 508. *The Onondaga Fauna of the Allegheny Region.* By E. M. KINDLE. No. 516. *Results of Spirit Levelling in Florida.* By R. B. MARSHALL. No. 517. *Results of Spirit Levelling in Alabama,* 1911. By R. B. MARSHALL. No. 540. *Contributions to Economic Geology,* 1912 Part I. *Metals and Non-Metals, except Fuels.* By DAVID WHITE. No. 543. *Geology and Geography of a Portion of Lincoln County, Wyoming.* By ALFRED REGINALD SCHULTZ. No. 546. *Mineral Resources of South-Western Oregon.* By J. S. DILLER. No. 547 *Reconnaissance of the Grandfield District, Oklahoma.* By MALCOLM J. MUNN. No. 551. *Results of Triangulation and Primary Traverse,* 1911 *and* 1912. By R. B. MARSHALL. No. 552. *Results of Triangulation and Primary Traverse in Ohio,* 1898 *to* 1911, *inclusive.* By R. B. MARSHALL. No. 553. *Results of Spirit Levelling in Illinois,* 1911 *to* 1913, *inclusive.* By R. B. MARSHALL. No. 554. *Results of Spirit Levelling in Kentucky,* 1898 *to* 1913, *inclusive.* By R. B. MARSHALL. No. 558. *Results of Spirit Levelling in Wyoming,* 1896 *to* 1912, *inclusive.* By R. B. MARSHALL. No. 564. *Results of Spirit Levelling in Oklahoma,* 1895 *to* 1912, *inclusive.* By R. B. MARSHALL. No. 575. *Geology of the Standing Rock and Cheyenne River Reservations, North and South Dakota.* By W. R. CALVERT, A. L. BEEKLY, V. H. BARNETT, and M. A. PISHEL. Washington: Government Printing Office.

Business Life: Hints on Office Management. By W. J. PARKINS. London: H. R. Allenson, Limited, Racquet-court, E.C. [Price 1s. net.]

THE NEW ARMY.—The number of recruits who were employees of the British Thomson-Houston Company, Limited, of Rugby, has been raised from 900 to 1000.—On the 18th ult. Mr. Charles Bright, F.R.S.E., M. Inst. C.E., M.I.E.E., gave an address at Leigh, Kent, dealing with the cause of the war and Britain's requirements as regards new forces. Enlistments followed.

THE LATE MR. JOHN JAMES WEBSTER.

We regret to have to announce the sudden death of Mr. John James Webster, which occurred at his residence, 81, Mount Nod-road, Streatham-hill, S.W., on Friday last, the 30th ult.

Mr. Webster was a member of the Institution of Civil Engineers, of the Institution of Mechanical Engineers, and a Past-President of the Liverpool Engineering Society. He was born in Warrington, on June 9, 1845, and was articled pupil to Messrs. E. T. Bellhouse and Co., Manchester, in 1861, and remained in their employ for over ten years, occupying for over four years the position of head draughtsman and assistant manager. During his apprenticeship he was also an engineering student at Owens College, under Professor O. Reynolds. Whilst on the staff of Messrs. E. T. Bellhouse and Co., Mr. Webster was engaged on the construction of several large road and railway bridges, from the designs of Mr. E. Woods and Mr. William Martineau. He also made many original designs for bridges, roofs, piers, &c. In the year 1871 he was engaged by Mr. William Parsey, manager of the Ashbury Carriage and Iron Company, on plans for a number of Indian bridges, and on plans for a new steel-making plant for the works. In October of the same year he took up a position at the works of Messrs. Thomas Brassey and Co., as chief of their Bridge Department, a position which he held until April, 1876, and where he had charge of the designing and construction of numerous important structures for all parts of the world. He had charge, among other works, of the construction of the Liverpool landing-stage, from the designs of Mr. G. F. Lyster. In 1876, also, he held a short engagement as assistant to Mr. William Dyce Cay, Engineer to the Aberdeen Harbour Board. He was further engaged, in October, 1876, as assistant to Mr. R. A. Marillier, engineer to the Hull Dock Company, under whom he had charge of the designs, construction and erection of an hydraulic swing-bridge, two tilt and draw-bridges, one fixed bridge, grain warehouses 500 ft. by 50 ft., five floors and cellars, a sliding caisson, two large hydraulic pumping-stations, a large double dredger, a hopper-barge, &c. He left this position in December, 1880.

Mr. Webster received the Telford Medal and Premium in 1880, and in 1881 he commenced private practice in Liverpool, when he designed a bridge 600 ft. long for erection in Australia, a pier and landing-stage for South America, and assisted in the designing of the Leyland Water Works; he also designed wire ropeways for Spain. In 1883 he was appointed engineer for the new bridge to be erected over the Ouse, at Bedford, the bridge having a 200-ft. clear span, and 35 ft. width between parapets. He also had charge of improving the River Ouse at the bridge site. Among his other work carried out in the 'eighties of last century we may mention the plans for the Lyndhurst Gas and Water Works; designing and supervising the construction in Liverpool of three roadway bridges for the Indian frontier; superintending the construction of 100-ton and 25-ton cranes for the Alexandra Dock, Hull; designing further bridges for India; and surveying for civil engineering work generally.

Mr. Webster was also responsible for the following works: Promenade piers at Dover, Bangor, Minehead, Llandudno, Menai Bridge, Penmaenmawr, Egremont, &c.; bridges for the Corporation of Cambridge, Bedford, the Guildford Town Bridge and the Northwich Town Bridge, the reconstruction and widening of Conway Suspension Bridge, the Portsmouth Bascule Bridge, Littlehampton Swing Bridge, Kemaes Bridge, near Abergavenny, &c.

Among his later activities may be mentioned the transporter bridge across the Mersey, joining Widnes, on the Cheshire bank, with Runcorn, on the Lancashire bank, which he designed in conjunction with Mr. J. T. Wood. The bridge was constructed by the Arrol Bridge and Roof Company, Glasgow, and we described it on its completion—April, 1905—in former issues (see ENGINEERING, vol. lxxix., pages 451, 716, and 783).

In open competitions he was placed either first or second on fourteen occasions, including the Watkin Tower, for which eighty-seven competitors sent in designs, the Sydney Harbour Bridge, &c. He also designed the big wheel at Earls Court, the Stadium, and the structural work of four of the largest buildings at the Franco-British Exhibition. In 1911 he completed the design of a large transporter bridge for South America, the construction of which was immediately proceeded with. His last work was on a reinforced-concrete bridge at Warrington, now practically completed.

Mr. Webster had for many years established a private consulting engineer's practice at 39, Victoria-street, Westminster, acting of recent years in partnership with Mr. H. W. FitzSimons. His services were in frequent request by the Local Government Board and for Parliamentary work.

QUICKSILVER AND THE WAR.

Trading interests in quicksilver are attracting attention on account of the very extensive use of mercury in the preparation of fulminate for explosives, the present and probable future consumption of which must have an important bearing on the market for the metal, the withdrawal of available supplies, and the future demand.

Quicksilver is put to many practical uses, such as gold-mining, but probably the most important is for percussion caps for igniting powder. The world's production is increasing; the average for the last decade has been 3728 tons. The output during recent years has been as follows, in tons:—

1913.	1911.	1909.	1907.	1905.
4171	3419	3233	3307	3336

The world's supply is obtained from only six countries, the main source being Spain; the Almaden mines of that country produce nearly a third of the entire quantity. Recent outputs have been as follows, in tons:—

—	1913.	1911.	1909.
Spain	1490	1055	1000
United States	688	742	717
Italy	888	815	700
Austria	855	685	609

Ten years ago the United States' output of quicksilver was the largest in the world, exceeding 1000 tons for several successive years, but since then it has been declining; the main American supply is obtained in California, mostly from one mine. Great Britain's trade in quicksilver is peculiar, in so far as none is produced in the country; it is purchased and distributed, and, in effect, controls the world's markets in the metal. The following schedule shows the imports, exports, and British consumption, in flasks, during recent years:—

—	Imports.	Exports.	Consumption.
1913	45,348	26,815	18,533
1912	47,262	32,240	15,022
1911	46,547	31,438	15,109
1910	44,595	24,748	19,847
1909	43,163	22,051	21,112
1908	43,605	22,348	21,257

The flasks contain 75 lb. each. Our consumption fluctuates within very wide limits, as shown by these figures. At the commencement of next year the effect of the war will be ascertainable on both the supply and our consumption. In Austria the quicksilver deposits occur in Idria, Western Carniola, and in Italy at Monte Amiata, Tuscany. The Mexican and Russian outputs are on a very limited scale; four years ago the Russian output was only 4 tons. The price of quicksilver has risen enormously since the war commenced; the Austrian supply, controlled by the Government, is definitely cut off from the world's markets, and the Italian supply is uncertain. The Spanish supply is controlled mainly in London, and very little may be available for export. American supplies can scarcely be obtainable for export to Europe, as the consumption appears to have overtaken the production in the States. In fact, we have been exporting quicksilver to the United States in small quantities for some years—during 1913, 154,500 lb., to the value of 14,960*l.*

Quicksilver imported was worth 7*l.* 9s. 3d. per flask last year, compared with 8*l.* 12s. 3d. during 1911. The war has had a marked effect on our quicksilver imports, as shown by the following figures:—

Imports for August.

1914.	1913.	1912.
1792 lb.	67,196 lb.	101,779 lb.
24 flasks	896 flasks	1357 flasks

Imports for September.

18,240 lb.	61,851 lb.	32,818 lb.
243 flasks	824 flasks	437 flasks

Personal.—The Council of the University of Sheffield has made the following appointments:—(1) Mr. Wilfrid Vickers, M.Sc. (Manchester), to the post of Junior Lecturer in Education and Assistant-Master of Method. (2) Mr. H. J. Davies, to the post of Demonstrator in Engineering. (3) Mr. F. Orme, B.Met., to the post of Demonstrator in Non-Ferrous Metallurgy.

University of Bristol.—A copy of the calendar of the University of Bristol for the current session has recently been received from the Registrar. The book gives lists of officers, professors, staff, and graduates, as well as the almanac for the session. It also prints the charter, Act, statutes, ordinances, and regulations of the University, and gives particulars of scholarships, exhibitions, and prizes. Particulars of courses of study in the faculties of arts, science, medicine, engineering, and other subjects are not given in the calendar, but will be found in separate prospectuses which are issued for each faculty.

GERMANY'S FOREIGN TRADE AND THE WAR.

When the war had only been in operation for a couple of months, responsible German papers made the galling confession that it had caused the German foreign trade to come almost to a standstill, and with it the German industry. This spontaneous admission certainly did not agree with a statement by W. E. Havenstein, the President of the German Reichsbank, who, at a Board meeting of the bank on September 29, stated "that even the foreign trade had to a great extent been maintained." "It was," he added, "a matter of special interest that our exports in August, in spite of all obstacles, had receded less than England's."

Be this as it may, and although the statements made by the authority above referred to should not be subject to any doubt, German industry, however brave a show it is making, unquestionably feels the position very keenly. German journals deal with the question in a less hopeful vein than Mr. Havenstein, and their remarks have all the more interest, because they distinctly deal with the English danger. "The tumult of war," says one journal, "has burst upon us as a devastating flood over a fertile country. Shall we always be victorious?" This anxious question at present weighs upon the entire German industry as a nightmare. "We all know," adds the German source from which we quote, "that England can do but little harm to our coasts, but the great majority of our people may not have yet realised the amount of damage to our industry and commerce with which the untrammelled rivalry of this Power threatens us, nor can they realise it, since they know nothing about the vast values which will be lost for us with markets over the seas; only those who will have to suffer are aware of the figures." In order to make the situation clear, the following figures are given:—

Imports to Germany.

—	1913.	1912.	1911.
	£	£	£
Europe	294,465,000	300,420,000	284,500,000
Asia	52,470,000	50,315,000	42,800,000
Africa	24,840,000	23,930,000	20,835,000
America	149,720,000	144,270,000	123,110,000
Australia	16,385,000	15,210,000	13,655,000

Exports from Germany.

Europe	384,360,000	337,180,000	303,495,000
Asia	27,395,000	21,010,000	19,175,000
Africa	10,535,000	9,265,000	9,065,000
America	77,325,000	74,820,000	68,095,000
Australia	5,180,000	4,995,000	4,585,000

In the following table is shown the relation between imports and exports for the last three years:—

—	Imports.	Exports.	Imports, Surplus.
	£	£	£
1913	537,880,000	504,795,000	33,085,000
1912	534,145,000	447,270,000	86,875,000
1911	484,900,000	404,415,000	80,485,000

Whilst the imports in 1912 showed an unprecedented increase of 49,245,000*l.* over the figure for 1911, the increase for 1913 above 1912 was only 3,735,000*l.* On the other hand, the exports, which in 1912 showed an increase of 42,855,000*l.* over those for 1911, had in 1913, compared with 1912, the unparalleled increase of 57,525,000*l.* Hitherto the largest increase in the year had been for 1910 compared with 1909, *i.e.*, 44,050,000*l.* Looking back over ten years, we find the imports to have increased by 238,350,000*l.*, or about 80 per cent.; the exports having increased by 254,100,000*l.*, or over 100 per cent.

The aggregate German foreign trade amounted in 1913 to 1,042,675,000*l.*; in 1912 to 981,415,000*l.*; and in 1911 to 889,315,000*l.* It will appear from the first table that the greater portion of the German exports remain in Europe. All the figures given will no doubt be most materially altered by the war, since exportation to certain countries will become impossible.

The aggregate trade with the Colonies amounted in 1912 to 23,225,000*l.*, as against 4,980,000*l.* in 1902. The imports to the Colonies consisted principally of textile goods, iron goods, and articles of food; the exports from the Colonies consisted of rubber, palm kernel, cocoa, palm oil, ivory, bananas, gutta-percha, coffee, cattle, diamonds, and phosphate. Of course, the commerce with the mother-country plays the most prominent part, and all future German Colonial trade remains more than doubtful. The financial harm Germany will suffer by losing her colonies is immense.

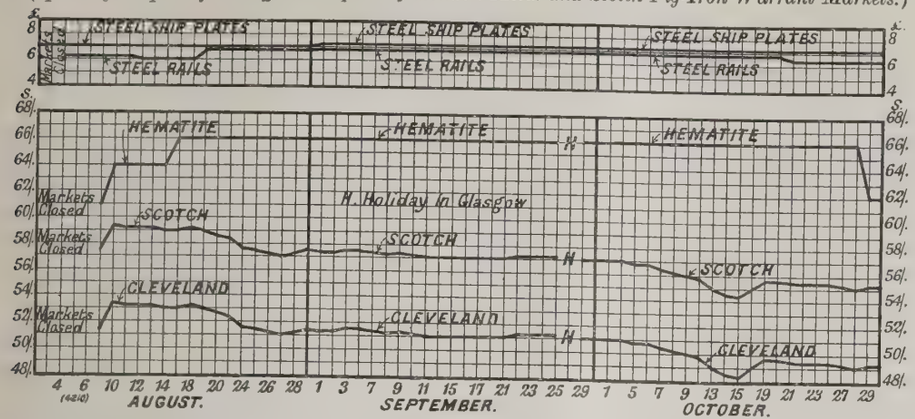
In connection with the question of Germany's foreign trade, her turnover with the countries with which she is now at war are naturally of great importance. Last year Germany's dealings with these four countries were as follow:—

	Exports.	Imports.
	£	£
England	71,900,000	48,800,000
France	39,500,000	29,200,000
Russia	49,000,000	73,500,000
Belgium	27,550,000	17,230,000
Total	187,950,000	168,730,000

Canadian Steel Production.—According to the American Iron and Steel Institute, the Canadian production of steel ingots and castings amounted in 1913 to 1,042,503 gross tons, or 189,472 tons above the total for 1912. The total for 1913 is made up of 1,006,149 tons of ingots and 36,354 tons of steel castings.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



Note.—Owing to the fact that the London Metal Exchange remains closed we are unable to continue the publication of our Monthly Diagram of Metal Prices in its usual form. The above diagram, however, shows the prices of steel ship-plates and heavy steel rails to Middlesbrough quotations, and also gives the Glasgow settlement prices for warrant iron. Each vertical line in the diagram represents a market day, and the horizontal lines represent 1*l.* in the case of ship-plates and rails, and 1s. in the case of hematite, Scotch and Cleveland iron; the prices are per ton in all cases.

Private dealings, of a very restricted nature, have taken place in all metals, but the markets generally have been very dull throughout the month. Straits tin fell from 135*l.* 10s. on the 1st ult. to 123*l.* on the 19th, and then rose sharply to 136*l.* 10s. on the 26th. Some reaction followed the rise, and the metal stood at 133*l.* 10s. at the end of the month. English ingots, which have undergone similar fluctuations, were quoted at 132*l.* 10s. to 134*l.* on the 30th ult. According to Messrs. Ricard and Freiwald's statistics, the quantity of standard tin in stock or in transit to the United Kingdom on the 31st ult. was 8708 tons, as compared with 7142 tons on the same date last year. The price of electrolytic copper, which stood at 52*l.* 15s. on the 30th ult., has ranged from 52*l.* 10s. to 55*l.* during the month, the latter figure being quoted on the 6th ult. Best Selected, which was quoted at 56*l.* 15s. to 57*l.* 5s. on the 2nd ult., gradually fell to 54*l.*—54*l.* 10s. on the 20th, and afterwards recovered slightly, its price on the 30th ult. being from 54*l.* 10s. to 55*l.* The price of antimony has increased greatly, owing to the scarcity of spot metal. 55*l.* to 56*l.* was asked for English regulus towards the end of the month, whereas on the 1st ult. its price was 37*l.* 10s. to 40*l.* In spelter the market was generally dull, and at the end of the month 24*l.* to 24*l.* 5s. was asked for American G.O.B.'s to arrive; Specials are nominal. English lead, which stood at 19*l.* for the first part of the month, fell to 18*l.* 15s. on the 9th, and to 18*l.* 10s. on the 13th, at which figure it was stationary until the end of the month. Quicksilver shows a considerable increase in price. On the 3rd ult. its price advanced from 7*l.* 17s. 6d. to 9*l.*, and on the 8th ult. another advance to 10*l.* took place. A further advance to 10*l.* 10s. occurred on the 19th, this figure being maintained until the 26th, when it fell to from 10*l.* to 10*l.* 5s., remaining at the latter figure until the end of the month; these, however, are only nominal prices. The prices for quicksilver, it should be mentioned, are per bottle, the contents of which vary in weight from 70 lb. to 80 lb; the prices of all the other metals mentioned are per ton. There has been but little demand for tin-plates, and the market has consequently been dull and lifeless. The price per box of I.C. cokes fell from 12s. 9d. to 13s. early in the month to from 12s. 6d. to 12s. 7½d. on the 30th ult. According to Messrs. W. Jacks and Co.'s statistics, the total shipments of pig-iron from Middlesbrough (including Skinningrove) during October amounted to 56,406 tons, as compared with 58,923 tons in September, and 31,870 tons in August. During October of last year the shipments amounted to 125,190 tons.

BRITISH MANUFACTURERS AND THEIR SALES METHODS.

To the Editor of Engineering.

Sir,—Now is an opportune time to consider this important subject. Many of our manufacturers still continue in the old-fashioned style of waiting until someone brings them something to manufacture, and even then, if anything new, the difficulty of getting this accomplished has been almost beyond belief. We must have a complete change in these methods; new articles made to customers' requirements at competitive prices must be manufactured suitable for the new markets now available.

Many seem to imagine sales organisation only consists in appointing a large number of agents as canvassers and travellers on commission, without providing them with any funds or giving them power to do anything if they could. In many cases this is done simply with a view of trying to get sales conducted at other people's expense; these agents accept these positions from want of something better, and are helpless, and so it continues, neither party doing anything in a permanent direction. The term "agent" would be better abolished as now applied in the engineering trade, unless it is to be recognised in future as representing a person of position and capability. All employees, from the managing director downwards, are in reality agents of any company; but buyers are tired of interviewing what are now known as agents, and they require to see the equivalent of a principal.

We have, therefore, on the one hand, in many cases manufacturers employing, on starvation terms and on temporary arrangements, agents, canvassers, and travellers, and immediately thereafter proceeding to stultify their position and efforts by corresponding direct behind their backs with the customers, and in other ways lowering what prestige they possess, thereby destroying their connection and chance of success. Possibly this is done in some cases to prevent their getting too strong a hold of the business, but in others, we fear, with a view of preventing them earning too much money. This system is carried out in many ways right down to the man at the works that offers better terms if the sales can be completed without the knowledge of their own representative. Such methods must be exterminated.

On the other hand, we have the customers, the architects, the consulting engineers, trying to exterminate these agents, canvassers and travellers, by shutting their doors against them and communicating direct with the works. This arises in some cases through the utter incompetence of the men employed and their failure to satisfy the customers' requirements, but in many owing to the behaviour of the works correspondents.

The natural result must be to throw thousands of these men out of their present employment, but being a gradual process, they will, when unable to take the place of the expert salesman, no doubt be provided for in offices and works where they would be better employed. When this is accomplished, think of the relief to the buyers and the relief to many of these weary individuals themselves, to say nothing of the enormous saving to everybody when they are found definite employment with a visible earning capacity benefitting to themselves and the country in general.

Out of this medley, if we are to improve, must arise the expert salesman and the enlightened works correspondent, both engaged on terms of possible permanency with the firm, the one realising that he must satisfy his customers' requirements in every way, the other admitting the salesman's position and giving him the utmost support.

Such expert salesmen should be welcomed with appointments by the customer again and again, if only they were available, and the persecution of buyers by incompetence discontinued. The salesmen of the future should be fewer in number and much better paid, and of permanent and superior position with the manufacturer. They must be men who, having passed through every shop, are selected and finally trained for this position in the estimating and designing departments, and with at least ten years' experience. Such salesmen will be expected to answer any questions and give any advice, and be in a position to take particulars, making hand sketches of suggestions, and, if required, preparing and pricing estimates; and, in cases of necessity, concluding contracts on the spot.

What a rarity such men are to-day; equally so the manufacturers that have sufficient confidence in the outside agents and travellers they now employ.

The works correspondent is in reality the manufacturer, as, after all, this correspondent is the person who controls the situation, making or marring any concern. Anyone nowadays is permitted to deal with correspondence, from the junior partner to almost the office boy, the result in many cases being as might be expected.

The works correspondents should have been salesmen for five years at least, having had what workshop experience a salesman should possess before he occupied that position; we should then have correspondents knowing all the difficulties, and trained in both the positions necessary for success. They must realise that the entire system of customers, salesmen, and works staff are in a sense under their control, and that they can by carelessness or want of forethought destroy the best-laid plans; and until such men are appointed by merit only we shall continue as we are. The subject of advertisement in the technical Press is another opportunity sadly neglected, many of our manufacturers never appearing. This should form the first subject of discussion between the salesmen and the works correspondents, as without this how are purchasers ever to know, more especially abroad, of a manufacturer's existence. Many manufacturers seem to imagine, nowadays, that if they employ large numbers of commission agents, advertisement is unnecessary: the greatest fallacy of all.

If only we can persuade our manufacturers to devote a reasonable sum to their selling organisations, instead of spending their all on the works, and to select their salesmen and works correspondents by merit, encouraging them with permanent appointments, and, having done this, persuade the British workmen to do as much work as they can if they like, then there will be little trouble in holding our own and securing our full share of trade at every opportunity. Surely there has never been a better time for a change.

Yours faithfully,
Victor H. Coates, M.I. Mech. E.
121, Victoria-street, London, S.W.

Spanish School Annual.—We have received a copy of the annual issued by the Instituto Católico de Artes é Industrias, Madrid, for the term 1914-15. This Institute was inaugurated in October, 1908, and commenced both with day classes for the instruction of mechanical and electrical engineers, and with evening classes for workmen. In the term 1909-10 session courses for the Bachelor degree were started, and both the day and the evening classes were made to cover a wider field. Recently classes have also been added to prepare students for entering the Spanish Military Academy. The annual gives the names of the professors, the programme of studies, and illustrations of the college, which show this to be a well-appointed institution.

British Coal Production.—British coal production in 1913 beat the previous record, the output for the year having been 287,430,473 tons. This aggregate compared as follows with the extraction of each of the nine preceding years:—

Year.	Tons.	Year.	Tons.
1904 ..	232,428,270	1909 ..	263,774,312
1905 ..	236,128,936	1910 ..	264,433,028
1906 ..	251,067,628	1911 ..	271,891,891
1907 ..	267,830,962	1912 ..	260,416,338
1908 ..	261,528,793	1913 ..	287,430,473

This year the war has interfered seriously with our coal exports, and probably the extraction of the twelve months will also show some falling off. The value of the coal raised in the United Kingdom last year was 145,535,669*l.*

Argentine Railway Working.—The present year has been a decidedly adverse period in Argentine railway history, revenue having fallen off, while flood difficulties have also had to be contended with. Floods commenced in August and September, 1913, and resulted in considerable loss of traffic and damage to the property of the Buenos Ayres Great Southern Railway Company, amounting to 138,112*l.* No sooner was the flood difficulty got over, than Argentina was visited by hot, dry winds and drought, which caused the failure of cereals in the southern portion of the company's zone. Rains, which set in again in the latter part of the company's financial year, caused dislocation of agricultural business and delayed the transport of the maize crop, great part of which still remains to be carried. During the past financial year 145 miles of extensions were opened for traffic by the Buenos Ayres Great Southern Railway, bringing its total completed lines up to 3727 miles. The company is now restricting its expenditure upon capital account, only absolutely essential works being undertaken. In view of the working difficulties experienced by the Great Southern Railway in 1913-14, it is not surprising to find that the traffic receipts declined to 5,464,588*l.*, as compared with 6,569,345*l.* in 1912-13*l.* On the other hand, the working expenses were brought down to 3,200,093*l.*, as compared with 3,698,996*l.*, so that the decline in the net revenue was reduced to 605,854*l.* A transporter bridge built for road traffic between the capital and Avellaneda and the Sud Dock were brought into operation in June, and by a Presidential Decree the Government formally accepted the bridge from the company.

SHALLOW-DRAUGHT STEAMER FOR THE YANGTSE KIANG.

We illustrate in our two-page plate the latest of a long succession of shallow-draught steamers, built by Messrs. Yarrow and Co., Limited, Scotstoun, Glasgow. This vessel, named the Shu-Hun, was constructed for the Szechuan Steam Navigation Company, for their passenger and cargo service between Ichang and Chungking, on the Yangtse River. The length of the voyage is about 400 miles, and is very dangerous and difficult owing to the rapids and whirlpools, the position of which frequently changes as the river rises and falls. Hitherto it has been found necessary for the small steamers running on this service to be warped up the rapids by means of ropes taken ashore, which was a slow and dangerous operation. The Shu-Hun was built to the special designs of Captain S. C. Plant, one of the best-known navigators of the river, and with many years' experience on this particular part of the great inland waterway. His aim was to produce a vessel sufficiently large and powerful to negotiate the rapids under her own steam without the assistance of warps. To achieve this end it was also necessary that the steering capabilities should be such that there was no possibility of the bow being slewed round when entering the rapid. At the same time it was desirable that the vessel should have sufficiently good passenger and cargo capacity to enable her to be a financial success.

It was finally decided that a length of 190 ft. and a beam of 30 ft. was the largest size vessel which could safely navigate the rapids on a draught of 5 ft., when the load of cargo was 300 tons, and the Shu-Hun was accordingly built to these dimensions, and with machinery of 2000 indicated horse-power.

Another feature conducive to the success of the design was the fitting of the tunnels, in which the twin-screw propellers work, with Yarrow's patent automatic hinged flap, arranged to give the maximum efficiency of propulsion in all conditions of load. It has, of course, been long a practice for vessels of this type to be driven by screws working in tunnels; but the introduction, by Messrs. Yarrow, of the hinged flap very materially increases the efficiency of this system. Various shallow river gunboats for the British Admiralty, such as H.M.S. Widgeon, were fitted with this device; but recently the system has been still further improved by the adoption of a balanced flap, by which means the flap automatically is always at the most efficient position. The detailed drawings of this flap, given on the two-page plate, are therefore of special interest.

The third essential to the realisation of the aim was the steering-gear, which consists of three balanced rudders actuated by hand and steam. There are two steam steering-wheels, one in the wheel-house and one on the upper bridge, and the hand-gear is also in the wheel-house. The steering-engine is in the main engine-room. The vessel turns within two lengths, with both engines working at half power.

The general features of the design of the Shu-Hun are clearly shown on the drawings reproduced on the two-page plate. Fig. 1 is a longitudinal section, Fig. 2 a plan of the forecastle, Figs. 3 to 5 plans of the decks, Figs. 6 to 9 cross-sections, and Fig. 10 a perspective view of the vessel on the Yangtse Kiang. The hull is divided into nineteen compartments by transverse and longitudinal bulkheads, and water-tight doors are also fitted to the bunker bulkheads, as damage to the hull of vessels on this river more frequently occurs at the turn of bilge than on the bottom of the vessel. Fig. 1 shows that there are four decks in all—namely, main deck, upper deck, boat-deck, and awning-deck. The accommodation for European passengers and the officers is on the boat-deck (Fig. 3), and consists of a dining-saloon, eight two-berth state-rooms for passengers; also captain's, chief officer's, and chief engineer's cabins, pantry, galley, bath-rooms, and W.C.'s, and steward's cabin. The accommodation on the upper deck (Fig. 4) is for the Chinese first and second-class passengers, and consists of a first-class saloon with dining-tables, and eight first-class two-berth cabins; a second-class saloon and eleven four-berth cabins; also purser's cabin and office, and assistant purser's cabin. On the main deck (Fig. 5) there is accommodation for 170 Chinese steerage passengers, 15 firemen, and three Chinese engineers. In the forecastle (Fig. 2) there is accommodation for 4 petty officers and 12 men, and there is also a mess place for 14 cooks and boys.

The vessel is lighted throughout with electric light, the current being supplied by an oil-driven dynamo, so that it is not necessary to keep up steam when the vessel is moored for the night. There are five separate holds for cargo, having a total capacity of about 16,000 cub. ft., and on a draught of 5 ft. the steamer has a dead-weight capacity of about 300 tons.

There is a special double-headed steam capstan forward, one head being arranged for working the anchors and for ordinary warping purposes, the other head being specially designed for warping up the rapids, if found necessary, and large rollers are fitted on the berthing for bringing in the warp. There is an unusual number of bollards and fairleads both forward and aft.

The main propelling machinery, Figs. 5 and 9, consists of two sets of triple-expansion surface-condensing engines, balanced on the Yarrow-Schlick-Tweedy system. Piston-valves are fitted to the high-pressure, mean-pressure, and low-pressure cylinders. The link motion is of the twin-bar Stevenson marine type, with adjustable bearings. All the bearings have large surfaces, so as to ensure satisfactory results with these engines when running at somewhat higher revolutions than those usually adopted for this class of vessel. One condenser of the "Uniflux" type is fitted as common to both engines, and an independent Weir air-pump is fitted in conjunction with it. A circulating-pump by Messrs. Matthew Paul, of Dumbarton, is fitted, the engine being of the enclosed forced-lubrication type. A fire and bilge-pump by Messrs. Turnbull is also fitted in the engine-room, and arranged to pump from several compartments and the sea. At the forward end of the engine-room is placed a feed-filter tank.

In the closed stokeholds, Figs. 5 and 8, are fitted two Yarrow patent double-ended water-tube boilers, each boiler being fitted with an independent funnel. These boilers are designed so that, if at any time an overload power is required, it can be quickly obtained by burning oil-fuel in conjunction with coal. Other auxiliaries fitted in the stokehold are as follow:—Two forced-draught fans and engines by Messrs. Paul, of Dumbarton, the engines being of the enclosed, forced-lubrication type; two main feed-pumps (one to each of the boilers) and one auxiliary feed-pump, all by Messrs. Weir; and one oil-fuel pump by Messrs. Mumford, of Colchester.

Owing to the fact that the water in the Yangtse-Kiang carries in suspension a very large percentage of foreign matter, it was considered advisable to fit some form of settling and filter-tank in place of an evaporating plant. It was finally decided to supply three tanks for this purpose; these have been fitted on the deck above the engine-room. The water supply is taken from a branch-pipe off the fire and bilge-pump discharge to the sanitary tank (this system being under slight pressure). The water is discharged into the uppermost of the three tanks through a ball-valve (which maintains a fixed level in this—the settling-tank), and then flows from this tank into the second tank containing strata of filtering material, and passing through this it flows into the third tank, where it is again filtered. If desired, the course of the water can be short-circuited. We understand that this system of making up the feed-water and providing the drinking-water has proved thoroughly satisfactory.

Figs. 11 to 13 show the Yarrow hinged balanced flap for the propeller tunnel. The efficiency of the propellers depends upon their working in solid water, and it is therefore important that when the propeller starts revolving in the tunnel, and the air is forced out and water takes its place, there shall be no leakage back of air. The after part of the tunnel must project below the surface of the water, even when the vessel is at its lightest draught. When the vessel is loaded, and this projection is more deeply immersed, resistance is increased very considerably. Messrs. Yarrow, many years ago, arranged for the after part of this tunnel to be movable, so that it could be adjusted corresponding to the draught of the vessel. The adjustment was effected by hand, and the range was such that, while the tunnel was always sealed, the after part would only just be below the surface of the water. It was found in practice, however, that this adjustment was not always made by the ship's company. Messrs. Yarrow therefore arranged for the flap to be self-balancing, as illustrated in Figs. 11 to 13. The forward part of the tunnel forms part of the hull in the usual way, but the after part is hinged at a point about the centre of the tunnel, and the flap is balanced by means of weights attached to the end of a chain, which passes over pulleys and is secured to the end of the flap, as shown. By this means the flap automatically regulates itself. If, for instance, a quantity of cargo is put on the boat and the draught increased, the increased pressure of water on the after part of the tunnel, due to the action of the more deeply-immersed propellers, tends to raise this flap, and thereby reduces its resistance. Under all conditions of load and draught the flap is always in an efficient position.

We understand that throughout the trials of the Shu-Hun the machinery gave every satisfaction, and that practically no vibration was felt in any part of the ship at any speed. The double-ended Yarrow water-tube boilers provided an ample supply of steam without recourse to oil fuel in conjunction with coal. The vessel has made several voyages, and in each case crossed the rapids without the aid of hawsers. She has broken all records in the run from Chungking to Ichang and back. She did the round trip of 800 miles in 5½ days, and this against a strong freshet, the water in the gorges during the short run up of under 44 hours' steaming rising from 13 ft. to 35 ft. The actual times upwards are as follow:—Ichang to Qui-few, 13 hours (first day); Qui-few to Wan-shen, 8 hours 55 minutes (second day); Wanshen to Foochen, 14 hours 20 minutes (third day); Foochen to Chungking, 7 hours 25 minutes (half a day). The above runs were only at three-quarter speed, except at the Yehtan and Fuhtan rapids, when full speed was necessary. Had the vessel gone full speed all the trip, she could easily have taken 8 to 10 hours off the time on the upward run; but at full speed the wash of the vessel would have partially swamped the majority of the small and deeply-laden rice and other native craft in the vicinity of the numerous rapids, and more or less in one continuous line. In the near future, when the number of steam-vessels on the river has been doubled or trebled, conformity to some future rules of speed will require to be made obligatory. At present no rules or regulations of any kind are in force.

The University of Sheffield Scientific Advisory Committee.—The Council of the University of Sheffield realising that, under the present exigencies of trade, manufacturers will be more than ever faced with problems requiring scientific solution, has approved the formation of a University Scientific Advisory Committee to offer assistance, under conditions arranged to safeguard the interests of the consulting profession, to manufacturers carrying on processes within the Sheffield University area. From applications already received, they consider that there is undoubtedly a big field for work in front of the Committee.

Competition with Germany and Austria-Hungary.—We have, from time to time, drawn attention to the campaign undertaken by the Board of Trade, on the advice of their Advisory Committee on Commercial Intelligence, to assist British manufacturers and merchants to secure trade formerly in the hands of German or Austro-Hungarian firms. The Board have received since the outbreak of hostilities a very large number of inquiries for names of sellers or buyers of articles of which the sources of supply or markets have been interfered with. Several lists have been prepared and circulated by the Board of articles which inquirers desire (*a*) to purchase and (*b*) to sell. The third list, in which is incorporated the first and second lists, was published on October 14; the fourth list, which is a supplement to the third list, is now ready and may be obtained, together with copies of the third list, on application to the branch. Firms interested in any of the goods mentioned, either as buyers or sellers, should communicate with the Director of the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C.

Uses of the Hydraulic Mining Cartridge.—"Uses of the Hydraulic Mining Cartridge" was the subject of a paper read by Mr. James Tonge, M.I.M.E., F.G.S., before the Society of Engineers (Incorporated) on November 2. The author stated that the disadvantage and danger of employing explosives to excavate rock and other material from confined places had long been recognised. The effect of blasting could not always be confined to the area desired to be dislodged, and the use of explosives must involve either the risk of accident through insufficient charge or the production of misapplied energy. Many mechanical substitutes for blasting had been devised to avoid these drawbacks, the simplest form being the wedge. The stub and feather and the multiple wedge had been used as improvements on the simple wedge, and in coal-mines wedges invented by Bidder, Burnett, Shreeve, and Hall had been employed. These all had proved impracticable, and, except in the case of the simple wedges, were now practically out of use. The hydraulic mining cartridge was not worked on the principle of a wedge. It consisted of a steel cylinder containing a number of telescopic pistons operating at right angles, which expanded upon the application of water from a hand hydraulic pump attached to the cylinder by a steel pipe. The cylinder was placed in a suitably drilled hole, and the rock removed gently. As the operation proceeded it was possible to see the rock slowly fracturing, and at the conclusion of the operation the débris was left in good round condition suitable for speedy removal. Explosives could not be made to take advantage of the natural bedding and cleavage of rocks, their violence being expended on "backing through" to the nearest unsupported edge. With the hydraulic cartridge it was possible to excavate greater areas at one operation, the weight of the detaching strata itself being used to increase the scope of the operation. The hydraulic cartridge was used to a large extent in mines for (*a*) commercial reasons; (*b*) safety. The machine had been found equally applicable to work either in open trenches or under water. In considering the excavation of concrete beds by a method which would not involve explosive blasts, it was necessary to remember that there was a wide difference between concrete and stratified deposits. In the latter case there was only slight crushing of the rock before the applied pressure caused the mass to bend and crack; whereas in concrete considerable pumping had to be employed without any apparent effect before the fracture appeared. This was due to the crushing or compressing that the mass would withstand before finally breaking. Further pressure, of course, increased the magnitude of the break. It was found that concrete foundations were particularly well suited to the application of this machine, horizontal and vertical shots being arranged at intervals all round the bed and pumped off in turn. About 3½ tons of material could be excavated per thrust.

THE TWIN-SCREW SHALLOW-DRAUGHT STEAMER "SHU-HUN," FOR THE YANGTSE KIANG.

CONSTRUCTED BY MESSRS. YARROW AND CO., LIMITED, SCOTSTOUN, GLASGOW.

(*For Description, see Page* 572.)

Fig. 1.

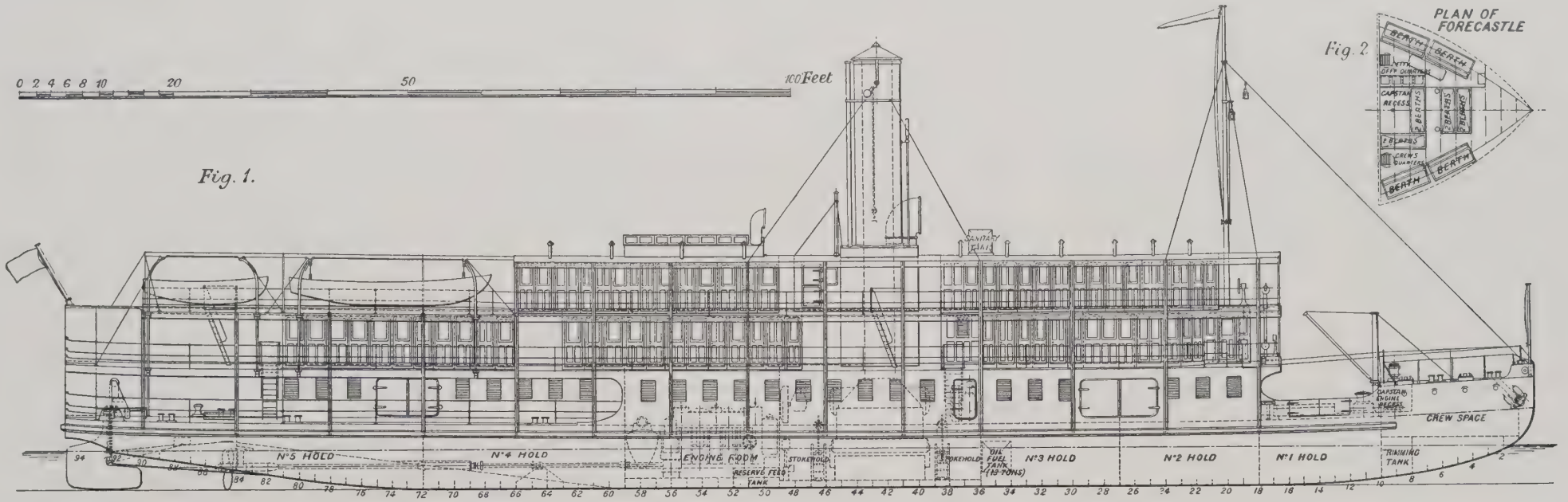


Fig. 2.

Fig. 3. BOAT DECK

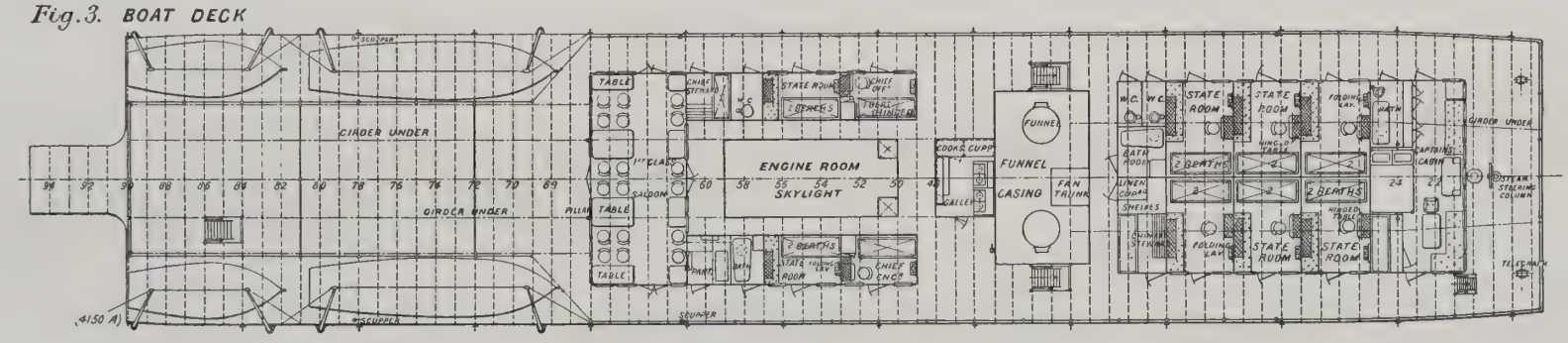


Fig. 6. SECTION AT 30 LOOKING AFT.

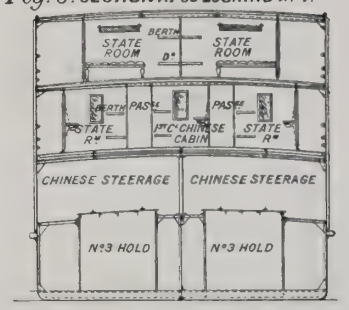


Fig. 4. UPPER DECK

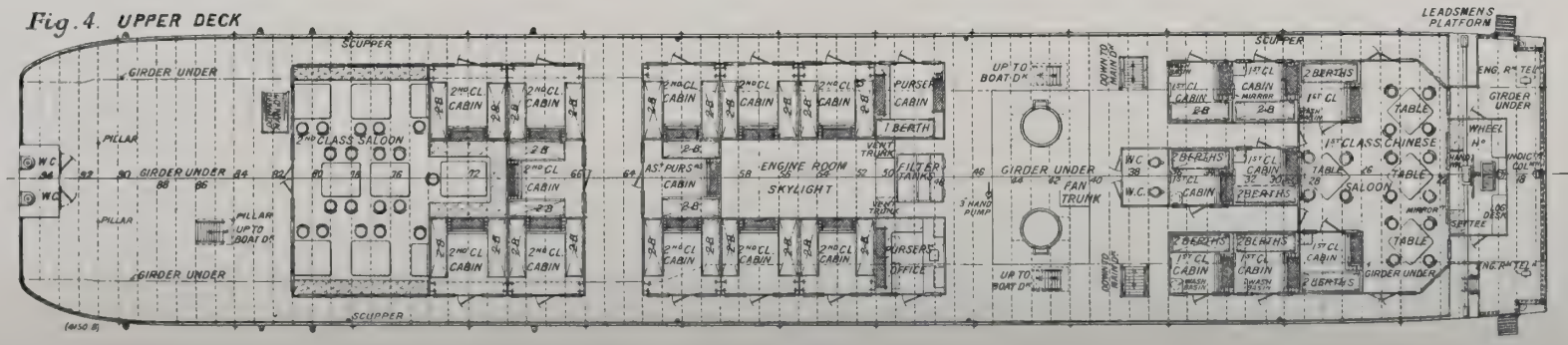


Fig. 7.
SECTION AT 72 LOOKING FORWARD.

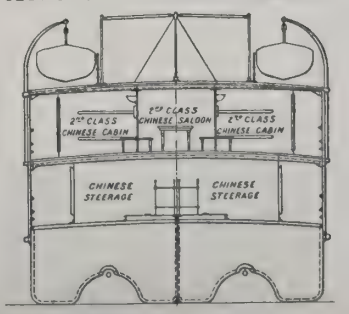


Fig. 5. MAIN DECK.

Fig. 8. SECTION AT 41 LOOKING AFT.

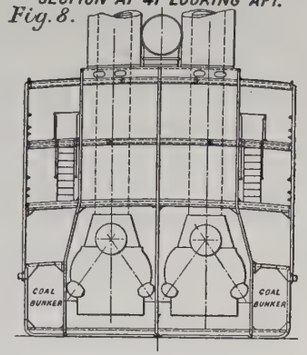


Fig. 9. SECTION AT 50 LOOKING FORWARD.

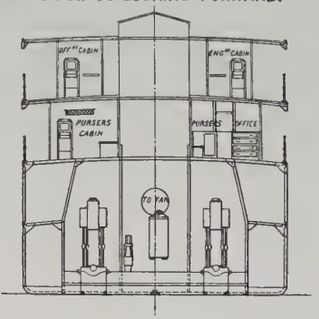
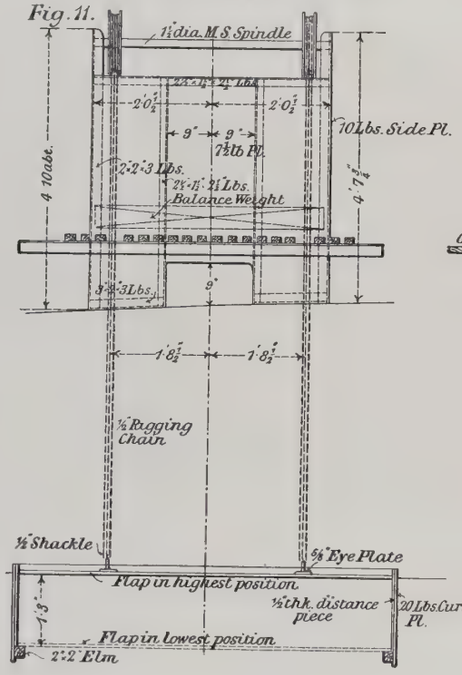


FIG. 10.

FLAP GEAR AT FRAME 92. LOOKING FOR?

Fig. 11.



Cast Iron Weights for Balancing Each Flap

Fig. 12.

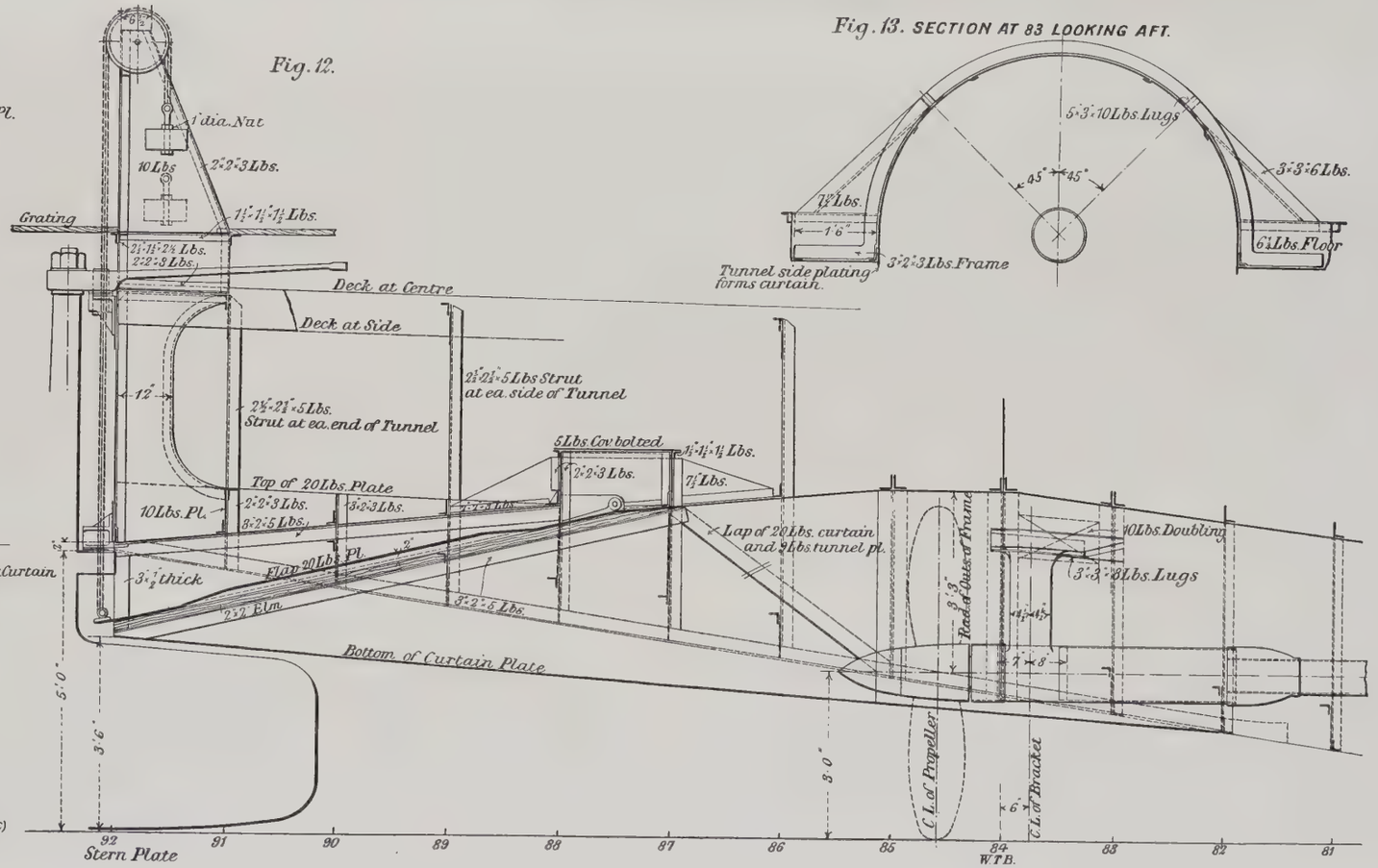


Fig. 13. SECTION AT 83 LOOKING AFT.

SEMI-AUTOMATIC MULTIPLE TAPPING-MACHINE.

CONSTRUCTED BY THE LANGELIER MANUFACTURING CO., PROVIDENCE, R.I., U.S.A.

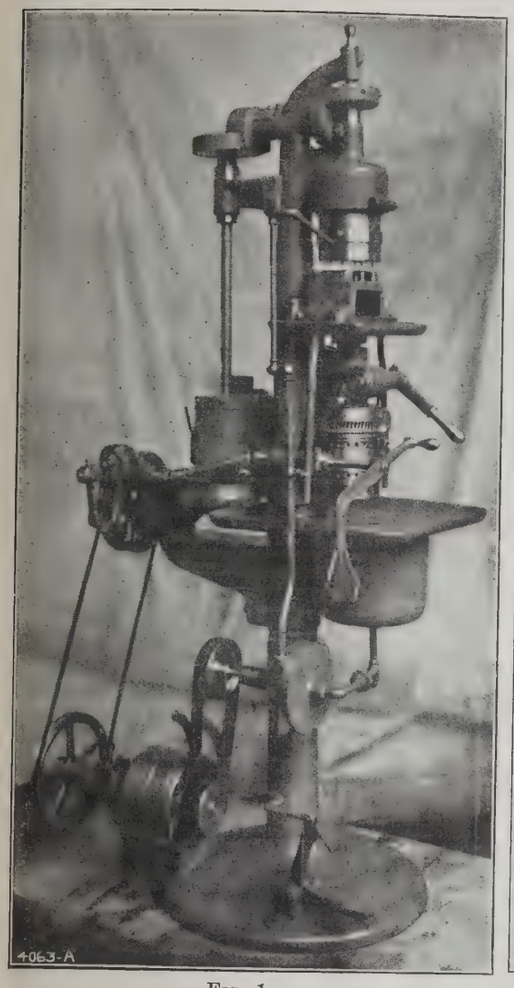


FIG. 1.

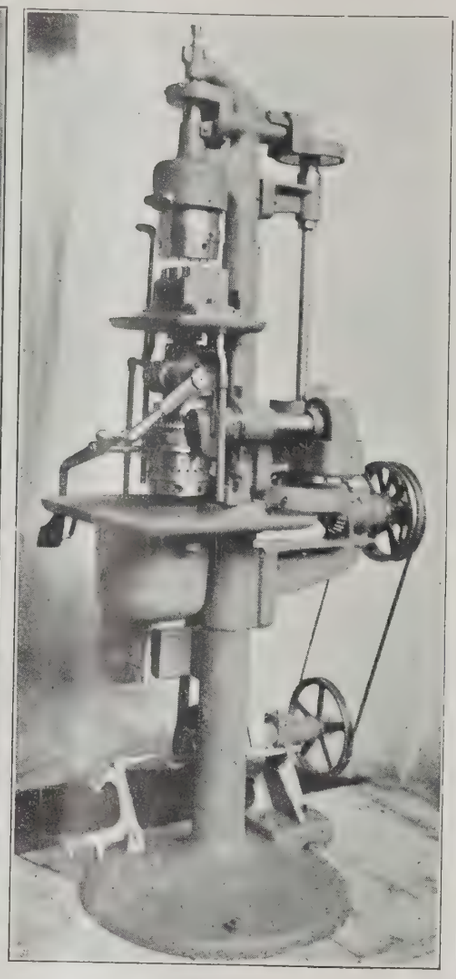
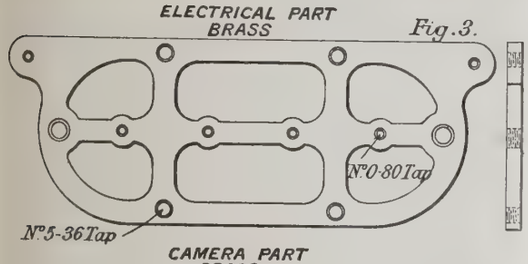
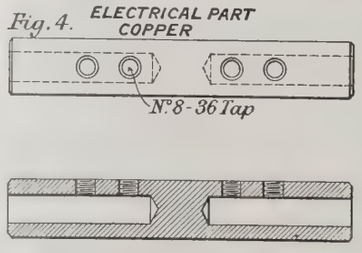
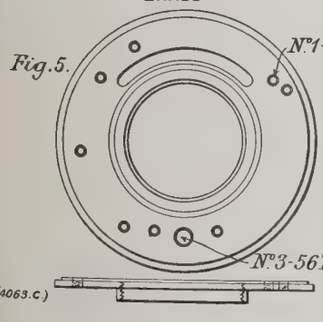
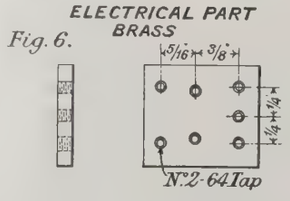


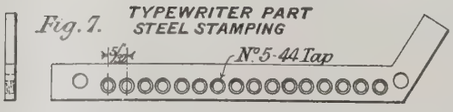
FIG. 2.











We illustrate, in Figs. 1 and 2, on the present page, two views of a vertical semi-automatic multiple tapping-machine for small taps and close spacings, which is built by the Langelier Manufacturing Company, Providence, Rhode Island, U.S.A. It has a stationary head and a movable working-table, and is designed to tap a large number of holes in one operation in practically the same time that it would take ordinarily to tap one hole with a single-spindle tapping-machine. With the machine we illustrate, the operator has merely to place the blanks on a simple folding-down device, and to take off the tapped parts. As many as fourteen brass plates, $\frac{1}{16}$ in. thick, with seven holes each, have been tapped in one minute. The feed is claimed to be practically as rapid as that of a printing-press. The machine is specially suited to the manufacture in large quantities of similar parts, such as those used in automobile work, clock-work, the manufacture of typewriters, electrical work, camera-shutter manufacture, telephone work, &c., where the highest standard of workmanship is required, coupled with low manufacturing cost.

The operator sets the machine in operation by tripping the bent lever located at his left, or by lowering the opposite end of this lever by hand; this operates the belt-shifting mechanism, and moves the round leather driving-belt which runs up from the base countershaft very quickly over to the forward driving-pulley. This immediately sets in motion, through bevel gearing at the rear, an upright shaft which drives the main spindle of the multiple tapping-head through another series of bevel gearing near the top of the machine column. The tapping-spindles in the tapping head are crank-driven, machined out of a solid alloy-steel bar, hardened, heat-treated, very carefully ground, and all fitted with extreme accuracy on fixed centres in a hard phosphor-bronze spindle bearing, which is so designed as to be quickly removable from the machine, to permit the insertion of other heads having the spindles arranged according to other lay-outs within a 5-in. circle.

In the tapping-heads, each spindle is provided with a special compensating device, which allows each tap to follow its own lead independently of the other taps; by this means every hole is tapped with clean-cut threads free from drag or stripping, even when working through very thin soft brass or other material, and with taps of small diameter. This feature also allows of tapping simultaneously with taps of different pitches, and, moreover, ensures uniformly accurate and interchangeable work. On reaching the required depth, the taps are reversed automatically; the resistance on the taps is not depended upon for reversal, thus obviating the risk of all straining or breakage of the taps. Reversal is very rapid.

The upright shaft above referred to, which drives the multiple head, also drives through steel and bronze spiral gearing a short horizontal shaft on the right-hand side of the machine. On the front end of this latter shaft is mounted a steel worm in mesh with a worm-thread cut round a vertical hub under the working-table. This hub has an edge cam-path cut on its upper end, over which runs a cam-roller trunnioned to the stub-post of the working-table when the hub is rotated by the worm on the horizontal shaft.

During tapping the working-table is progressively raised by the edge-cam and roller at the same ratio that the taps enter the work, until the taps have penetrated to the depth wanted, when an automatic tripping device operates, shifting the round driving-belt sharply and very quickly over to the grooved reversing-pulley, at the same moment instantly reversing the taps, and lowering the table at about double the tapping speed.

When the table reaches its lowest, or loading and unloading position, the tripping device again shifts the round driving-belt to the loose pulley, when the machine stops. The cycle of operations repeats itself with great exactness and rapidity during the tapping of each part. The automatic tripping device may be set to stop the table at practically any point wanted, and the upward and receding speed of travel of the working-table may be closely adjusted to correspond in each case with the pitch of the taps used and with the thickness of the work, so as to prevent over-travel of the table, breakage of taps, or spoiled work. No time is therefore lost in the tapping of each piece.

The base of the machine carries fixed and loose pulleys $6\frac{1}{2}$ in. in diameter for a 2-in. belt, running at 960 revolutions per minute; the belt is shifted by the action of a foot-lever. An efficient oil-feed maintains a constant flow of oil on the taps while the machine is running, the oil returning to a self-straining reservoir connected to the pump suction; this enables the same oil to be used over again without waste, the lubricating device requiring only periodical attention from the attendant. The moment the machine stops running, the flow of oil stops also, automatically; the flow starts again immediately the machine is set in motion afresh. All the running bearings and movable parts are efficiently lubricated. The whole of the gearing is carefully guarded to comply with the regulations in regard to safety.

The machine has a net weight of 828 lb., and the floor space occupied measures 22 in. by 28 in. Figs. 3 to 7 are examples of work done.

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.—The Calendar for the current session at the University College, Gower-street, W., has recently been issued. It is in the form of a large bound volume, of some 880 pages, containing a list of the departments and staff of the College, and giving full particulars of courses of study, scholarships, exhibitions, &c. The class and other examination papers set during last session are reprinted, and much other information relating to the history, organisation, and work of the College is also included in the volume.

"MANUEL PRATIQUE DE SERRURERIE."—We have received from Messrs. H. Dunod et E. Pinat, 47, Quai des Grands-Augustins, Paris, a copy of a manual published by them at the price of 4.50 francs, and edited by Mr. E. Henriet. This is a locksmith's hand-book, which, although written primarily for the use of apprentices, will prove most useful as a guide-book to working smiths. It gives brief notices on the manufacture of iron and steel, describes all the tools used in the trade, and gives very detailed illustrated information on all the various methods followed for assembling parts of metallic fittings, such as the joining together of built-up girder lengths, the making of window and door framework, balcony work, and so forth.

THE INSTITUTION OF CIVIL ENGINEERS.

Address of BENJAMIN HALL BLYTH, M.A., *President.**

GENTLEMEN,—My first duty is to thank you for the great honour you have done me, and, through me, the engineering profession in Scotland, by electing me President of this great Institution. Although I am not the first Scotchman who has occupied that position, I am the first engineer practising in Scotland on whom you have been pleased to bestow that honour. I can assure you that it will be my most earnest endeavour during my year of office to do everything in my power to uphold to assist the industrial progress of the country and to advance the interests of the community.

First, with regard to the railway systems in Scotland, I have prepared a cartoon,* which hangs on the wall, and which shows in black the railways existing in Scotland in 1864, and in red those that have been constructed since that date. I endeavoured at one time to sub-divide the red railways into those constructed during the decades following 1864 down to the present time, but I found that the variations in many cases were so small that it would be almost impossible to show distinctly the increases from time to time. Translating this map into figures, it will be found that the total mileage of Scotch railways in 1864 amounted to 2105, and in 1912, the last year for which statistics are available, it extends to 3802. The capital in 1864 amounted to 47,736,564*l.*, and at the present time is 184,933,062*l.* The passengers carried in 1864 were 20,205,455, and now 88,791,783.

The tonnage of goods and minerals in 1864 was 17,822,846, and now amounts to 66,870,702. The amount received for passengers in 1864 was 1,428,690*l.*, and now amounts to 5,260,053*l.* The amount received for goods and minerals in 1864 was 2,337,619*l.*, and at the present time 8,182,868*l.*, showing the total receipts from all sources in 1864 to have been 3,766,309*l.*, and at the present time 13,442,921*l.* The figures I have before me are divided into each decade, but I shall not trouble the meeting with reading them at the present time. [See tables below.]

In 1865, 1866, and 1867 the great Scottish amalgamations, which completely altered the whole railway systems in the country, took place. In 1865 the Edinburgh and Glasgow Railway was amalgamated with the North British Railway, and the Scottish Central Railway was amalgamated with the Caledonian Railway. That left the Scottish North-Eastern to be fought for between the Caledonian Railway and the North British Railway; and though naturally it ought to have gone to the North British Railway, as the completion of an East Coast route, the Caledonian bid higher terms, and the Scottish North-Eastern was amalgamated with it in 1866.

In the Session of 1865 the North British and Caledonian Companies had many schemes in Parliament competing with each other, and the passing of the amalgamation of the Edinburgh and Glasgow and of the Scottish Central with the North British and Caledonian respectively was part of a general agreement which included also the withdrawal of the opposition of the Caledonian Company to the first proposed Forth Bridge, and the withdrawal of the opposition of the North British Company to the passing of the Bill authorising a direct route, in the hands of the Caledonian Railway Company, from Edinburgh to Glasgow. In 1867 the Caledonian Company amalgamated with the Forth and Clyde Canal, whereby they became

SCOTTISH RAILWAYS, 1864.

Name of Company.	Miles Open for Traffic.	Capital Paid up to Date.*	Number of Passengers, Excluding Season Tickets.	Tonnage of Goods and Minerals.	Passenger Receipts.	Goods Receipts.†	Total Receipts, All Sources.
		£			£	£	£
Caledonian	615	18,130,860	8,105,514	7,495,719	565,240	1,095,743	1,660,983
Glasgow and South-Western	250	5,510,173	2,499,911	3,208,715	165,012	347,669	512,681
Great North of Scotland	258	3,370,696	1,592,967	556,221	81,734	85,991	167,725
Highland	233	2,296,749	843,769	305,871	94,189	68,946	163,135
North British	749	18,428,086	7,163,294	6,256,327	522,515	739,270	1,261,785‡
Totals	2105	47,736,564	20,205,455	17,822,846	1,428,690	2,337,619	3,766,309§

* Including the capital of all undertakings absorbed at a later date by the five named companies.
† Including minerals and miscellaneous receipts.
‡ Exclusive of 8792*l.* Union Canal receipts.
§ An error of addition, amounting to 10,000*l.*, in the official return.

SCOTTISH RAILWAYS, 1874.

Name of Company.	Miles Open for Traffic.	Capital Paid up to Date.*	Number of Passengers, Excluding Season Tickets.	Tonnage of Goods and Minerals.	Passenger Receipts	Goods Receipts.†	Total Receipts, All Sources
		£			£	£	£
Caledonian	826	26,996,143	13,585,643	11,387,310	906,324	1,982,839	2,889,163
Glasgow and South-Western	317	10,011,198‡	6,784,891	3,931,841	324,856	565,161	890,017
Great North of Scotland	286	3,653,727	1,782,185	557,915	123,562	140,702	264,264
Highland	402	4,100,408	1,210,735	343,093	181,573	142,278	323,851
North British	869	26,565,664§	14,857,438	8,275,581	814,278	1,299,207	2,113,485
Totals	2700	71,327,140	38,220,892	24,495,740	2,350,593	4,130,187	6,480,780

* Including the capital of all undertakings absorbed at a later date by the five named companies.
† Includes minerals and miscellaneous receipts.
‡ Including half the capital and receipts of the City of Glasgow Union Railway.
§ Includes 56,862*l.* for Wigtownshire Railway, subsequently managed by a Joint Committee, and half the capital and receipts of the City of Glasgow Union Railway.

SCOTTISH RAILWAYS, 1884.

Name of Company.	Miles Open for Traffic.	Capital Paid up to Date.*	Number of Passengers, Excluding Season Tickets.	Tonnage of Goods and Minerals.	Passenger Receipts.	Goods Receipts.†	Total Receipts, All Sources.
		£			£	£	£
Caledonian	878	40,504,864	17,568,514	14,870,586	1,045,313	1,983,000	3,028,313
Glasgow and South-Western	369½	‡14,461,588	10,333,725	5,576,917	486,498	680,425	1,166,923
Great North of Scotland	298	5,010,815	2,054,647	681,998	154,093	167,247	321,340
Highland	416	4,456,028	1,502,245	376,780	230,497	163,418	393,915
North British	1017½	‡36,069,326§	22,743,603	14,001,113	1,010,711	1,666,323	2,677,034
Portpatrick and Wigtownshire Joint Committee	20	152,366	102,340	19,527	4,625	3,241	7,866
Totals	2999	00,654,987	54.305,074	35,526,921	2,931,737	4,663,654	7,595,391

* Including the capital of undertakings absorbed at a later date by the named companies, excluding the Joint Committee.
† Includes minerals and miscellaneous receipts.
‡ Including half the capital and receipts of the City of Glasgow Union Railway.
§ Includes 685,776*l.* for Forth Bridge, and half the capital and receipts of the City of Glasgow Union Railway.

SCOTTISH RAILWAYS, 1894.

Name of Company.	Miles Open for Traffic.	Capital Paid up to Date.*	Number of Passengers, Excluding Season Tickets.	Tonnage of Goods and Minerals.	Passenger Receipts.	Goods Receipts.†	Total Receipts, All Sources.
		£			£	£	£
Caledonian	891	48,628,774	27,042,302	16,740,476	1,291,906	2,068,233	3,360,139
Glasgow and South-Western	388½	15,957,433‡	15,865,814	5,966,138	561,109	748,819	1,309,928
Great North of Scotland	316	5,661,503	3,011,631	807,869	203,400	198,212	401,612
Highland	445	5,571,165	1,794,601	487,821	275,927	189,428	465,355
North British	1205½	56,990,823§	34,562,520	16,443,754	1,336,388	2,048,060	3,384,448
Portpatrick and Wigtownshire Joint Committee	82	541,879	459,663	137,900	32,747	26,848	59,595
Totals	3328	133,351,577	82,736,531	40,583,958	3,701,477	5,279,600	8,981,077

* Including the capital of undertakings absorbed at a later date by the named companies, with the exception of the Joint Committee.
† Includes minerals and miscellaneous receipts.
‡ Including half the capital and receipts of the City of Glasgow Union Railway.
§ Includes 3,048,333*l.* for Forth Bridge, and half the capital and receipts of the City of Glasgow Union Railway.

SCOTTISH RAILWAYS, 1904.

Name of Company.	Miles Open for Traffic.	Capital Paid up to Date.*	Number of Passengers, Excluding Season Tickets.	Tonnage of Goods and Minerals.	Passenger Receipts.	Goods Receipts.†	Total Receipts, All Sources.
		£			£	£	£
Caledonian	1034	70,678,134	38,205,940	28,495,103	1,760,363	2,945,104	4,705,467
Glasgow and South-Western	417	24,252,605	16,511,341	8,796,092	751,037	1,064,050	1,815,087
Great North of Scotland	336	7,600,929	3,595,406	985,779	255,089	244,496	499,585
Highland‡	531	6,748,009	2,476,380	506,107	337,866	196,824	534,690
North British	1305	67,997,987‖	39,795,952	25,783,940	1,771,081	2,830,140	4,601,221
Portpatrick and Wigtownshire Joint Committee	82	501,552	510,670	148,488	38,589	26,391	64,980
Totals	3705	177,779,216§	101,095,689	64,715,509	4,914,025	7,307,005	12,221,030

* Including the capital of undertakings absorbed at a later date by the named companies, with the exception of the Joint Committee.
† Includes minerals and miscellaneous receipts.
‡ The figures include the returns for the Invergarry and Fort Augustus Railway.
‖ Includes 3,048,333*l.* for the Forth Bridge.
§ Return for Glasgow District Subway omitted.

SCOTTISH RAILWAYS, 1912.

Name of Company.	Miles Open for Traffic.	Capital Paid up to Date.*	Number of Passengers, Excluding Season Tickets.	Tonnage of Goods and Minerals.	Passenger Receipts.	Goods Receipts.†	Total Receipts, All Sources.
		£			£	£	£
Caledonian	1075	73,745,346	31,684,886	26,393,166	1,937,882	3,202,940	5,140,822
Glasgow and South-Western	466	24,934,056	16,328,326	8,842,452	823,046	1,191,315	2,014,361
Great North of Scotland	333	7,661,325	3,276,093	1,012,970	259,922	258,127	518,049
Highland	507	6,928,495	2,094,683	604,061	352,203	222,387	574,590
North British	1339	71,171,660‡	34,984,829	29,867,262	1,849,759	3,284,487	5,134,246
Portpatrick and Wigtownshire Joint Committee	82	492,180	422,966	150,791	37,241	23,612	60,853
Totals	3802	184,933,062§	88,791,783	66,870,702	5,260,053	8,182,868	13,442,921

* Including the capital of all undertakings absorbed at a later date by the named companies, with the exception of the Joint Committee.
† Includes minerals and miscellaneous receipts.
‡ Includes 3,048,333*l.* for the Forth Bridge.
§ Returns for the Glasgow District Subway and the Campbeltown and Machrihanish Light Railway omitted.

* Delivered November 3, 1914.

* Not reproduced here.

owners of the original docks at Grangemouth. These amalgamations conferred innumerable running powers on the various Scottish companies over the lines of the other companies, and most of the great English companies also got running powers over the amalgamated Scotch railways, and those Acts of Parliament have practically fixed the terms upon which running powers are granted—namely, 75 per cent. of the receipts being given to the owning company and 25 per cent. to the running company.

It has always been a great mystery to me why railway managers have almost invariably set their faces against the granting of running powers. The terms prescribed in the Acts I have mentioned make the use of running powers almost prohibitive, and as far as I know there is only one case in Scotland where running powers are exercised under the provisions of any of these Acts. There are many cases where they are exercised by agreement, but the only case I know of under the terms of any of these Acts is that the North British Company run over the Caledonian Railway from Kinnaber Junction to Aberdeen, a distance of about 38 miles; but there, instead of costing the company only 25 per cent., it costs them about 42 per cent. of the receipts, so that they are running at a dead loss, of course, recovering a lot of this by securing at Aberdeen a large proportion of the traffic to and from Edinburgh and the through traffic to and from England.

It seems to me that if the division of the rates between the owning company and the running company had been equitably adjusted, many competitive lines might have been saved, and one company might have quite well carried the traffic of other competing companies in addition to its own.

At the present time there are, to all intents and purposes, only five railway companies in Scotland and a joint committee—namely, the North British Railway Company, the Caledonian Railway Company, the Glasgow and South-Western Railway Company, the Great North of Scotland Railway Company, and the Highland Railway Company, and the Portpatrick and Stranraer Joint Committee, which, however, has no rolling-stock of its own. Although in 1864, and since, many other different companies existed, all the smaller companies have been amalgamated with one or other of the five I have mentioned, and in dealing with any figures in comparison between 1864 and 1914, I have dealt with those smaller companies as if they had at the earlier date belonged to the larger one with which they have since been amalgamated.

The North British Railway Company was originally incorporated by an Act of 1844 for the construction of a line from Edinburgh to Berwick, with a branch to Haddington—in all about 62 miles. The Edinburgh and Glasgow Railway Company was incorporated by an Act of 1838, and, as I have already said, was amalgamated with the North British Railway Company in 1865. The total length of the North British lines in 1865 was 625 miles.

Since that date the company has obtained powers to construct various branches throughout the country, and has amalgamated with no less than seventeen other companies, including the West Highland Company, which extends from Helensburgh to Fort William, a distance of 100 miles, with an extension from Fort William to Mallaig, a distance of upwards of 40 miles. The total mileage owned by the North British Railway Company at this date is 1395 miles. It is of interest to note that the Mallaig extension and the harbour there were promoted chiefly in the interests of the fishing traffic on the West Coast. The Government guaranteed interest at the rate of 3 per cent. on a capital sum of 260,000*l.*, and they also contributed a sum of 30,000*l.* towards the cost of constructing the pier and breakwater at Mallaig.

The original West Highland Railway was sanctioned in 1889 and it was opened throughout its whole length from Helensburgh to Fort William in 1897—very rapid work considering the country through which the railway passed; and it is probably the greatest length of railway opened at one time in Great Britain during the period under review.

The outstanding works on the North British Railway constructed during the last fifty years are the Tay Bridge and the Forth Bridge. The original Tay Bridge, which was opened for traffic on June 1, 1878, was, as is well known, destroyed by an exceptional gale on December 26, 1879, and the company immediately took steps to replace it by a new bridge, much more substantial in character. Powers for this were obtained in 1881, and the bridge was opened for traffic in 1887. The opening of this bridge so greatly increased the East Coast north and south traffic that it became imperative that a bridge should be built across the Forth for this increased traffic. Already power had been obtained from Parliament in 1865 to cross the Forth by a bridge 3 or 4 miles further west than the existing bridge, but these powers were abandoned in 1868. A new Act was obtained by the North British Railway in 1873 for a new bridge practically on the same site as the existing bridge.

This proposed bridge, I believe, was of the nature of a stiffened suspension bridge. The contract for its construction was actually let to Sir William Arrol and the work was begun, when the fall of the Tay Bridge directed the serious attention of the company to the proposed design, with the result that the scheme was abandoned, and an arrangement was made between the East Coast companies, namely, the North British, North Eastern, Great Northern and Midland, to construct a bridge under their joint guarantee. The consulting engineers of these four companies were asked to submit designs, with the result that that of Sir John Fowler and Sir Benjamin Baker was adopted, and an Act authorising its construction was obtained in 1882. This bridge was constructed by Sir William Arrol, and was opened for traffic in March, 1890. I do not propose to give any description of the Forth and Tay Bridges, as they have been already fully described in the Proceedings of the Institution.

Prior to the opening of these two bridges the time taken to travel between Edinburgh and Aberdeen, *via* the Granton and Burntisland Ferries, was 6 hours 25 minutes. No train left Aberdeen after 4 o'clock in the afternoon, so that it was impossible to do the outward and return journeys in a single day. Now, since the opening of the Forth and Tay Bridges, one can leave Edinburgh at 10.45 and arrive at Aberdeen at 2.7, in 3 hours 22 minutes; and can either leave at 5.35, arriving at Edinburgh at 9.6, in 3 hours 31 minutes, or at 7.35, getting into Edinburgh at 10.51, in 3 hours 16 minutes.

While dealing with train services such as these, although the journey is not entirely confined to Scotland, I may mention that one can leave Edinburgh by the East Coast train at 7.45 in the morning and get to London at 4.10 in the afternoon, which gives ample time for 2 hours' business, for dining at a fashionable restaurant and going to a theatre afterwards, and returning from London at 11.30, getting back to Edinburgh at 7.15 the next morning, or considerably under 24 hours from the time of leaving.

The opening of the Forth Bridge in 1890 enormously increased the volume of traffic passing through the then existing Waverley station, with the result that it became quite incapable of dealing with the traffic, and in 1891 the North British Railway got an Act for rebuilding the Waverley station and duplicating the tunnels leading to and from the station in both directions, including also a line to Leith, with a new station there.

The new Waverley Station was begun in 1895, and was completed and opened for traffic in 1900. At the date of its opening it was, if it is not indeed at the present time, by far the largest station in Great Britain, extending to over 23 acres, of which upwards of 11½ acres are under roof. It is fitted up with the most modern appliances in the way of hydraulic lifts and machinery of every description. It has two main-line platforms running the whole length of the station, each about 560 yards in length, and a suburban railway platform on the south side of, and outside the main station, with lines on either side of it, each about 470 yards in length. There are, in addition, four docks at each end of the station accommodating trains at both sides of them. The dock platforms average about 180 yards in length. The total length of platforms in the new station is 4660 yards, and there are 32,520 square yards, or about 6½ acres. The station is situated in the valley of the old Nor' Loch, about 50 ft. below the level of Princes-street, and the main accesses to it are off the Waverley Bridge, which crosses the valley of the old Nor' Loch, but at a considerably lower level than the North Bridge, a description of which is given later. These accesses are 30 ft. wide and on an incline of 1 in 15. The roof covering the station may appear to some to be rather low, but its height was fixed by Act of Parliament to meet the views of the Corporation, and was not to be more than 42 ft. above the level of the rails running through the station.

In connection with the reconstruction of this station the Waverley Bridge had to be entirely rebuilt. The piers carrying the old Waverley Bridge interfered very much with the laying out of the station; and, in addition, the structure itself, although only built in 1872, was too light for the heavy loads now passing over it. There is a large block of station offices in the centre of the station, and the total cost of the Waverley station and bridge amounted to 1,500,000*l.* The station itself is now approached from the east by four lines of rails under the Calton tunnels, and from the west by four lines of rails through the Haymarket and Mound tunnels. The company have also widened very considerable portions of their lines and provided large marshalling yards at many points on the system, and they are now in a position to deal with a very large traffic. For instance, at Portobello, in the eastern district, the accommodation for wagons has been increased from 560 to upwards of 2000. At South Leith it has been increased from 1200 to 2500, and many other yards have been provided throughout the district.

The line between Edinburgh and Glasgow is, between Haymarket and Cowlairs, one of the straightest and flattest lines in the kingdom. It has no gradient steeper than 6 ft. in 1 mile, and no curve with less than ½-mile radius. When the line reaches Cowlairs, however, it descends to Glasgow on a gradient of 1 in 44 for a distance of 1800 yards, the last 1030 yards of this being in tunnel. This gradient, from the time of the opening of the railway till November, 1908, was worked by a wire rope controlled by an engine at Cowlairs. The annual cost of this was very considerable, and the directors had frequently considered the advisability of removing the top of the gradient farther east, and so, while increasing the length both of the gradient and the tunnel, reducing the gradient to 1 in 100. This would also have enabled them to improve Queen-Street Station, but nothing in this direction has as yet been carried out. At the date I have mentioned the rope was done away with, and since then the traffic has been worked, both up and down, by the ordinary locomotives, and so far quite successfully. This was only rendered possible by the enormously increased power of the modern locomotives.

In common with all the other Scotch railways, the weight and size of the rolling-stock has very much increased. In 1864 the heaviest type of locomotive running on the main lines in full working order did not exceed in weight 60 tons, and the majority of the locomotives weighed considerably less. To-day the total weight of locomotives under running conditions, including tender, amounts to about 120 tons. The weight on one pair of driving-wheels is 20 tons, which is about double the maximum axle weight in 1864.

Similarly, the rolling-stock has increased in weight. In 1864 the heaviest carriages weighed 13 tons and were 24 ft. in length, carried on four wheels. To-day the dining-cars are 66 ft. in length and weigh nearly 44 tons, with six-wheel bogies at each end. The heaviest wagons running fifty years ago weighed 5 tons, carried 6 tons, and were 15 ft. long. To-day they weigh 7 tons, carry 16 tons, and are about 20 ft. long.

I recollect once sitting at dinner next our late colleague, Mr. Webb, when he told me that in his early days the weight of a train was equal to ¼ ton per passenger, and that at the time he was speaking, now some years ago, the weight had increased in the dining and sleeping-car trains to 3 tons per passenger—an extraordinary increase.

All the Scotch railways have from time to time increased the weight of their permanent-way to keep pace with the increased weight of the engines and carriages running over it. Rails, instead of being 65 lb., which was the ordinary weight 50 years ago, have been increased up to 90 lb. and 100 lb., and the other parts of the permanent-way in proportion.

The Caledonian Railway Company was incorporated by Act of Parliament in 1845, the lines authorised being the main line from Carlisle to Wishaw, the Edinburgh branch from Carstairs, and the Castlecary branch from near Gartsherrie to Greenhill. Prior to that the Glasgow, Garnkirk, and Coatbridge Railway and the Wishaw and Coltness Railway were in existence, but these lines were amalgamated with the Caledonian Company in 1846 and 1849 respectively, so that the Caledonian Railway extended from Carlisle to Glasgow and Edinburgh, and on to Greenhill, the total length being 144 miles.

Subsequently to 1864, a number of amalgamations with other companies were made, the chief of these being, as I have already pointed out, the amalgamation with the Scottish Central Railway in 1865, with the Scottish North-Eastern in 1866, and the Forth and Clyde and Monkland Canals in 1867. In 1864 the mileage of the railways was 230 miles, and since that time, in addition to these and other amalgamations, the Caledonian Railway has been constantly building new lines and branches throughout the whole of its system, and to-day it extends to about 900 miles.

Among the principal extensions may be mentioned the Callander and Oban Railway, which was the first railway to open up the Western Highlands. It was authorised in 1865, but after it had been constructed as far as Tyndrum the rest of the line was abandoned, as the traffic was so inconsiderable, and so much less than the promoters had expected, that the Caledonian Company, who were by this time responsible for the line, despaired of ever making it pay. A new Act, however, was got for the completion of the line to Oban in 1874, and it was opened throughout, a total length of 72 miles, in 1880. Owing to the very difficult nature of the country through which it passed, it was found necessary to adopt gradients of 1 in 50 and 10-chain curves, but there are on it no works of any great magnitude.

Prior to 1872 all traffic from the south and east coming to Glasgow terminated on the south side of the Clyde, and this was found exceedingly inconvenient for the largely increasing passenger traffic. Accordingly, in 1873, the Caledonian Railway obtained an Act for the construction of a short line carrying their railways from the south side of the Clyde by means of a viaduct over the river into what is now the Central station at Gordon-street. The viaduct over the Clyde has already been described in the Proceedings of the Institution, but it may be noted that it consists of five spans, the southmost, over Clyde-place, being 61 ft., the three river spans, respectively, 164½ ft., 186 ft., and 151 ft., and the northmost span over the Broomielaw, 89 ft. The piers were sunk to the rock at depths varying from 83 ft. to 101 ft. below high water, by excavating with grabs inside cast-iron cylinders weighted with cast-iron weights. It is believed that this was the first bridge on which hydraulic riveting was used *in situ*, and that was done by Sir William Arrol, whose first important contract this was.

The station at Gordon-street and the bridge over the Clyde have been very largely increased under the Act of 1899. The extension works were begun in 1901, and the new bridge and station were opened for traffic in 1910. The piers for the new bridge were exactly in line with the piers of the existing bridge, but were not, like the piers of the existing bridge, carried down to the rock, but only to a depth of 66 ft. below high water. These piers were sunk under pneumatic pressure. The extension of the Central station and the extended bridge over the Clyde have already been described in detail by Mr. Matheson in a paper read before the Institution.

Among other very important works carried out by the Caledonian Railway Company was the extension of the Glasgow and Greenock line to Gourock. Prior to 1885 the terminal station at Greenock was in the heart of the town, and passengers had to walk a considerable distance through narrow and crowded streets to get to the coast steamers. To obviate this the railway was extended to Gourock by driving a tunnel, which is the longest in Scotland, through the heart of the town. The extension was 3¾ miles in length, and occupied 5 years in construction.

Probably the most interesting and important work which the Caledonian Railway Company has carried out in recent years is the Glasgow Central Underground Railway, about 7 miles in length. This railway passes for several miles underneath some of the most crowded streets in Glasgow, with high buildings on both sides. These buildings were underpinned from their foundations down to the formation level of the new railway, then the side walls of the tunnel were built in trenches, after which the roof, which was partly of steel girders and

partly of arching, was put on, the dumpling was removed, and the invert of the tunnel completed. This railway was constructed at enormous cost, mainly with the view of giving the Caledonian Railway Company direct access from the east to Stobcross Docks, instead of having to run over the North British Railway, round the north of Glasgow.

When the Caledonian and North British Railway Companies were vying with each other in promoting unremunerative railways in the Highlands, the Caledonian Railway Company constructed an extension of the Callander and Oban line to Ballachulish from Connel Ferry. Power was obtained in 1896 for this extension, which was 28 miles in length, and it was opened for traffic in 1904. There are two large and important bridges on this line, the Creran Bridge over Loch Creran, with two spans, each of about 150 ft., and a cantilever bridge over Loch Etive, with a clear span of about 500 ft., and a total length of steelwork of 735 ft. In addition to this, the Caledonian Railway Company have constructed a whole network of lines in the Mid-Lanark and Ayrshire districts, and on these lines there are many large and important viaducts.

Many of the early viaducts and bridges on the Caledonian Railway consisted of timber laminated arches with timber rail-bearers. These have all been renewed and replaced by wrought iron or steel, and nearly all the cast-iron under-line bridges have been replaced with steel superstructures.

In addition to the bridges, the roof of Carstairs Station, which must be well known to travellers to Scotland, was also of laminated timber. It was long kept up out of respect to Mr. George Graham, the late engineer of the Caledonian Railway, who drove the first train which ran from Carlisle to Carstairs, and who thought Carstairs one of the finest stations in Scotland; but it has at last been pulled down, and Carstairs is now to have a modern station with a modern roof.

The Glasgow and South-Western Railway Company dates from 1811, when it consisted of only 9½ miles of short lines connecting several collieries near Kilmarnock with the coast town of Troon. In 1864 the system extended to 198 miles. The principal station in Glasgow in 1864 was the Bridge-street terminus on the Glasgow and Paisley Joint line on the south side of the Clyde.

In that year the City of Glasgow Union Railway was authorised. This was a short line connecting the Glasgow and South-Western Railway at Shields-road, on the south side of the Clyde, with the North British, Edinburgh, and Glasgow line at Sighthill, on the north of the Clyde, and with a large terminal station at St. Enoch-square, branching off the main line. This station, which was opened in 1876, was modelled on the Midland Railway Company's Station at St. Pancras, and was the first large terminal station of modern days to be opened in Glasgow. The station and approach-lines became vested in the Glasgow and South-Western Railway Company in 1883.

In 1896 the remainder of the City of Glasgow Union line was divided between the North British and Glasgow and South-Western Railway Companies, so that the City of Glasgow Union Railway Company then ceased to exist.

Since 1864 the Glasgow and South-Western Railway Company have made many amalgamations and extensions, and their lines now extend to 492 miles. They claim that their original line, already alluded to, from Kilmarnock to Troon, was the first railway made in Scotland under an Act of Parliament. It was constructed with cast-iron rails resting on stone blocks.

The Great North of Scotland Railway Company began by a line between Elgin and Lossiemouth, which was opened in 1852, and, with the exception of the Moray Firth Coast line from Portsoy to Elgin, the Cruden Bay Railway opened in 1897, and a light railway from Fraserburgh opened in 1893, the whole of the lines were in operation in 1867. The coast line from Portsoy to Elgin crosses the River Spey near Garmouth. The bed of the Spey at that point has a nominal width of 2200 ft.; that is to say, the main channel of the river fluctuates from side to side within that width. The Spey is one of the wildest rivers in Scotland, and during the celebrated Moray floods in 1829, graphically described by Sir Thomas Dick Lauder, it showed what it was capable of doing. After two or three days of continuous rain the river rose from 17 ft. to 20 ft., carrying away the Fochabers Road Bridge some miles above the site of the proposed railway bridge referred to, and flooding the adjacent country for miles.

In designing the railway bridge across the river, provision had to be made to carry off a similar flood should it ever recur, and the original intention was to cross by a bridge with eleven spans of 100 ft., with long training-walls to confine the river within moderate limits; but the then Duke of Richmond opposed this design, as he thought it might interfere with his salmon fishings, and insisted on a bridge being built with one central span of 350 ft. and three spans of 100 ft. at either side. This was done, and although on one occasion it was severely tried, it has been found equal to the requirements.

There is also on this railway a small viaduct known as the Lower Cullen Viaduct, which consisted of six spans, each of 42 ft. The piers of this viaduct were founded on what to all appearance was an excellent foundation. But the hill on which three of the piers were built were very steep, and underlying the foundation at some considerable distance was a bed of clay. After the traffic had been running over the railway for a little time the clay had evidently slipped down, and three arches of the viaduct collapsed, nothing being left but the rails hanging in mid-air for a space of about 150 ft. As the traffic on the railway had to be resumed as quickly as possible, it was not considered desirable to rebuild these arches, and the place was filled up with an embankment of ashes. I have mentioned this as I do not think any notice was ever taken of the accident in the Proceedings of the Institution, and I am sure nothing gives more useful information to all members of the profession than the description of accidents which have actually taken place, with, if possible, the causes and the means adopted to overcome them.

The largest station on the Great North system is that in Aberdeen, which is jointly owned with the Caledonian Railway Company, and is at the present time being reconstructed. The original station, constructed in 1867, has long been quite insufficient to deal with the traffic, and there is no doubt that the present reconstruction ought to have been undertaken many years ago.

It is interesting to note that the Great North of Scotland Railway Company never had any second-class carriages. They were also the first to introduce the interchange of tablets at high speeds, the tablets being exchanged by means of catchers fixed on to the locomotives and standards set at the side of the line. These were introduced in 1899, and tablets are successfully exchanged at speeds up to 60 miles an hour.

For several years the Great North of Scotland Railway Company tried by various means to get access from their system into the capital of the Highlands. First, in 1883, the year in which the Highland Company were promoting their direct line from Inverness to Aviemore, the Great North of Scotland Railway Company promoted a line practically over the same country from their Speyside railway at Nethy Bridge into Inverness at an estimated cost of 400,000*l.* That was thrown out, and they returned again to the charge in 1889 by promoting another line running nearly parallel with, but a little distance from, the existing Highland line from Elgin to Inverness, at an estimated cost of 550,000*l.*; but that again was thrown out, and, as a last resort, in 1892 they endeavoured to reach Inverness by a direct application for running powers over the Highland Railway from Elgin to Inverness. This was also thrown out by Parliament.

I never could understand what the Great North were driving at in their anxiety to reach Inverness. Inverness is a small, quiet town, and the traffic that would have been got from it never could have remunerated them for the great capital expenditure they would have incurred.

The Highland Railway Company began by the opening of a short line, 15 miles in length, from Inverness to Nairn, in 1855. The system now, including the Dornoch Light Railway, extends to 560 miles. The main lines are constructed through some of the wildest and most mountainous districts in Scotland, and much of the railway over deep moss and soft moorland. The summit of the old main line at Drumochter is 1484 ft. above Ordnance Datum, and the new line from Aviemore to Inverness rises to a height of 1320 ft. above Ordnance Datum.

There are many large and important viaducts on the system, but the principal viaducts are on the new direct line from Aviemore to Inverness, where the River Nairn is spanned by a very fine stone viaduct of red sandstone with twenty-eight arches of 50 ft. span, and one large semi-circular arch of 100 ft. span. The total length of this viaduct is 600 yards, and the height from the river-bed to the parapet is 135 ft. It is on a gradient of 1 in 60, and at the south end on a curve of 40 chains. A little farther south the River Findhorn is crossed by a viaduct with nine spans of steel girders, each 130 ft. span, and with a height of 145 ft. above the river. This also is on a 1 in 60 gradient.

Many members may have noticed that a serious accident occurred on this part of the Highland Railway in the early summer of the present year, owing to the washing away of a small bridge carrying the railway over a mountain stream. It is no uncommon thing in the Highland districts to have bridges washed away after severe floods, but in this instance the whole rainfall took place in one hour, and the destruction caused by that rainfall is almost inconceivable. Immediately above the railway a road-bridge, which had stood for more than one hundred years, was washed away, and the railway-bridge itself had been in existence for over twenty years, and was amply large enough to carry away any flood which an engineer might anticipate and think it necessary to provide for.

One of the great difficulties which the Highland Railway has to contend against is snow. On parts of the line the snow drifts into the cuttings with great rapidity. This is met, to a certain extent, by having double sleeper fences along the line at the exposed places, and by having a complete system of snow-ploughs.

In order to show the fluctuating amount of engineering works in Scotland and the consequent difficulties that engineers there have to contend with, I have prepared a diagram* showing in red the total amount of deposited estimates for all Bills in Scotland from November, 1865, up to the present time, and in solid blue the amount of those estimates which are for railways, the balance being municipal, tramways, docks, water-works and others. By far the largest amount of deposited schemes in any one year was in 1865, when the total of the Parliamentary estimates amounted to about 14½ millions, of which all but 1 million was for new railways. Many of these schemes were thrown out, and of those which were passed many were abandoned in the following two years, while in 1868 no Bill from Scotland was introduced into Parliament. The recurring periods of activity in railways in Scotland were those of 1872, 1882, and 1890 and 1896, and since 1900 there have been very few railways promoted in Scotland. This, to a large extent, is due to a peace agreement which was entered into between the North British and Caledonian Railway Companies, whereby each undertook not to promote any schemes invading the district of the other company. While the applications for new railways have been decreasing in later years, there has been a considerable number of new schemes for municipal and other purposes.

* Not reproduced here.

During the period under review the total number of Bills introduced from Scotland was 677, representing an estimated capital expenditure of nearly 119 millions, and of that number 341 were railway Bills with an estimated capital expenditure of upwards of 74 millions.

In the early part of the period, although many here may be ignorant of the fact, passenger luggage was carried on the roofs of the passenger coaches, covered with tarpaulins and carefully strapped down, and when it came to its destination it was slid down to the platforms on broad wooden slides. The guards in those days sat in little wooden boxes raised above the level of the roofs of the carriages. I have endeavoured to find out the exact date when this practice was given up, but I can get no definite information, and am told it was some time in the 'seventies.

The largest single Bill in any one year was the Caledonian Railway Company's Glasgow Lines Bill of 1865, with an estimate of 2,100,000*l.*, but this Bill did not pass the Committees of Parliament.

Several large railway schemes have been promoted in Scotland by independent parties, some of which have been withdrawn or rejected, while some have been adopted by one or other of the existing companies. One of the boldest, and also one of the wildest, was a scheme promoted by a London syndicate in 1883 for a railway all the way from Glasgow to Inverness. It passed along the east side of Loch Lomond, up Glenfalloch, across the Moor of Rannoch, down Glencoe, and up the route of the Caledonian Canal, keeping the south side of Loch Ness. Much of it was over ground having a natural angle of little over 45 deg., for which, in the opinion of many engineers who knew the district well, very inadequate provision was made in the estimates, and the Bill was rejected in Committee.

Another bold, independent scheme was that of the West Highland Railway, 100 miles in length, from Helensburgh to Fort William; but the promoters were fortunate enough to get the North British Railway to take it up, although it cost more than double the Parliamentary estimate. The original estimate was 776,000*l.*, but it actually cost upwards of 1¾ million, and the estimated traffic has never yet been nearly realised. The line was opened for traffic in 1897.

As a further instalment of a new through line from Glasgow to Inverness, the Invergarry and Fort Augustus Railway, extending from Spean Bridge, a station on the West Highland line, to Invergarry, at the foot of Loch Ness, was promoted in 1896. This line is 24 miles in length, and was estimated to cost 240,000*l.*, but its actual cost was much in excess of that sum. There never has been any traffic on it to speak of. The company, having no plant of their own, first entered into an agreement with the North British Railway Company, and afterwards with the Highland Railway Company, to work it, but both these companies found the terms of their agreements unremunerative, and ultimately the railway was closed altogether. Owing to the pressure of the County Council and the landed proprietors, it has again been opened for traffic, and only this year the North British Railway Company acquired the whole railway for a sum of 27,500*l.* It is very doubtful if, even at that price, it can be worked at a profit.

The line was sanctioned in 1896, and in the following Session of Parliament no less than three Bills were promoted for railways between Fort Augustus and Inverness, and all practically over the same route. One of these was promoted by the Invergarry and Fort Augustus Railway Company; another by the North British and West Highland Railway Company, who asked for running powers over the Invergarry and Fort Augustus Railway, and for a line from Fort Augustus to Inverness; and the third was promoted by the Highland Railway from Inverness to Fort Augustus. The estimates for these lines varied from 540,000*l.* to 371,000*l.*, the distance from Inverness to Fort Augustus being about 34 miles.

The Fort Augustus terminus was on Loch Ness, which has direct communication with Inverness and the Moray Firth by means of the Caledonian Canal, and the canal and loch were amply sufficient to deal with any traffic in the district. These three railway companies, however, were so impressed with the necessity of having a through line to Inverness that they all promoted Bills. Two of them were thrown out in the House of Commons, and the third, the Highland Railway Company's Bill, was thrown out in the House of Lords. These Bills were promoted before the days of motor-cars, and it is exceedingly doubtful now, with motor-cars on land and steamboats on the loch and canal, whether the intervening link between Fort Augustus and Inverness will ever be filled up by a railway.

Another independent scheme was the Paisley and Barrhead Railway, which was authorised in 1897, and was taken over by the Caledonian Railway Company. The construction of this line was proceeded with immediately after the Act was obtained, and it was completed and passed by the Board of Trade some years ago; but from that time to the present not a single train has ever run over it. It was used a few years ago during the time of the wagon difficulty in Scotland as a great siding for the storing of empty wagons.

During the great part of the period under review the Bills for the construction of new works were introduced into Parliament in the ordinary way, and heard at Westminster before Committees of the Houses of Lords and Commons.

In 1899 the then Government passed the Private Legis-

lation Procedure (Scotland) Act, which provided that in future new schemes were to proceed by way of Provisional Orders, and were to be heard by a Commission composed of Members of the Houses of Lords and Commons, and of an extra Parliamentary panel. There was to be no dual inquiry under this procedure, and the Act also provided for Orders being introduced both in November and March, instead of as in the Parliamentary procedure in November alone. Fortunately, this Act also provided that it was in the power of the Chairmen of the two Houses to transfer any Orders under the Scottish Act to be heard as Bills at Westminster in the ordinary way.

I believe the origin of this Act was a clamour raised by a number of briefless Scotch advocates, who desired to share in what they believed to be the large fees paid to counsel for promoting private Bills. The Act was advocated as being a more rapid and a more economical way of carrying out the inquiries; but after having had experience of such inquiries since their introduction in 1899, I am satisfied, and I have no hesitation in saying that those best qualified to judge share my opinion, that this Act has been a lamentable failure. The cost of inquiries is certainly not reduced, and in many cases it has been considerably increased.

The composition of the tribunals which preside over the inquiries in Scotland has rarely been satisfactory, and what is worse than all, in some cases, after the tribunal has given its decision, the Scottish Office has taken possession of the Order and held it up for more than a year before the necessary Act has been passed giving effect to the decision of the Court of Inquiry.

There has never, in my opinion, been an Act relating to public works passed which has been a greater failure than this one, and it is almost invariably the custom now that, when any large scheme is promoted in Scotland both the promoters and opponents of the measure appear before the Chairmen of the two Houses and ask that it may be sent to London to be heard as a Bill in the ordinary way. I understand the Government are contemplating amending this Act, and if I might be allowed to make a suggestion for their consideration, the best amending of the Act would be to make the proceeding under it optional, and let those in charge of measures in Scotland decide whether they wish to have them heard at Westminster in the ordinary way, or whether they wish to have them heard in Scotland before this special tribunal.

In 1896 the Light Railways Act was introduced to facilitate the construction of light railways in Great Britain. It has always been difficult to understand what was meant by a light railway. Certainly the term has nothing whatever to do with the weight of the permanent way, and it was at one time thought that by adopting light railways a great deal of money would be saved in connection with the fencing and signalling of the line. The Act has not been very much made use of in Scotland, but it has been found in most cases that it is better, as in the case of an ordinary railway, to fence the light railways throughout, and to have the usual amount of signalling on them. No doubt some promotion money is saved by the procedure before the Light Railways Commissioners, and I believe the Act has been much more taken advantage of in England than it has been in Scotland. During the eighteen years that this Act has been in operation only eight light railways in Scotland have been constructed under its provisions.

So far nothing has been done in Scotland with regard to the electrification of any of the railways, but I think there can be no doubt it would be a great improvement and a considerable saving in cost if many of the suburban tunnel lines in and around Glasgow were equipped for electric traction.

Coming next to docks, these may be divided into two classes—railway-owned docks and municipal or private company docks. Both the Caledonian and North British Railway Companies have large docks on the East Coast of Scotland. The North British Railway Company have docks at Alloa, Bo'ness, Burntisland, and Methil, and the Caledonian at Grangemouth and South Alloa.

The principal docks on the North British Railway are at Methil, in Fife. These have been fully described in a paper read before the Institution in November, 1912. The first dock there was built by the late Mr. Randolph Gordon Erskine Wemyss, who did a great deal for the development of the county of Fife. Not only did he build docks and railways, but he constructed a large system of tramways and built a large garden city, and also greatly assisted in the development of the Fife coalfields, in which he had a large personal interest.

After he had completed the first dock at Methil, and the branch railway to it from the North British Railway at Thornton, he sold these to the North British Railway Company, binding himself at the same time not to make any other competitive dock on his own property along the shores of the Firth of Forth. But, unfortunately for the North British Railway Company, the agreement entered into with him did not prohibit him from making a complete set of independent railways on his own property to carry his own coal traffic to the docks at Methil, and so enable him to avoid using the railway he had sold to the North British Railway Company, and which he had constructed for that very purpose.

The first dock was comparatively small, about 4½ acres in extent and 23 ft. deep, and soon after it was acquired by the North British Railway they had, owing to the increasing output of coal, to supplement it with a second dock, 6¼ acres in extent and 27 ft. deep, and only about 18 months ago they completed a third dock, 16¼ acres in extent and 32 ft. deep. All these docks, when trade is good, are fully occupied in shipping coal for the Baltic, Mediterranean and other ports.

At Grangemouth the Caledonian Company in 1867 acquired the original docks, which were quite small and shallow, and which formed part of the Forth and Clyde Canal, and in 1876, to meet the large coal traffic coming from Lanarkshire, they built a new dock about 20 acres in extent and 24 ft. deep, entering directly off the River Carron, which they deepened up to the entrance of the new dock. In 1906 they again enlarged their accommodation at Grangemouth by constructing a dock about 30 acres in extent, with a depth of about 30 ft. This dock connects, by means of a lock, directly with the Firth of Forth, and so does away with the necessity of using the River Carron as an entrance—a river not only tortuous, but very difficult to keep efficiently dredged.

The Grangemouth docks and the docks at Methil are fully equipped with the latest appliances for the shipment of coal, and they are both capable of dealing with large quantities, Methil alone having sufficient appliances to ship from 7 to 10 million tons per annum. There are railway docks on the west coast at Ayr, Troon and Ardrossan, and other places, but none of these are very large or important.

With regard to the docks owned by municipalties and others, the principal of these are at Glasgow, Leith, Dundee and Aberdeen. With regard to the Clyde, as I hope the members of the Institution will have the advantage of hearing a paper read during the present session by Sir Thomas Mason, the chairman of the Clyde Trustees, I shall deal very shortly with the great works that have been carried out there.

The first dock to be opened on the Clyde was the Kingston Dock, on the south side, extending to about 5⅓ acres. That was opened in 1867, and was unfortunately burned down this summer. Since then the Queen's Dock on the North and Princes Dock on the south, and Rothesay Dock at Clydebank, have all been opened; and, in addition, docks have been constructed at Yorkhill, on the north side of the river.

The Clyde Trustees have power to construct extensive works on the south side of the Clyde, authorised by the Act of 1911, and also two tidal basins, authorised in the last Session of Parliament. These two tidal basins are only an instalment of five which it is ultimately proposed to construct.

Fifty years ago the quayage measured 4400 lineal yards, and at the present time it extends to 19,200 lineal yards, with powers to increase, as I have already mentioned. The revenue of the Clyde Trustees in 1865 was 121,000*l.*, and in 1913 it was 634,000*l.*—an increase of 500 per cent. Since 1899 the net tonnage of vessels using the harbour has increased from 8⅔ million tons to 13⅓ million tons, or 54 per cent., and the tonnage of goods from about 7 millions to 10½ millions, or nearly 50 per cent.

When I talk of the docks on the River Clyde, I really mean large tidal basins, as there is not a single gate on any of them. Such a state of affairs is only feasible where the rise and fall of the tide is comparatively small. In 1871 this rise and fall of the tide was at Glasgow Bridge 10 ft. Now, owing to the dredging and deepening of the river lower down, it has increased to 12 ft.

The river has now been deepened from Glasgow Bridge right down to deep water in the lower stretches of the Firth of Clyde, so that vessels of the largest class can be built at Glasgow and taken down the Clyde, and the Clyde Trustees have done everything in their power to facilitate the building of large vessels. No better instance of this can be found than the launch of the Aquitania, which, at the time of its launch, eighteen months ago, was the largest vessel afloat in the world.

The jurisdiction of the River Clyde is at the present time in the hands of three different bodies. From Albert Bridge, Glasgow, to Newark Castle, Port Glasgow, a distance of 18½ miles, it is under the Clyde Trustees. From this last point to the west end of Greenock Harbour, a distance of 4 miles, it is under the Clyde Lighthouses Trustees; and from there downwards, a further distance of 4 miles, it is under the Greenock Harbour Trustees. There have been several attempts in recent years to have these three bodies joined together to form one large controlling body, to manage the whole of the River Clyde, and it seems to me that such a course is eminently desirable, and would be the best way of securing the interests of the traffic and the continued improvement of the river.

At Leith three new docks have been built since 1864, and four graving docks, one of the latter being 550 ft. long. There is nothing special about the docks at Leith, except that a large quantity of land on which they have been built has been reclaimed from the sea by means of heavy sea-walls. In 1864 the number of vessels arriving at Leith was 4830, with a net tonnage of 527,000 tons. The number of vessels had increased in 1913 to 7552, with a tonnage of 2,927,000, and the goods exported and imported amounted to 4,700,000 tons, of which 2,200,000 tons were coal.

In the last Session of Parliament the Commissioners of Leith Harbour obtained further powers to increase their dock accommodation by reclaiming more land from the sea. No doubt this is to enable them to deal with the increasing output of coal from the Lothian coal-fields. Much of this capital expenditure might, however, be saved, at any rate meantime, if the facilities for dealing with the shipment of the coal were more up to date. When one sees coal for shipment being brought to a coal-hoist over the same line of rails on which the empty wagons are taken back, it is evident that the best possible results cannot be obtained.

The harbours of Aberdeen and Dundee have also been improved, the latter having erected the newest machinery for the discharge of jute.

With regard to water works. Glasgow has the advantage of a vast supply from Loch Katrine, and during the last fifty years the aqueduct for bringing that water from Milngavie into Glasgow has been duplicated, and a second service reservoir at Milngavie, called the Craigmaddie reservoir, has been constructed. This reservoir has a very deep puddle-trench extending to about 200 ft. below the surface. The level of Loch Katrine was raised 5 ft. some years ago, and it is in contemplation to duplicate the aqueduct from Lock Katrine to Milngavie.

The Corporation of Glasgow applied to Parliament this year for power further largely to increase the supply of water by raising the levels of Lochs Doine and Voil, and taking the water by means of a long tunnel into Loch Katrine for transmission to Glasgow. This scheme, or some substitute, must very soon be promoted again, as it is essential that an ample supply of water must be secured to Glasgow.

In the Edinburgh district the supply of water to the populace in 1864 was 724 cubic feet per minute, which is equal to 31.12 gallons per head per day to a population of 208,000. The water supply of Edinburgh was at that time in the hands of a water company, who managed their affairs, it was stated, not so much in the interests of the consumers of water as in the interests of the shareholders of the company. After a great deal of quarrelling with the Corporation, and when a B ll promoted by the Corporation was in Parliament, an agreement was arranged by which the Corporation bought up the old water company and established the presently existing Edinburgh and District Water Trust, composed of members of the Corporations of Edinburgh and Leith.

In 1874 the Edinburgh and District Water Trustees promoted a scheme to bring water from the Moorfoots to Edinburgh, giving an additional supply of nearly 9,000,000 gallons per day, at an estimated cost of 324,000*l.* That supply was duly introduced, but again a shortage of water became apparent, and in 1895 they introduced another Bill to bring water from the Talla, a branch of the Tweed. This scheme gives a further supply of 10,000,000 gallons per day, and includes a reservoir with a storage capacity of 2,800,000,000 gallons.

It has been so laid out that a further supply, when necessary, can be taken at a very small additional cost by diverting the waters of the Fruid and the Menzion into the Talla Reservoir. The supply of water to Edinburgh now amounts to 45 gallons per head per day. There is nothing very striking in connection with either the works of the Moorfoots or the Talla schemes.

Aberdeen promoted a scheme for an additional supply of water from the River Avon in 1909, but this was thrown out by the Committee to whom the Bill was referred. It is, however, essential that some new supply of water be got for Aberdeen. The present supply is very much overtaxed, and the culvert by which the water is supplied to the town is in a very unsatisfactory condition, besides which the supply is drawn from the River Dee, only about 20 miles from the sea, above which point there are many villages and thousands of acres of highly-cultivated land.

(To be continued.)

Concrete Foundations for Guns.—*Concrete* publishes drawings of the building at Willesden which was stated in the daily papers to have a flooring and roof capable of supporting heavy guns. It turns out to be an ordinary building, with floors 5 in. thick, except where provision was made for the engine and boilers, and to have a ferro-concrete saw-tooth roof. In one part there is a flat ferro-concrete of the usual section.

The Hadfield Research Prize.—We gave a preliminary announcement concerning this prize in a former issue (see vol. xcvii., page 819). The Iron and Steel Institute now states that a Research Prize of the value of 200*l.* has been placed by Sir Robert A. Hadfield, F.R.S., Past-President, at the disposal of the Council of the Institute, to be awarded by the Council for original research work on the subject of "The Different Forms or Combinations of Carbon in Iron, Steel, and Alloys of Iron with other Elements." Competition for the prize is open to metallurgists, chemists, and others interested in metallurgy, and it is proposed that the prize shall be awarded at the annual meeting of the Institute in May, 1916, for the best report presented before February 1, 1916. Sir Robert Hadfield is also prepared to offer a second prize for the report next in merit to the one that gains the first prize, provided it is adjudged to be a really meritorious paper. It is not desired to limit the scope of the research too closely, but it is suggested that the work should be in continuation of, or based upon, the work of previous investigators, such as Jullien, Abel, Müller, Ledebur, T. Sterry Hunt, Akerman, Arnold, E. D. Campbell, Hogg, Parry and others. The object of the Research Prize is to stimulate the study of carbides in iron and iron alloys generally, also with a view to discovering the best method of determining the forms and combinations in which carbon occurs in iron and steel. These carbides are now spoken of by metallurgists in a general way, as sub-carbides, carbides, or double carbides. It is very desirable to define the composition of these more accurately and to ascertain whether other carbides exist which have hitherto not been identified. The study of the molecular constitution of the carbides will also fall within the range of the investigation, and, in this connection, attention may be directed to previous researches on particular combinations of carbon or forms of carbide. For instance, it would be of interest to determine whether the ordinary carbide is Fe_3C, Fe_6C_2, or some other combination. If so, what is its nature and molecular constitution? The foregoing is a general direction which should guide intending participants in this research. It is hoped that the results obtained will throw much light on the cause of hardness of steel, also on the nature and form of carbon combinations with iron and its alloys. Intending competitors should communicate, in the first place, with Mr. G. C. Lloyd, Secretary of the Iron and Steel Institute, 28, Victoria-street, London, S.W.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

South Africa: The office of H.M. Trade Commissioner for South Africa reports that tenders are invited by the Johannesburg Municipal Council for the supply of a tramway lay-out (points, crossings, rails, &c.). Copies of the specification and form of tender may be obtained from the office of the Controller of Stores, Municipal Offices, Johannesburg. Sealed tenders, on the proper forms will be received by the Town Clerk, Municipal Offices, Plein Square, Johannesburg, up to noon on December 4. It will be observed that the time for the receipt of tenders is limited, and owing to forms having to be obtained from South Africa, this intimation will be of use only to firms having agents in the Union who can be instructed by cable.

British India: The Director-General of Commercial Intelligence in India reports that an English timber merchant and contractor in that city is desirous of getting into touch with United Kingdom manufacturers of cheap light-railway material. He states that he is in touch with all likely purchasers of this class of material.

New Zealand: H.M. Trade Commissioner for New Zealand reports that, according to the local Press, the ratepayers of Pahiatua have approved the raising of a loan of 10,000*l.* to establish electric-lighting and power works in the borough.

France, Netherlands: A gentleman with a good business connection in France and the Netherlands, who is starting shortly on a business tour in those countries as the representative of United Kingdom manufacturers of tool-steel and metal soap, is desirous of getting into touch with United Kingdom manufacturers of other engineers' supplies and allied articles with a view to representing them.

Spain: The *Gaceta de Madrid* notifies that a concession has been granted by the Ministerio de Fomento to Don José F. Solórzano y Freire for the construction of an electric tramway from Ferrol to Santa María de Neda. The *Gaceta* also contains a decree authorising the Dirección General de Obras Públicas, Ministerio de Fomento, Madrid, to call for tenders for the dredging of the port of Alicante at an estimated cost of 283,038 pesetas (about 10,480*l.*). A further decree authorises the execution of dredging works at the port of Ibiza, Balearic Islands, at an estimated cost of 296,988 pesetas (about 11,000*l.*).

Russia: H.M. Consul-General at Moscow reports that a firm in Ekaterinoslav desires to get into touch with manufacturers in the United Kingdom, or preferably their local agents, who can supply the following articles:—Electric motors and parts, lathes, drilling-machines, wood-working machinery and benches, steam-engines, materials for electrical installations, iron and steel implements and tools, belting, furnace bricks, tool-steel compressors, Manila hemp ropes and steel ropes.

Greece (New Territories).—H.M. Minister at Athens reports that the Greek Government has ratified the following contracts for surveys of new railways, all of which are to be of the 1.44-m. (4-ft. 8½-in.) gauge:—Kalabaka-Kozani-Sorovitz line and the Kozani-Verria line, by the German firm of Lentz and Co.; Drama-Cavalla line and the Larissa-Kozani line, by Mr. Emile Garguilo; Salonica-Angista line, by the Compagnie des Chemins de Fer Orientaux; Kalabaka-Yanina line (*via* Kozani and Sorovitz), by the Batignolles Company.

Chili: The *Diario Oficial*, Santiago, contains a decree, dated August 27, approving the project of Señores Emilio Rodriguez and Eduardo Arzon for the establishment of an electric-lighting system in the town of Curepto. Work must be commenced within a period of six months from the date of the decree, and completed within a further twelve months.

Brazil: According to a report by the British Vice-Consul at Maceio, State of Alagoas, motor-cars are now being imported into that district, and this branch of trade should expand considerably, as the Government is improving the streets in the city, and also the roads connecting the suburbs. The United States supply most of the cars, as they are cheaper than British cars, which are not advertised and put forward with sufficient energy. The *Diario Official* contains a decree approving the plans of the Companhia Paulista de Estradas de Ferro for the extension of the Rio Claro-Itirapina line to São Carlos, at a cost of 1,632,773 milreis (about 95,200*l.*), and authorising the company to make surveys for further extensions.

Falmouth.—The Town Clerk of Falmouth states that in view of the fact that large numbers of people who have hitherto spent the winter abroad will not be able to leave England for the present, he will be pleased to send free, on receipt of a post-card, an illustrated booklet which the Corporation have published on the town and its environs. He is also prepared to give advice as to accommodation.

Argentine Permanent-Way.—During the past year track has been relaid with hard-wood sleepers and 85-lb. rails between the following points upon the Central Argentine Railway:—Main line to Tucuman, 22½ miles; Firmat to Chucul section, 19¾ miles; Galvez to Maria Juana section, 33¾ miles; Pilar and Villa del Rosario section, 18¾ miles; Maria Juana and Morteros section, 27 miles; and Melincue and Pergamino section, 21¼ miles; or altogether, 143 miles.

CATALOGUES.

Accessories for Power Transmission.—The Smith and Grace Screw-Boss Pulley Company, Limited, of 35, Queen Victoria-street, E.C., have issued a new illustrated catalogue giving prices and full particulars of belt-pulleys, shafting, collars, shaft-couplings, plummer-blocks, swivel adjustable bearings, hangers, floor-standards, wall-brackets, wall-boxes, and other accessories for the transmission of power by mechanical means.

Flame Arc-Lamps.—A catalogue, giving prices and full information relating to their Crompton-Blondel flame arc-lamp, has been issued by Messrs. Crompton and Co., Limited, of Arc Works, Chelmsford, Essex. The lamps are made for continuous-current and alternating-current circuits, and are suitable for burning in parallel, in series, or in series-parallel. Particulars are also given of auto-transformers, raising and lowering gear, steadying resistances, choking coils, and other accessories.

Motor-Starting Panels.—Mr. George Ellison, of Victoria Works, Warstone-lane, Birmingham, has sent us a number of separate sheets giving particulars of his auto-transformer starting-panels for squirrel-cage induction-motors. The panels are of the totally-enclosed ironclad type, and are suitable for motors up to 100 horse-power running on two-phase or three-phase circuits in which the line pressure does not exceed 650 volts. They contain all that is necessary to start, stop, and protect the motors, and are fitted with full automatic releases; a separate circuit-breaker is therefore not required. Prices are stated for the panels on wall and floor mountings.

Briquetting Machinery. — We have received from Messrs. Yeadon, Son and Co., of Albion-place, Leeds, a catalogue of their latest machinery for briquetting small coal, iron ore, and other materials. Two presses are dealt with—one for making rectangular briquettes, and the other for making briquettes of ovoidal shape. The former machines are made in five sizes, capable of producing from 15 to 200 tons of briquettes per day of ten hours, while the latter are made in four sizes, with capacities ranging from 30 to 200 tons in the same time. The firm supply complete plants for briquetting coal, &c., and the catalogue illustrates some examples of these.

Roots' Blowers.—We have received from the Alldays and Onions Pneumatic Engineering Company, Limited, of Great Western Works, Birmingham, a copy of their latest list, giving prices and full particulars of their "Climax" Roots' blowers. The list contains much interesting and useful information about these machines, which are made in many different types for hand, belt, steam or electric driving, and in widely varying capacities; the latter range from 0.042 cub. ft. per revolution in the smallest to 110 cub. ft. per revolution in the largest. Particulars of Roots' type gas-exhausters and boosters are also included in the list.

Rotary Converters.—The latest bulletin issued by the General Electric Company, Limited, of 67, Queen Victoria-street, E.C., is devoted to "Witton" rotary converters. The bulletin is divided into four sections, of which the first gives a standard specification covering the construction of these machines, and the second explains the principles of rotary converters in general. The two remaining sections deal respectively with the control of rotaries and with the lay-out of rotary-converter sub-stations. The pamphlet is fully illustrated, and the reading-matter, which is clear and concise, contains a great deal of interesting and useful information on the subject—more, in fact, than is to be found in many text-books on electrical engineering.

Plug-Cocks.—Messrs. W. H. Willcox and Co., Limited, of 38, Southwark-street, S.E., have sent us a pamphlet giving prices and particulars of their new patent full-way cocks for steam, water, gas, and air. These cocks are claimed to have all the advantages of round-way full-bore cocks without the added cost, the full-bore feature being obtained by gradually varying the circular inlet and outlet at the flanges to an ellipse of equal area in the plug. The passage through the cock is quite smooth from end to end, so that it offers the minimum resistance to the flow of the fluid. Prices are stated for cocks ranging from ½-in. to 6-in. bore, with flanged and screwed ends. Special "bathed" cocks for acids and alkaline solutions are also listed.

Petrol and Alcohol-Engines.—A catalogue giving full particulars, with prices, of engines for running on petrol, alcohol, and other similar fuels, has come to hand from the Dudbridge Iron Works, Limited, of Stroud, Gloucestershire. The engines are of the horizontal type, and are similar in general design to the firm's gas-engines, but they are fitted with a carburettor suitable for the liquid fuel. Ignition is effected either by a magneto or by means of a heated porcelain tube. Standard engines are made in two types, for industrial work and electric lighting, respectively, and with capacities ranging from 3 to 60 horse-power on petrol or benzine, and from 3½ to 62 horse-power on alcohol. Portable engines giving from 7 to 27 horse-power on benzine or petrol are also listed.

Laundry Machinery. — Messrs. R. G. Whitaker, Limited, of 22, Southwark Bridge-road, S.E., have issued a booklet illustrating four laundry-machines constructed by them. The first is known as the "Waterleap" flannel-washer. In this machine, which is suitable for all kinds of delicate fabrics, all rubbing and squeezing is avoided, and the cleansing is effected entirely by the washing liquors. It consists of an outer case of galvanised steel, with cast-iron ends, and an inner cage constructed of brass rods and ends; the inner cage is given a reciprocating rotary motion. The machine is open, so that the work is always in view, and it is claimed that it will not shrink or otherwise injure the most delicate woollen articles or other fabrics. The other machines dealt with are a rotary washer, a hydro extractor, and a shirt and collar-ironing machine. All are illustrated, and their many special features are pointed out.

High-Pressure Gas Lighting.—The James Keith and Blackman Company, Limited, of 27, Farringdon-avenue, E.C., have sent us copies of two of their latest pamphlets relating to the use of the Keith high-pressure gas-lighting system in engineering works, textile mills, and other factories. Many installations are illustrated by reproductions of photographs taken at night by means of the Keith light, and a number of testimonials from users are printed. An interesting comparison of the cost of producing a light of 10,000 candle-power for one hour by various systems of lighting is included in one of these pamphlets. With gas at 2s. 6d. per 1000 cub. ft., and electric energy at 3d. per Board of Trade unit, the figures given are as follow:—Carbon filament lamps, 10s.; metal filament lamps, 3s. 1½d.; half-watt lamps, 1s. 3d.; flat-flame gas-burners, 8s. 4d.; ordinary incandescent gas-burners, 1s. 3d.; and Keith high-pressure gas-lamps, 6d.

Centrifugal Pumps.—The British Electric Plant Company, Limited, of Alloa, Scotland, have issued a new catalogue of their patent self-balancing centrifugal pumps for high and low lifts. A general specification covering the construction of these pumps is given, together with a table showing the speeds and outputs at heads varying from 20 ft. to 150 ft. of single-stage pumps, with outlets up to 12 in. in diameter. Similar tables are given for pumps with from two to six stages, and with outlets up to 9 in. in diameter; the six-stage pumps can be used for heads up to 1070 ft. The catalogue gives some useful hints on the installation of electrically-driven turbine-pumps, and also deals with sinking-pumps, boiler-feed pumps, and other pumps for special duties. Illustrations show these pumps, as well as standard pumps, driven by electric motors, which are also constructed by the firm. Few people, we imagine, will dispute the advantage of making one firm entirely responsible for the success of an installation.

Temperature Control. — A catalogue illustrating and describing their "Isothermal" valve, and dealing with some of its very numerous applications, has reached us from Messrs. James Baldwin and Co., of Devonshire Works, Keighley. These valves are used in connection with steam-heating processes to regulate the supply of steam, and thus maintain a constant temperature. They are sufficiently sensitive to give a maximum temperature variation of not more than 1 deg. Fahr. The valve is operated by means of a solenoid, and this, in turn, is controlled by a mercury thermometer placed in the vessel or chamber which has to be maintained at a constant temperature. A transformer and relay is interposed between the thermometer and the solenoid, so that a very small current in the former controls a much heavier one in the latter. The catalogue illustrates the application of the system to the temperature-control of dyeing vessels and other processes in the textile industry, as well as of laboratory and chemical processes, jacketed pans, rooms, and workshops, drying-machines, superheated-steam mains, &c. Valves on a similar principle are made for the control of gas-heating, and heating by hot-water pipes.

Measurement of Vibration. — Messrs. Kelvin, Bottomley and Baird, Limited, of 16 to 20, Cambridge-street, Glasgow, have sent us a pamphlet illustrating and describing the Fullarton vibrometer for measuring the intensity, direction, and frequency of the vibrations of turbo-generators and other machinery. The instrument comprises a light and rigid frame attached to a spanner-shaped arm, by means of which it can be clamped under the bearing-nuts or other part of the machine being investigated. The frame carries a vibrating reed, the free length of which is adjusted by means of a sliding clamp until the maximum amplitude of vibration is obtained. The end of the reed vibrates in front of a millimetre scale, which serves to measure the amplitude. To enable the direction of the vibrations of the machine to be determined, the frame supporting the reed is mounted on two axes at right angles, and the frame is adjusted about these two axes until the reed is vibrating with the maximum amplitude. The pamphlet gives full instructions for using the instrument, and reproduces a number of specimen log sheets on which complete records of the vibrations of a machine can be kept. It is pointed out that such records, if made at regular intervals, afford a ready means of detecting any change in the running of a machine.

Junior Institution of Engineers.—The September issue of the Journal of this Institution contains the conclusion of some notes on "National and Industrial Efficiency," by Professor H. J. Spooner, M.I.Mech.E., an article on "The Status of the Gas-Producer in the United States," by W. J. Lindsay, A.M.I. Mech. E., and the index and title-page to Vol. xxiv. of the Journal. In addition to the usual general observations and personal notes concerning members there is a report on National Service, in which particulars are given of what members of the Institution are doing, and are prepared to do, to serve their country during the present crisis. The report, which is dated August 27, states that 124 members had, at that time, joined either the New Army, the Territorial Force, or the Special Constabulary; 67 other members were employers of labour, or men employed on Government work or connected with the public services, and were thus serving their country by remaining in their usual employment; and 128 other engineers had offered the whole or a part of their time for guarding the public services, and had expressed their willingness to take shifts in the maintaining of these services in case of emergency.

THE BRITISH ASSOCIATION IN AUSTRALIA.

(*Continued from page* 553.)

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

Section A met, like all the other sections, in the University Buildings of Melbourne and Sydney, in the former city on the three mornings, Friday, Tuesday, and Wednesday, August 14, 18, and 19, and in the latter on Friday, Monday afternoon, and Tuesday, August 21, 25, and 26. A programme of forty-one reports and papers, comprising two important discussions, had to be discarded, and the subdivision into a mathematical and a physical department not giving sufficient relief, Monday afternoon had to be given to sectional work. The President-elect, Professor F. T. Trouton, F.R.S., of University College, London, having been too ill to proceed to Australia, his place was taken by his college colleague, Professor A. W. Porter, F.R.S. The other Vice-Presidents were Professors E. W. Brown, of Yale College, New Haven; H. S. Carslaw, of Melbourne; Sir Oliver Lodge, and Sir Ernest Rutherford, all Fellows of the Royal Society. The Secretaries were: Professor A. S. Eddington, F.R.S., M.Sc., of Cambridge (Recorder); E. Gold, M.A., of London; S. B. McLaren, M.A., of Reading; A. V. Rankine, D.Sc., of University College; T. R. Lyle, F.R.S., of Melbourne; and J. A. Pollock, D-Sc., of Sydney. The presidential address of Dr. Trouton was read by Professor Porter.

Absorption and Adsorption.

In his introductory remarks Professor Trouton alluded to the Australian meeting as the "scientific coming of age of Australia," a kind of recognition of the well-known maturity of scientific Australia, and expressed the opinion that the readiness with which "the fundamental principles of relativity had been accepted was characteristic of present-day physics, or, more correctly speaking perhaps, an exaggerated example of it." He then passed to the subject of his recent researches, "Absorption and Adsorption." The latter term, he explained, had been introduced to distinguish between absorption taking place throughout the mass of the absorbing material and adsorption which took place over the surface only. When glass—powdered to provide a large surface—was introduced into an aqueous salt solution, some of the salt left the body of the solution and adhered in some form or other to the surface of the glass. Physicists had only recently taken up the serious study of these phenomena, which had long before occupied biologists and physiological chemists.

The laws of adsorption appeared to be very complicated, and that might account for the many apparently contradictory experiments. On the whole, however, it might be said that the amount adsorbed increased with the strength of the solution according to a simple power law, and diminished with rise of temperature. But there were many exceptions to this simple law. For instance, in the case of certain sulphates and nitrates, the amount adsorbed by the surface of precipitated silica, *e.g.*, increased only up to a certain critical point as the concentration of the solution was increased. When the concentration was further raised, the surface actually gave up some of the adsorbed salt, or the amount of salt then adsorbed was smaller than that adsorbed before from the weaker solutions; beyond that critical stage there followed again increased adsorption. There might be two modes in which the salt was adsorbed or taken up by the solid surface. The first mode resulted from a simple strengthening of the solution in the surface layers; the second mode appeared like a deposition, in more concentrated solutions, of the salt in what was apparently analogous to the solid form. The former adsorption seemed to reach out from the solid surface to about 10^{-8} cm., which was the order of the range of attraction of the particles of solids. The cause of the diminution in the adsorption at a critical value was difficult to understand. It might be analogous to the critical thickness of oil-films floating on water, studied by Rayleigh. As oil was being applied, the thickness of the film increased, but only to a certain thickness; on adding more oil the film thinned out in certain places and became much thicker in others, the intermediate thicknesses being apparently unstable. Similarly, the adsorbed surface layer might become unstable, and the second mode of deposition just referred to might then set in. On account of this instability the process was irreversible, and the applicability of thermodynamics restricted.

A possible cause of the instability might be found in the change of attraction between particles into repulsion, as suggested by Kelvin. Within the molecular range the particles attracted one another mutually; but at very close distance they must repel one another, for two particles refused to occupy the same space. At some intermediate distance the force should hence pass through zero, and it had, for various reasons, been thought that this occurred twice more; that is to say, as the distance between neighbouring particles increased, the force was first negative (repulsion), it vanished to zero, became positive, decreased once more, passed through the second zero, became negative once more, and finally, after changing sign once more, remained positive. If a repulsive force could intervene between the particles in the adsorption layer, because the particles became so crowded that repulsion set in, instability would arise. A rise of temperature, as stated already, generally reduced the amount adsorbed, but below the critical point the opposite held for sulphates and nitrates, and also for alkali chlorides. The isothermals thus crossed one another, and that might be the reason why certain experimenters had not observed any change with temperature. That solids—sand, or better, precipitated silica—would filter out salt from a solution had been already known to Daniel Defoe, the author of "Robinson Crusoe;" in one of his books he let travellers in Africa filter salt water through bags of sand in order to make the water potable. It was hardly a practical proposal, however; for only the first portion of the liquid became purified in this way, and when the sand had taken up all the salt it could absorb, the salt solution passed unaltered.

It would be interesting, Professor Trouton continued, to investigate the influence of pressure on adsorption. Little had been done in this respect, although the question was very important for the phenomena of osmosis. In osmotic experiments solution and water were separated by a semi-permeable membrane which was supposed to absorb only water (throughout its mass), but not any salt or sugar. Though this ideal state was not realised, a medium or membrane would absorb less water from an aqueous solution of sugar than from pure water, and the absorption or release of water by the medium, according as the solution was made weaker or stronger, was accompanied by a swelling or a shrinkage greater than could be accounted for by the water taken up or rejected. This amount of water absorbed by the medium depended upon the hydrostatic pressure and increased when the pressure was increased; it was therefore possible by applying pressure to force the semi-permeable medium to take up as much water from a solution as it would take up from pure water at atmospheric pressure. If the medium were so arranged as to separate the solution and the water, and were strong enough itself to bear the strain, the pressure of the solution might be increased without increasing the pressure of the water on the other side. The thickness of the membrane did not directly enter into this consideration, and it was sometimes helpful to consider the membrane as very thick, lest the idea of molecules shooting through peep-holes in the membrane should arise. The advantage of a thin membrane was simply that the necessary moisture could rapidly be applied to the active surface, thus enabling the pressure on the solution side to rise quickly; the thickness had no effect on the ultimate equilibrium, however, and the membrane might be infinitely thick—*i.e.*, there was no real need for a receptacle of the pure solvent at all, provided the membrane could be kept moist.

The real field where the osmosis took place was the surface of separation between the saturated semi-permeable medium and the solution. If a large mass of colloidal substance (silica) were saturated with water, and if there were a cavity inside containing some solution, the pressure inside would rise up to the osmotic pressure, until an equilibrium was established in the surface transfer of molecules from the solution into the medium, and *vice versâ*. That often occurred in Nature, and the high-pressure cavities occasionally found in rock crystals might be cases in point; the medium was colloidal silica, subsequently changed into quartz crystals, and the solvent carbon dioxide. In considering equilibrium between a saturated semi-permeable medium and a solution the adsorption layer over the surface of the medium should not be neglected. Solutions were profoundly modified in the layers adjoining certain surfaces. The equilibrium of surface transfer of water was not between the unmodified solution and the membrane, but between the altered solution in the absorption layer and the saturated medium; and if there were any adsorption, it might help to account for the exceptionally high osmotic pressures observed at high concentration; there might further be the above-mentioned deposit in the solid state. Quantitative determination of absorption by solid media from solutions were difficult to carry out, but there was less difficulty with liquid media. Ether, *e.g.*, constituted an excellent semi-permeable membrane for use with sugar solutions, for it dissolved only a small amount of water and no sugar at all. Experiments had shown that the absorption of water from a solution diminished with the strength of the solution and increased with the pressure; thus ether could, by applying pressure, be made to take up the same quantity of water from solutions as it would take up from pure water at atmospheric pressure.

Finally, Professor Trouton referred to Van't Hoff's discovery that the hydrostatic pressure was equal to the pressure that would be produced by a gas having the same number of particles as those of the introduced salt. A colloid or semi-permeable medium placed in a vessel of water would hold, when in equilibrium at atmospheric pressure, the normal amount of moisture; that moisture could be increased by increasing the pressure, and be reduced by introducing salt, and the amount of salt required for this purpose was approximately the same as that which in the gaseous state would produce the pressure. Thus the salt, although confined within the liquid, produced the same molecular bombardment as it would if it were in the gaseous state, although the free path must, of course, be enormously restricted compared with what it would be in the gaseous state. This view had not met with general acceptance; but the recent work of Perrin and others on molecular movements removed many of the difficulties. The diminution of the vapour pressure by the addition of salt to the solvent was a cognate fact; that vapour pressure was also increased by the application of hydrostatic pressure which might be done by the aid of an inert gas. In both cases there was equal molecular transfer backward and forward across the bounding surface; in the osmotic pressure phenomena transfer from the solution to the medium and back again into the solution; in the vapour pressure phenomena transfer from the solution into the superambient vapour and back into the solution. The phenomena of osmotic equilibrium might hence with Callendar be attributed to evaporation, not to evaporation in its restricted sense, from a free surface of liquid, but from a saturated colloidal surface into the solution; the process might perhaps better be referred to as "molecular migration."

We now pass to radiotelegraphy, because this subject was discussed in a joint meeting with G; but we may first mention a Committee report.

Radiotelegraphic Investigations.

The Interim Report of the Committee on Radiotelegraphic Investigations (Sir O. Lodge, chairman; Dr. W. H. Eccles, of the Chelsea Polytechnic, secretary), pointed out that the Committee had the cordial support of the Navy, Post Office, and other Government departments of the British Empire, as well as of foreign governments, telegraphic companies, and private individuals in Europe and in the other divisions of the world. Forms for recording observations had been sent out to all these, and some completed forms had already come to hand. Special preparations had been made to take observations during the solar eclipse of August 21, and the Governments of Norway, Sweden, Russia, and India had, in particular, been approached, as the central line passed through these eclipses. Special signals were also to be sent from different stations in Western Europe, Australia, New Zealand, Africa, &c. It is to be feared that most of these preparations have been in vain; the Australian newspapers, at any rate, did not refer to the eclipse at all as long as the British Association was over there. The report further emphasised that the work of the British Commission, which concerned the relation between geophysical phenomena and the propagation of electric waves, did not in any

way interfere with the work of the Commission Internationale de Télégraphie sans Fils Scientifique at Brussels, which aimed at quantitative measurements concerning the emission, propagation, and reception of electric waves. Dr. Eccles had been a delegate to the recent conference at Brussels.

Discussion on Radiotelegraphy.

A joint discussion of Sections A and G was held in A at Sydney, and opened by Sir Oliver Lodge; the large lecture theatre was overcrowded. Sir Oliver remarked that he merely wished to introduce the discussion; he was not going to attempt to settle points, nor were practical or commercial features to be discussed. Some remarkable observations required explanation. When Hertz waves had first been experimented with, they were found to possess astonishing energy, but they seemed to be limited to a few miles, and nobody had expected that they would go round the earth almost. Surprisingly large ranges (known as "freak" signalling) were commonly observed, however; at other times the signals failed at relatively short ranges. Then stray waves and atmospheric disturbances were known to interfere with the signals; the Committee on Radiotelegraphic Investigation was to deal with these; the Committee had been suggested two years ago, by Professor Fleming, and Dr. Eccles had thrown all his energy into the work.

Waves were apparently bent round the earth according to the laws of diffraction. H. M. MacDonald, of Aberdeen, had investigated the problem, and concluded that considerable amounts of energy might travel as far as 2000 miles. Sir Oliver thought that surprising, though yet insufficient. Why did the waves not go off tangentially? Then refraction had been suggested. If there were an upper, rarefied layer of the atmosphere, with waves travelling at a quicker rate than in the lower atmosphere, refraction should come in, and J. A. Fleming had calculated a formula for the radius of curvature ρ, at which a ray starting tangentially to the earth in a medium of a certain density should be deflected. That formula contained a constant characteristic for each element. For air the ρ was equal to 4 R, R being the radius of the earth; for hydrogen $\rho = 100$ R; that was to say, there was hardly any refraction; for krypton $\rho = $ R, which meant that the waves would travel round and round the earth, if the air consisted entirely of krypton. Again conductivity would come in, though the waves did not really travel through an electric wire conductor, but were only guided by it. Sir Oliver here interposed the remark that if radiotelegraphy had been discovered before cable telegraphy, the latter would be regarded as an improvement of the former. According to Eccles, waves travelled faster in air containing free ions than in ordinary non-conducting air. Conductivity might help, as to certain waves, somewhat after the manner of the human ear, which was able to pick out one voice or one instrument of the orchestra. The waves might be conducted or guided, and it was found that signalling was easier over salt water than over land. None of these factors sufficed to explain the facts, however. There was a capriciousness connected with the position of the sun. Night signalling was better than day signalling; but after sunset signalling might temporarily become impossible. Now air at low pressure was a conductor, and if the upper layer conducted, it would be opaque to the waves and reflect them down to the earth, as in a whispering-gallery. The boundary might be steady and regular at night, but become irregular and corrugated (puckered) in daytime; the waves and rays would hence be scattered. Ionisation of the air by the sun-light might produce this puckering. The irregularity would affect long waves more than short waves, just as almost any surface acted like a mirror for long acoustical waves, but not for optical waves. The more sudden the changes in density, the better would be the reflection. In conducting air the waves would also travel faster, and that would partly account for the transmission through very large distances, and, further, for the sunrise and sunset effects. Half of the earth was always illuminated, and the other half dark; if one of the stations, sending or receiving, were in daylight, the other in darkness, transmission might be impeded in one direction and facilitated in the other, there being a north-south belt of ionisation (and recombination) between the two hemispheres; the radiotelegraphic eclipse observations had been planned to investigate this point. Auroræ seemed to be favourable to radiotelegraphy, and meteorology on the whole would profit from this investigation. Very long antennæ could be used for very long waves (of almost acoustic frequency), and, finally, telephones might directly be inserted into the circuits without coherers. But the whole subject was in its infancy.

Dr. Eccles then abstracted a very long and very technical contribution by Mr. Balsillie, chief of the Wireless Telegraph Department of the Commonwealth, who was absent. The department had nineteen stations all around the coast, under one control, and they were thus in a position to conduct systematic observations under different conditions. The day range might be only 450 miles, whilst the night range generally came up to 2000 miles and more. Land or sea did not appear to make much difference, probably because the waves were transmitted in the upper atmosphere. Plotting the time of the day as abscissa against the intensity of the received signal as ordinate, Mr. Balsillie found on the Melbourne-Adelaide line (410 miles) that for a wave-length of 600 metres the intensity rose rapidly at 4 P.M. and fell off rapidly again at 9 A.M., the curve resembling an inverted U with flat top; between 8 A.M. and 5 P.M. communication was impossible. For the wave-length of 850 metres the curve was much flatter throughout and the maximum weaker; for 1 = 1200 metres the time of day would no longer make any difference at all apparently. On the Melbourne-Brisbane service (950 miles) similar curves were obtained, but the early afternoon was bad for all wave-lengths. As regards freaks, too many meteorological factors might come into play to justify any special theory. Yet dust-storms from the north certainly weakened all signals at Melbourne badly, chiefly in the wind direction, without making them impossible, because they seemed to affect the disturbances in the same way as the signals. But when the north-south transmission was better than usual, the south-north transmission was worse; this polarity and irreversibility, unknown in optics, was unaccounted for. As regards stray waves, the northern stations suffered less than the southern stations. But Hobart (Tasmania) was a very peculiar case; there disturbances known as "wipers" (sounding as if metal was rubbed on a grindstone) made all communication impossible, for periods of six or ten minutes, over a range of more than 2 miles, about sunset and sunrise; these wipers were only known in Hobart, which Dr. Eccles regarded as a rather suspicious feature.

Professor A. W. Porter (chairman) suggested that the irreversibility pointed out by Lodge and Balsillie might possibly be due to the boundary of the conducting layer being corrugated, not in waves, but in steps.

Professor G. W. O. Howe regretted the small attendance of members of Section G (which was sitting in two departments that same morning). He said that Boston had often overheard the signals from Clifden (Ireland) to Glace Bay (Cape Breton, Ireland); but at sunrise and sunset the intensity dropped down altogether. Observations made between Madrid and Barcelona, and between Barcelona and Ceuta (partly across the sea) also showed that the sharp midnight maximum itself was complex, having the shape of a W, quite different from Balsillie's curve. Whatever the cause of these fluctuations, the ionisation would be diffused round the earth, and the enormous influence of changes of wave-lengths seemed to upset all ordinary explanations, also Lodge's puckering. Coming over to Australia on board the Orvieto, he had made some experiments with the assistance of the Marconi operator, and he had found most of his notions unconfirmed. Thus he had never observed any sunset effect (in the tropics), and the operator had told him that signalling across water and land were equally effective, and day and night made little difference there for wave-lengths of 600 metres. But operations on board were very difficult; there was too much noise on deck, especially when sports were going on. The Marconi Company, on the other hand, certainly had a longer range over the Atlantic at night time, working with waves of 600 metres. Dr. Howe did not know how matters could be improved. But they might determine the most suitable wave-length for each transmission; that could be done by making the antenna bigger, or by increasing the antenna area, or also by putting inductance in the foot of the antenna; the radiated power was decreased by the latter expedient, but the energy was radiated at greater wave-length, and though the resistance was likewise increased, the device appeared to be profitable, according to the researches o Austin.

Dr. Eccles himself, in commenting on Balsillie's experiments, said that they were driven into belief in ionisation and a conducting layer, separated from the lower atmosphere by a sharp boundary; some whispering-gallery effect would, according to Rayleigh, exist even when there was no sharp boundary. In daytime the conducting layer descended and refraction came in, different for different wave-lengths. There was really no proof of the existence of this ionised layer, however, and they had to rely on radiotelegraphic research for its investigation; at considerable heights the signals certainly became stronger. He had at Pago-Pago (on the American Island of Tutuila, in the Samoa group) picked up signals from Alaska, and other spots 4000 miles away, sent by small ships equipped with stations of 1 kw. or 2 kw. On that island the operator's hut was 1000 ft. up on a lava hill, standing on glass, so to say. They had first anchored on one side of another lava mountain, 1800 ft. high, and moving afterwards over to the other side of the mountain, they had picked up signals from Honolulu, 2000 miles away, with the same facility, so that the intervening insulating hill had no effect. With kites, ½ mile up in the air, Marconi signals from Clifden had been received at 5000 miles range, in Argentina. Thus high-level stations on non-conducting rock seemed to be commendable. Freaks (of excessive range) were not freaks in the Pacific; night after night distances of over 2000, and even 4000, miles had been overcome. Stray waves were common in the tropics, where thunderstorms always occurred somewhere in the distance, and where anti-trade winds were blowing above the trade winds; those winds were a source of dust. Sunset minima, frequent in England, were not observed in the tropics; he could offer no solution to the problem.

Sir Oliver Lodge, in concluding the discussion, took up the last remarks of Dr. Eccles that strays seemed to originate in the equatorial regions. The solar rays were concentrated there, and the positive α particles fell there, whilst the negative particles were deflected towards the poles, so that there was an excess of positive electricity near the equator. He agreed that stations should be at high level and insulated; then sharp tuning was possible. The lengthening of the waves by means of self-induction had long been practised at Birmingham. As regards the irreversibility, another point might have to be considered. There was some tangential ionisation at sunset and sunrise, and also at midnight, owing to the orbital movement of the earth. The earth was sweeping up meteorites and ions on the one hemisphere, but the other hemisphere was screened; at midnight a spot hitherto screened passed into the unscreened half.

On behalf of Mr. J. G. Balsillie, Dr. Eccles subsequently, in Section G, gave a brief abstract of a paper on "The Balsillie System of Wireless Telegraphy as Employed on the Radiotelegraph Stations of the Commonwealth of Australia." This system—which is in use in most of the Australian stations, a few being equipped on the Telefunken system—relied, it was explained, on unidirectional impulse excitation, the radiator being excited by the action of three circuits permanently associated with it, distinguished as the primary, charging, and exciting circuits. Connection between the first two was by a transformer, between the exciting and radiator circuits by a common condenser. The discharge was not oscillatory, but single, giving a simple sharp-peaked curve like an inverted V; this was also shown by the image of a spark at frequency 360 per second, taken in a mirror rotating at 5400 revolutions per minute. The spark electrodes were a tube, with an orifice $\frac{1}{64}$ in. in diameter, through which air was blown at a pressure of 100 lb. per sq. in., and a disc.

Mechanical Analogue of Coupled Circuits.

Professor T. R. Lyle, D.Sc., F.R.S., of Melbourne, gave a demonstration of an "Exact Mechanical Analogy to the Coupled Circuits used in Wireless Telegraphy." Having derived a simple formula expressing the coupling angle between two inductively coupled circuits in terms of the inductances, he showed his model. It consisted essentially of a steel beam M (Fig. 3) built up of two parallel straight edges, 4 ft. long, 3½ in. apart, connected rigidly by aluminium distance-pieces and clamps, and resting with its edges on the over-

hanging axles of two pairs of steel discs, which were 1½ in. apart and made from 5-in. slotting cutters (⅛ in. thick), by grinding off the teeth. The wheels rested on a carefully-levelled plate of glass, all friction being so well reduced that the

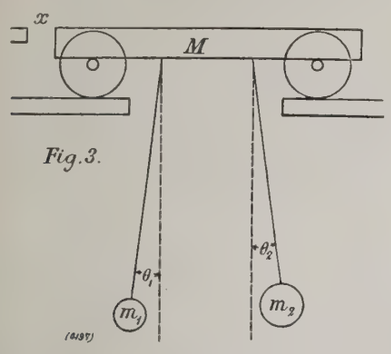


Fig. 3.

beam system, when once set in motion, would continue to oscillate to and fro for a long while; x indicated the distance of the beam from a stationary origin. Two pendulums, of masses m_1 and m_2, were suspended from cross-boards by means of V's, so that they could swing in the longitudinal space between the two members of the beam. Dr. Lyle showed that the angular displacements of the two pendulums θ were mutually connected by equations identical in form with those connecting the potential differences of the condensers in the corresponding electrical system. The relations of the resultant frequencies were best presented by the aid of a triangle, the apex of which was the coupling angle. As described so far, the mechanical system was the analogue of the coupled circuits of a radiotelegraphic transmitter. The beam might itself be considered to represent the ether. The variation of the coupling was imitated by placing masses on two platforms at the ends of the beam; by increasing the load on the beam the coupling was diminished. When the beam was first steadied and then started by hand, and the one pendulum let go simultaneously, the second pendulum began to swing with increasing amplitude, whilst the amplitude of the first pendulum diminished; after a certain time the conditions appeared reversed, and so the transfer of energy forward and backward changed many times. These surgings could be calculated, and the advantages of loose coupling were demonstrated. The pendulum model also explained the theory of the quenched spark; as it was impossible to "break" the primary circuit, without disturbing the whole mechanical system, if the bob of the primary pendulum was not placed on its platform, but taken in the hand so as to slacken the string. In order to imitate the conditions of a receiver when receiving signals, the first pendulum was made compound, and disturbances were transmitted to it from the beam by means of a simple electro-magnetic device energised through flexible wires, for instance, by attaching one permanent bar magnet to the pendulum between two electro-magnets on the beam. The model would also elucidate some of the problems arising in connection with the paralleling of alternators. The many models that others had described utilised rubber cords and steel springs, whilst inertia forces should alone be resorted to.

In the discussion Dr. Eccles sketched a model of his own on the board, consisting of a string passing over two pulleys in fixed bearings and under a loose pulley hanging between the two. The loose pulley was loaded by the mass M, each of the other two by the mass ½ M, these latter loads being pulled down by two fixed spiral springs, imparting two natural frequencies to the system; the inertia of the fixed pulley could be varied by weights sliding on rods to represent variations in the inductance. The model, Dr. Eccles said, led to the same equations as Dr. Lyle's; but Dr. Lyle objected that the Eccles model would only explain transmission, not reception.

Wave-Length in Air.

Professor J. A. Pollock made a communication on "Some Measurements of the Wave-Length in Air of Electrical Vibrations Associated with a Thin, Straight, Terminated Rod." He said he wished to draw attention to a discrepancy in the theory of electric radiation. According to Rayleigh and J. J. Thomson, the wave-length should, under certain conditions, be twice the length of the rod; but according to MacDonald (theory and experiments) the coefficient should be 2.53, and not 2. Rayleigh had recently returned to this old controversy. Professor Pollock had some time ago made experiments supporting MacDonald. Using the coherer method for detecting nodes, he had recently found the value 2.09, which agreed with the 2.1 of American experimenters. The theory was very difficult on account of the discontinuities at the edges of the rod and for other reasons, and he did not understand why he found different values, 2.5 and 2.09, in different experiments. Sir Ernest Rutherford, Sir Oliver Lodge, and Professor Porter offered comments on the paper.

Nature of γ Rays.

The paper by Sir Ernest Rutherford, F.R.S., on "The Origin and Nature of the γ Rays from Radium" attracted as much attention as the general discussions. Professor Rutherford said he would give a digest of the work of the last six years, including some unpublished researches by himself, F. N. da C. Andrade, and H. Robinson. The γ rays could by their absorption in aluminium be separated into groups of soft and of very penetrating rays. The method of Laue and Bragg had opened out another way of study. A homogeneous pencil of X rays or γ rays was reflected from a crystal when received at the proper angle of incidence, such that $n\lambda = 2d \sin\theta^2$, where λ was the wave-length of the rays in question, n an integer, d the spacing of the parallel planes within the crystal, and θ the angle the rays made with these planes. If the rays were kept the same, but different crystals were used, this examination revealed the spacings of the various planes; if the same crystal were used, and the angles of reflection of different rays were measured, the wave-length of the rays could be studied; the n indicated the order of the spectrum in which the lines corresponding to reflection at definite angles were observed. The study of the soft γ rays from RaB by this method was very difficult, for several reasons: the photographic effect of these rays was very feeble, so that exposures of twenty-four hours (instead of ten minutes with X rays) were required; and both the more penetrating rays of RaC and particularly the primary β particles had to be shut out; for this latter reason the whole apparatus was placed within a very powerful magnetic field.

The apparatus sketched out in plan showed two blocks of lead (or a thick block horizontally slotted) and a fine tube of radium emanation (a circle in plan) held over the slot; the rays passed through the slot and impinged on the centre of a crystal (rock salt, 1 mm. thick), mounted centrally on a turntable; the reflected ray fell on the photographic plate. Very soft γ rays gave in this apparatus two strong lines deflected at about 10 deg. and 12 deg., and a good many weaker lines; magnified these lines proved to be images of the tube, the edges being dark and the middle portion fainter. The strong lines appeared identical with the characteristic L radiation of lead, which, according to Soddy and Fleck, was an "isotope" of RaD, being chemically inseparable from RaD, and having the same general properties, but different atomic weight, RaD = 214, Pb = 207; lead was not radioactive, of course. To test this identity further, they had placed the emanation tube in such a position that the rays were first reflected from a strip of lead before entering the slot, thus exciting the characteristic radiation of lead. Another transmission method was also tried. In this case the arrangement was: emanation tube, rock-salt crystal, 5 mm. thick, photographic plate; then they obtained with the tube end on, in addition to dark reflection lines, also white transmission lines, crossing the others at 45 deg., just as they had expected. RaC gave in these examinations a very large number of lines.

Now, Professor Rutherford proceeded, they were dealing with the extreme end of the short-wave spectrum, and he had thought that the spectra should be very simple. They were not, he found, and there was, moreover, an indication of a faint continuous spectrum in addition to the line spectra. These difficulties he explained by Planck's theory of the emission of energy in definite quanta, $E = h\nu$, where h was Planck's constant, and ν the frequency, and by the following considerations as to the origin of β and γ rays. Bragg had suggested that the energy of a single X ray was converted, by the passage through matter, into the energy of a single β ray, without any loss of energy. This had to be generalised, because a train of X rays of the same frequency, each of definite energy, might be given out, and the whole energy of the train might appear in the form of a swift β ray. The primary effect on the atom was the excitation of γ rays by the escape of β rays from the nucleus; the appearance of homogeneous β rays was a secondary effect, due to the partial conversion of γ into β rays in their passage through the radioactive atom. That escape of β rays disturbed the nucleus of the atom and the electrons surrounding it enormously, and there were certain regions of the atom capable of high-frequency vibrations at frequency ν and of energies $1h\nu$, $2h\nu$, &c. On the other hand, the continuous β radiation was ascribed to the β particles escaping from the nucleus which had lost energy, though not in definite quanta, in setting the electronic system of the atom into vibration. The matter is too complicated for further abstracting.

Sir Oliver Lodge thought that these researches promised to become most fruitful; when chemists and physicists discussed those problems together, both sides generally gave only the results without the details, and hence each side thought the other jumped at conclusions. Mr. Moseley explained why the lines were really images of the slit; it was owing to diffraction. Professor Hicks was not satisfied as to the spectroscopic identities. According to Rutherford and others, he said, the total internal charge (positive atoms and negative electrons) determined the chemical properties (which the removal of the outer electrons would not alter), whilst the atomic weight depended only on the atoms, and the outer electrons gave the spectra. But as those outer electrons moved under the attraction of the central charge, all isotopes—derived successively from one another by the emission of one α particle with two positive charges, and the additional emission or picking up of two electrons—should give the same spectra. The only experimental determinations available, however, concerned thorium and ionium, and were quite inconclusive; Rutherford and his pupils had only examined the visible spectrum, of ionium, of which they had possessed a very small undetermined quantity, and neither of the two bodies, thorium and ionium, was ever free from the other. Professor Nicholson supported these objections; should a difference of 7 units in the atomic weight not make a considerable difference in the spectra? Professor Rutherford replied that his identity meant rather analogy of type than real identity.

Scattering of α and β Rays by Magnetons.

In a "Note on the Magneton as a Scattering Agent of α and β Particles," Professor W. M. Hicks, F.R.S., of Sheffield, pointed out that the magnetons, or elementary magnets, which P. Weiss regarded as constituents of the atoms, should act as very effective scatterers of rays, but the general mathematical treatment of the problem was too difficult. He therefore discussed the simpler case of charged particles moving in the equatorial plane of a fixed magneton, without taking account of the nuclear charge. If the plane of the paper were the equatorial plane of the magneton, the north pole being above the paper, the particles approaching in parallel lines from infinite distance, then the particles would all be deflected, the curvature of the orbit depending upon the lateral distance of the path from the axis. Particles moving near the axis would be returned in hyperbolic orbits, and loops would be formed; under certain conditions series of loops or circles would be described; the final result would be that the majority of the particles were scattered in all directions. Incidentally a theory of combined electrons appeared.

(To be continued.)

GRANARY AT GLASGOW HARBOUR.

(*Continued from page* 526.)

The Considère system of reinforcement was used throughout in the reinforced-concrete work, which included the 168 ft. of the length of the building arranged with 150 silos, the largest of which were 102 ft. in depth, and collectively having a capacity of 20,000 tons. The reinforced-concrete work is illustrated in detail on pages 582, 583, and 584. In making calculations, the limits of working stresses laid down in the Report of the Committee of the

GRANARY AT GLASGOW HARBOUR.

MR. W. M. ALSTON, M. INST. C. E., ENGINEER TO THE CLYDE NAVIGATION TRUST, GLASGOW.

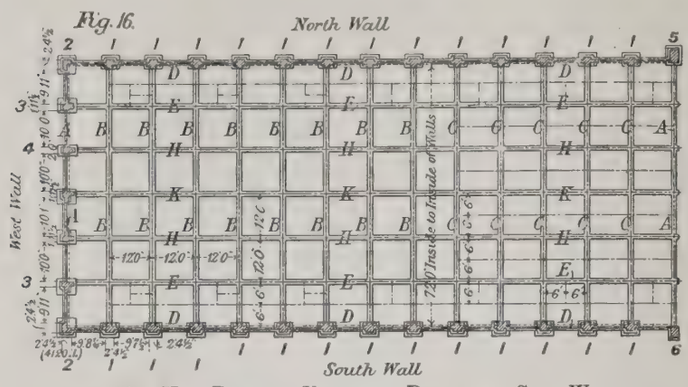


FIG. 16. KEY PLAN OF EXTERNAL PIERS AND SILO WELLS.

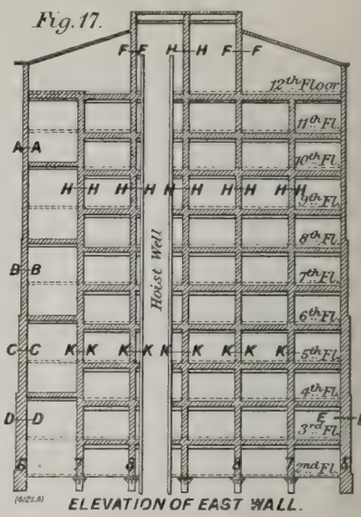
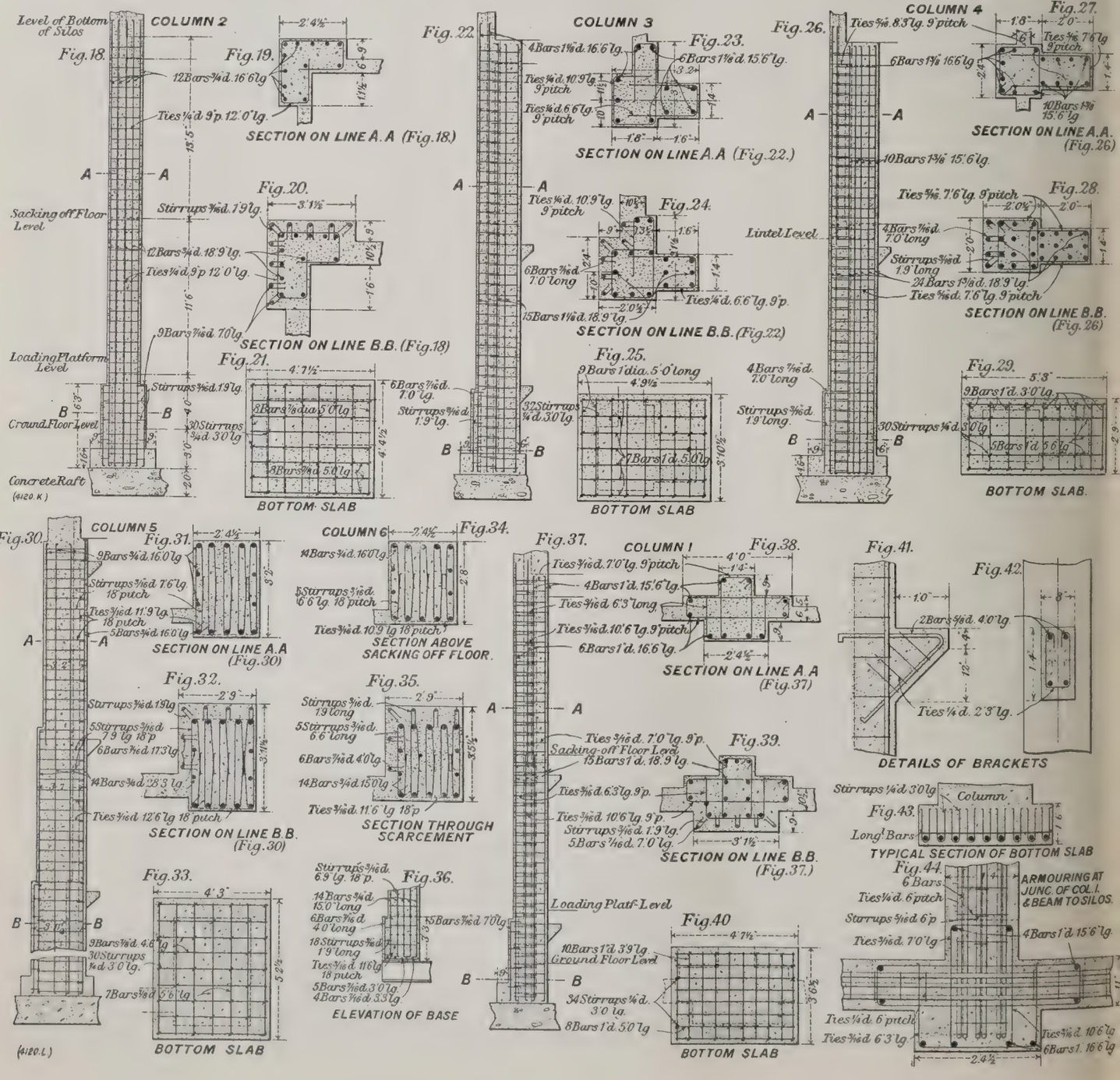
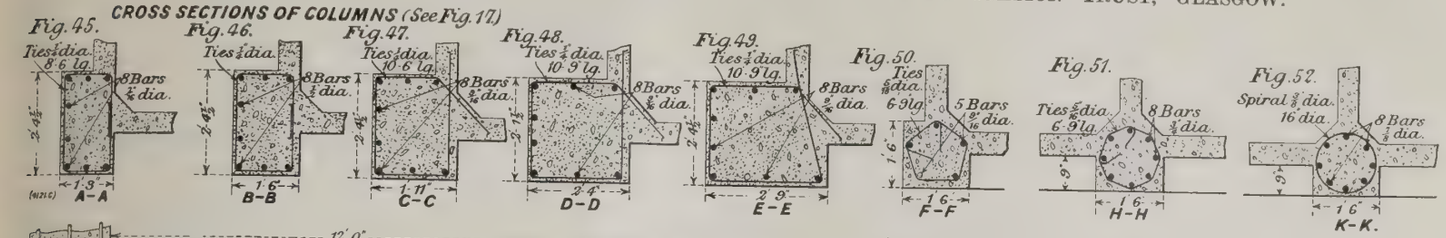


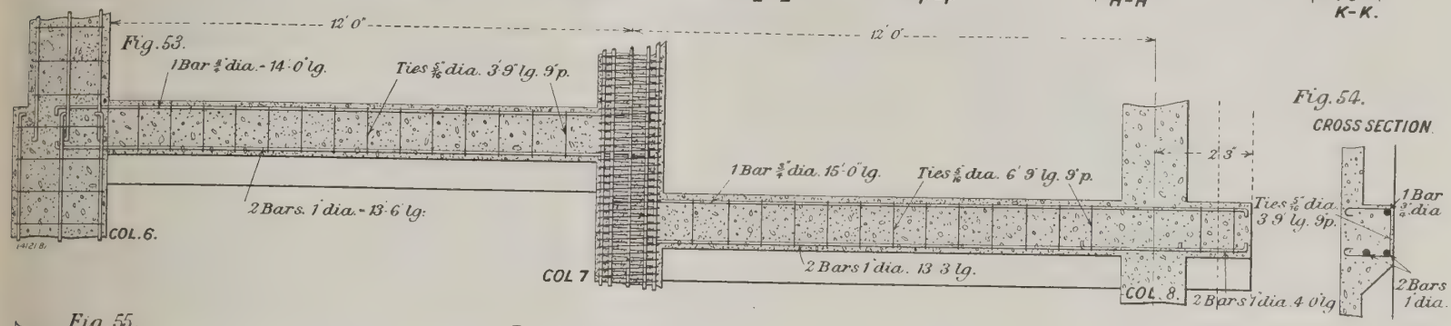
FIG. 17. KEY ELEVATION OF EAST WALL SHOWING COLUMNS AND PIERS BETWEEN SILO AND FLOOR CONSTRUCTION.

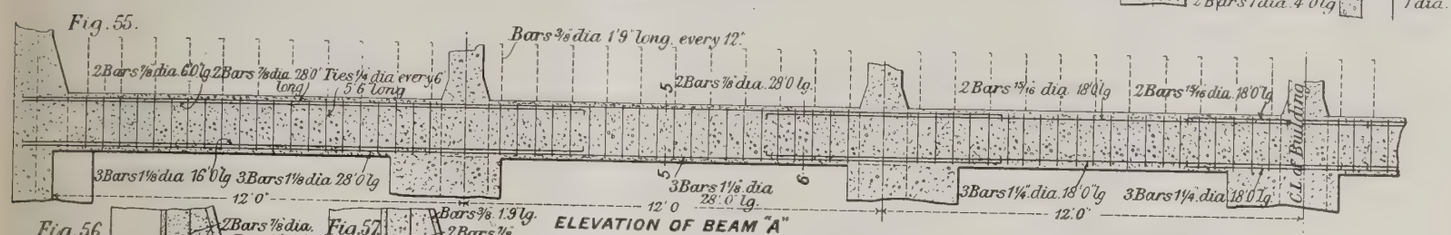


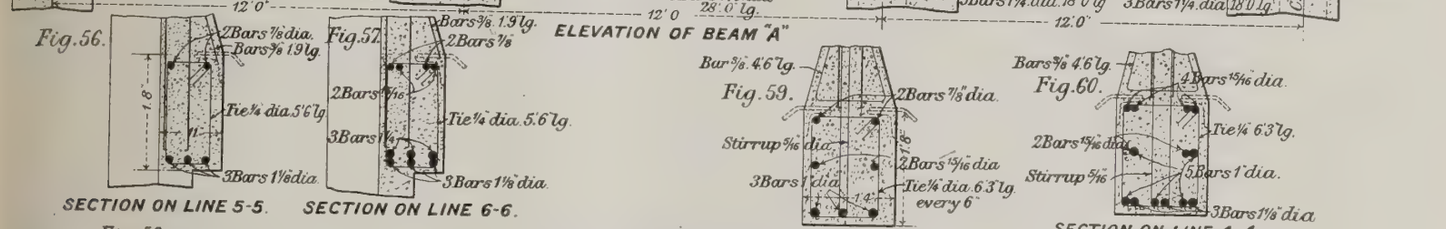
GRANARY AT GLASGOW HARBOUR.

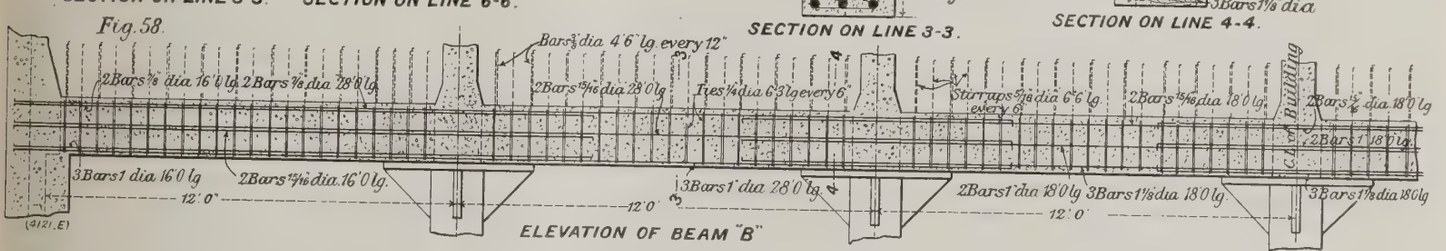
MR. W. M. ALSTON, M. INST. C. E., ENGINEER TO THE CLYDE NAVIGATION TRUST, GLASGOW.

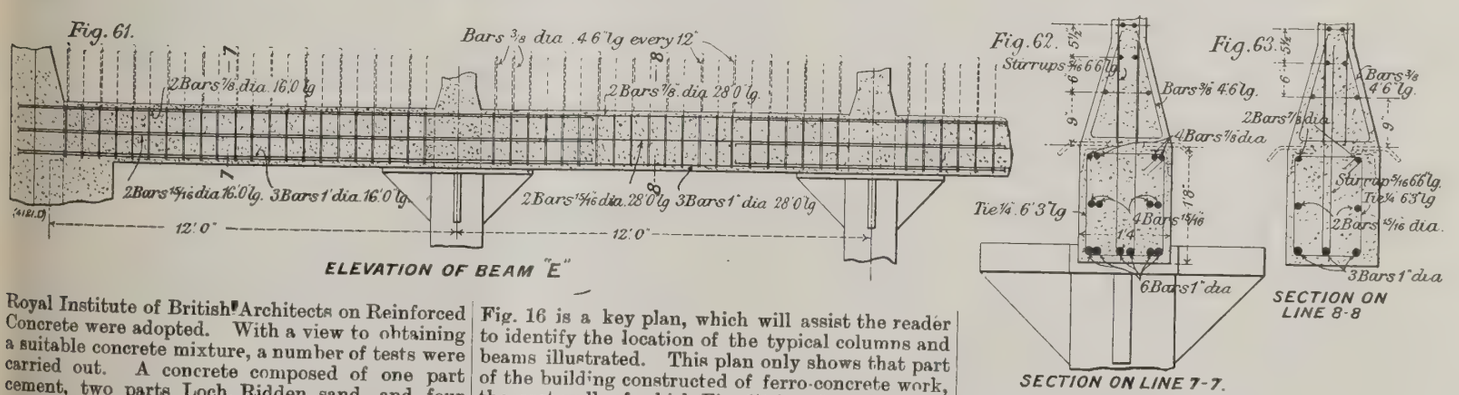












Royal Institute of British Architects on Reinforced Concrete were adopted. With a view to obtaining a suitable concrete mixture, a number of tests were carried out. A concrete composed of one part cement, two parts Loch Ridden sand, and four parts whinstone chips from Hillhouse quarry was found to satisfy the specification requirements. Loch Ridden sand is a sea sand, and the presence of salt rendered its use in the construction of grain silos inadvisable. After experiments were made, it was decided to use a mixture consisting of one part cement, two and a-half parts crushed granite, and two and a-half parts granite chips, in all reinforced concrete with which grain would come in contact.

The external walls of the building are constructed with piers, 2 ft. 4½ in. in width, and intermediate panels. Including the brick-work facing, the piers are 3 ft. 10½ in. in width.

The piers or columns are illustrated on page 582. Fig. 16 is a key plan, which will assist the reader to identify the location of the typical columns and beams illustrated. This plan only shows that part of the building constructed of ferro-concrete work, the east wall, of which Fig. 17 is a key elevation, being the divisional wall between this portion of the building and that arranged with floor accommodation. The two corner piers of the west wall, numbered 2 on the key plan, are illustrated in detail by Figs. 18 to 21; the next adjoining columns, numbered 3, by Figs. 22 to 25; while the column numbered 4, which is placed between two rail-tracks, and therefore had to be made narrower to provide clearance for wagons, is illustrated by Figs. 26 to 29. The outer column at the north end of the east or partition wall, between the two sections of the buildings, numbered 5, is shown in detail by Figs. 30 to 33. The opposite column, numbered 6, at the south end of the partition wall, adjoining the staircase, has slightly lighter reinforcement, and is shown by Figs. 34 to 36.

The ordinary piers in the north and south walls, numbered 1, are illustrated by the details, Figs. 37 to 40, while Figs. 41 and 42 show the details of the brackets on these piers to carry the loading-platform and the sacking-off floor respectively; Fig. 43 gives a typical section of the bottom slab forming the base of the pier; and Fig. 44 shows the details of armouring at the junction of the pier, and the beam forming the base of the silos. Various details in connection with the east division wall are given in Figs. 45 to 54, annexed, in conjunction with the key elevation, Fig. 17. Figs. 45 to 48 illustrate

the south external pier, numbered 6; and Fig. 49 is a section of the north pier, numbered 5. Figs. 50, 51, and 52 are cross-sections of internal walls, according to the sectional lettering on Fig. 17. Near the level of each floor in the eastern portion of the granary, a corbel is formed in the silo east wall to carry the rolled-steel beams and concrete composing the floor, and details of this are shown in Figs. 53 and 54.

Generally it may be said the thickness of the reinforced concrete at the panels is 6 in., and at the piers 20 in. for the greater part, and 9 in. more for a width of 16 in. at the centre (Fig. 38).

Fig. 64.

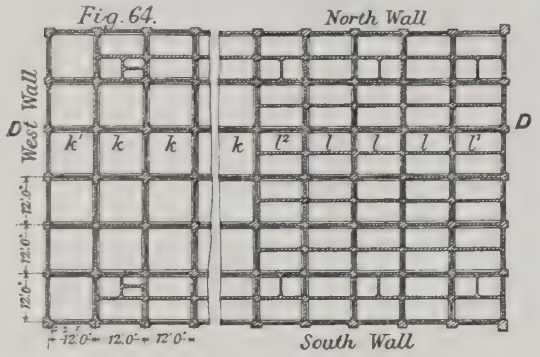


Fig. 65. HORIZONTAL SECTION OF PARTITION WALL D.D.

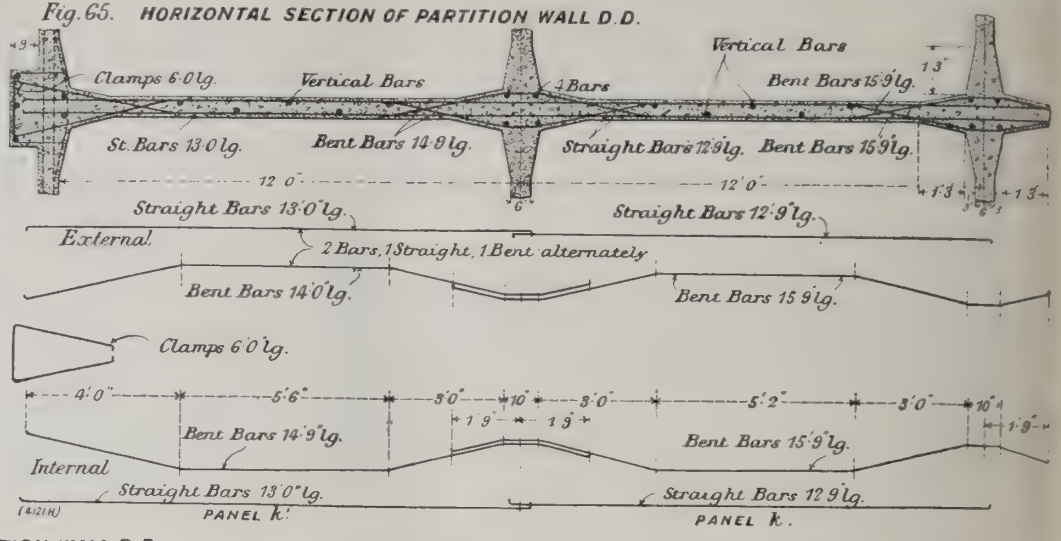


Fig. 66. HORIZONTAL SECTION OF PARTITION WALL D.D.

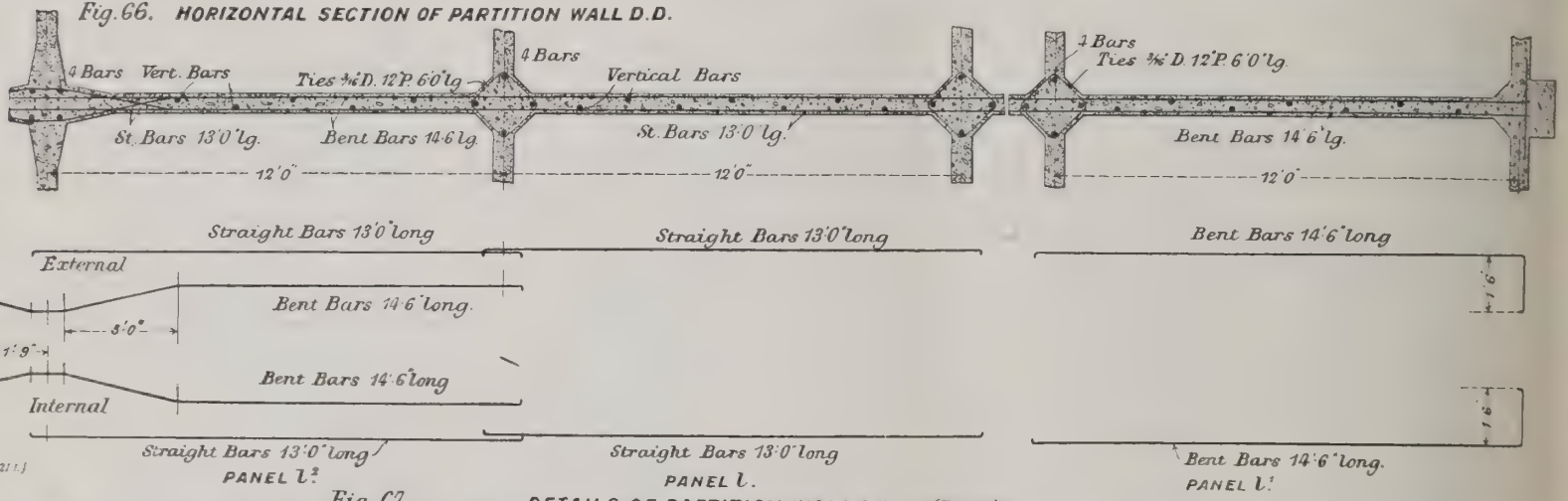


Fig. 67. DETAILS OF PARTITION WALLS D.D. (Fig. 64)

The bottom of the piers, at the level of the foundation layer, rests on a reinforced-concrete slab, 4 ft. 6 in. by 3 ft. 6 in. by 18 in. in depth. Each slab is reinforced in both directions by eighteen 1-in. diameter bars, with vertical stirrups at the corners (Figs. 40 and 43). The reinforcement of the piers consists of ten vertical bars, 1 in. in diameter, four on the outer face, four in the centre, and two at the inside of the pier (Fig. 38). These bars are connected together by ties $\frac{3}{16}$ in. in diameter and 9 in. pitch. The wall panels are reinforced in both directions on the external and internal faces. The horizontal reinforcement consists of bars varying in diameter from $\frac{7}{16}$ in. to $\frac{1}{4}$ in., and placed at distances varying from $5\frac{1}{2}$ in. to 10 in. apart. The vertical reinforcing-bars, which are $\frac{5}{16}$ in. in diameter throughout, are spaced 1 ft. 6 in. apart. The external walls have a 9-in. brickwork facing, so as to correspond with the eastern portion of the building, the walls of which are of brickwork. This facing was built up in advance of the reinforced concrete, in sections of twelve courses of brickwork, so as to serve as shuttering for the concrete. In order to tie the two portions of the wall together, the back stretcher course at the top of each section was omitted, and the spaces left were filled in with concrete as the inside portion of the wall was brought up. In addition to this, hoop-iron hooks were built into the brickwork, the inner ends of which were hooked round the reinforcing-bars in the concrete. These hooks were spaced 3 ft. apart horizontally, and twelve courses of brickwork apart vertically.

The internal reinforced-concrete structure commences at a height of 12 ft. above the level of the sacking-off floor, where longitudinal and transverse beams are placed on the top of the cast-iron columns to support the hopper-bottoms and division-walls of the bins. These beams are illustrated on page 583. Figs. 55 to 57 show the beam or corbel at the east wall, marked "A" on the key plan, Fig. 16. Figs. 58 to 60 represent one of the transverse beams, all of which are marked "B" on the same key plan, while Figs. 61 to 63 are details of a longitudinal beam from east to west in the building, and marked "E" on the key plan. These beams are 16 in. broad by 20 in. deep, with at least seven reinforcing-bars from 1 in. to $\frac{7}{8}$ in. in diameter. The maximum pressure on each column carrying these beams, with the bins full, is 500 tons.

The bin or silo division-walls are illustrated on the present page. The dimensions of these differ, because, as shown in the key plan, Fig. 64, the largest of the bins are 12 ft. by 12 ft. between centres of walls; others are 12 ft. by 6 ft., while others again are 6 ft. by 6 ft., and a few 6 ft. by 3 ft. The details of the reinforcement of a complete series of silos from the outer west wall to the east, or partition, wall are given in Figs. 65 to 67, in conjunction with the key plan, Fig. 64. An

examination of the key will show that there are five distinctive sections or types of panel in the length. The outer silo is necessarily of heavier reinforcement; then follow eight ordinary 12-ft. by 12-ft. silo sections; both of these sections (k^1 and k) are shown in Fig. 65. Fig. 66 shows three other sections, one (l^2) being heavier than the others, because, although it is only a 12-ft. by 6-ft. silo, it is adjacent to a 12-ft. by 12-ft. silo, and called for heavier reinforcement. The panel l is only 12 ft. by 6 ft., and the panel l^1 of the same dimensions, but it adjoins the east wall. Generally it may be said that the division-walls are 6 in. in thickness, and are reinforced in both directions. The horizontal reinforcement consists of $\frac{7}{16}$-in. bars at 5½ in. pitch for the greater portion of the depth of the bin; near the top the reinforcement is reduced by steps to ¼-in. bars at 8 in. pitch on one side of the wall, and 12 in. pitch on the other side. The vertical reinforcing-bars are $\frac{5}{16}$ in. and ¼ in. in diameter, and spaced 18 in. apart, being alternately on the internal and external sides of the walls. The shuttering for the division-walls was carried on a series of timber frames 6 ft. in height. The reinforced-concrete work was carried up in sections of 6 ft., a height of from 12 in. to 24 in. being laid at a time. As each section was completed, the frames were removed, placed in position on the top of the completed section, and the walls carried up a further 6 ft. The concrete was mixed on the ground, and brought to the working level by means of an electric hoist capable of dealing with 27 cubic yards of concrete per day. The concrete was mixed in a machine mixer having a capacity of 10 cub. ft. A coating of cement grout was given to all exposed surfaces of the bin-walls after the shuttering was removed.

The covering of the bins, forming part of the twelfth floor and conveyor gallery, is of concrete, 4 in. in thickness, reinforced by ¼-in. bars at 5 in. pitch, each alternate bar being turned up to near the upper surface of the floor at the junction of the floor with the bin division-walls.

The sloping roof over the twelfth floor is illustrated on the present page. It is 4 in. in thickness, and is carried by transverse beams and columns. The reinforcement of the roof consists of $\frac{5}{16}$-in. bars at 5 in. pitch, with distributing-bars ¼ in. in diameter at 12 in. pitch. Fig. 68 is a plan and Fig. 69 a section of a typical area of the roof, and Fig. 71 is a part longitudinal section through the skylight.

The transverse beams are supported at the lower end on the external wall of the building, at the centre by reinforced-concrete columns, and at the upper end by a beam or corbel formed on the side walls of the central rows of bins, which rise to a greater height than the side rows.

The beams, shown in elevation in Fig. 72, are 6 in. broad by 16 in. deep, with ⅝-in. diameter reinforcing-bars and ¼-in. vertical stirrups connected to the roof reinforcement. The intermediate columns, shown in Figs. 73 and 74, are 8 in. square, with chamfered corners, and are reinforced by four ½-in. bars and wiring ¼ in. in diameter and 9 in. pitch. The wall beam or corbel, Fig. 70, is 16 in. deep and has ⅝-in. and ½-in. reinforcing-bars, with ¼-in. ties at 9 in. pitch. The surface of the roof is covered with asphalt to a depth of 1 in.

The contract for the building was carried out by Messrs. John Train and Taylor, contractors, Rutherglen, Glasgow, to the design and specification of Mr. W. M. Alston, engineer-in-chief to the Trustees of the Clyde Navigation. In our next article we shall deal with the elevating and conveying machinery.

(To be continued.)

Fig. 68. PART PLAN OF ROOF; SOUTH SIDE.

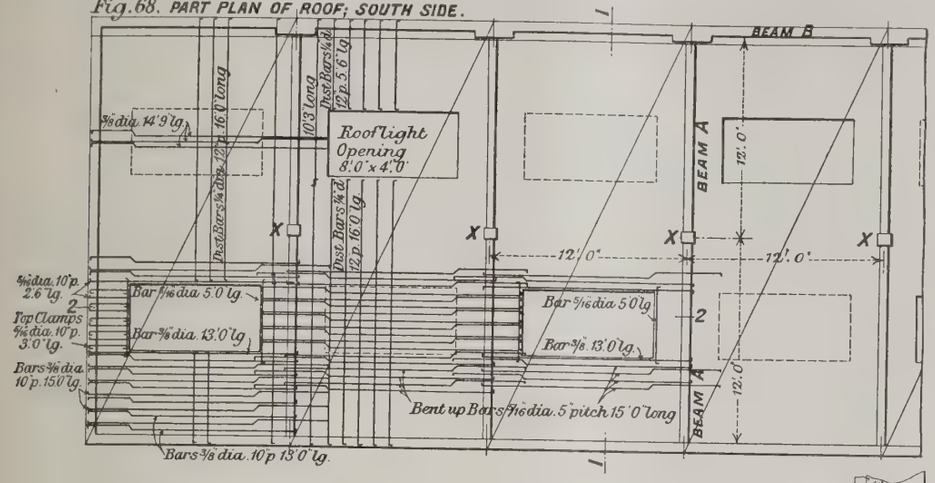

BEAM B
BEAM A
Rooflight Opening 8'0" x 4'0"
Dist Bars ¼ dia. 12" p. 16'0" long
Dist Bars ¼ dia. 12" p. 5'6" lg.
⅝ dia. 14'9" lg.
12'0"
Bar ⅝ dia. 5'0" lg.
Bar ⅝ dia. 13'0" lg.
Top Clamps ⅝ dia. 10" p. 3'0" lg.
Bars ⅝ dia. 10" p. 15'0" lg.
Bent up Bars ⅝ dia. 5" pitch 15'0" long
Bars ⅝ dia. 10" p. 13'0" lg.

Fig. 69.
SECTION 1-1 (Fig. 68.)

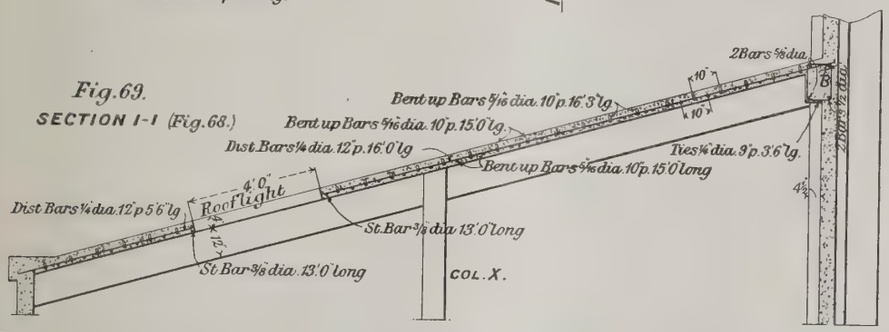

2 Bars ⅝ dia.
Bent up Bars ⅝ dia. 10" p. 16'3" lg.
Bent up Bars ⅝ dia. 10" p. 15'0" lg.
Dist Bars ¼ dia. 12" p. 16'0" lg.
Ties ¼ dia. 9" p. 3'6" lg.
Bent up Bars ⅝ dia. 10" p. 15'0" long
Dist Bars ¼ dia. 12" p. 5'6" lg.
4'0"
Rooflight
St. Bar ⅝ dia. 13'0" long
St. Bar ⅝ dia. 13'0" long
COL. X.

Fig. 70. ELEVATION OF BEAM B.

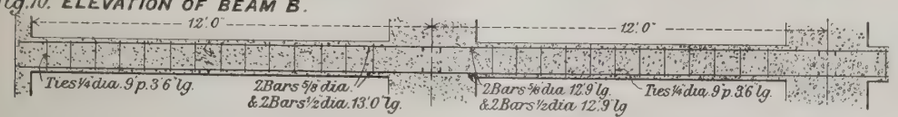


Fig. 71. SECTION 2-2. (Fig. 68.)

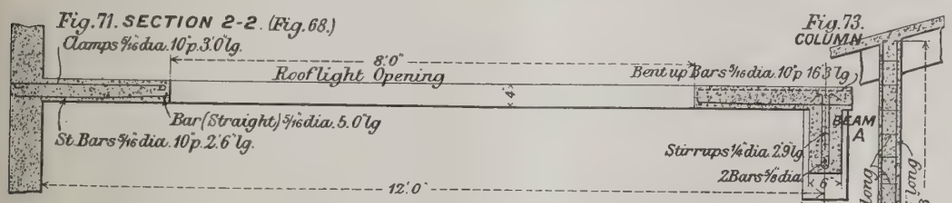

Clamps ⅝ dia. 10" p. 3'0" lg.
8'0"
Rooflight Opening
Bent up Bars ⅝ dia. 10" p. 16'3" lg.
Bar (Straight) ⅝ dia. 5'0" lg.
St. Bars ⅝ dia. 10" p. 2'6" lg.
Stirrups ¼ dia. 2'9" lg.
2 Bars ⅝ dia.
12'0"

Fig. 73.
COLUMN.

Fig. 72.
ELEVATION OF BEAM A.

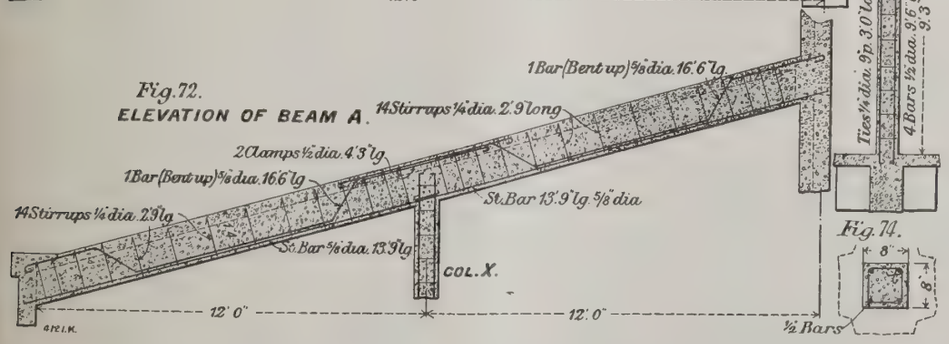

1 Bar (Bent up) ⅝ dia. 16'6" lg.
14 Stirrups ¼ dia. 2'9" long
2 Clamps ½ dia. 4'3" lg.
1 Bar (Bent up) ⅝ dia. 16'6" lg.
St. Bar 13'9" lg. ⅝ dia.
14 Stirrups ¼ dia. 2'9" lg.
St. Bar ⅝ dia. 13'9" lg.
COL. X.
12'0"
12'0"

Fig. 74.

INDUSTRIAL NOTES.

On the 6th inst. the sailors and firemen of two ships signing articles at South Shields asked for 7*l.* per month, and their demand was granted. Sea-going engineers are also asking an increase of wages corresponding to that granted to the crews; we understand that on the Tyne an advance of 1*l.* per month has been given.

A meeting of the Durham Coal Trade Conciliation Board was held at Newcastle on Friday, the 6th inst., Sir Lindsay Wood presiding. Others present included Sir Hugh Bell, one of the owners' representatives, and Mr. John Wilson, M.P., one of the miners' representatives. Wages were reduced 3¾ per cent., and now stand at 53¾ per cent. above the 1879 basis. The last change was in May, when there was a reduction of 2½ per cent.

A correspondent at the Hague of the *Manchester Guardian* states that there is much unemployment in the German textile industry, despite military requirements. The *Vorwärts* says that in September the unemployed in this branch of industry amounted to 24.7 per cent., as compared with 15.1 per cent. in August. The number of unemployed in September was 200,000, whilst most of those still employed only worked part of the day. The total number of workless days in the third quarter of this year was 895,055, as against 139,248 in the corresponding months of last year.

A letter from a Berlin trader states the following:—"As regards business, everything is at a standstill in the matter of blouses, jackets, &c. Nothing can be sent to Spain, Finland, and Russia, while Switzerland, Denmark, Sweden, and Norway each have a moratorium. Of the various establishments most have gone bankrupt or have liquidated. Raw material is simply not to be got."

At a meeting of the Birmingham Trades Council which was held on Saturday, the 7th inst., at the Queen's College, Mr. J. Kesterton, the secretary, read a letter which he had sent to the Postmaster-General. In this he stated that the council was not at all satisfied that the Post Office was living up to the Government maxim of "business as usual." The letter continued: "two of the most important deliveries in Birmingham have been dropped, and the public consequently inconvenienced. Collections have similarly been curtailed; 103 clerks have been withdrawn, and only 15 taken on in their places The most serious complaint we have to lodge is in regard to the rate of pay to temporary clerks, few being paid more than 24s. per week. The minimum standard in Birmingham is 30s. per week, and for a Government department to fall so greatly below this amount is a very serious thing." The secretary also dealt with the wages paid to labourers in the engineering department at Hill-street, which, he stated, were almost generally below the minimum standard obtaining in private employment and that established by the Corporation. He strongly protested against the Government's action.

Mr. F. C. Simpson, secretary of the local branch of the Postal and Telegraph Clerks' Association, stated the following:—"The public are posting letters under the impression that they are receiving practi-

cally a full service. That is not so. Two deliveries have been cancelled in the town area; this means that the deliveries have been decreased by 33 per cent., and the department is saving practically that number of men on delivery work. We cannot possibly dispose of correspondence as it should be disposed of, and the result is that numbers of letters are left behind and fall into a later delivery at the towns to which the letters are addressed."

The chairman pointed out that 3000 hours per week overtime were worked at the Birmingham Post Office. The condition of affairs had reached a point when a great public protest should be made.

On the motion of Councillor Beard, it was decided that a copy of the secretary's letter should be sent to the Members of Parliament for Birmingham.

Mr. John Byass, of the Manor House, Warter, York, says, in the *Yorkshire Post*, that the places of the men mobilised in the Waggoners Reserve have never been filled. He adds the following:—

"All sorts of supplies have been tried. Many of them were useless. Some did not want work at all. A farmer engaged two of these men; they went on Saturday, they had supper on Saturday night, three meals on Sunday, and breakfast Monday morning, and then walked off. All the work they did was eating. A good many farmers tried the Labour Exchanges, but again and again was I told the men were no good. There would be, of course, exceptions, but, taking it as a whole, the Labour Exchange men are not much good to a farmer. . . . Then, in the East Riding, the men engage for a year, and live in the house with the hind or master, board and lodging. Our men leave us on November 23, and a good many have openly said they are going to enlist. Seeing that there is such a scarcity now, what is going to happen then?

"The letter from the Board of Trade to the Central Chamber said that there was a concerted scheme in operation between the Board of Trade and the Board of Agriculture to supply any shortage. The only thing we could learn at the Chamber was that farmers were to put themselves in direct personal touch with the Labour Exchange. This was what those two wonderful organisations were going to do for us. They had better put up their shutters if that is all that they can do. Farmers are willing to go to any source if only they can get suitable men, or men willing to learn. Failures are no good to us, neither are men who are constantly on the move. I think one or two things could easily be done; let all the lads in country schools go to the farms earlier. Again, why shouldn't the Belgian refugees be put on the land? Surely some organisation could be called into existence to put in the country those who are used to the land, and I am sure it would be better for them than being dependent on charity. There need be no fear that they would injure the English labourer by bringing wages down; no farmer wants to do this."

The same journal, in a later issue, says that the annual November hirings for single farm servants at Alnwick on Saturday, the 7th inst., was attended by a large gathering of agricultural servants. A dull tone prevailed, and engagements were generally entered upon at last year's rates. Women obtained 9*l.* to 12*l.*, and girls 5*l.* to 7*l.* for the half-year. Men were hired at 12*l.* to 15*l.*, and boys at 6*l.* to 9*l.*, according to age and ability. In exceptional cases 1s. per week more was conceded to men who could undertake responsible farm duties.

Several of the Northumberland collieries are working irregularly in consequence of the dislocation in the export coal trade due to the war, and relief pay to unemployed men is costing the Northumberland Miners' Association a little under 1000*l.* a week.

Since the war began, the disbursements of the union in this respect have amounted to over 12,000*l.* The sum required for unemployment benefit will doubtless become larger, since the recent closing of two or three collieries has appreciably increased the number of members out of work. The association has resources sufficient to last a few more weeks.

Owing to the very large demands made upon the Midland manufacturers of saddlery and harness by the British Government and by the Governments of the Allies, several Birmingham gentlemen propose to start a factory in the town for the purpose of increasing the supply of military saddlery, &c., of which the country is now so much in need, and at the same time to provide profitable employment for men of adaptable trades who, as a result of the war, are at present out of employment. Work has already been found for about thirty men, including several Belgian refugees, and it is hoped that some hundred men who would otherwise be idle will very shortly be found employment at full trade-union rates.

The report for October issued by the United Pattern-Makers' Association states that on the North-East Coast trade is good, and on the Tyne it could scarcely be improved upon, considerable difficulty having been experienced by the local district secretary in filling all the situations he had the chance of filling during the past few weeks. On the Clyde trade is on the whole fair, although Glasgow shows a proportion of unemployed members rather above the average. As might be expected, Barrow maintains its position as being one of the best employed districts in the kingdom, and Belfast shows a considerable improvement over last month's returns, although things there leave much to be desired. Inland centres show a considerable improvement as compared with a month ago. Manchester makes fair returns, but trade is dull in other parts of Lancashire. Leeds and other districts throughout Yorkshire show a distinct improvement, with the exception of Sheffield, where it is somewhat surprising to find so large a proportion of members signing the vacant-book. The Birmingham districts furnish, on the whole, excellent returns, and throughout the Metropolitan area trade is fair, with as many men as there are jobs for. Falkirk reports trade as very good, a little misunderstanding with regard to overtime rates being attended with the happiest results to members, who would otherwise be idle if unlimited overtime were being generally worked. The branches which seem to be mostly in need of outside assistance are Sheffield, Liverpool, and Belfast, and a little effort on the part of members who find it difficult to cope with the work in hand should result in a speedy clearance of the vacant-books of these branches. The chief reason for the present position of the union is the Government work, which, very properly, is being as widely spread as circumstances admit, and this class of work and the circumstance attending its executing is not of a character that may be expected to possess the element of permanence, nor is this desired. However, whatever be the wishes with regard to the present European war, there is no doubt but that its immediate effect is to have given almost full employment to all workmen connected with the pattern-making industry.

The joint wages agreement terminates at Liverpool at the end of the year, and the local officials consider the conditions favourable enough to justify an application for an advance of 6s. per week.

The Board of Trade issued on Monday last a report on strikes and lock-outs, and on the work of the conciliation and arbitration boards, for 1913. It states that the year 1913 was remarkable for the number of disputes, which far exceeded the number recorded by the Department in any previous year. Practically all the main groups of trades were affected, notably the building, metal, engineering, shipbuilding, and textile trades. In addition to the 1497 disputes which occurred during the year, 50 disputes which began before the year, involving 8885 workpeople, were in progress for varying periods of the year. The number of workpeople involved in disputes during the year (686,925) was higher than in any other year except 1911 and 1912 (when great disputes in the transport trade and coal-mining industry were in progress), and this high figure tends to show the widespread character of the unrest, as no single dispute involved more than 50,000 workpeople. The aggregate duration of working days of all disputes was 11,630,732. A large portion of the aggregate was due to three disputes—viz., the motor-cab drivers' dispute in London, the metal-workers' dispute in the Midlands, and the general dispute in Dublin. The remaining portion, amounting to nearly 8,000,000 working days, was much in excess of the total for any of the years of normal industrial disturbance during the whole comparative period of from 1904 to 1913. Of the 1497 disputes, 701 involved less than 100 people, and 1366 involved less than 10,000. The percentage of people involved, compared with the number of people employed in industrial occupations, in 1913 was 5.6, as compared with 13.4 in 1912, and 4.4 the mean for the ten years 1904-13. The amount of time lost would have been about one day per head if spread over the whole industrial population.

The report states that just as the majority of disputes involved only a comparatively small number of people, so also the largest number of disputes were of very short duration. During the ten years from 1904 to 1913 the number of disputes lasting less than one week has varied from about one-third to one-half of the total; in 1913, 669 disputes lasted less than one week, and the number of workpeople involved therein was 246,900.

Disputes arising out of demands for advances in wages accounted for nearly one-half of the total number of workpeople directly involved in disputes beginning during the year. The trades with the largest proportion of disputes arising from this cause were building, mining (other than coal), quarrying, metal, woollen and worsted manufacture, railway, transport (especially carters), brick, pottery, chemical manufacture, &c., and the wood-working and furnishing trades. In coal-mining, only nineteen disputes, of small magnitude, out of a total of 163, arose out of demands for advances in wages.

The great majority of disputes that occured were settled by direct arrangement or negotiations between the parties or their representatives, without the intervention of third parties. About three-quarters of the number of disputes, involving over two-thirds of all the workpeople directly involved, were settled in this manner. Disputes which were brought to a close by return to work on the employers' terms without negotiations numbered 8 per cent. of the total.

During the first seven months of 1914 the time lost owing to labour disputes was even greater than in 1913, but since the beginning of the war the majority of the outstanding differences have been settled.

COPPER AND THE WAR.

The world's production and consumption of copper have been seriously interfered with by the war, and prices are very unreliable, as no one can foresee, at the moment, the probable demand during the immediate future, nor the length of the war. In France, according to apparently reliable reports, the end is expected next year, whilst in this country some look forward to years of fighting. The world's production of copper during recent years has been as follows:—

	Tons.
1913	1,005,900
1912	1,018,600
1911	893,800
1910	891,000

More than 50 per cent. of the total is produced in the United States; last year 589,100 tons out of 1,005,900 tons. It is noteworthy that although the American output largely exceeds the American consumption, copper is, nevertheless, imported. Thus, during October 475 tons of slabs were imported from Japan and 690 tons of pig copper from Peru. Copper was produced last year in the following countries:—Mexico, 90,000 tons; Japan, 77,200 tons; and Australia, 41,800 tons. As regards Europe, German and Austrian output was the largest, the quantity being 52,100 tons, out of a total European output of 186,500 tons. Great Britain is second, with 41,100 tons; then Russia, 34,300 tons; and Spain with 23,600 tons. European consumption during 1913 reached 643,100 tons; after allowing for the European output, 456,600 tons had to be imported, obviously mainly from America. The European consumption was as follows:—Germany, 259,300 tons; Great Britain, 140,300 tons; France, 103,600 tons; Russia, 40,200 tons; Austria, 37,200 tons; Italy, 31,200 tons. The American consumption reached the enormous quantity of 351,000 tons. Reduced consumption has necessarily resulted in reduced production; the world's copper output, now that curtailment has become effective, has dropped, according to very competent expert opinion, to a basis of about 550,000 tons per annum. At the great Rio Tinto copper mine in Spain operations have been slowing down; its operations are said to have been curtailed to bring it in line with orders issued by other companies. It may be assumed that the leading copper mines of Germany, if not entirely closed down, have also curtailed their production, as the two leading consumers of copper in that country have been idle for some weeks.

The Russian output is entirely required by Russian consumers; the Austrian output is unimportant; and the Italian output, 1600 tons, is very insignificant; whilst the Scandinavian output is only 12,000 tons. The Australian output has been reduced 50 per cent. There are three main mines in Australia—Mount Lyell, Mount Morgan, and Mount Elliot. A fourth, Great Cobar, has not been working for some months. Chili has drastically cut down production, as, with the exception of the mine at Braden, all others have stopped operations. The Chilian output last year was 30,385 tons. The Peruvian output has been cut down 50 per cent. Mexican output is reduced to a nominal quantity; the great Greene-Cananea copper-mine is closed now, whilst the Smelting and Refining Company is doing next to no work. The Canadian output is also cut down.

It is important to note that, although the output of ore was stopped as soon after the outbreak of war as possible, the output of the smelting and refining works cannot show a similar decrease until the materials in the vats have been withdrawn; ninety days must be allowed for that. After peace has been proclaimed, three months must elapse before normal refinery supplies can again be obtained. The total American exports for October have been estimated at about 16,200 tons, equal to 36,288,000 lb.

Towards the end of September, a noteworthy feature of the copper market was the action of the British Government in acquiring all the stocks of copper carried in Dutch warehouses, as this metal almost always is destined for Germany. Three cargoes of copper afloat for Holland were also taken by the British

Government. As a result of the attitude of the British Government the export of copper from the United States is restricted, as shipments can only be made with impunity to Great Britain, France, Italy, and Roumania, and not to the Scandinavian countries and Holland. Germany imports annually over 200,000 tons of copper; a prolonged war might result in a copper famine. American copper exporters, who had copper aboard the steamship Rotterdam, which was seized by the British Government, although consigned to Holland, will be settled with on the basis of 56*l.* 10s. per ton. There were 1542 tons in the consignment. Owing to varying prices for exchange, the 3 per cent. war risk, and high freight rates, it becomes more difficult than usual to figure what the exporters will receive for their metal, but it may be estimated at about 6d. per pound. Under ordinary conditions, with normal exchange and no war risk, the equivalent of 56*l.* 10s. per ton would be close to 6⅛d. a pound. With regard to copper stored in Holland belonging to Americans, the following statement is made on behalf of the United Metals Selling Company :—"The stocks of copper carried by this company in warehouses at Rotterdam at the commencement of the war were stored in the public warehouses, and were covered by warrants in the name of a British Corporation. The British Government formally notified the Corporation not to deliver the warrants, and upon instruction of the United Metals Selling Company that they be delivered into neutral hands, the position of the British Government regarding them was disclosed. The warehouses in Rotterdam refused delivery of the copper except on presentation of the warrants, and the British Government took possession of the warrants, paid for the copper represented by them, and at its own cost and risk removed the copper from Rotterdam to London, thus putting it absolutely out of the power of the United Metals Selling Company to make any other disposition of the copper."

The copper exported from America, practically all to Europe, during the nine months of the year and the corresponding months in the preceding four years has been as follows :—

—	1914.	1913.	1912.	1911.	1910.
January .. .	35,566	24,659	30,967	29,357	26,699
February	34,384	26,767	35,418	18,992	25,238
March	46,504	42,428	27,074	23,200	19,963
April	34,787	33,024	23,341	27,466	31,062
May	31,948	38,251	32,984	26,655	20,832
June	35,182	27,808	26,547	30,074	23,430
July	34,145	29,096	25,445	34,955	22,875
August	19,676	34,722	29,526	27,893	27,876
September	16,838	34,314	25,572	25,745	31,733

These figures distinctly indicate the effect of the war during August and September on the world's copper markets. The activities of the British Government to prevent shipments of copper to Holland increased those to the Scandinavian peninsula.

The total value of the American copper exports may be taken at 30,000,000*l.*, of which 26,250,000*l.* represents metal in pigs, ingots, and bars, whilst nearly all the remainder was exported in plates, sheets, rods, and wire. All these exports come to European countries, with the exception of about 1,458,000*l.* worth, which were sent mainly to Canada. Trade in articles manufactured of copper and brass is comparatively small. The value of European exports of articles manufactured from copper and brass are many times that of the exports of similar goods from the United States. American manufacturers are looking forward to the possibility of obtaining a considerable share of the world's trade in goods of manufactured copper, as a result of the war, especially to South America, Africa, China, and Australia. To what extent they will succeed remains to be seen; it depends in part on the continuance of raw copper supplies to our manufacturers.

British exports and imports of copper occur as ore, unwrought bars, blocks, slabs, cakes, and ingots, and copper goods manufactured. Our imports of copper ore have been as follow :—

	Tons.	£
1909	89,153	909,720
1910	98,179	968,740
1911	86,596	855,740
1912	98,226	950,860
1913	94,265	1,005,060

Our exports of copper ore mined in this country are on a very limited scale, and are practically ceasing, as shown in the next table.

	Tons.	£
1909	2333	44,083
1910	221	3,186
1912	169	829

Our imports come in small quantities from Germany, Belgium, France, and Scandinavia, and in larger quantities from South America, as follow :—

		Tons.	£
Venezuela ...	1913	12,949	90,744
Peru	1913	6,451	75,754
Chile	1909	50,998	493,549
	1913	39,028	419,624
Bolivia ...	1913	388	16,974
Transvaal ...	1909	1,964	54,294
	1913	4,026	122,365
Australia ...	1909	5,032	45,372
	1913	13,284	109,997

These figures show decreased imports from Chile and increased imports from the Transvaal and Australia.

Our imports of copper, regulus, and precipitate are :—

	Tons.	£
1909	65,292	2,192,157
1910	68,974	2,265,450
1911	64,873	2,007,432
1912	51,565	2,007,886
1913	39,110	1,449,406

Our exports are very limited; last year only 1870 tons, value 37,222*l.* The imports are mainly from Belgium, Portugal, Mexico, Spain, South America, Cape of Good Hope, and Australia as follows :—

		Tons.	£
Mexico ...	1910	14,381	437,690
	1912	15,387	520,766
	1913	9,637	357,765

[The decrease last year is probably due to internal political difficulties. Increased imports may be expected now that the country is again settling down.]

		Tons.	£
Peru	1911	7,461	223,182
	1913	783	23,297
Cape of Good Hope	1911	15,567	371,856
	1912	16,502	522,922
	1913	9,656	321,520
Spain	1909	16,367	799,517
	1913	4,322	190,004

We import unwrought copper in bars, blocks, &c., from Germany, France, Belgium, Spain, Japan, United States, and Chile, as shown below :—

		Tons.	£
Spain	1912	9,175	659,307
	1913	5,950	399,977
Japan ...	1909	12,282	729,495
	1913	8,445	600,408
United States	1909	69,728	4,188,812
	1910	40,922	2,412,595
	1913	52,183	3,715,084
Australia ...	1909	21,817	1,286,476
	1913	21,880	1,514,533
Chile	1909	14,218	826,269
	1913	6,900	477,409

Our imports of copper manufactures have steadily increased from 540,126*l.* during 1909 to 1,095,406*l.* last year.

Our exports of unwrought copper in ingots, cakes, or slabs produced in this country are given below :—

	Tons.	£
1910	11,710	752,240
1913	14,900	1,136,430

and of the same imported and re-exported :—

	Tons.	£
1910	30,620	1,767,510
1913	19,270	1,337,010

Our exports of copper manufactures, the produce of this country, are as follow :—

	Tons.	£
1910	15,710	892,640
1913	14,470	989,450

and of the same imported and re-exported :—

	£
1911	17,790
1913	21,160

Our total copper exports of all varieties are on a large and increasing scale, as shown by the following figures over a term of years :—

	Tons.	£
1909	40,440	2,745,300
1910	50,210	3,340,000
1911	50,300	3,374,300
1912	43,040	2,901,200
1913	53,200	4,180,400

Our total imports have been as below :—

	Tons.	£
1909	288,430	11,569,200
1910	237,950	9,295,800
1911	263,740	9,355,300
1912	251,650	11,029,200
1913	257,620	11,312,000

These figures show a decreased quantity of imports, and an increase of prices.

The world's consumption of copper over a term of years has been as follows, in tons :—

—	1913.	1912.	1911.	1910.
England .. .	140,300	148,877	159,736	148,187
France	103,600	106,753	106,408	92,338
Russia	40,200	38,318	31,330	28,237
Germany	259,300	253,429	234,985	208,826
Austria	37,200	51,574	41,101	37,150
Italy	31,200	34,378	40,949	32,487
United States	351,000	365,922	316,791	334,565

The smaller countries of Europe and the Far East take the remainder.

It is reported that the German Government has followed the lead of the British Government in the compulsory acquirement, and paying at prices fixed by the British Government, of all stocks of copper stored in Rotterdam warehouses, and captured afloat in neutral vessels, belonging to American companies. Considerable stocks of copper are stored in Germany belonging to American owners; the German Government has confiscated them, and is paying for them on precisely the same terms as those fixed by the British Government. Both these purchases involve a loss to American companies, who are by no means pleased with this double interference with their trading. No information is at hand as to whether there are similar stocks in France.

GERMAN INVENTION.

To the Editor of Engineering.

Sir,—Your article in Engineering of October 16 on "German Science" suggests another on German invention. Is it not a fact that not one of the great revolutionary inventions of the modern world has been made by a German? The Germans do splendid work in developing discoveries and inventions after the foundation has been laid; but, as you say, in regard to their scientific achievements, they do not bring forth the great basic ideas. The great creative imagination which leads its possessor into new material fields so far has been shown by but few of the nations anyway, and not once by the Germans. Since the disputed discovery of the art of printing have come the telescope, the steam-engine, the steam-boat, the railroad, the telegraph, photography, the sewing-machine, the Bessemer process, the telephone, the incandescent lamp, and the typewriter. Italy, England, France, and the United States have contributed to these great achievements, but not Germany. The nearest approach to a German invention worthy to be classed with these is perhaps the Siemens regenerative furnace, which, though great, hardly rises to the plane of a revolutionary invention.

Yours truly,
Henry D. Hibbard.

Plainfield, N.J., U.S.A., October 29, 1914.

SHEFFIELD UNIVERSITY SCIENTIFIC ADVISORY COMMITTEE.

To the Editor of Engineering.

Sir,—On behalf of the Sheffield University Scientific Advisory Committee, I shall be glad to receive from manufacturers information concerning any new apparatus, plant, or material which may be put on the market with the view of transplanting or substituting that which has hitherto been supplied from German sources.

The Committee is constantly receiving inquiries concerning apparatus, machinery, and material, and for this reason will welcome information of the character above mentioned.

Yours truly,
W. E. S. Turner,
Secretary to the Committee.

Department of Applied Science, St. George's Square, Sheffield, November 11, 1914.

Telephonic Progress.—The number of telephones under the control of the Post Office has made an extraordinary advance during the last ten years. This is shown by the annexed table :—

Year.	Telephones.	Year.	Telephones.
1903-4	22,479	1908-9 ..	86,744
1904-5	32,995	1909-10 ..	98,296
1905-6	44,849	1910-11 ..	121,730
1906-7	54,476	1911-12 ..	701,125
1907-8	79,099	1912-13 ..	730,763

The results indicated are largely due to the Post Office taking over systems developed by private enterprise.

Patents and the War.—The general principles upon which the Board of Trade will act in dealing with applications for the avoidance or suspension of enemy-held patents under the Patents, Designs, and Trade Marks (Temporary Rules) Acts, 1914, are now known. The principles mentioned hereunder may be taken as generally applicable, but special cases will of necessity receive exceptional treatment. The applicant for avoidance or suspension must prove that the patentee or licensee is the subject of a State at war with His Majesty; he must also prove that he intends to manufacture, or cause to be manufactured, the patented article, or to carry on, or cause to be carried on, the patented process; further, he is required to prove that it is in the general interests of the country, or of a section of the community or of a trade, that such article should be manufactured or such process carried on. When the applicant is able to fulfil these conditions, it may be assumed that licences will, as a general rule, be granted (1) where there is no manufacture in this country under the patent, and (2) where what manufacture there is is carried on by a company or firm on behalf of alien enemies resident abroad, and there is any reason to doubt that the manufacture will continue to be carried on, or where it is in the interests of the country that some other manufacture should be started in the British interests.

PETROL FIRE-BOAT FOR THE PORT OF GEORGETOWN, DEMERARA.

CONSTRUCTED BY MESSRS. MERRYWEATHER AND SONS, LIMITED, ENGINEERS, GREENWICH.

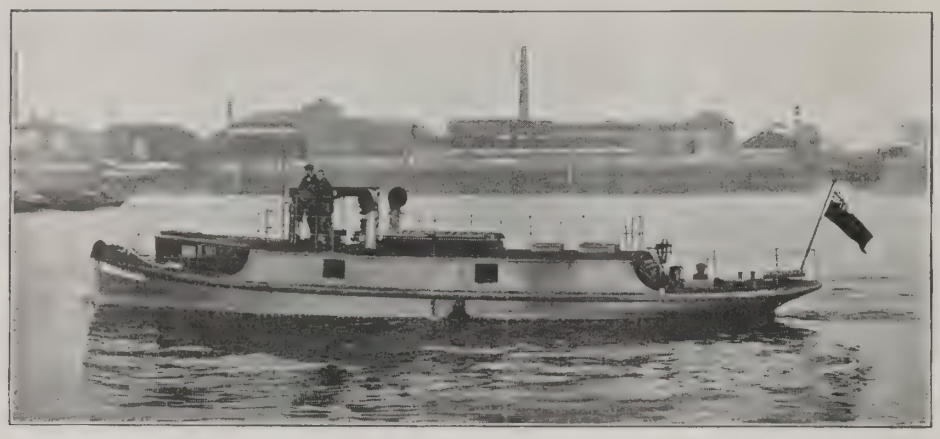


Fig. 1.

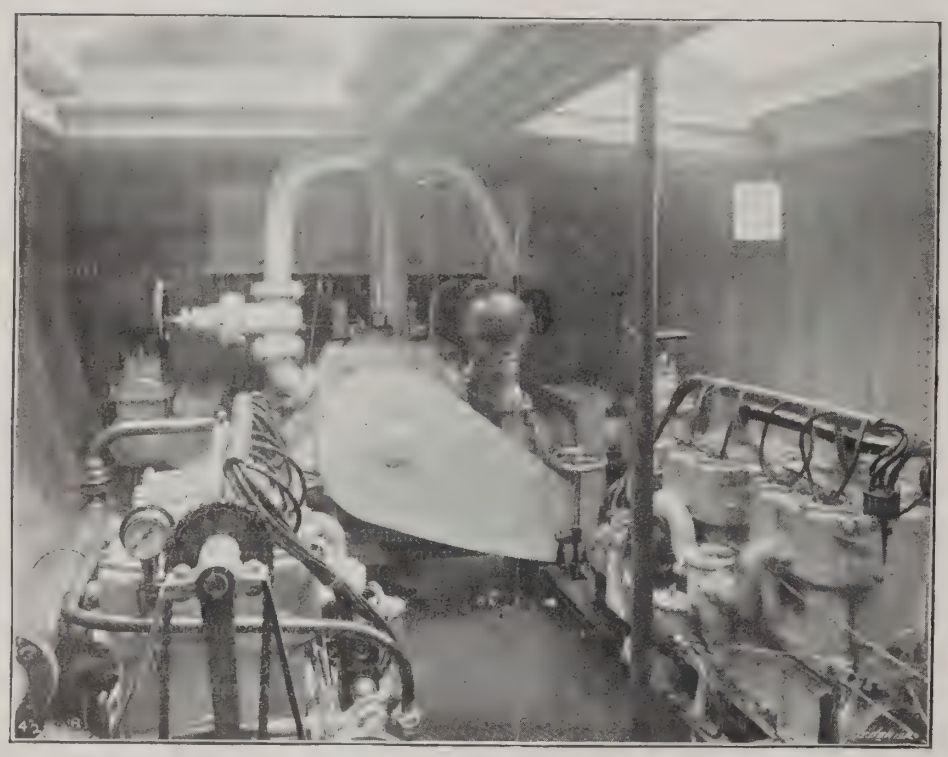


Fig. 2.

Fig. 3.

The Municipality of Georgetown, Demerara, has recently acquired a powerful petrol-driven fire-boat, illustrations of which we give above. This little vessel has been constructed by Messrs. Merryweather and Sons, Limited, Greenwich. It is of steel throughout, with double plating on the water-line, in order to withstand the rapid corrosion that occurs in the waters of the port. The boat is 50 ft. between perpendiculars, having a breadth of 12 ft. 6 in. and draught aft of 2 ft. 6 in. There are four water-tight bulkheads. A general view of the little vessel is shown in Fig. 1.

The centre of the boat is occupied by the engine space. A raised deck extending right across the boat provides a very commodious engine-room, a view of which is to be seen in Fig. 2. This deck plan provides ample area for the manipulation of the salvage-gear. Forward of the engine-room is cabin accommodation for two duty men, and there are compartments aft for two hose-reels and other accessory apparatus.

The propelling and pumping machinery consists of two four-cylinder marine-type petrol-engines, each of 53 horse-power, with cylinders $5\frac{3}{4}$ in. in diameter and $6\frac{1}{2}$ in. stroke. These engines drive from one end twin-screw propellers, and from the other two reciprocating pumps. The thrust-blocks and clutch-gear to the propellers are arranged in the same units as the reverse-gears. The pumps are driven by metal-to-metal cone clutches. The pumps are of the well-known Hatfield pattern, having three single-acting cylinders, with 7-in. plungers driven off a single 5-in. crank. The crank is totally enclosed. The pumps are placed on the centre line of the vessel, and are driven from the engine transmission-shafts by silent chains.

The suction inlets are arranged so that each pump can draw from either side of the boat through the large strainer-boxes. Suction branches are also taken up to the deck, where a fitting is provided for the attachment of flexible suction-hose for over-side salvage operations. The delivery-pipes are taken up to the deck and coupled to a four full-way outlet fitting, screwed for hose-couplings, and to a universal swivelling monitor. The total capacity of the pumps is 1000 gallons per minute at a pressure of 140 lb. per sq. in., the single working nozzle being of $1\frac{3}{4}$ in. diameter. The boat is shown with this nozzle in action in Fig. 3, which illustrates the solid and compact character of the jet produced. The vessel has a speed of 8.84 knots, the average of several runs over the measured mile at Long Reach. The engines run at about 600 revolutions per minute.

It will be realised that the petrol-driven fire-boat possesses similar advantages to the motor-driven fire-engine. While not in actual use the cost of upkeep is practically nil, while it is instantly ready for action. Boats of this class often have long periods of inaction, and during these the running costs are little more than the wages of the two duty men.

DRAG-LINE BUCKET EXCAVATOR WITH MARTINSON TRACTOR.

The drag-line type of excavator, though not used in this country, is a very popular machine in the United States, where it is extensively employed in all classes of drainage, irrigation, canal, railway, and other excavation work. In distinction from the steam-navvy, the drag-line excavator moves backwards ahead of its work in excavating, and for this reason has advantages over the steam-shovel. The steam-navvy usually swings to dispose of its spoil in wagons alongside or in its rear. If the cut be narrow, these operations are only performed at some inconvenience, while, if deep, the spoil cannot easily be dumped from the shovel into cars on the normal surface-level, owing to the limitations of the jib. For rapid work, therefore, a shovel-cut has to be wide enough to allow the spoil-train to be brought alongside the excavator at its own level.

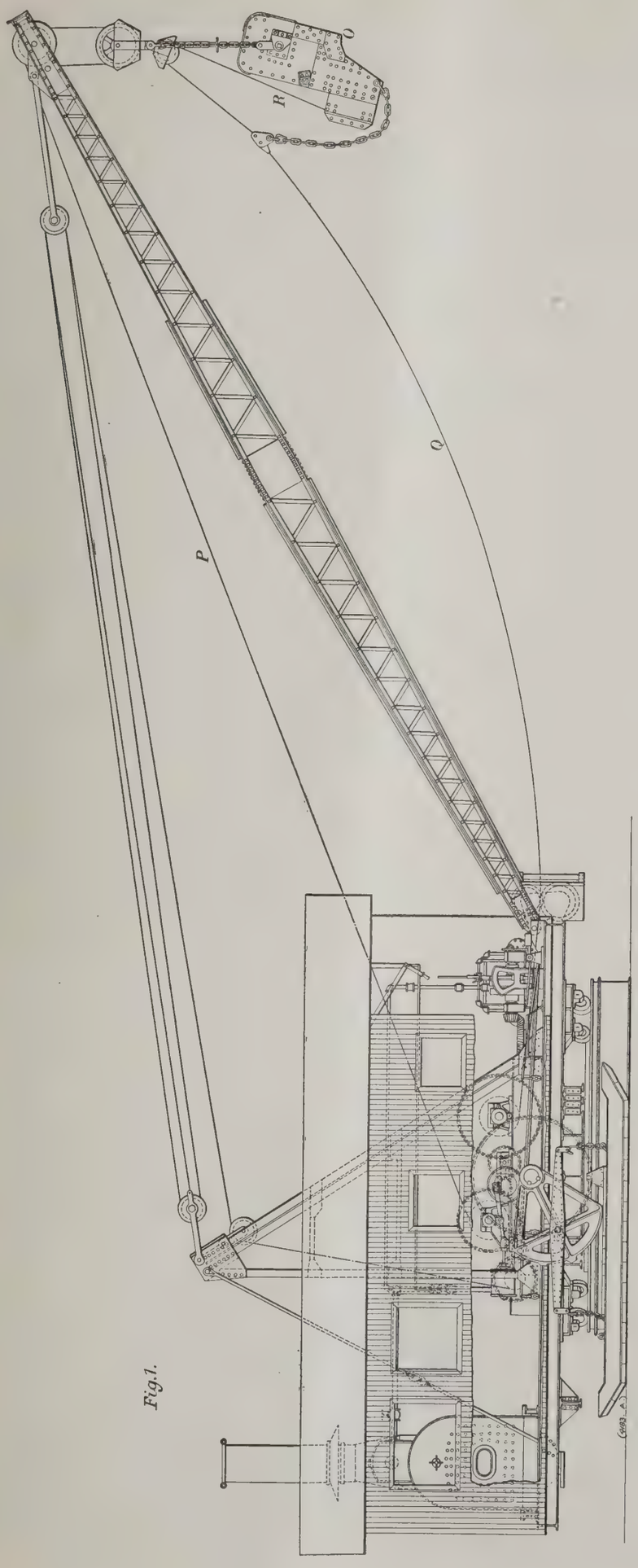
The drag-line excavator, on the other hand, standing on the normal ground surface, can dispose of its spoil much more conveniently in many cases, as it is free to dump it either well back on the berms on each side of the cut, or into wagons brought up to it on the ground-level. In many circumstances the latter can easily be arranged for with, frequently, much greater freedom in choice as to approach-lines and the location of dump-heaps than is possible when the trains have to work into and out of a long cut. At the same time there is a considerable reduction in the risk of congestion, delay in clearing, and interruption in excavation while waiting for wagons. The drag-line excavator consists of a crane-like machine, with a scraper-bucket attached to the hoisting-rope. The bucket is drawn towards the machine by the drag-line, scraping up soil as it goes; it is then hoisted, the machine is swung, and the bucket-load dumped where required.

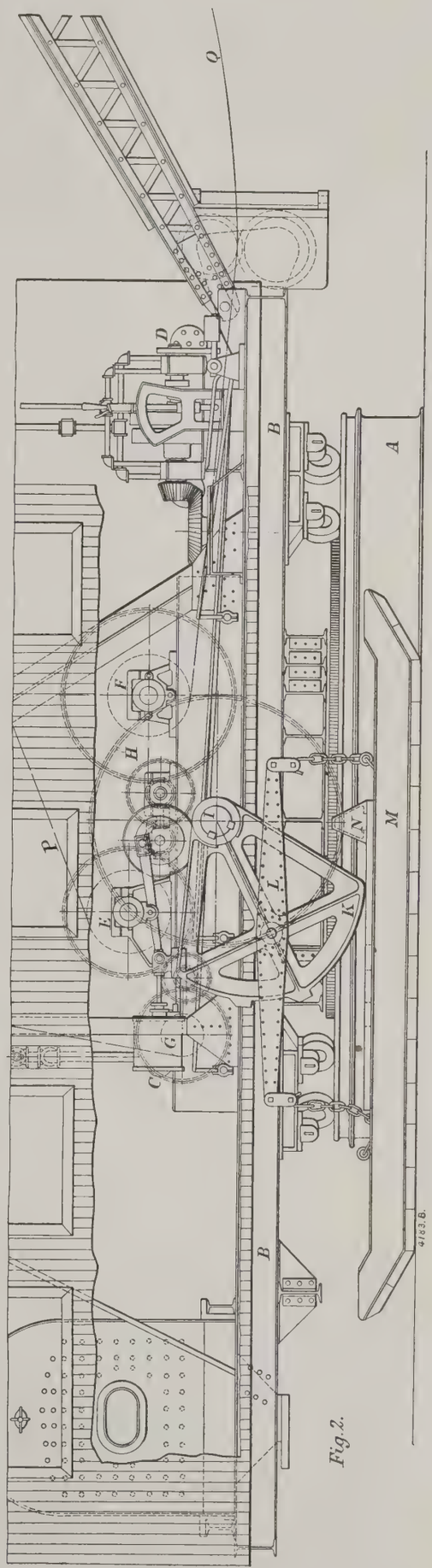
An interesting and rather unusual example of this class of machine is shown in Figs. 1 to 6, pages 589 and 592, in this issue. Commonly, drag-line excavators are mounted on wheels or rollers, for which a track, or at least planking, has to be laid down. The machine we illustrate is specially designed with a view to

DRAG-LINE BUCKET EXCAVATOR WITH MARTINSON TRACTOR.

CONSTRUCTED BY THE MONIGHAN MACHINE COMPANY, CHICAGO, ILL., U.S.A.

(*For Description, see opposite Page.*)





mobility and rapid work, and is for use on drainage and irrigation ditch construction, levee work, &c. A general view of the machine is shown in Fig. 1, the machinery being shown to a larger scale in Fig. 2. Fig. 3, page 592, is reproduced from a photograph of the machine at work, while Figs. 4, 5, and 6 show the machinery more clearly. The advantage of this type of machine is that it can move comparatively rapidly. It dispenses with the planking under platform, and therefore with the men required for preparing this track. Instead of needing a gang of four or more men, it only requires an engineman and a fireman. The temporary planking usually laid is rendered unnecessary by the machine carrying its own platform. Its manner of moving will be clear from the following description in conjunction with our illustrations.

The machine proper has attached to it underneath a circular platform A, Fig. 2, which serves the purpose of a large turntable for the main frame B. This platform is covered on its under side with steel plates, thus providing a large area for the distribution of the load. The area thus provided is so ample that the machine is able to travel over very soft ground. The machinery is mounted on the frame B, and includes three main units—viz., a steam-boiler, a main engine C, and a swinging or slewing-engine D. The latter, by means of bevel-gears and a pinion meshing with a large gear on the platform A, swings the main frame round to any position. The main engine performs four duties, its operation being controlled by clutches worked by levers at the jib end of the main frame. When one friction-clutch is operated, this engine drives the winding-drum E, on which is coiled the hoisting-rope of the bucket. By engaging a jaw-clutch the drum G is operated, this being the winding-drum for luffing the jib. A third drum F can also be engaged by a friction-clutch for the purpose of winding in the drag-line attached to the bucket. The fourth operation is, perhaps, the most interesting. Extending across the frame is a heavy shaft I, on which is mounted a large gear-wheel H driven, when engaged, by clutch through the train of gears which also operates the drum F when clutched in. At each end of the shaft I is keyed a large sector K, which carries pivoted on its central arm a lever L. To each end of L are attached two chains, of which the lower ends are attached to large shoes or auxiliary platforms M.

When the machine has to be moved the auxiliary platforms M rest on the ground, and the sectors K, the circular periphery of which is eccentric to the shaft I, are revolved by the main engine. The sectors, by reason of their eccentricity, slide on the upper surfaces of the platforms until they come into contact with the stops N. On the movement being continued, the whole machine is lifted off the ground and at the same time moved forward (to the left in Figs. 1 and 2), and deposited in a new position 8 ft. distant. If the sector rotates further, the beams L are gradually raised until the auxiliary platforms M are lifted off the ground. The completion of the revolution of the sector results in the platforms being swung forward 8 ft. and deposited again in a new position underneath the descending sector, ready for the machine to be lifted afresh. The disposition of the weight causes the machine to tilt slightly, so that the leading edge of A is always off the ground when moving. The movement forward of 16 ft. for each setting can be accomplished in half a minute. Fig. 6 shows plainly the two auxiliary platforms or shoes M and the sectors, chains, &c., raised. Figs. 3 and 4 show them in the act of being raised; Fig. 5 shows one of the platforms M rather more clearly. As soon as the machine has been placed in position, or brought to a new one, the sectors are raised into the position shown in Fig. 3, and are there locked by a brake. The clutch is then disengaged, and the machine is ready to commence excavating. It will be evident that this machine may be moved in any direction. All that has to be done is to swing it on the turntable A while the shoes are off the ground, so that it points the proper way before moving it. Its direction is changed with the greatest ease. It is therefore suitable for excavating wide ditches as well as narrow, since it can dig out half the width, depositing on the berm on one side, and can then move over and excavate the other half, depositing the spoil on the other berm. This method of handling also enables rapid work to be accomplished, as a stiffer jib and a larger bucket can be employed with short reaches than is the case with the less mobile long-jib machines of the ordinary pattern. This Martinson tractor does not add to the total weight of the machine, as the special gear is about equal in weight to the rollers, skids, planking, &c., eliminated. In addition, the whole machine is set somewhat lower—an advantage in the scraper type of excavator.

The Page scraper bucket, with which the machines illustrated are equipped, has a cutting edge, armed with teeth if necessary, at O. After being allowed to fall on the ground by running out the hoisting-rope P, the bucket is dragged in towards the machine by the line Q. This is attached to the bucket at a point which gives it sufficient tilt to bite well in. When the bucket is loaded, the hoisting-rope is drawn in. This puts a tension on the line R, and the mouth of the bucket is thus raised. When the jib is swung round to the dumping position, the drag-line is relaxed, and the bucket tips over and empties its load. We should explain that the hoisting and drag-line drums E and F are provided with friction-clutches worked by auxiliary steam-thrust cylinders placed on the ends of the shafts, while outside asbestos-lined band-brakes are also fitted to them for the proper manipulation of the bucket. These machines are made by the Monighan Machine Company, 2016, Carroll-avenue, Chicago, Ill., U.S.A., in three sizes. One is furnished with a 40-ft. jib and 1-cubic-yard bucket; the intermediate size has a 50-ft. jib and a 2-cubic-yard bucket; the third has a 65-ft. jib and a 3-cubic-yard bucket. The shipping weight of the latter is about 85 short tons, the turntable platform having a rail circle 24 ft. in diameter. The main engines have cylinders 10½ in. by 12 in., and the swinging engines cylinders 7 in. by 10 in. The locomotive boiler is 15 ft. long and has a barrel 60 in. in diameter.

Air-Filter for Tube Railway: Addendum.—In connection with our description of the Balcke wet air-filter, in our issue of October 23 last, page 502, we should have stated that the filter fitted to the ozonising plant for the Baker street and Waterloo tube railway was supplied by Messrs. Balcke and Co., as sub-contractors to Messrs. Siemens Brothers and Co., Limited, who supplied the ozonising plant.

Contracts.—The Gledhill-Brook Time-Recorders, Limited, Huddersfield, state that they have recently been favoured with an order for twenty-three British-made Gledhill-Brook time-recorders from Sir W. G. Armstrong, Whitworth and Co. for their Ordnance Works, Newcastle-on-Tyne. They have also recently supplied forty-five recorders to other British engineering firms.—The New South Wales Government have accepted the tender of the Brush Electrical Engineering Company for generator plant, condensers, and auxiliaries for equipment of the Albury electricity-supply station.—The tender of the Brush Electrical Engineering Company has been accepted for the supply of hydro-electric plant and transformers for the township of Tauranga, New Zealand.—The six months' contract for the supply of Osram lamps to the General Post-Office has again been secured by the General Electric Company, Limited.—The Mirrlees Watson Company, Limited, Glasgow, have recently received orders for condensing plants from six corporations and municipal bodies, from ten collieries, from four iron works, and from four other manufacturers.

Textile Machinery in Russia.—In the textile machinery markets of the world the United Kingdom holds a strong position, having an annual export valued at some 8,000,000*l.*, against about 2,000,000*l.* for Germany. In some markets, however, German competition is important. Russia is one of these, being a country to which Germany exports annually some 300,000*l.* worth of textile machinery. In a recent brochure dealing with this subject, issued by the Commercial Intelligence Branch of the Board of Trade, some interesting information in reference to the Russian market is quoted. It is stated that textile machinery, as well as other machinery and electrical apparatus, coming into Russia has to pay duty by weight. This fact has been more clearly realised, or more definitely acted on, by German manufacturers than by British. Thus, in some of the comparatively rough machines of the textile trade, although they may be cheaper delivered at the makers' works in England than corresponding German machines in Germany, they are dearer delivered free in Moscow, simply owing to their heavier framework. It is suggested that the cheapness of cast iron in England leads sometimes to heavier construction than is really necessary, and that during present efforts to extend export trade the matter should be given attention.

The French Lorraine Iron-Mines.—We read in the Madrid journal *Revista Minera Metalúrgica y de Ingenieria* an article which refers to *Stahl und Eisen*, and states the following amongst other points:—"The French iron works located in the regions where hostilities are raging have not suffered any considerable damage. As an instance, Longwy and its vicinity may be stated, where the works hardly suffered any deterioration, although the bombardment lasted over eight days. The Germans occupied the rich mineral district of Briey from the first week of their advance upon French territory. The German Government, and this, if exact, is a really interesting news item, has established a Technical Bureau, the duty of which is to inspect all the mines of the district, and to see to the safe keeping of the works and installations there, preventing subsidences, flooding, &c. By this means, although the mines will be idle for a few months, once matters return to their normal state, exploitation can be resumed without the necessity of previously carrying out important and costly work, such as the clearing of galleries, strengthening operations, draining, and reconstruction." From this we gather that either German artillery is not good, or that German artillerymen can avoid destruction by gun-fire when they are so minded; also that the war is to last "a few months;" and, further, that someone "sits up aloft" watching for the safety of the French iron industry in the Briey district.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with an easier tone, but no dealing took place. At the close sellers named 49s. 3d. cash and 49s. 6d. one month for Cleveland warrants. In the afternoon another idle session was recorded, and sellers' quotations were unchanged. On Friday morning the market was again lifeless, and the prices of Cleveland warrants were steady at 49s. 3d. cash and 49s. 6d. one month. In the afternoon there was little change in the conditions, but 2000 tons of Cleveland warrants were put through at 49s. 1½d. seven days, and the closing quotations were down to 49s. 1d. cash and 49s. 4½d. one month. On Monday morning business was at a standstill, and although sellers of Cleveland warrants quoted firmer at 49s. 2d. cash and 49s. 4½d. one month, buyers' prices were easier at 48s. 10½d. and 49s. 1½d. respectively. A firm tone prevailed in the afternoon, when 2000 tons of Cleveland warrants were done at 49s. 4½d. one month, with sellers over at ½d. more. For the cash position sellers named 49s. 2d. On Tuesday morning the firmness of Cleveland warrants continued, but no transactions took place, and sellers quoted 49s. 3d. cash, 49s. 6d. one month, and 49s. 10½d. three months. In the afternoon Cleveland warrants were steady, and one lot changed hands at 49s. 5½d. one month, and the session closed with sellers at 49s. 3d. cash and 49s. 6d. one month. When the market opened to-day (Wednesday) Cleveland warrants were held for an advance of 2d., but no business was done. At the close sellers named 49s. 5d. cash and 49s. 8d. one month. The afternoon session was firm, and 1000 tons of Cleveland warrants were done at 49s. 5½d. twelve days, and at the close sellers quoted 49s. 6d. cash and 49s. 9d. one month.

Sulphate of Ammonia.—The sulphate of ammonia market is still rather dull, and dealings are of a very limited nature. The current price for prompt lots is 10*l.* 17s. 6d. per ton, Glasgow or Leith, and 5s. per ton more for forward delivery.

Scotch Steel Trade.—The situation in the Scotch steel industry has not changed to any extent, either the one way or the other, and while there is still a scarcity of new business, a fairly hopeful feeling pervades the trade. With shipbuilding rather quiet, the demand for plates shows little immediate signs of expansion, and boiler-plates are also somewhat dull. The black and galvanised sheet trade is also a bit easier, and the same may be said with regard to structural sections. In normal times the output of the various kinds of steel material from Scotch works is on a large scale, with the result that when plant is not running very full we are apt to think that there is little doing. In the meantime, considering the great upheaval caused by the present war, and the very wide area of the world which is affected, it is little short of wonderful to find so much business going through. Of course, the shipping side of the trade has lately been rather quiet, owing partly to the uncertainty of cargoes getting safely to their destinations, but now that two of the enemy's warships, which have recently caused much trouble and loss, have been put out of action, a fillip will be given to the export trade. Some of the foreign markets have not been sending forward many orders of late, but India and Australia have done tolerably well in a limited way, and the general inquiry all round is moderately good at the present time. Prices are without change where under official control, but the offer of a decent line for prompt delivery is a strong inducement for a very keen quotation to secure the order.

Malleable-Iron Trade.—In the West of Scotland malleable-iron trade the conditions have varied very little during the past few weeks, owing to the scarcity of specifications. The report is again "no change," and home prices continue on the basis of 7*l.* 12s. 6d. per ton, less 5 per cent., for "crown" bars, and 7*l.* per ton net for shipment lots.

Scotch Pig-Iron Trade.—The demand for Scotch pig-iron has not increased, despite the fairly low prices at present ruling, and stocks show a slight increase. The output is smaller than at this time last year, when there were eighty furnaces in blast as against sixty-six now. Prices are easier, and the following are the market quotations for makers' (No. 1) iron: Clyde, 67s. 6d.; Calder and Langloan, 68s.; Gartsherrie and Summerlee, 68s. 6d.; (all shipped at Glasgow); Eglinton, 62s., and Glengarnock, 69s. 6d. (both at Ardrossan); Shotts (at Leith), 68s.; and Carron (at Grangemouth), 68s. 6d.

The Junior Institution of Engineers.—In the rooms of the Junior Institution of Engineers, Mr. Robert Rankin, B.Sc., lectured recently on "The Working of Storage Batteries." One fruitful source of trouble with batteries being excessive discharging, Mr. Rankin described an instrument which he has invented to enable battery-operators to keep within proper limits, the instrument, and curves showing the variations of battery capacity, with rate of discharge, amongst other things, being shown on lantern-slides.

Printing Machinery in the Balkans.—According to the British Chamber of Commerce of Turkey and the Balkan States, the trade in printing machinery, which was at one time almost entirely in the hands of British firms, has gradually passed over to the Germans, the chief reason being that facilities are given for payment. British makers insist, as in the past, on payment part in cash with order and balance against documents. To-day in the different printing establishments (Government and private) the machines most highly spoken of are of British make.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—The official returns relating to coal traffic by way of Hull during October last show that though there is a substantial slump in shipments, South Yorkshire collieries manage to maintain a big overseas business, and that the undertone of the market is not so weak as is represented in some quarters. The total traffic registered for the ten months (including October), was a little short of 5 million tons, about $1\frac{3}{4}$ million tons below that of the corresponding period last year. Exports, which totalled $2\frac{1}{2}$ million tons, declined by an almost equal amount as compared with last year's turnover. For the month, foreign trade reached 167,572 tons, being almost equal to that of September. There was a marked decrease in comparison with the October, 1913, level, but this was more than accounted for by the collapse of business with Germany and Russia. France, the best customer, took 48,559 tons—an increase of no less than 30,000 tons. Belgium also took about 10,000 tons more than a year ago. An average trade was done with Sweden. Exports to Holland and Norway declined. The total tonnage sent to the port during the month—382,635 tons—was little more than half that of October, 1913. The biggest declines were in the cases of the Denaby and Cadeby Main Collieries, which sent about 21,000 tons less than October, 1913, and the Grimethorpe and Frickley, which sent about 13,000 tons less.

South Yorkshire Coal Trade.—Very little business is passing in house coal. Orders for local and country consumption are chiefly for the best sorts. London is only taking small quantities. The steam-coal market is a little easier. Home industrial consumption is heavy, particularly in the case of the local armament houses and other similar concerns, which are working at the highest pressure night and day, weekday and Sunday alike. On the other hand, shipments at the Humber ports are on the decline, and there is small hope of an early improvement. Collieries which have built up their business solely on export requirements are only working two days a week. They are, of course, exceptions. Most pits have on their books contracts with home railway companies and other home consumers, and they are making about four days a week. Values remain steady, despite a small amount of forced selling. Stocks are not unduly heavy. Gas fuel is a firm, but quieter, market. Little business is passing in slacks, and though hopes are entertained of a better demand from the cotton areas, no improving tendency has yet been noted. Stocks are on the increase, and there is a good deal of selling pressure The market for coke is stagnant. Prices are stationary. Quotations:—Best branch hand-picked, 16s. to 16s. 6d.; Barnsley best Silkstone, 12s. 6d. to 13s. 6d.; Derbyshire best brights, 12s. 6d. to 13s. 6d.; Derbyshire house, 11s. to 12s.; best large nuts, 11s.; small nuts, 9s. 3d.; Yorkshire hards, 10s. to 11s.; Derbyshire hards, 9s. 6d. to 10s. 6d.; best slacks, 7s. to 8s.; seconds, 4s. 9d. to 5s. 9d.; smalls, 1s. 9d. to 2s. 9d.

Iron and Steel.—The continued inaction of raw material consumers has resulted in a sharp deflation of values. Fortunately, coke is cheap, and makers are able to produce at a low cost, thus leaving a profit on reduced selling prices. West Coast hematites are now quoted at 80s., East Coast hematites at 70s., Lincolnshire foundry at 56s. 8d., Lincolnshire forge at 55s. 8d., Derbyshire foundry at 55s. 6d., and Derbyshire forge at 53s. 6d. On the month, West Coast hematites have declined 1s., East Coast hematites, 3s. 6d.; Lincolnshire foundry, 3s.; Lincolnshire forge, 3s.; Derbyshire foundry, 1s. 3d.; and Derbyshire forge, 1s. 6d. At the moment prices are steady, but new business is still scarce, and a further lowering of values is not improbable. Swedish material is dearer on account of the extra cost of shipment, but supplies are adequate. The South Yorkshire Bar-Iron Makers' Association has decided, in view of the better outlook in finished iron, to continue its basis quotation of 8*l.* 5s. Sheets are quoted at 9*l.* 10s. The high price of steel billets, consequent upon the unusually heavy demand made by special-steel makers, is causing inconvenience to those manufacturers who are competing for orders for low-priced finished goods of the kind that Germany has been supplying. The scarcity of skilled workers is more pronounced than ever in the engineering trades. Export business shows an improvement in several important directions. South Africa, Norway, and Australia are taking considerably larger supplies of steel bars, angles, rods, &c. Tools are on order for Yokohama and Rangoon, and special steel is being made for New York, Montreal, and Cape Town. Armaments of an unusually large type are being made by Messrs. Vickers, Limited, and Messrs. Hadfields, Limited.

THE TYNE.—Coal was shipped from the Tyne in October to the extent of 1,226,988 tons; 31,258 tons of coke were also shipped. These totals showed a decrease of 596,904 tons in coal shipments, and an increase of 990 tons in coke shipments, as compared with October, 1913.

OUR LOCOMOTIVE EXPORTS.—In spite of the war there can now be no doubt that 1914 will be a good year for our locomotive exports. This is explained by a larger demand for engines for South Africa, British India, and Australia, which has more than off-set a reduction observable in shipments to Argentina. The value of the locomotives exported in October was 368,540*l.*, as compared with 244,247*l.* in October, 1913, and 263,383*l.* in October, 1912, while in the ten months ended October 31 this year shipments were made to the value of 3,298,011*l.*, as compared with 2,311,563*l.* in the first ten months of 1913 and 1,694,360*l.* in the first ten months of 1912.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—War news has assisted materially in strengthening the market so far as Cleveland pig-iron is concerned. Information to hand has induced shippers to take a less despondent view of the situation, and home consumers are running rather short of supplies. The result is that pig-iron is being taken up to an extent that makes demands upon makers' stores, current output being inadequate. No. 3 g.m.b. Cleveland pig is now 49s. 9d. f.o.b.; No. 1 is up to 52s.; No. 4 foundry is 49s. 3d.; No. 4 forge 48s. 9d.; and mottled and white iron each 48s. 3d.—all for early delivery. There is a little inquiry on forward account, and buyers are prepared to pay quite 6d. above the foregoing quotations for delivery over periods next year. Quotations for East Coast hematite pig tend downward, but values are still high as compared with prices for Cleveland iron. Both makers and merchants offer Nos. 1, 2, and 3 rather freely at 61s. 6d. for either early or forward delivery, and doubtless some second hands would accept a trifle below that figure. Foreign ore is decidedly firmer. Freights are moving upward, and vessels are difficult to fix. Market quotations are based on 17s. 6d. ex-ship Tees for Rubio of 50 per cent. quality, for early delivery; whilst nothing under a basis of 19s. is named for delivery over periods next year. Coke is decidedly weaker, though leading sellers are very unwilling to admit actual reductions in quotations. Durham beehive blast-furnace kinds of average quality are put at 17s. 3d. delivered at Tees-side works.

Stocks and Shipments.—Stocks of Cleveland pig-iron in the public warrant stores now stand at 103,282 tons. Since the beginning of the month the stock has been reduced by 779 tons. Shipments of pig-iron from the Tees to date this month average 2436 tons per working day, the total despatches being returned at 21,927 tons, 19,762 tons of which have gone from Middlesbrough, and 2165 tons from Skinningrove. To the same date last month the loadings were given at 13,532 tons, or a daily average of 1503 tons, and for the corresponding part of November a year ago the clearances reached 32,298 tons, or an average of 3588 tons per working day.

Manufactured Iron and Steel.—There is little new to report concerning the manufactured iron and steel trades. Works are kept busy, but new orders are scarce. Principal market quotations stand:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 5s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 8*l.*; iron ship-rivets, 8*l.* 7s. 6d.; iron girder-plates, 7*l.* 5s.; steel bars (basic), 7*l.* 10s.; steel bars (Siemens), 7*l.* 15s.; steel ship-plates, 7*l.* 5s.; steel ship-angles, 7*l.*; steel boiler-plates, 8*l.* 5s.; steel strip, 7*l.* 5s.; steel hoops, 8*l.*; steel joists, 7*l.* 2s. 6d.; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 7s. 6d.; steel railway sleepers, 7*l.*—railway material net at works, and all other descriptions less $2\frac{1}{2}$ per cent. discount; galvanised corrugated sheets, 24 gauge, in bundles, 14*l.* f.o.b.—less 4 per cent.

BELGIAN ENGINEERS.—The offices of the Society of Engineers at 17, Victoria-street, Westminster, are open daily from 10 a.m. to 4 p.m. (Saturdays, 10 a.m. to 1 p.m.), and Belgian engineers who are now in England on account of the war are cordially invited to apply to the Secretary when they are in need of any information.

THE "MECHANICAL WORLD" POCKET DIARY AND YEAR-BOOK.—We have received a copy of this annual for 1915. It is published at the price of 6d., by Messrs. Emmott and Co., Limited, 65, King-street, Manchester, and 20, Bedford-street, London, W.C., the present volume being the twenty-eighth annual edition. The work is a well-known one; it is a most handy epitome of facts and formulæ on steam reciprocating engines, steam-turbines, boilers, oil and gas-engines, the component parts of machinery, structures, &c. Several chapters of this latest edition have been re-written, the section on gearing contains useful notes on gear-cutting, and all the matter has been revised, where necessary, to conform with the progress made in engineering. The book carries with it its own commendation; almost all that need be said concerning it is that the new edition is now available.

THE ROUMANIAN MACHINERY MARKET.—We read in the Bulletin for September of the British Chamber of Commerce of Turkey and the Balkan States that the value of the machinery imports in Roumania in 1911 was 2,342,574*l.*, of which 1,212,477*l.*, or more than half, came from Germany, 474,690*l.* from Austria-Hungary, 324,250*l.* from the United States, and 211,914*l.* from the United Kingdom. The United Kingdom has thus fallen from the third to the fourth position among the countries exporting machinery to Roumania. The extremely rapid advance of the United States under this head has been due to the greatly increased importation in recent years of agricultural machinery, and in particular of reaping-machines, which are almost entirely derived from that country. Hydraulic machinery came mostly from the United Kingdom and Germany; steam-engines almost entirely from Germany and Austria-Hungary; oil-engines from Germany, the United Kingdom, and Switzerland; portable engines and thrashing-machines from the United Kingdom, Germany, and Austria-Hungary; printing, paper-making, and textile machinery practically all from Germany; machine-tools from Germany and Austria-Hungary; electrical machinery and apparatus from Germany, Austria-Hungary, and France; typewriters and sewing-machines mostly from the United Kingdom, but probably in the form of re-exports.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has been generally dull. Exporters have maintained quotations at previous levels, although those with heavy stocks and threats of pit stoppages have been willing to make concessions to buyers who would take deliveries within the next few days. Some colliery owners holding large Admiralty contracts still find it difficult to keep their pits fully occupied. The best Admiralty large steam-coal has made 21s. to 22s. per ton; best secondary qualities have brought 19s. to 20s.; other secondary descriptions, 18s. to 18s. 6d.; best bunker smalls, 7s. 9d. to 8s.; and cargo smalls, 5s. to 6s. 6d. per ton. The best household coal has made 19s. to 20s.; good households have realised 17s. to 18s.; No. 2 Rhondda large has brought 12s. 6d. to 14s.; and No. 2 smalls have made 7s. to 7s. 6d. per ton. Patent fuel has been quoted at 16s. 6d. to 17s. 6d. per ton. Special foundry coke has realised 27s. to 30s.; good foundry coke, 20s. to 24s.; and furnace coke, 17s. 6d. to 18s. 6d. per ton. As regards iron ore, Rubio has realised 16s. 6d. to 17s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Great Western Railway.—The second half of 1914 is now so well advanced that some attention is being given to the probable dividend upon Great Western Railway ordinary stock. Since the outbreak of the war and the consequent virtual control of the railways of Great Britain by the State, the publication of weekly traffic returns has been suspended, and stockholders have to grope very much in the dark. It is stated, however, that the Government has promised railway companies that they shall not suffer from Government military traffic taking precedence of ordinary business, and that the companies shall be in as good a position as that which they occupied before the outbreak of hostilities. Upon the faith of this promise Great Western Railway ordinary stock has rallied to 107½.

Barry.—The directors of the Barry Graving Dock and Engineering Company, Limited, recommend a dividend of 10 per cent. for the past year upon the ordinary shares of the company. Full provision is, of course, made for the dividend accruing upon the preference shares.

Newport.—The steam-coal trade has not shown activity. Current prospects are not regarded as particularly encouraging, stocks of all qualities being heavy. The best Newport black vein large has made 16s. 9d. to 17s.; Western Valleys, 16s. to 16s. 6d.; and Eastern Valleys, 15s. 6d. to 16s. per ton.

Bristol Relief Works.—Should relief works have to be started in Bristol during the coming winter, one of the first matters which will be taken in hand will be the widening of Filton-road, from Horfield Barracks to the city boundary. Terms have been arranged for the purchase of the land required to provide a road, 50 ft. wide, in the place of an existing one which, at certain points, has barely a width of 20 ft.

The Swansea Valley.—There have been substantial outputs at the anthracite and bituminous pits. The output of pig iron has also increased. There is still depression in the tin-plate trade, and several mills are stopped, only three mills being in operation at Ystalyfera, three at Gilwern, and three at Ystradgynlais. The Mannesmann Tube Works are well supplied with orders, and have even had to resort to overtime.

Newport Bridge.—Further consideration was given on Monday to schemes for re-building Newport Bridge. Mr. De Vesian submitted plans for a temporary bridge while the main structure was being built. It was decided that the Borough Engineer (Mr. H. Tremelling) should report upon one of the schemes, which contemplates the building of a bridge, 25 ft. wide, to form part of the main structure.

HONG KONG UNIVERSITY.—The University session 1914-15 commenced on September 14 with a good entry of students—eight entered from the province of Chihli, and several from the Straits, Shanghai, &c. Since the last session the staff has also been increased, the latest addition being Mr. Walter Brown, M.A., B.Sc., a lecturer in mechanical engineering. There are now seventy-six students in the University studying engineering, and the British staff consists of the Taikoo professor, five lecturers, and an electrician.

UNITED STATES STEEL CORPORATION.—This important company has reduced the dividend upon its ordinary, or common, shares from 5 per cent. per annum to 2 per cent. per annum. The unfilled orders which the company had on hand at the close of September were only 3,787,667 tons, showing a decrease of 245,190 tons as compared with the corresponding total at the close of August, and the business of the company is at present barely 50 per cent. of the capacity of its mills. The dividend upon the ordinary, or common, shares had been at the rate of 5 per cent. per annum since June, 1910; but the reduction just announced to 2 per cent. per annum had been fully anticipated. It should be observed that the surplus funds were drawn upon to the extent of 5,159,237 dols. in order to maintain the 5 per cent. dividend for the June quarter, while with a distribution at the reduced rate of 2 per cent. the dividend account surplus at the close of September was 89,479 dols. The balance available for dividend for the quarter ending September 30 was 8,935,911 dols., as compared with 7,499,463 dols. available for the quarter ending June 30. The dividend upon the preferred stock absorbed 6,304,919 dols. for the September quarter, and 2,541,513 dols. has been distributed upon the common stock.

DRAG-LINE BUCKET EXCAVATOR WITH MARTINSON TRACTOR.

CONSTRUCTED BY THE MONIGHAN MACHINE COMPANY, CHICAGO, ILL., U.S.A.

(*For Description, see Page* 588.)

FIG. 3.

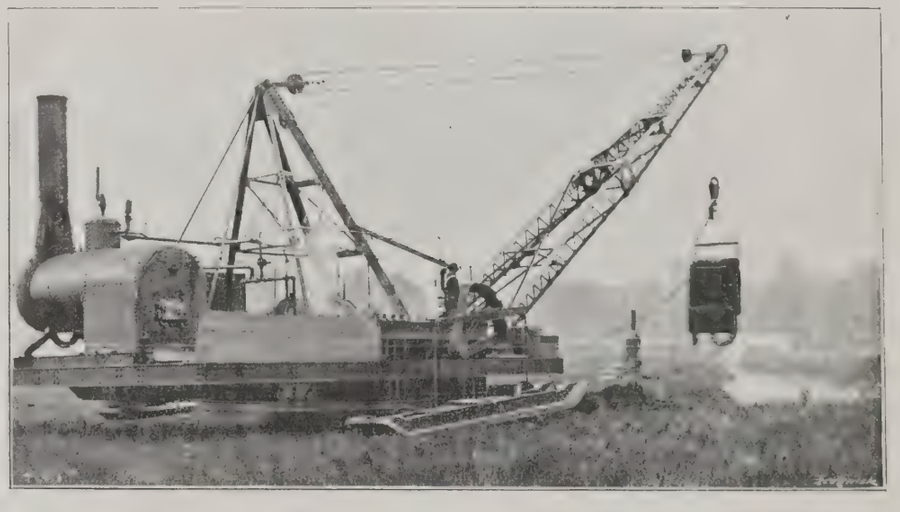


FIG. 4.

FIG. 5.

FIG. 6.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 13, at 8 p.m., at 39, Victoria-street, Mr. F. D. Evans will read a paper on "The Engineer and Malaria." On November 20, at 8 p.m., Mr. J. H. Pearson will read a paper on "Building Contracts and Sub-Contractors."

THE CLEVELAND INSTITUTION OF ENGINEERS.—Monday, November 16, at 7.30 p.m., in the Hall of the Cleveland Literary and Philosophical Society, Corporation-road Middlesbrough; address by the President, Sir Thomas Wrightson, Bart.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, November 17, at 8 p.m. Paper to be read, "Economics of Electric Railway Distribution," by Mr. Horace Field Parshall, D.Sc., M. Inst. C.E.

THE INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, November 18, at 7.30 p.m., in the Latin Theatre, at the University, Edmund-street, the Chairman, Dr. A. H. Railing, will deliver his inaugural address.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 18. A paper by Mr. J. Denholm Young, on "The Transport of Merchandise by Sea and by Land: Some Figures and Comparisons."

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, November 18, at 7.30 p.m., in the Surveyors' Institution, 12, Great George-street, Westminster. Papers to be read: 1. "Isomeric Rainfall Maps of the British Isles," by Messrs. Hugh Robert Mill, D.Sc., and Carle Salter. 2. "A See-saw of Temperature between England and Egypt," by Mr. J. I. Craig, M.A., F.R. Met. Soc.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, November 19, at 8 p.m., at the rooms of the Geological Society, Burlington House, Piccadilly, London, W. The following paper will be discussed:—"Persistence of Ore in Depth," by Mr. T. A. Rickard, Member.

THE CONCRETE INSTITUTE.—Thursday, November 19, at 7.30 p.m., in the Lecture Hall at Denison House, 296, Vauxhall Bridge-road, Westminster, S.W. Presidential address by Professor Henry Adams, M. Inst. C.E., M.I. Mech. E., F.S.I., M.S.A., &c.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 20, at 8 p.m., a paper on "The Effect of Vacuum on Steam-Turbines" will be read by Mr. G. Gerald Stoney, F.R.S., Member, of Newcastle-on-Tyne.

NOTICE.

In consequence of the regrettable state of affairs on the Continent it is impossible to ensure that copies of ENGINEERING addressed to some Continental subscribers will reach them. It is therefore proposed (unless instructions are given to the contrary) to retain such copies until they can be forwarded under normal conditions.

ENGINEERING.

FRIDAY, NOVEMBER 13, 1914.

ELECTRICITY IN LONDON.

AT the meeting of the London County Council on Tuesday last it was decided that a Parliamentary Bill should be promoted, in the 1915 Session, for the establishment of a new electricity authority for Greater London. This represents another step, vain or not we cannot yet say, in the sisyphean labour of reducing the chaos of London's electricity supply to some sort of order. The Bill will follow the lines of the recommendations of the Special Committee which reported during last summer. The Committee's proposals should have come before the Council in July, but, owing to the press of other business, had to stand over until after the recess. They have been brought to the notice of the Council once or twice since July, owing to the requirements of various Standing Orders, but it was only on Tuesday last that they were the subject of discussion. We gave a summary of the proposals last July, and dealt in leading articles with various aspects of the problem concerned when commenting on Messrs. Merz and McLellan's report to the Special Committee last April. The stage reached on Tuesday justifies a return to the subject.

It will be convenient if we begin by restating briefly what the Committee's proposals are. The intention is that an entirely new authority shall be constituted to have control over the electricity supply of an area containing the whole of Middlesex and the county of London, the county boroughs of Croydon, East Ham, and West Ham, and parts of Essex, Kent, Hertford, and Surrey. The precise limits of the new area we do not know, but it would cover 964 square miles. Its great extent will be indicated by the fact that the present Metropolitan Police area covers only 691 square miles, and the Water Board area 559 square miles. The new authority would be made up of members representing the various counties and boroughs concerned. It would have power to take over any existing authorised distribution, but it is not proposed that either company or municipal rights shall be compulsorily acquired. The rights now possessed by the London County Council and the extra-London local authorities for the purchase of existing undertakings would pass to the new authority, which would have power to acquire by agreement or take on lease the undertakings of any company or companies, or any local authority or authorities, in the new area. The London Electric Supply Acts of 1908 and 1910 would, when necessary, be modified to enable existing company undertakings to be taken over by agreement before 1931. The new authority would have power to build generating-stations, lay mains, &c.

It is of the first importance to realise that the suggested scheme is in no way comparable with that which resulted in the formation of the Metropolitan Water Board. Nothing is to be taken over by compulsion, and, as a result, it is hoped that the authority will be enabled to start work with no burden of dead capital to hamper its freedom. The essential idea is of a body having some powers and control over the electric supply of the whole of the new Greater London area, which shall be enabled to work towards a unification of supply methods, and an ultimate ideal which will cover the generation of all electricity in riverside stations outside London proper. It is clear that an authority of this class may have difficulty in obtaining the co-operation of existing undertakers, either company or municipal, and to partly meet this difficulty it is proposed that the authority shall have certain general powers of approval in regard to extensions of existing undertakings. It is also proposed that authorised distributors in the area of supply shall be required to take from the new undertaking any additional power they may require, subject to it being shown to the satisfaction of the Board of Trade that it would be more profitable for them to do this than to extend their own plants. Further, any extensions of generating-stations or distributing networks allowed by the Board of Trade should, as far as that Board considers practicable, be carried out in accordance with the standard and unifying scheme of the new authority.

These various proposals are of a novel nature, and the likelihood of an authority of such limited powers being able to carry out any important modifications in the general technical methods of London's electricity supply in anything like a reasonable time is a question that will stand much discussion. The Special Committee's recommendations, however, cover matters of an even more novel character than anything we have yet dealt with. It is proposed that the new authority shall delegate its powers to a public company which shall construct the necessary works and operate the undertaking for a term of fifty years. The capital would be provided in part by the authority and in part by the company, and the authority's position would be safeguarded by it being given power to take over the undertaking at the end of the term of contract on payment to the company of a sum equal to the capital provided by it. The authority would also have power to take over the undertaking in the event of the company failing to fulfil its statutory or contract obligations. The rights of the authority would further be safe guarded by a permanent technical committee appointed, and, as far as we understand it, paid by the authority. This committee, it is proposed, might consist of the chairman of the authority, the engineer of the authority, the financial adviser to the authority, and an outside member appointed by the Board of Trade. The committee would consider and report on all matters connected with the establishment and working of the undertaking on which the decision of the authority was required, and in particular would approve designs, technical arrangements, and contracts made by the company, approve arrangements made for repairs and maintenance, and would exercise, on behalf of the authority, such powers vested in the authority under the scheme as would appear desirable.

The general lines of this ambitious scheme appear to us fairly sound, but its success in practice would depend on many things. As we have already hinted, it is doubtful if the powers proposed to be given to the new authority would be complete enough to enable it to carry on its work on a scale sufficiently large to justify its creation. The greatest trouble is likely to arise with the local authorities, and it is beyond question that many of them would do all in their power to avoid the absorption of their electricity departments in the new authority. Many of their undertakings are carried on with great technical merit, and it will frequently be no easy problem to demonstrate that they could buy bulk supply at a lower cost than they could increase their own output. Sir John Snell, in his presidential address to the Institution of Electrical Engineers

on the 29th ult., had some very pertinent remarks to make in this connection. He was not referring to the London County Council scheme, but dealing with the matter generally. He stated that "once a small station is built, and the expenditure has been incurred, then, and so long as the system is kept within definite limits of extension, the extra operating cost of an addition to the local power-station is often cheaper than any commercially feasible bulk supply." At the present time, however, it is impossible to pursue this aspect of the discussion. One is too much in the dark. The London County Council scheme has been brought forward without any detail figures of any kind. Sir John Snell says that often bulk supplies will not pay, but, *audi alteram partem*, Messrs. Merz and McLellan say that, were they in the hands of one authority, it would pay to shut down all the existing generating stations in the central area, sell most of the plant, and generate all energy on sites down the river. If this were done, the saving in working costs would be not less than 18 per cent., or about 170,000*l.* a year, after allowing for all capital charges on the new plant and mains, and, in conjunction with the present sinking funds, would enable the existing generating plant to be written off by 1931.

This technical question apart, however, it will be matter for amazement if many of the local authorities do not do all in their power to keep outside the scheme. An amendment to allow any Metropolitan borough which wished to stand aside was proposed at the meeting of the Council on Tuesday, but was defeated. So far so good, but it is in a Parliamentary Committee-room that this matter has to be finally decided. The question of the existing companies should, on the whole, prove a simpler one. It would appear reasonable that the new operating company should represent these companies. The matter is one for private arrangement, of course; but clearly, the companies at present in possession and with a local standing and experience in London electricity supply should, if possible, be allowed to carry on their work under the new arrangement. The financial and technical reputation of these companies is such that, if willing, they should have no difficulty in putting forward a satisfactory claim to undertake the work. We have no doubt that *pourparlers* have already taken place between the Special Committee and some of these companies, and trust that some satisfactory proposals will come to light when the matter reaches a Parliamentary stage. It must be remembered that while the new authority will have power to take over existing companies, it will have no right to do so, and clearly a mutual arrangement, by which some of the stronger companies would form the new operating company, would probably result in the authority being enabled to take over some of the existing organisations from the first, and so get a fair start in its great unifying task.

On the general question of ownership by a public body and operation by a company the Council's proposals have all our support. It is pretty clear by this time of day that no pure company arrangement is going to be allowed in London, and the new proposals are a wise compromise. Up to the present they have been received very quietly by the municipal interests, and, although we fear that important opposition is likely to appear later, there seems at least a chance that the matter may go through. The arrangement will allow the municipal traders to remember all the time that the electrical scheme is really a publicly-owned one, while at the same time their opponents will realise that they are getting the advantages of the greater freedom and initiative which company management allows. The standing of the scheme is enhanced by the fact that somewhat similar arrangements are in operation in connection with the electricity supply of some of the large towns of the Continent, while an even closer parallel is furnished by some of the Indian railways which are built and managed by companies for the Government. An interesting question of detail, into which we are hardly able to enter now, is the relation which will exist between the Technical Committee and the company. Unless the Committee's rights and duties are very carefully specified, a pedantic or officious member might so hamper the company's operations as to seriously reduce the possibilities of progress, which form the main argument for introducing the company at all.

This is a matter which the company's representatives may be expected to keep well in mind when the clauses of the Bill are reaching their final form. It cannot well be commented on in detail until more information is available.

EXPLOSIONS IN MINES.

The Sixth Report, presented by the Explosions in Mines Committee to the Home Secretary last week, deals with various new researches conducted in the experimental galleries at Eskmeals. The fifth report* had seemed to demonstrate that a mixture of equal parts by weight of coal and of incombustible stone-dust could not be ignited by a charge of 24 oz. of blasting-powder fired from a stemmed cannon, provided the mine atmosphere did not contain any combustible gas. It remained to be seen what proportion of combustible gas present in the air would render the mixture ignitible. For this purpose experiments have been conducted with fire-damp from the Cymmer Colliery, and also with coal-gas, which has often to be used in laboratory tests. It soon became evident, as expected, that the kinds of gas behaved differently, though similarly. The composition of the two gases—A the coal-gas, B the Cymmer fire-damp—were the following :—

	A.	B.
	Per Cent., by Volume.	
Carbon dioxide	0.10	0.90
Ethylene hydrocarbons ...	3.75	0.20
Carbon monoxide	5.95	0.20
Hydrogen	52.75	Nil
Methane	30.65	96.40
Ethane	3.40	Nil
Nitrogen (by difference) ...	3.40	2.30

Thus the fire-damp was nearly pure methane, free from hydrogen and ethane, and almost so from ethylene; and it was, indeed, found much "milder" in its explosive effects than the coal-gas, which was rich in hydrogen. Mixtures of either of the two gases with air in different proportions were drawn through the fan into the big gallery. Immediately before firing the cannon a valve leading to the return was closed, so that the firing took place in the still atmosphere of a gallery closed at one end. The gun was placed 50 ft. from the closed end, and pointed into a tube, 3 ft. in diameter, 10 ft. long, open at both ends, in which 30 lb. of the mixture of coal-dust and stone-dust (1 : 1) were strewn. The dust-mixture also covered shelves and the gallery floor for a distance of 150 ft. beyond the tube, and an opening was made in the gallery-tube (7½ ft. in diameter) at the end of this length by taking out a plate. Experiments were also made in the 3-ft. gallery.

With coal-gas it was found that the presence of 2.5 per cent. of this gas allowed the flame to travel throughout the gallery; with 2.3 per cent. of gas the flame-length did not exceed 40 ft. When fire-damp was used, the respective percentages were 4.6 and 4.5; less than 4.5 per cent. of fire-damp in the air did not lengthen the cannon flame appreciably. The lower limit of inflammability of methane in dust-free air had previously been found to be 5.6 per cent.; a little combustible dust in the air suffices, however, to render a 4.6 per cent. methane-air mixture explosive. The general conclusion is that the presence of methane does not diminish the protective effect of incombustible dust to any notable extent, although it facilitates the inflammation of pure coal-dust.

The second question investigated was the watering of coal-dust. Watering of coal-dust is probably the oldest remedy tried, and the United States Geological Survey has, in recent experiments,† found that dust from a bituminous coal containing 35 per cent. of coal and 5 per cent. of ash would not propagate a flame if the moisture content reached 30 per cent. The Eskmeals experiments are in accord with this conclusion. The general arrangements were as just described, but in the experiments in which both stone and moisture were applied to render the coal-dust incombustible fullers' earth (as before) and also shale-dust from Altofts were used. In mixtures containing not more than 10 or 15 per cent. of stone-dust, the nature of the stone-dust was immaterial with respect to the amount of water required to secure incombustibility; in richer mixtures shale-dust proved preferable to fullers' earth, because the shale binds the water better. Roughly, it may be said that a mixture containing 15 per cent. of stone-dust (which would still be ignitible, as 50 per cent. of stone-dust is needed to render the mixture incombustible) should further contain 25 or 30 per cent. of water to attain the desired result.

Much depends, of course, upon the way in which the coal is wetted, and the Eskmeals experiments are instructive in this respect. When the dust and water were worked into a paste outside and then spread in the gallery, 30 per cent. of water (without stone-dust) was sufficient. That process would be too laborious, however. The ordinary spraying by jets and roses required an excess of water, because the water collects in pools in some places, and leaves heaps of splashed-up, relatively dry coal-dust in others. The "atomiser" sprays, producing a fine mist of water, answer better, and coal-dust damped in this way with an equal amount of water proved no longer capable of propagating a flame beyond a limited distance. When the coal-dust in the cannon tube was itself watered, less water was needed to make the dust beyond incombustible. In some of these experiments the explosion was started in the small 3-ft. gallery, and the flame was allowed to travel into the large gallery. Here again a coal-gas charge in the atmosphere gave a more violent explosion than a charge of fire-damp, evidently because the hydrogen explosion stirred up more dust than the methane explosion. It is for this reason, because properly-applied water prevents the stirring up of coal-dust better than stone-dust, that water sprays are, on the whole, more effective than stone-dust protection. The Committee points out, however, that limited zones of stone-dust, or of watering, should not be relied upon; in the general interest of safety all coal-dust should be treated, lest the untreated dust in interzonal spaces should become ignited. An average of 30 per cent. of moisture, maintained in a gallery by alternate zones or patches of wet and half-wet dust, should not be trusted.

The comparative values of various incombustible dusts have also been investigated. The materials were: — Fullers' earth, substitutes for fullers' earth, pulverised shale, dolomite dust (superfine), oolitic dust (containing 97 per cent. of calcium carbonate), Chance mud-lime, and sand. Between 80 and 90 per cent. of all the materials (except the sand) would pass through a 200 by 200 sieve. It was found that the nature of the material made little difference. Three of the materials mentioned are practically carbonates, and it has been claimed by some investigators that the liberation of carbon dioxide would help to stifle the flame. This is improbable, since the carbonates in question require fairly high temperatures for their decomposition. The case is different with sodium bicarbonate, which readily gives off its carbon dioxide and also its water; but that material is out of question, of course. The degree of fineness of the material is of importance, however, and the finer the dust the more effective it will prove. The Committee reports that the dust used for covering the roadways should contain not less than 50 per cent. by weight of fine material capable of passing a 200 by 200 sieve.

Finally, the Committee studied the effect of a diminished oxygen percentage in the air on the explosions of fire-damp and coal-dust. It will be remembered that Harger* and others proposed that the oxygen percentage of the air in mines might, by the addition of waste gases from boiler flues, be reduced and the percentage of carbon dioxide be increased to such an extent that the fire-damp and coal-dust could no longer be inflamed. The experiments conducted at Eskmeals do not favour this suggestion, which in any case, we think, would be too risky to adopt. When the oxygen contents of the air were, at Eskmeals, gradually reduced from 20.9 to 13.5 per cent., the lower limit of the inflammability rose from 5.6 to 6.5 per cent. of methane, and the corresponding upper limit fell from 14.8 to 6.8 per cent.; the two limits thus approached one another. When the oxygen percentage fell to 13.2, no methane mixture was capable of propagating a flame. But no man or animal could live in such an impoverished atmosphere, and when the oxygen percentage was 17—the figure which has been proposed as still admitting of practical work in mines—mixtures containing from 5.8 to 10.5 per cent. of methane remained explosive. Very little, if anything, would thus be gained by impoverishing the air to that extent. As regards coal-dust, explo-

* See Engineering, vol. xcvi., page 861.
† *Ibid.*, vol. xcvi., page 861.

* See Engineering, vol. xciii., page 812.

sion tests were made in bombs. The dust explosions failed when the oxygen percentage fell below 17.1 per cent.; but when 2 per cent. of methane was further present, a little more than 16 per cent. of oxygen would still render inflammability possible.

In their final conclusions the Committee recommend:—(1) The maintenance throughout the roads of such a proportion of incombustible dust in a state of fine division as would make a mixture yielding on incineration at least 50 per cent. of ash [that the 1 : 1 mixture is to be understood in this sense had been explained by the Committee and by us on former occasions]; or (2) the maintenance of at least 30 per cent. of water in a state of intimate mixture with the dust throughout the roads; or (3) a combination of the two previous methods —*i.e.*, the treatment of the roads first with incombustible dusts and then with water.

The next problem again to be attacked is the question of possible danger to the health of the workers by the sprinkling of dust. The first report dealt with that question, and it had been stated that the dust of argillaceous shale is innocuous, whilst gritty dust should not be used. Dr. Haldane will further study the problem.

ALUMINIUM APPLICATIONS.

It seems but a few years ago, although we fear it is twenty or more, since aluminium in the metallic state was little more than a laboratory curiosity. Twenty years in a man's life is a longish period, but in the history of mechanical progress it is no more than a little while. In that twenty years aluminium has advanced from the position of a metal practically unknown to the general public and the engineering world, costing, say, a shilling an ounce, to one of the common metals of commerce, employed in practically all engineering and allied trades, and costing something less than a twelfth of the earlier price. These things, as most people know, have been made possible by the development of electrolytic reduction, and by production on a very large scale. This latter condition has naturally had to come gradually, but its advent has been hastened by an able educative campaign undertaken for the most part by the aluminium interests.

Although, as we have said, aluminium is now employed to a greater or less extent in almost all engineering and allied trades, it is doubtful if the full extent and variety of its applications is generally realised. The average engineer, giving the matter brief consideration, would probably first think of aluminium in connection with the various developments of the petrol-engine, following this up possibly by recollecting that it is also employed for the construction of cooking utensils. These are important applications, particularly the former, but they make a poor list of the manufactures in which aluminium is very directly concerned. The petrol-engine in its various manifestations accounts for much aluminium; but, even when reinforced by the domestic kettle, it is hardly able to account for the 60,000 or so tons of the material which are produced every year. We do not know that anyone is in a position to give a complete list of aluminium applications—certainly we are not—but to our petrol-engines and kettles must certainly be added motor-car fittings, panels, and tread-plates; brewers' tuns, tanks, and wagons; evaporators, condensers, stills, &c., for sugar-refining, soap and candle manufacture, dyeing, &c.; nitrating pans for explosive manufacture; vessels of various kinds for varnish-making; electric transmission lines, insulated cables, busbars, &c.; gas-fittings, pulleys, railway-coach panels, door-handles, finger-plates, &c.; collecting cups and coagulating trays for the rubber industry; magnet-coils for motors; vulcanising moulds; foil for wrapping tobacco, &c.; and granules for deoxidising iron and steel.

In spite, however, of the extensive field which aluminium can and is helping to cover, we think it has hardly yet made its way into the ordinary engineering workshop. It is still largely in specialised hands. There are many exceptions, of course, but in a general way the average engineer who may know all about the manipulation of mild steel, brass and copper, is not practised in aluminium, and, as a consequence, is apt to neglect to employ it when he might with advantage do so. This state of affairs is natural enough with a new material, and will probably disappear. There is no reason why, for instance, the foundry of a general engineering shop should not produce aluminium castings in the same way that it now produces those of the copper alloys. For quite a number of purposes the aluminium would be just as good and cheaper. If this sort of thing is to become general, the foundry-men will want a little training in the new material, but there is nothing in the matter to prevent general success. The metal may well be cast in any ordinary foundry if a few simple precautions are observed. It is best cast in green sand lightly rammed. Vertical risers and ample-sized gates are required, and the moulds should be faced with plumbago or French chalk. Melting is one of the most important points. The metal is easily overheated, and care is required. The melting temperature is 1160 deg. Fahr., and should never be much exceeded. Pouring should be carried out at as low a temperature as possible.

We are not sure that the employment of aluminium in ordinary and everyday shops has not been hampered by the very large number of proprietary mixtures which have been evolved. This has tended to give an air of mystery to the business. Mr. William Smith, after a little experience with aluminium, launches a new mixture under a fancy name. He calls it possibly "Smithalium," and does not fail to add something to the price to cover the brainwork involved in the thinking of the name. The mixture may be a perfectly satisfactory one, but when all is said and done it is open to anyone to buy a bit and analyse it if he wants to know what is in it, and it is always possible to make dozens of other satisfactory mixtures in the same way. The manager of the ordinary and everyday shop, however, usually has neither the facilities nor the time to analyse other people's aluminium mixtures, and the galaxy of fancy names he encounters in connection with the matter suggests that the subject is rather a complicated one, and that on the whole it had, perhaps, better be left alone, the truth of the matter all the time being that there is no reason why aluminium should not be employed in an ordinary way just as yellow-brass and gun-metal are.

All this is not to say that none of the proprietary alloys are of special value. This is far from being the case. Our point is that the thing has been ridiculously overdone. The whole subject of the aluminium alloys is such a vast one, as is clearly shown by the work of the Alloys Research Committee of the Institution of Mechanical Engineers, that the discovery of specially valuable alloys, either by accident or by private research, is always possible. Many important proprietary alloys have been produced. The question is, moreover, not always merely one of mixture, and many alloys cannot be reproduced simply after analysis of a sample. The properties frequently depend on the working the metal receives during manufacture and the method of mixing, as well as on the content. We believe, for instance, that this applies to Duralumin.

In some of the applications we have mentioned, aluminium does not appear to be making the rapid progress which its advantages would apparently render natural. Thus for low-tension electric cables, particularly those of large section, a quite definite case can be made out for its employment. There are a number of important installations in existence, among which we may mention that of the Paris General Omnibus Company, which covers cables containing over 650 tons of the metal, and yet on the whole the material certainly does not occupy the position which might be expected. This, presumably, is a condition which will gradually alter, but there is little doubt that in many cases copper cables are now being installed where important saving might be made by employing the rival metal. The matter can only be explained partly by ignorance, or rather insufficient appreciation, of the relative advantages of copper and aluminium by many engineers, and partly by a natural opposition from the copper-refiners and wire-drawers. There is probably also a certain opposition from some of the cable manufacturers, since, although it might be supposed to be a matter of indifference to them whether the cables they produce have cores of copper or aluminium, it is clear that the supply of a cheaper aluminium cable will cut down their turnover, while some changes will be necessary in their standards, and possibly in their shop methods. Bare overhead transmission lines are also an example of an application in which, at least in this country, the metal does not occupy the position which it deservedly might.

An interesting and important field for the employment of aluminium has arisen in connection with panelling for motor-cars and side-cars. A large and increasing business is, we understand, being done by the aluminium companies in this way. The panels are easily shaped on a block with a wooden mallet, and smoothed with a planishing hammer, and take paint well. Such panels are also used to a considerable extent for railway stock. In cases where weight-saving is of much importance, as, for instance, on electric railways where a high acceleration is used, very important economies may result from their use. It will be remembered that a good case for this application was made by Mr. H. E. O'Brien in a paper read before the Institution of Electrical Engineers in March last, in which he described the methods of saving weight which had been employed for the electric stock of the Lancashire and Yorkshire Railway Company.

Another recent application of aluminium sheet is in connection with the construction of vats, tanks, tuns, &c., for various chemical processes. Vessels of this material seem to have special advantages for some of the operations of brewing, varnish-making, &c. Such tanks are generally made from sheet, joined by autogenous welding and without the use of rivets. They can be made of quite large dimensions. For smaller vessels, such as cooking utensils, latex-cups, &c., press tool methods are used. Kettle-spouts and similar irregular items it is usual to form in two parts by dies, and afterwards to join them by autogenous welding. The spouts are secured to the kettles in the same way. This class of domestic ware does not seem to be made to any great extent in this country, our supplies mostly coming from the Continent. In a recent White Paper issued by the Commercial Intelligence Branch of the Board of Trade a figure of 25,800*l.* is given as the annual value of aluminium articles exported from Germany to this country. The nature of the articles is not specified, but the figure does not include crude aluminium, sheets, bars, wire, castings, &c., and it is probable that it largely represents material of the class we are dealing with. As has been said so often in other connections, the present should be a favourable time for our manufacturers to get some of this trade into their own hands.

NOTES.

German Industries.

German industries are feeling the effects of the war more keenly as time goes on, owing to the cessation of all exports, the diminished home demand and, for those special branches which, through war requirements, otherwise might be kept well employed, the shortage of skilled labour and the rise in prices and scarcity of certain raw materials. Reduced output and a material reduction in the number of employees are the order of the day; thus, the production of coal has gone down 50 per cent. compared with the corresponding period last year. Unemployment is on the increase, and much disappointment is being experienced because no public funds have been voted under this head, although the Diet the other day, amongst other big grants, voted 400,000,000 marks for the aid of sufferers from the war in East Prussia. Apprehensions as to the future have already shown their very pronounced effect in the direction of dividends recently declared by large industrial concerns for the last financial year. Several have found it advisable to reduce their dividends as much as 10 per cent. below last year's, amongst them some large firms in the iron and mining industry; the greatest disappointment has perhaps been caused by the Allgemeine Elektricitäts Gesellschaft stepping down from 14 to 8 per cent., 10 per cent. having been reckoned upon in any case. Germany and Austria, naturally, are exerting themselves to substitute home-made plant for such as has formerly been imported from Britain. Thus, the Government some time ago made a request to German manufacturers of spinning and weaving machinery to go in for the manufacture of such specialities, which, before the war, were imported from Britain. This advice, it would seem, has already borne fruit; thus some large engineering firms in Alsace and elsewhere are said to be already making machines for fine yarn, which compensate for the British machinery

now used. Some of the Chemnitz manufacturers are understood to be turning out satisfactory plant for flax, hemp, and jute spinning, &c. The Königs and Laurahütte is another example of how seriously the war affects industrial concerns in Germany. The dividend for the year 1913-14 has been fixed at only 4 per cent., against 8 per cent. for the previous year. The profits certainly were somewhat smaller (3,553,828 marks, against 4,854,058 marks); but it transpires from the report that it is chiefly concern for the future which has influenced the dividend. About 33 per cent. of the hands and staff are engaged in the war, the railway service is out of gear, bad debts may be expected, and the Polish iron works of the company had to be stopped almost directly the war broke out, without any prospects of re-opening.

Naval Engineers and the War.

It was particularly gratifying to find in the official despatches regarding the engagement of the British and German ships off Heligoland on Friday, August 28, commendation, implied and expressed, regarding the splendid work done by the naval engineers of the Fleet. One of the outstanding features of the engagement, as well as of that led later by the Undaunted, was the great speed maintained by the ships. Reading between the lines, too, one could realise the quick changes involved in the manipulation of the machinery for tactical reasons. Without in any way disparaging the splendid work of the military officers, and in particular those behind the guns, it is obvious from the despatches that the engine-room staffs did magnificent service. We find, indeed, that the names of several engineering officers have been specially mentioned in the various despatches, along with others of military rank, obviously so that their services would be recognised by promotion or otherwise. Amongst these is Engineer-Lieut.-Commander Charles de F. Messervy, of the Fearless, who, with the carpenter, "displayed great resource and energy in effecting repairs to Fearless after returning to harbour;" Engineer-Lieut.-Commander Alex. Hill, of the Laertes, "for repairing steering-gear and engines under fire;" Engineer-Lieut.-Commander Edward H. T. Meeson, "who behaved with great coolness during the action, and steamed the ship out of action, although she had been very severely damaged by explosion of her lyddite, by which the after funnel was nearly demolished," and who "subsequently assisted to carry out the repairs to the vessel;" Engineer-Lieut.-Commander Frank A. Butler, "who showed much resource in effecting repairs during the action." Several engine-room artificers, chief stokers, stokers, and petty officers are also mentioned in the despatches. We have delayed referring to the honourable records of these officers in the official despatches in the hope that we should be able to refer at the same time to some recognition of their services by the award of decorations or by promotions. It is with some surprise and considerable regret that we now find that although twelve of the fifteen surviving military officers, including warrant and chief warrant officers, have received such recognition, no mention has so far been made of any honour or promotion for engineer officers. On the other hand, eleven members of the ordinary ratings of the engine-room complement have received the distinguished service medal. We hope that this is only a case of delay rather than of neglect, because there is no need to enforce, even to the layman, the fact that service in the machinery department of a ship during action calls for the same resource and precision, and equal, if not greater, heroism than that so brilliantly exemplified by the navigating and gunnery officers on the deck.

German Chemical Industries and the War.

The Italian journal *L'Industria* gives publicity to an article by Professor Otto N. Witt in the *Chemiker Zeitung*, on the situation of the German chemical industries created by the war. From this article we take the following notes:—The first effects of the war were to remove the technical and managing staffs from the various factories and to prevent exports. Passing in review the various branches of the chemical industries, Professor Witt states that the makers of sulphuric acid will not be able to procure pyrites from Spain and Portugal when existing stocks are exhausted; he calls attention to Norwegian pyrites, and adds that it may be possible to revert to the utilisation of Italian sulphur. Grave preoccupations rule in regard to the preparation of nitric acid, which plays an important part in the manufacture of modern explosives, and for which Peruvian nitrates are required; this latter mineral cannot now be imported through German ports. For this reason the existing stocks of nitrates in Germany, which were destined to be used for manure, are to be kept for use by the chemical factories, and to be replaced for agricultural purposes by ammonium sulphate, the production of which is abundant. There is in Germany a lack of mercury, copper, chromium, and nickel. With regard to this latter metal, since it is not possible to obtain it at the present time from New Caledonia, nor from Canada and the United States, it is proposed to take in hand afresh the treatment of the poor deposits of Hungary and Upper Italy. The aluminium industry, which is based on the utilisation of the French bauxites, will now be compelled to work another clay found in Dalmatia; this, however, is of a somewhat different composition, and will require a different treatment. There is a superabundance of alcohol; the decrease in consumption for industrial purposes renders available for food purposes the grain and potatoes which otherwise would be taken up by the distilleries. The residues of sugar beets form an abundant source for the production of alcohol, and this can be increased by the utilisation of sawdust. The distillation of lignites, which for many years suffered a heavy competition, will now increase in activity, owing to the prevention of imports of benzene, petroleum, lubricants, and paraffin into Germany. In regard to benzol, toluol, phenol, naphthalene, and anthracene, the situation is different now from what it was in 1870, when Germany imported these products from Great Britain. The German industry of artificial dyes is now so strongly established that it need fear no competition; the output may be reduced by half, owing to the cancelling of exports to the belligerent nations, but the chief sufferers will be the dyeing works of those nations who have no other source of supply apart from Germany. On the other hand, Germany will suffer through lack of textile goods, cotton, wool, and jute. The soap works will have a lack of coco-nut and palm oil and tallow, and the chief anxiety under this head will be the decrease in the output of glycerine required for dynamite manufacture. Great stress is laid by Professor Witt on the prevention of exports from Germany to the South African gold-mines of the cyanides required for gold-extraction.

THE LATE MR. EDWARD BAYZAND ELLINGTON.

We record with very great regret the sudden death, on the 10th inst., at his residence, 73, Addison-road, Kensington, of Mr. Edward Bayzand Ellington, M. Inst. C.E., M.I. Mech. E., at the age of sixty-nine. Mr. Ellington was a Past-President of the Institution of Mechanical Engineers. We propose to publish a memoir of the deceased in our next issue.

Electricity on Steamships.—The Scottish local section of the Institution of Electrical Engineers held their opening meeting for the current session on Tuesday evening, the 10th inst., when Mr. James Lowson, of Messrs. W. C. Martin and Co., delivered the inaugural address as chairman, taking for his subject "Electrical Equipment of Steamships." Mr. Lowson gave an interesting *résumé* of the application of electricity to shipwork during the past thirty-four years, and thereafter gave a detailed description of the electrical equipment of the Aquitania.

Telegraph Working. — The dividend upon the ordinary shares of the Western Telegraph Company, Limited, for 1913-14 has been fixed at 7 per cent. per annum, 160,000*l.* being transferred to the general reserve fund, 30,000*l.* to the land and buildings' depreciation fund, and 130,000*l.* to the provision for investment fluctuations' fund, a balance of 33,157*l.* being carried forward. The cost of the cables, land lines, stations, ships, and investments in other companies stood in the company's books at the close of June, 1914, at 3,109,202*l.*, 300,000*l.* being written off reserve-fund investments to provide for continued depreciation of securities. The reserves stood at the close of June, 1914, at 2,017,232*l.*—viz., general reserve, 1,697,063*l.*; maintenance ships' fund, 59,160*l.*; marine insurance fund, 75,000*l.*; land and buildings' depreciation fund, 185,000*l.*; and guarantee fund, 1009*l.* Spare cable held by the company at the close of June, 1914, was valued at 85,842*l.* In the course of the six months ending June, 1914, 3621*l.* was charged to the general reserve fund for loss sustained upon the sale and redemption of investments, and 52,643*l.* was also charged to the same fund for the partial renewal of the Pernambuco, Bahia, and Rio de Janeiro No. 2 cable.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. XI.

By Frederick William Lanchester, M. Inst. C.E.

Aircraft in Naval Warfare.

The position of aircraft in connection with naval warfare requires to be studied almost as an independent problem, since many of the circumstances and conditions are different from those which obtain on land. Altogether apart from the constructional features of the machine itself, which, in the case particularly of the aeroplane, are considerable, the questions that arise in the matter of attack and defence are so entirely modified, at least so far as affected by the primary function of the arm, as to affect fundamentally the question of armament. Thus gun-fire, except as against hostile aircraft, ceases to have any appreciable value; no gun that can, or could, be mounted in any aeroplane or dirigible at present built, or contemplated, would be of the least service directed against the smallest unit of the enemy's navy. Again, when we consider the duties of reconnaissance, we are faced with totally altered conditions. In the case of the aeroplane, so long as we are confined to bases situated on or near the coast, the area that can be reconnoitred is limited to a distance of some 300 or 400 miles (possibly 500 miles) from the coast-line, this being at present an altogether outside estimate. Since we commonly have to regard our frontier as being the limit of the enemy's territorial waters, it is clear that any such restriction is to be considered inadmissible. In the case of the large airship, especially the rigid type, the range or radius of action is usually taken to be considerably greater, possibly some 1000 miles as an extreme. If we admit this (crediting the machine with considerably more reliability than it has at present shown), we are still faced with the fact that such a machine cannot operate with safety in the presence of, or within the zone patrolled by, the enemy's aeroplanes.

So far as the scouting aeroplane is concerned, the obvious solution to the difficulty is the provision of a floating aeroplane base, capable of accompanying, or acting in co-operation with, the fleet on the high seas, or of acting independently if required. Various schemes in this direction have been proposed; the possibilities seem to lie between a "mother-ship" adapted to take on board the necessary complement of aeroplanes (or "seaplanes," as they are frequently termed when fitted with floats), and to fulfil the functions of storage, transport, and supply; and a more thoroughgoing scheme in which the floating base takes the form of a specialised vessel with a clear deck of sufficient area to permit of machines being launched or alighting without entering the water at all. In the former scheme the normal condition would be that the machines are lowered into the water from which they require to rise, and on which, in due course, they alight. In the latter the machines are not presumed to enter the water at all, any immersion is by way of being an accident, for which eventuality, however, the machines would be adapted by being furnished with floats in addition to the ordinary landing gear. To be effective a quite special design of vessel would be necessary, with a completely clear and flush upper deck. In order to obtain the requisite area it would probably be necessary to design something comparable in tonnage to one of the largest of our existing battle-cruisers, and in particular the maximum beam possible should be provided. A closer study of this problem will be given in a later article.

The Armament of the Naval Aeroplane.

Dealing for the time being entirely with the primary function of the Aeronautical Arm in the service of the Navy, we have already pointed out that the gun, whether the machine-gun or the one-pounder, is of no value whatever. Hence, if the aeroplane or the airship is to possess any power of offence at all against the ships of the enemy, it must be sought elsewhere. A great deal has been said on the subject of bomb-dropping as a means of attack on armoured ships, but it is not as well recognised as it should be how comparatively impotent a bomb, even charged with a high explosive, may be when used without "tamping" against armour-plate. It is quite true that a certain amount of mischief would be wrought by a bomb of large size if successfully dropped on to the deck of a battleship or cruiser, and the effect would certainly be more

disagreeable still if the recipient were a destroyer or some still smaller craft. The effect, however, would in no degree be comparable to that of a torpedo, where the inertia of the surrounding water plays an important *rôle*. It would, in any case, take a vast number of hits to put a first-class battleship or cruiser out of action. Further, the difficulties of aim, as pointed out in the preceding article, are considerable, and with the counter-aircraft armament with which warships are now being fitted, it will not, generally speaking, be possible for an aeroplane to descend to close quarters with impunity. The dropping of bombs from an airship is a matter of somewhat less difficulty; moreover, the bombs employed may themselves be of really formidable dimensions; but here the writer is of opinion that an airship will not in the future be able to approach a warship of any kind by daylight without certain destruction, and it will be little or no better off by night.

Some experiments reported recently as having been made in Germany appear to indicate a direction in which aircraft may become an actual source of danger to even the most formidable battleship or cruiser. It is said that a Zeppelin has recently been fitted with means of discharging a Whitehead torpedo with complete success. We may presume that the airship is brought down close to the sea-level, and then fires the torpedo, just as is done from the deck-tube of a torpedo-boat. In view of the great range of the modern torpedo—at the present day over 2 miles—this form of attack cannot be ignored. It is evident that what is possible to the airship in this direction is also possible to the aeroplane, provided that the latter be built of sufficient carrying capacity; and whereas the airship would find it difficult to approach a battleship or cruiser within 2 miles without detection and destruction, the aeroplane would rarely find this either difficult or dangerous; the matter is mainly one of choosing the proper time and direction of attack. In the haze of the early morning, or in the dusk after sunset, an aeroplane at the distance in question is quite invisible; or, again, it is frequently possible for an aeroplane to approach in broad daylight against a landscape background without being observed, especially if assisted by suitable protective colouring; much depends also upon the direction of the sun's rays. Night attack would also in many instances be possible, although the absence of light may be a greater hindrance than help to the aeronaut; added to this there is the not inconsiderable risk of being located by searchlight. The aeroplane for the duty in question will need to be somewhat larger and of greater carrying capacity than the present standard; for example, the modern 21-in. torpedo weighs approximately 1 ton, and would require a machine of about 4 tons gross lifting power. The older model, the 18-in. weapon, weighs about 12 cwt., and would require a machine with a gross lifting-power of 2½ tons, the latter being not very much in excess of the largest machines already in service.

It might be thought, considering the matter superficially, that the dropping of one-quarter of the gross weight of a machine whilst in flight would be a dangerous and risky business. But closer investigation shows that this is not the case; the disturbance that will result is one that can be quite easily rectified by the pilot. In the case of the modern machine, whose flight path is stable (the *dynamically-stable* machine), and which is said to be—and undoubtedly is—capable of flying itself, the disturbance that will take place on the release of the torpedo is well within the permissible limit. The only condition that requires to be observed is that the centre of gravity of the machine shall not be thrown forward or backward by the discharge; in other words, the centre of gravity of the torpedo, as carried, must be approximately in the same vertical line as that of the machine. If this condition is complied with, the resulting disturbance, assuming the torpedo as constituting one-quarter of the gross weight, is shown by the diagram, Fig. 15. The torpedo being dropped at point p_1, the path of flight $p_1 p_2$ becomes undulatory, the undulations dying out, as indicated in the figure, at a rate depending upon the degree of dynamic stability provided. The extent of the initial undulation is correctly represented to scale in the figure, and is the same as would be produced in a 70-mile-an-hour machine by an adverse wind gust of 10 miles per hour, a thing of everyday occurrence. The path of the torpedo is indicated by the dotted line $p_1 p_3$. It is even possible to diminish the disturbance still further by arranging the torpedo somewhat behind the position above assumed, so that on discharge the centre of gravity moves forward. This would in some degree compensate for the loss of weight as giving a less net change in the natural velocity. In the opinion of the writer, however, it is not to be recommended, since it would result in the machine (prior to the discharge of the torpedo) being catastrophically unstable, or would at least tend in that direction.

Fig. 15.

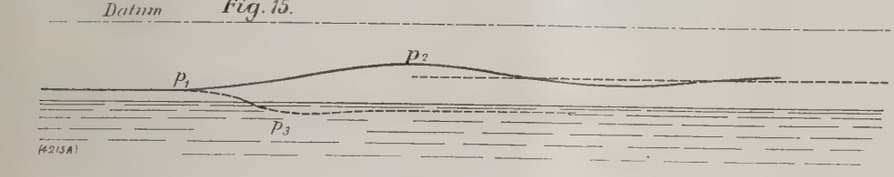


Fig. 16.

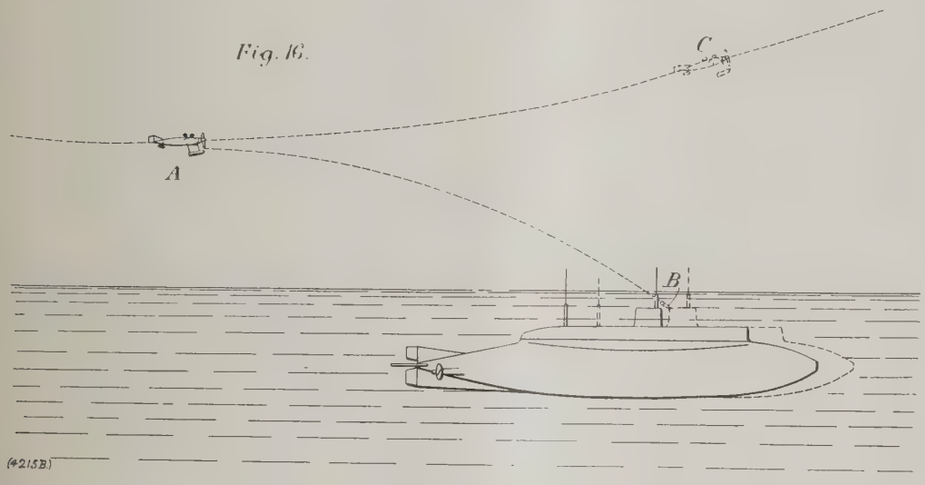


Fig. 17.

Aeroplane and Submarine.

It is well known that the submarine, although when submerged invisible to an observer or "look-out" on the deck of a warship or other vessel, is clearly visible, and may be readily located by an aeronaut from a sufficient altitude. The conditions are similar to those frequently noticed when fish in a river are seen clearly from a bridge, but are invisible from the river-bank. The torpedo-boat or destroyer when operating against the submarine is at a considerable disadvantage, inasmuch as when the latter is submerged the only visible sign of its presence is its periscope—a pole of a few inches in diameter, projecting some 8 ft. or 10 ft. out of the water. Ordinarily it is the point where the periscope "rips" the surface that forms the most conspicuous visible indication. Thus we may anticipate that in the future operations directed against the submarines of an enemy will involve the employment of aircraft, at least as a means of reconnaissance. It is an important fact that in this particular service the enemy (the submarine) has no power of offence; hence it is possible that the dirigible may prove itself as well suited to the work as the aeroplane. It is true that the modern submarine is being fitted with guns of light calibre, but these are only available after the vessel has come to the surface. We may presume that in any operations of the description contemplated one or more destroyers or light cruisers will accompany the aircraft scout, and the conning-tower of the submarine will be blown away within a few seconds of its making its appearance. It is not in any sense certain or likely that the operations of aircraft in relation to the submarine will be confined to observation. In the opinion of the writer, aircraft, whether aeroplane or dirigible, will prove to be the submarine's most deadly enemy, the submarine being attacked by bombs charged with high explosive while submerged. Owing to the absence of any danger of counter-attack the aeroplane may fly as low as deemed desirable to obtain the necessary accuracy of aim, and much of the difficulty commonly associated with bomb-dropping will accordingly vanish. Such an attack is depicted (somewhat diagrammatically) in Fig. 16, in which, for the purpose of illustration, the machine is shown as flying at a quite low altitude of about 60 ft., and when at the point A to drop a bomb, which, having the velocity of the machine in flight, describes the trajectory A B whilst the machine is travelling to the point C; the motion of the submarine in the intervening time is indicated by the dotted outline. It is not to be anticipated that in practice it will be found necessary to come down to as low an altitude as that shown in order to ensure the degree of accuracy required.

The type of bomb appropriate to the duty in question, although not greatly different from that required in connection with land service, will need a certain amount of consideration. In view of the fact that the size of the hole blown in the skin of the submarine is not important, the charge of explosive may be quite moderate; probably 10 lb. or 15 lb. of wet gun-cotton will be ample. A bomb of torpedo-like form, about 6 in. in diameter, and fitted with a sheet-metal cruciform tail, as shown diagrammatically in Fig. 17, would probably be found suitable; it would be furnished with a positive impact or contact fuse at its nose. The correct way of dropping a bomb of this type is broadside on, pointing in the direction of flight: the axis then remains tangent to the trajectory throughout the fall, the tail acting in the manner of the feathering of an arrow.

A bomb of the type described in the preceding paragraph will travel through water under the influence of gravity at a no inconsiderable velocity. Taking its weight to be (immersed) about half a hundredweight, its limiting velocity in water will be about 50 ft. per second, which is ample to ensure the certain action of the contact fuse. Thus it will be impossible for a submarine to escape by deep immersion, presuming it to remain sufficiently visible to permit of attack.

In brief, the aeroplane, and to some degree other aircraft, suitably armed, may be expected to prove an effective check on the unbridled activity of the submarine. With a properly-equipped naval aeroplane service, supported by a few fast, light cruisers, such as the type known as the "destroyer leader," the enemy's submarines will be unable to roam at large or to make unexpected attacks on our cruiser patrols. They will need to operate under the protection of a supporting force, and will only leave that protection at the risk of almost certain destruction. Or they will require to confine their activities to raiding by night—a form of activity in which their radius of action is essentially limited, and, save under exceptional circumstances, of doubtful promise. It must not be assumed, however, that the service necessary for the effective patrolling of the seas by aeroplane will prove at all a simple or easy matter. The provision of the needed bases,

coastal and floating, alone will be a formidable matter, and as the radius of action of the submarine is increased, and the field of operations is thereby widened, the work will become more and more arduous. Again, the enemy's aircraft will always have to be reckoned with. Thus, although the air service may be looked to to provide an effective limit to the power of the submarine, we can never expect or anticipate that the value or utility of the latter will be by any means nullified.

THE LAW OF POWER-HOUSE ECONOMY.

By R. H. Parsons, M. Can. Soc., C.E., Assoc. M. Inst. C.E.

There are figures in abundance as to the performances of the component parts of a power-station, such as boilers, turbines, generators, &c., under test conditions, but nothing appears to have been published with respect to the efficiency with which the whole aggregation of machinery performs its functions. It is the purpose of this article to examine the performance of a power-plant, considered as an organic whole and to suggest a basis of comparison between different plants which has hitherto been lacking. The development of the method, moreover, will furnish an answer to many important problems of the central station engineer, as will be shown later.

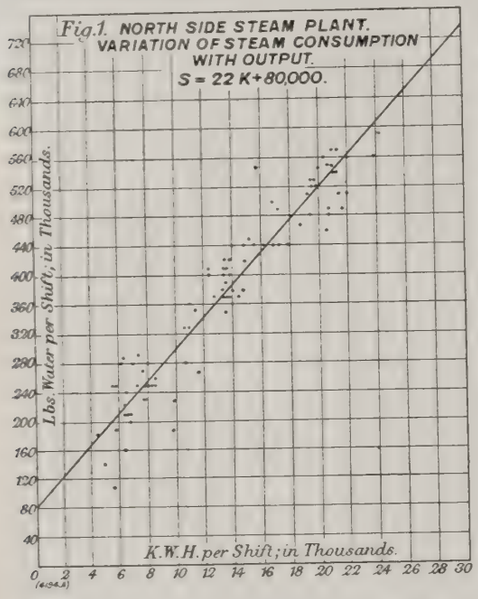


Fig. 1. NORTH SIDE STEAM PLANT.
VARIATION OF STEAM CONSUMPTION WITH OUTPUT.
S = 22 K + 80,000.
Lbs. Water per Shift; in Thousands.
K.W.H. per Shift; in Thousands.

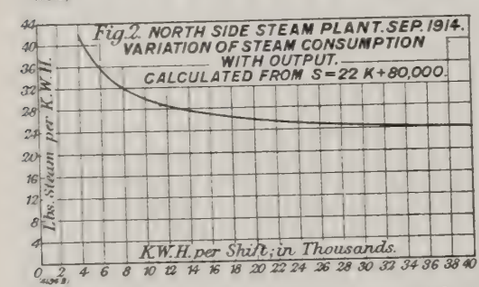


Fig. 2. NORTH SIDE STEAM PLANT. SEP. 1914.
VARIATION OF STEAM CONSUMPTION WITH OUTPUT.
CALCULATED FROM S = 22 K + 80,000.
Lbs. Steam per K.W.H.
K.W.H. per Shift; in Thousands.

The subject may be conveniently approached by an analogy. The efficiency of a steam-engine, under any conditions of working, depends upon a vast number of factors, mutually independent for the most part, such as cylinder condensation, radiation, friction of the various parts, leakage, &c. However carefully each of these items might have been investigated independently, their aggregate effect upon the economy of an engine would be an extremely difficult thing to forecast, and still more difficult would it be to deduce a law for the efficiency of the engine throughout its range of load, from the various rates of change of its multifarious sources of loss. By analogy we could hardly hope to determine the efficiency of a power-station at various loads from a consideration of the efficiencies of the different machines and apparatus which constitute its component parts.

The problem of the efficiency of the steam-engine was solved empirically by the late Mr. Peter Willans, who discovered that the total steam consumption per hour could be plotted as a straight line against the load on the engine. Thus, if the steam consumption at two different loads only were known, the consumption at any other load could be at once determined. This discovery placed in the hands of engineers an extraordinarily useful method of analysing and tabulating the results of steam-engine trials. Experience proved the Willans law to have a remarkably wide range of application to prime movers, and for many years it has been utilised by manufacturers so far as it concerns their products.

By considering the analogy between the numerous sources of loss in a power-station and the almost equally great number of losses inherent in a steam-engine, it appears reasonable to suppose that there may be some rule corresponding to the Willans law which will correlate the efficiency of a power-station with the load upon it. Experiment proves this to be so, at any rate in the case of the particular power-station for the management of which the author is responsible, and no doubt a similar rule would apply generally.

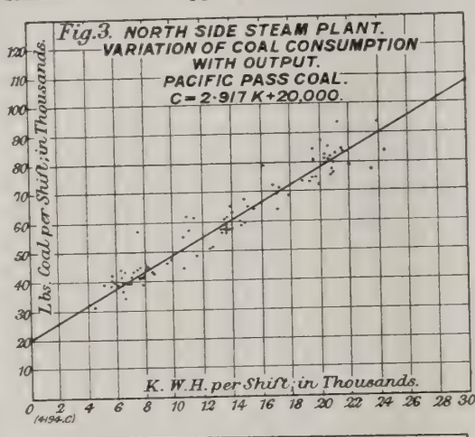


Fig. 3. NORTH SIDE STEAM PLANT.
VARIATION OF COAL CONSUMPTION WITH OUTPUT.
PACIFIC PASS COAL.
C = 2·917 K + 20,000.
Lbs. Coal per Shift; in Thousands.
K. W. H. per Shift; in Thousands.

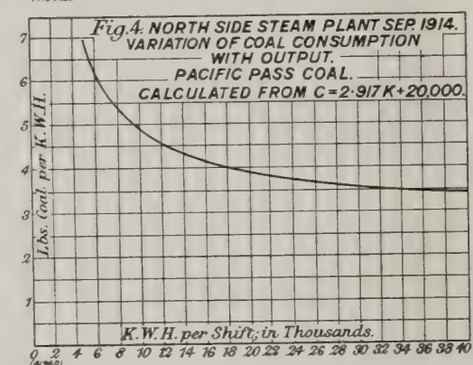


Fig. 4. NORTH SIDE STEAM PLANT SEP. 1914.
VARIATION OF COAL CONSUMPTION WITH OUTPUT.
PACIFIC PASS COAL.
CALCULATED FROM C = 2·917 K + 20,000.
Lbs. Coal per K.W.H.
K.W.H. per Shift; in Thousands.

In Fig. 1, above, the total steam consumption of the station per eight-hour shift is plotted against the gross electrical output of the station in the same period. The figures refer to the station performance during the month of September, 1914, and ninety records are plotted, covering a range of output varying from 4500 to 24,300 kilowatt hours per shift. It might have been better to have taken the readings hourly instead of at eight-hour intervals, as this would have eliminated the effect of varying load-factors; but, on the other hand, the error due to varying water-level in the boilers would be accentuated by the shorter intervals. The steam consumption during the shift is taken as being equal to the water pumped into the boilers, and the gross electrical output is the sum of the main-generator meter-readings.

By referring to Fig. 1, it will be seen that the mean of the observations is approximately a straight line, having the equation :—

$$S = 22\,K + 80{,}000,$$

where S is the total steam consumption per shift expressed in pounds, and K is the gross output per shift expressed in kilowatt-hours. It thus appears that there is a constant loss of steam, amounting to 80,000 lb. per shift, and that there is in addition a consumption of about 22 lb. of steam per kilowatt-hour.

Fig. 2 represents the steam-consumption curve of the station, expressed in pounds of steam per kilowatt-hour, the curve being deduced from the line shown in Fig. 1. The assumption has been made that the load-factor per shift was unity. From the equation it can be deduced that at an output of 80,000 kw.-hours per shift, which is the rated capacity of the station, the steam consumption would be 23 lb. per kilowatt-hour. The cousumption evidently tends to a limiting value of 22 lb. per kilowatt-hour with an infinite load on the station.

The principle illustrated in Figs. 1 and 2 may be applied with equal instructiveness to the investigation of the quantity of coal consumed in the power-station. Fig. 3 shows the total coal consumption per eight-hour shift, plotted against the gross station output per corresponding shift, during the month of September, 1914; we see again that the total coal consumption follows a straight-line law, and may be expressed by the equation :—

$$C = 20{,}000 + 2.917\,K,$$

where C is the total coal consumption per shift expressed in pounds, and K is the gross electrical output per shift as registered by the generator meters. The diagram shows that 20,000 lb. of coal are burned per shift to provide for the constant

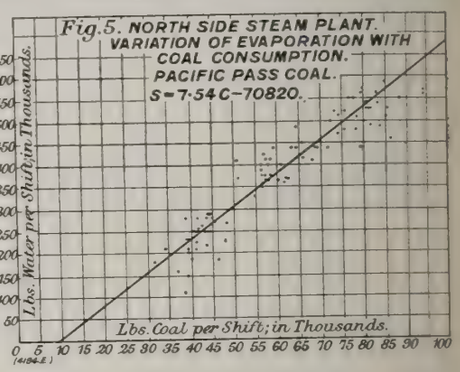


Fig. 5. NORTH SIDE STEAM PLANT.
VARIATION OF EVAPORATION WITH COAL CONSUMPTION.
PACIFIC PASS COAL.
S = 7·54 C − 70820.
Lbs. Water per Shift; in Thousands.
Lbs. Coal per Shift; in Thousands.

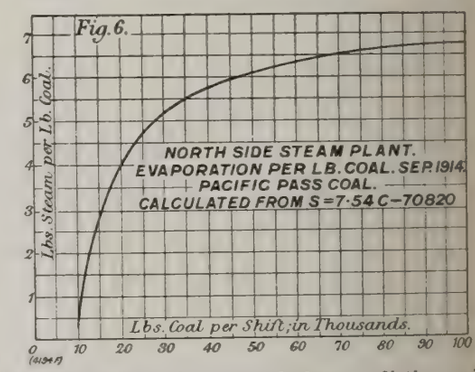


Fig. 6.
NORTH SIDE STEAM PLANT.
EVAPORATION PER LB. COAL. SEP. 1914.
PACIFIC PASS COAL.
CALCULATED FROM S = 7·54 C − 70820
Lbs. Steam per Lb. Coal.
Lbs. Coal per Shift; in Thousands.

station losses, such as steam leakage, radiation, and general stand-by requirements. An additional 2.917 lb. of coal per hour are needed for every kilowatt actually generated. With the station carrying its rated load of 80,000 kw. it may be deduced from the above equation that the coal consumption would amount to 253,360 lb. per shift, or 3.16 lb. per kilowatt-hour. In Fig. 4 is shown the coal consumption per kilowatt-hour, corresponding to the line drawn in Fig. 3. The limiting value of the coal consumption is 2.917 lb. per kilowatt-hour, which, of course, could only be obtained with an infinitely great load on the station.

From the two equations given above, namely—

$$S = 22\,K + 80{,}000,$$

and

$$C = 2.917\,K + 20{,}000,$$

we may deduce a third equation, representing the variation of the amount of water evaporated per pound of coal, as the load on the boilers is increased. This equation is :—

$$S = 7.54\,C - 70{,}820.$$

By equating it to zero, which represents the condition when no steam is being taken from the boilers, we get C = 9388, showing that 9388 lb. of coal are required per shift to maintain the head of steam in face of radiation and other losses. This quantity may be compared with the amount of 20,000 lb. per shift, which has already been found to be necessary to operate the station at no load. Thus about half the constant loss is attributable to the engines and half to the boilers. The equation further shows that the boiler-room losses are equal to the condensation of 70,820 lb. of steam per shift, and that if they were

absent we could evaporate 7.54 lb. of water per pound of coal.

The last equation, correlating the total evaporation per shift with the total coal consumption per shift, could, of course, have been obtained graphically by plotting down the readings of the water-meters against those of the coal scales. In Fig. 5 this has been done, the line representing the mean of the observations being, however, drawn to agree with the calculation above. Nevertheless it falls very fairly among the points. Fig. 6 shows the evaporation per pound of coal in accordance with this line.

In Figs. 1, 3, and 5, it may be objected that the variations among the observations do not allow a straight line to be drawn with any certainty, and hence a rather large amount of theory has been built up on a somewhat uncertain basis. This may be so, but the records are not put forward as being absolutely accurate. They are subject to corrections for water-level in boilers, coal on grates and in stokers, meter approximations, blow-off losses, &c., and they, of course, have a great dependence upon the economical operation of the plant, during the shift to which they refer. Nevertheless they do undoubtedly appear to give evidence of certain laws of economy to which it is the object of this article to call attention.

The first question which will be asked by the practically-minded central-station engineer will be, "What use can be made of the results obtained from such an analysis of the operation of a plant?" One very important use can be made. The curves show at once the coal consumption or the steam consumption of the plant for any load which the station may have to carry. Hence the fuel cost for any additional load is readily obtained. For example, in the plant under consideration two problems were presented. One involved the question as to whether it would pay better to do the main water-works pumping electrically or by steam-driven pumps. Steam had always to be maintained in the water-works boilers, because the low-lift pumps were exclusively steam-driven; but the writer had the option of running either the motor-driven or the steam-driven pumps, as he thought fit. The combined labour costs of the two plants were unaffected by the decision. The water-works load, when pumping was done electrically, was of a reasonably uniform nature, the load-factor per twenty-four hours being about 75 per cent. This load, as the equation corresponding to Fig. 3 shows us, can be carried on the steam plant at the cost for fuel of 2.917 lb. of coal per kilowatt-hour. In an average month this would amount to 440 tons of coal, which figure can be directly compared with the extra coal burnt in the water works when the steam-driven pumps are operated. A definite solution of the problem can thus be obtained.

The other question related to the advisability of operating a large producer-gas engine, which normally runs in parallel with the main steam-power station. The gas-engine uses a low-grade lignite, costing about 0.16d. per kilowatt-hour. We see, as above, that the load could be transferred to the steam plant at an extra cost of coal of 2.917 lb. per kilowatt-hour. But as the steam plant uses a more expensive fuel, the cost of 2.917 lb. of steam coal amounts to about 0.26d. The fuel bill alone would therefore be increased by 0.1d. per kilowatt-hour by making the change, but against this difference must be set the saving in labour, &c., which would result from shutting down the gas plant. The problem, like the former one, is therefore capable of an almost exact solution, which is only rendered possible by the foregoing analysis of the coal consumption of the main station.

The figures concerning the water and coal consumption of the power-station per shift, which have been taken as an illustration of the method, are actual working results obtained during the normal operation of the station. The month of September, for which they are given, was the first month for which it was possible to obtain them. They are put forward merely to illustrate a principle, and the writer is not concerned to defend them. Criticism should be directed not at the figures themselves, but at the use made of them. However, a brief explanation of certain points with regard to the station may not be out of place.

The power-station serves a non-manufacturing town of about 70,000 inhabitants, and furnishes alternating current for lighting and power, and direct current for street railway purposes. The plant comprises water-tube boilers with chain-grate stokers and superheaters, but without economisers. The generating machinery operated during the month of September consists of turbine-driven alternators for the lighting load and vertical high-speed engines and motor generators for the traction load. The condensing-plant is partly steam-driven and partly motor-driven, and exciting current was furnished by a steam-driven exciter. In the diagrams above referred to the gross output of the main generators is given, this including the electrical energy used for auxiliary machinery and induced-draught fans in the station. The fuel used was a class of coal intermediate between lignite and bituminous coal, its average analysis being about as follows:—

B.Th.U. per pound of dry coal	10,100
Moisture per cent.	7.3
Volatile matter per cent. (dry coal) ...	26.5
Fixed carbon per cent. (dry coal) ...	52.0
Ash per cent. (dry coal)	21.5

Although the writer trusts he has disarmed criticism of the operating results by the statements given above, it must not be assumed that the results are considered worthy of publication, except for the purpose of illustrating what appears to be the law of power-plant economy. The power-station is still rapidly approaching a higher degree of efficiency, as the following table of total generation costs will show:—

Period.	Total Cost (Including Capital Charges).
1st six months, 1912	1.56d. per kw.-hour
2nd ,, 1912	1.37d. ,, ,,
1st ,, 1913	1.12d. ,, ,,
2nd ,, 1913	1.02d. ,, ,,
1st ,, 1914	0.94d. ,, ,,

The costs per kilowatt-hour include the whole of the operation and maintenance charges of the plant in question, as well as the interest and sinking fund on the capitalisation, which is particularly heavy.

In conclusion, it is suggested that a method of analysis has been indicated which will enable engineers to compare the working results of different power-stations by studying the respective equations of cost. It is also hoped that a means has been provided for forecasting with reasonable accuracy the cost of generating any extra load which may be offered to the station. The method might have been made more general, though less practical, by giving the results on a thermodynamic basis.

The Institution of Gas Engineers.—Arrangements are being made for the annual meeting of the Institution of Gas Engineers next year to take place at Southport, from June 1 to 4, under the presidency of Mr. John Bonn, engineer and manager of the Gas Department of the Corporation of Southport.

Wireless Telegraphy in Norway.—While the work on the large Stavanger wireless station for the American and other services is being energetically pushed ahead, a comprehensive plan for wireless stations all along the Norwegian coast has been completed by the State Telegraphs. These stations are not intended for foreign service, but only for the benefit of shipping and connection along the coast. It will take some 10 to 15 years to carry out the entire plan, which comprises the building of five or six stations of a capacity similar to that of the Rundemanden station at Bergen; between these larger stations will be erected a number of what may be called second-class stations, and finally the system will be completed by means of a series of minor stations. When the scheme is completed a ship at sea with wireless installations will practically be able to obtain connection with any part of the coast.

The German Iron Industry.—The Phœnix Company has issued its report for the last financial year, showing net profits of 31,700,000 marks, against 32,200,000 marks for the previous year, but the Board has deemed it advisable to reduce the dividend from 18 to 10 per cent., 9,000,000 marks, in addition to other funds, having been added to a kind of war fund. The report deals at some length with the results of the war. The mobilisation at once deprived the company of 30 per cent. of its hands, and it was consequently necessary to close down six blastfurnaces, nine still being in operation. Both the production of pig-iron and the output from the steel works and rolling-mills have gone down to 60 per cent. of the normal. The production of coke has been reduced on a similar scale, and to what extent working can be carried on for the future will entirely depend upon developments and the possibility of obtaining the necessary raw materials. The company, however, considers it of great importance to keep the works going on as large a scale as possible, both for the sake of the people interested and because coal may be wanted both for the railways and the navy, in addition to which the by-products from the coke production, such as tar oil and benzol, are especially valuable when the import of heavy oils and benzine has been stopped. In the absence of imported artificial manure, the farmers will also want Thomas slag, &c. The export practically stopped at the breaking out of the war, excepting the unimportant trade done with some small neutral States.

NOTES FROM THE UNITED STATES.

Philadelphia, October 28.

The steel industry throughout the United States is improving in streaks, but generally is weakening in volume of business done and in prices. Many concerns are operating between one-fourth and one-third of capacity. Car and locomotive builders are getting very little business. Railroads refuse to expend an unnecessary dollar. Considerable general office and house building is going on, calling for structural material. Pig-iron is irregular and inactive. Steel billets for domestic use are dull, but numerous inquiries from abroad continue to keep interest alive. A number of cotton-storage warehouses are to be erected at various points in the south, and this will help out a little. A fair amount of bridge building is in progress, running in single orders, sometimes close to 1000 tons. All the heretofore-mentioned obstructing causes still remain to minimise business. About the only motive to do business at many steel plants is to get money to pay fixed charges. Margins are very narrow. Textile and machine-tool manufacturers ordered about 10,000 tons of special grades of pig this week. The financial situation has not improved. Banks are still restricting accommodations. Considerable improvement is noted in the export trade for supplies other than steel. Notwithstanding the serious conditions, a spirit of optimism prevails, but idleness among labourers, especially in the steel industry, is on the increase. Every sort of enterprise is held up that can be held up. The liberation of some 400 million dollars after the new Federal Banking Law goes into effect, November 16, is expected to afford a strong impulse to general business. For the present, trade is hanging uncertain, and all manner of supplies in users' and consumers' hands are at a very low ebb.

THE LATE MR. AUGUSTUS STROH.

We record with deep regret the death of Mr. Augustus Stroh, the last of the pioneers of the Electric Telegraph, which took place at his house on Haverstock Hill, on Monday of last week, November 2, in the eighty-seventh year of his age.

John Matthias Augustus Stroh was born at Frankfort-on-Main on May 7, 1828, and began his career by serving an apprenticeship in the craft of clock and watch-making. At that time, in Germany, the tests for qualification for apprenticeship to that industry were the most severe in Europe. The candidates were supplied with metals and a set of comparatively rough tools, and, until they entered the room, they were not informed what they were required to make. The task given to young Stroh was to construct a special form of vertical escapement, and so remarkable was the skill which he displayed in his work that he passed the examination first on the list, and in proof of the appreciation of the examiners, they made the unprecedented concession to him of allowing him to keep the instrument he had constructed, and that remains with his family to the present time.

In the year 1851 he came on a holiday excursion to London, to visit the Great Exhibition in Hyde Park, and, so impressed was he by the advancement of this country and its free institutions, that he then and there adopted England as his home, and became a naturalised British subject in 1869.

Soon after coming to London, Mr. Stroh was introduced to Professor (afterwards Sir Charles) Wheatstone, and then began an association which terminated only by the death of the latter in 1875. Throughout this period Mr. Stroh's inventive and unrivalled mechanical genius enabled Wheatstone to introduce improvement after improvement in telegraphy. First the "A.B.C. Telegraph," which was for several years largely used in banks and commercial offices, culminating in 1867 in the "automatic system," the most rapid method of telegraphy in existence, which is so largely used in the British post-office telegraphs at the present time. For this Mr. Stroh was, in 1878, awarded, by the International Jury of the Paris Exhibition, a gold medal (*Medaille de Collaboration*).

In addition to his many inventions in connection with electric telegraphy, Mr. Stroh devised an immense number of instruments connected with almost every branch of physical and mechanical science, electricity and magnetism, acoustics, optics and horology. In the year 1860 Mr. Stroh established in Tolmer's-square a factory for the manufacture of the Wheatstone and Stroh instruments and for developing his other inventions. These works were taken over by the General Post-Office in 1880, when he retired; but this retirement was only the starting-point of a new life of activity and scientific research, for, unhampered by commercial interests, he was enabled to devote his whole energy to the pursuits he so much loved. He established at his house on Haverstock Hill a workshop in which he spent almost every hour of the day, his consummate skill as a mechanician enabling him to construct, with his own hand, the most delicate instruments to aid him in his researches. As a remarkable horologist, he

devised and constructed many forms of clocks and watches and various kinds of escapements, and he also constructed a very perfect regulator for controlling the speed of clockwork, so that the speed could be increased or diminished, or kept at a uniform rate, at the will of the operator. When the phonograph was introduced, Mr. Stroh took up its study with great enthusiasm, with the result that he produced an instrument which is acknowledged to be the most perfect that has ever been constructed, the motor and moving parts being absolutely silent, and the speed perfectly uniform. Being constructed entirely in aluminium, the weight was reduced to a minimum.

In the year 1881 the late Professor C. A. Bjerknes, Professor of Mathematics in the University of Christiania, exhibited at the Exposition de l'Électricité at Paris his beautiful series of experiments on attraction and repulsion produced by vibration, which he afterwards demonstrated before the Physical Society of London. This research, and the series of experiments used therein, were fully described in a series of articles in this journal.* In consequence of these articles, Mr.

The late Mr. Augustus Stroh.

Stroh became deeply interested in the subject, and entered into an exhaustive research, which involved the design and construction of a series of extremely beautiful and delicate instruments. Professor Bjerknes's experiments were conducted in viscous liquids, such as syrup or glycerine, but Mr. Stroh was able to conduct the research in air at ordinary pressure. These experiments were fully described in this journal at the time.† Mr. Stroh brought these experiments before the Royal Society in 1882, and read a paper on them with the title "On Attraction and Repulsion Due to Vibrations, and a Comparison of the Phenomena with those of Magnetism."

Among the many pursuits in which he excelled there was none in which he was more successful than photography, and his beautiful work, whether in portraiture, landscape, stereoscopic, or colour photography, is well known to all his friends. (The portrait which we here reproduce is from a negative taken by himself.) In following this pursuit he constructed his own cameras, each embracing special refinements devised by himself. He, moreover, designed and constructed a most ingenious stereoscope which could project stereoscopic pictures on a screen, in which he made use of the phenomenon of the persistence of the image on the retina, for enabling the observer to combine two superposed images into one impression.

Mr. Stroh was of too retiring a nature to publish much of his work, but he contributed papers to the Royal Society, to the Physical Society, to the Institution of Electrical Engineers, and the Camera Club; and on February 17, 1879, he gave a Friday evening discourse at the Royal Institution on "Studies in Acoustics; a Synthetic Examination of Vowel Sounds."

He was a member of the Institution of Electrical Engineers (of which he was a member of Council for several years), of the Royal Institution, the Physical Society, and of the Société Internationale des Electriciens, of Paris, and he was a member of the jury for awards at several of the International Exhibitions.

So has passed away a man who, although his name was practically unknown to the general public, was truly a great man; for his inventions, several of which are of the highest importance, may be counted by hundreds. His house remains a monument to the fertility of his inventive genius, for it contains hundreds of the most delicate instruments devised by himself, and made with his own hands, all exhibiting a perfection of workmanship.

It was the extraordinary modesty of Mr. Stroh—amounting almost to self-effacement—that prevented him from having the highest honours conferred upon him. He was always not only ready, but eager, to place his unrivalled skill as a mechanician at the disposal of all his friends, and he will be missed for a very long time by a coterie of admirers, for he won the esteem and affection of all who had the privilege to know him.

Mr. Stroh was married to a Miss King, who predeceased him, and leaves a son and two daughters. He was buried on Friday last at Hampstead Cemetery.

* See Engineering, vol. xxxiii., pages 23, 147, and 191.
† *Ibid.*, vol. xxxiii., pages 455, 480, 506, and 558.

THE LATE MR. ARMAND CONSIDÈRE.

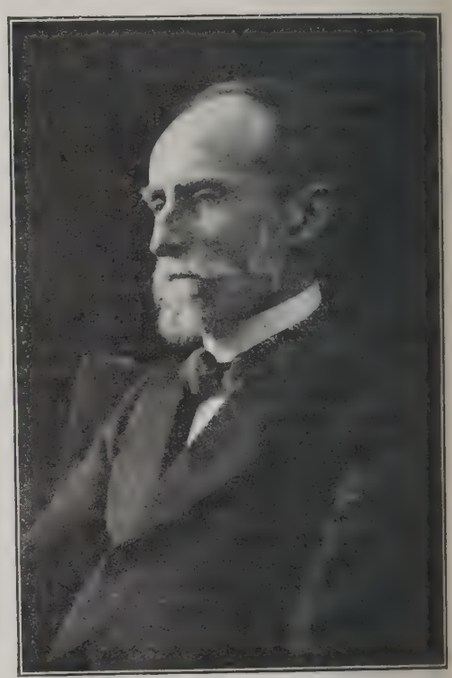
Owing to the fact that his death coincided with the outbreak of the war in France, the decease of the late Mr. Armand Considère escaped general notice. His work, however, was of such importance that no apology is needed for giving a sketch of his career, even at this late date. He was born on June 8, 1841, and entered the Paris Polytechnic School in 1860, and the Ponts et Chaussées School in 1862. From 1865 to 1904 he was successively Engineer, Chief Engineer and General Inspector of the Ponts et Chaussées, the French Government Corps of Civil Engineers.

During the whole of his period of active service with the Ponts et Chaussées, a period which, as will be seen, covered forty years, Mr. Considère carried out a large amount of work on road, railway, harbour and lighthouse construction. Notwithstanding his duties under Government, he found time to undertake numerous *études* and to issue a large number of standard publications, among which we may mention a treatise on the part played in the economics of the nation by local railway systems, and on the usefulness of such lines; a report on earth pressures; other papers on the properties and the use of steel in civil engineering work; on the shocks on permanent-way; on riveted work, &c. In a paper which he read as early as November 6, 1892, before the Commission for the Testing of Materials, he pointed out that a steel having a high tensile strength, able to bear a high percentage of elongation without fracture, and to withstand with complete success all the required tensile tests, might nevertheless be a very fragile steel, and a steel the use of which might be surrounded with real danger. On the same occasion he defined the fragility test; the preponderating importance of such a test for steel has since been admitted the world over. In the same year the French Académie des Sciences acknowledged the services rendered by Mr. Considère to civil engineering by appointing him a Corresponding Member.

Mr. Considère first gave his attention to reinforced concrete in the year 1899, and immediately published his standard work on the influence of metallic armatures on the properties of mortars and concrete, in which were given for the first time rational formulæ for the calculation of reinforced concrete, these formulæ establishing the bases on which the new science has since been reared. In the year 1901 he invented the spiral system of reinforcement, and published in the following year an important treatise dealing with the resistance to compression of ordinary reinforced concrete compared with that of spiral reinforced concrete. A further treatise of his was published in 1907, dealing with spiral reinforced concrete and its applications, which latter treatise contains the result of a large number of practical experiments and points to the most remarkable qualities of his type of reinforcement.

He designed and patented several other processes for civil engineering construction, among which we may mention his conical foundations which were patented in this country in 1910,* and in a period of two years have been resorted to for constructions carrying a total load of 125,000 tons. To him are also due temporary joints of spiral reinforced concrete for arched bridges, which remove the ill effects which otherwise would proceed from contraction of the concrete and the settling of the piles, abutments and centres. He also started the use of friction-slabs to withstand abutment and earth pressures. Mr. Considère was appointed chairman of the Reinforced Concrete Committee, which drew up the regulations issued in 1906 by the French Ministry of Public Works; he took a very large share in the experiments and operations carried out by this committee. In recognition of his work, the International Association for the Testing of Materials appointed Mr. Considère President of the Reinforced Concrete Section in 1907. His age and his numerous other duties did not allow him to continue long in this position of honour. In former issues (see Engineering, vol. lxxxix., page 578, and vol. xc., page 327) we gave particulars of Mr. Considère's system of piles and temporary joints. A brief illustrated description of his hollow-cone foundations of reinforced concrete was also published in one of our later issues (see Engineering, vol. xciii., page 573).

The spiral reinforcement, with which Mr. Considère's name will always be chiefly associated, has been very largely used in Great Britain since its introduction by the Considère Construction Company, in 1908. It is particularly applicable to arched bridges and to pile foundations. The largest bridge in this country in which the spiral reinforcement is being used is the one, now practically completed, over the River Mersey at Warrington, with which the late Mr. J. J. Webster was associated as consulting engineer (see



The late Mr. Armand Considère.

page 570 *ante*). Considère piles have been used very largely in this country also, notably for H.M. Ordnance dépôt at Rosyth, for the foundations of the six warehouses at the Hull Joint Dock, and for the foundations of the new Continental Station, Dover Harbour.

On page 523 *ante* we commenced a description of the Meadowside Granary for the Clyde Navigation Trustees, which we continue in our present issue. This, as our readers will have noticed, is an important structure of reinforced concrete, the details of which were designed according to methods developed by Mr. Considère.

* Described in Engineering, May 6 and September 2, 1910.

The Liverpool Engineering Society.—Owing to the absence of Major J. R. Davidson and Captain T. R. Wilton, who have joined their respective regiments, the duties of hon. treasurer and hon. secretary will be undertaken by Professor E. W. Marchant and Mr. Thomas L. Miller.

Radioactivity.—On the 5th inst. Sir William Crookes read a paper on "Acquired Radioactivity" before the Royal Society. In it he said that a diamond exposed directly to radium takes a full sage-green tint, and becomes persistently radioactive, continuously giving off α, β and γ rays. The acquired colour and activity continue for years with apparently undiminished activity.

Our Rails Abroad.—Our rails are still in good demand in British India and Australia, but orders have presented themselves less freely in New Zealand, and shipments to Argentina have also fallen off sharply, railway construction in the Argentine Republic being almost limited at present to the completion of sections which had previously been nearly ready for traffic. The exports of British rails for October were 37,005 tons, as compared with 40,625 tons in October, 1913, and 40,930 tons in October, 1912. The aggregate exports for the ten months ended October 31, this year, were 402,944 tons, as compared with 419,730 tons and 346,882 tons. Argentina took 26,404 tons of our rails to October 31, this year, as compared with 46,165 tons and 45,040 tons.

COMPOUND ARTICULATED 2-8-8-8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD.

CONSTRUCTED BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA., U.S.A.

Fig. 27.

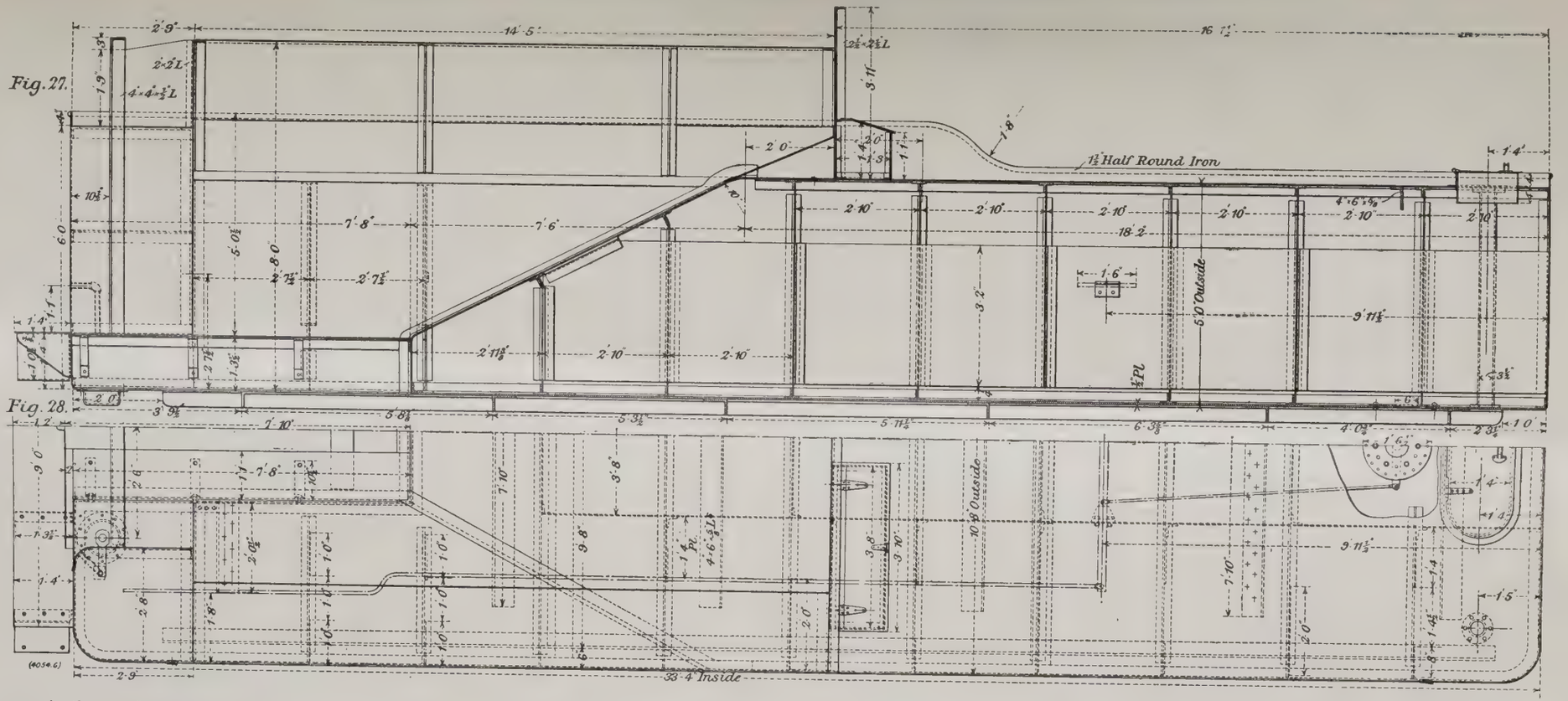


Fig. 28.

EARLIER in the year* we gave an illustration and brief description of the powerful articulated 2-8-8-8-2 type locomotive, built for the Erie Railroad by the Baldwin Locomotive Works, Philadelphia, Pa., U.S.A. This machine is quite unique in many respects. It is the most powerful locomotive in existence, developing a maximum draw-bar pull, according to the dynamometer, of 130,000 lb., and is of such an interesting character that we now propose to illustrate its design in some detail. We commence this week with the general arrangements and cross-sections shown on Plates XXXIX. and XL., with this issue, and herewith. It is constructed on the principle patented by Mr. G. R. Henderson, of the Baldwin Works, and has three articulated sections and six cylinders. The machine is so long that, departing from our usual custom, we have had to reproduce it in sections. In Fig. 2 we give a longitudinal drawing of the front portion, back to the first articulation. In Fig. 3 is shown the second section, and in Fig. 4 the third, which is really a locomotive tender.

The second portion is fixed to the boiler at the fire-box end. The front portion, hinged to the second, moves radially under the barrel on slides provided for it. The third section is hinged to the second at a point below the cab. Of the half views and sections shown in Plate XL., Figs. 5 to 12 relate to the first portion. The first of these gives a front elevation, while Figs. 6 and 7 are sections taken through the smoke-box, the latter being at a point near the front pair of drivers. Fig. 8 is at the second pair of drivers, while Fig. 9 is at the third or main pair of the first group. Figs. 10 and 11 are taken near the fourth pair, and Fig. 12 at the articulation. Sections, &c., of the second or middle portion are shown in Figs. 13 to 20, the first two being at the middle pair of cylinders. Figs. 15 and 16 are taken between the first and second pairs of drivers looking

Fig. 29.

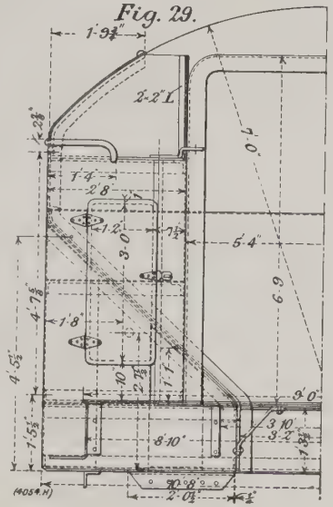


Fig. 30.

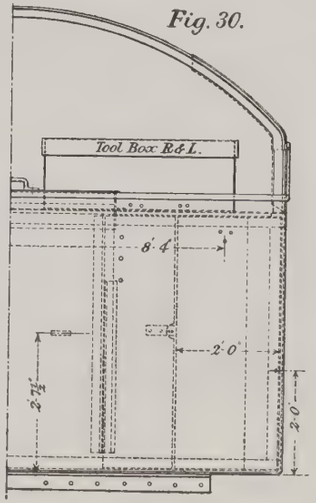
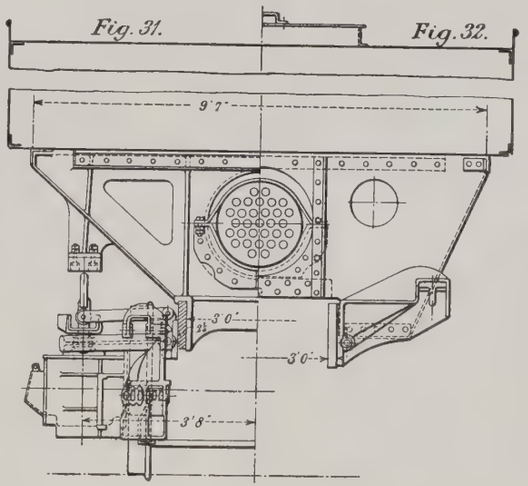


Fig. 31. Fig. 32.



* See ENGINEERING, vol. xcvii., page 667.

respectively forwards and back. Fig. 17 is a section at the third pair of drivers looking forwards; Fig. 18 a section through the cab at a point beyond the end of the frames; Fig. 19 shows the back of the cab. Fig. 20 is taken through the rear articulation.

Figs. 21 to 32 relate to the tender portion. Figs. 21, 22 and 23 are sections at the cylinders and motion. Fig. 24 is at a point near the main drivers and Fig. 25 near the trailing pair of coupled wheels. Fig. 26 shows the trailing end of the tender section. The tank is shown in longitudinal section, plan, and end elevations in Figs. 27 to 30, page 601, while Fig. 31 shows a cross-section just ahead of the trailing truck, and Fig. 32 a section at the trailing end of the tank.

We shall deal with details of the design on a subsequent occasion, and will now draw attention to such general features as are rendered clear by the illustrations we give herewith. The locomotive is a compound with two high-pressure and four low-pressure cylinders, all the same size, and cast to the same pattern. The middle cylinders are the high-pressure pair. Steam is brought to these cylinders from the dome nearly vertically over them, by way of the dry pipe leading to the smoke-box, then through the superheater, and from the header down through pipes shown in Fig. 7 along the outside of the barrel to the centre saddle, as seen in Fig. 2. The exhaust is divided between the front and rear units; that from the right-hand high-pressure cylinder is carried forward through a large pipe, fitted with ball-and-socket and expansion joints, to the saddle of the front pair of cylinders; that from the left-hand high-pressure cylinder is carried in a similar manner to the rear for the pair of cylinders on the trailing section. The exhaust from the front low-pressure cylinders is carried up through a swivelled pipe into the smoke-box, where it is employed to produce the blast. The exhaust from the trailing section is turned into a large feed-water heater running under the tender-tank, an uptake being arranged at the trailing end, as seen in Figs. 4 and 26. The feed-heater is shown in section in Figs. 24, 25, 31, and 32, &c. The valve-gears are of the Baker type; they are interchangeable; the piston-valves have inside admission. The cut-off is adjusted by power, the reversing mechanism being of the Ragonnet type adopted by the Baldwin works. One reversing-gear controls all sets of motion (see Figs. 2, 3, 4, and 11). A starting-valve admitting steam to the four low-pressure cylinders is provided.

At the front and back ends of the machine there are two-wheel trucks. The front truck is of the centre-bearing type, with three-point hangers for the cradle. It is equalised with the first group of drivers. The cross equalising beam at the back of the front saddle is shown in Fig. 7. The middle group of driving-wheels is equalised in one system. The third group is equalised with the trailing-truck, which is of the side-bearing type, with outside boxes. The cross-beam for connecting the driving-spring rigging with that of the truck may be seen in Fig. 25.

A locomotive of this size, would, of course, be out of the question with coal fuel unless fitted with a mechanical stoker. We do not propose to describe the particular stoker fitted to this Erie locomotive at this time, but, while the drawings are at hand, will just point out that the distributing gear is shown on the fire-box back plate in Figs. 13, 19, and 20. In the drawings showing the front end of the tender it will be noticed that the coal space is furnished with a hopper type of floor, sloping down to a trough. The latter contains a conveyor, by which the coal is transferred from the tender to the stoking-machine. It is shown in cross-section in Fig. 22. We will reserve further particulars until we deal with the details of the locomotive. In the meantime, we give below the principal particulars of the machine, which, as previously recorded in ENGINEERING, holds the record for train-loads, having handled a load behind the tender of 17,912 short tons on a grade of 0.09 per cent. This train had a length of 1.6 miles, and was made up of 250 fifty-ton gondola steel cars, dynamometer car and locomotive. It was moved at a speed of 14 miles per hour. Communication between the members of the train crew was maintained by telephone.

Cylinders, two high-pressure ...	36 in. by 32 in.
,, four low-pressure ...	36 ,, ,, 32 ,,
Valves, piston	16 in. diameter
Maximum tractive power calculated...	160,000 lb.
Draw-bar pull by dynamometer ...	130,000 ,,
Driving-wheels, diameter	63 in.
,, ,, journals	11 in. by 13$\frac{1}{16}$ in.
Truck-wheels, leading, diameter	33$\frac{1}{2}$ in.
,, ,, trailing, diameter...	42 in.
Boiler, minimum diameter ...	94 ,,
,, length of barrel	28 ft. 2$\frac{13}{16}$ in.
,, tubes, length	24 ft.
,, number of 2$\frac{1}{4}$-in.	326
,, ,, 5$\frac{1}{2}$-in.	53
Heating surface—tubes	6418 sq. ft.
,, arch-tubes ...	88 ,,
,, combustion-chamber	108 ,,
Heating surface—total	6886 ,,
Superheating surface	1584 ,,
Grate area	90 sq. ft.
Working pressure	210 lb. per sq. in.
Wheel base—total	90 ft.
,, driving	71 ft. 6 in.
,, rigid	16 ,, 6 ,,
Length over bumper-beams ...	102 ,, 9$\frac{1}{2}$,,
Weight on drivers	336.42 tons (long)
,, total...	377 25 ,, ,,

(To be continued.)

THE INSTITUTION OF CIVIL ENGINEERS.

Address of BENJAMIN HALL BLYTH, M.A., *President.**

(Concluded from page 577.)

IT would be quite impossible within the limits of an address such as this to describe, or even to enumerate, all the water supplies which have been constructed by counties and burghs in Scotland.

The Local Government Board exercises a zealous control and takes care that adequate supplies of water are provided where they are required. I think, however, that much money might be saved, and the water supply of the country conserved, if more combination took place between adjoining burghs and between burghs and counties before any of them were allowed to introduce a new water supply. It would be far better if a number of places in adjoining districts combined and introduced one large comprehensive supply rather than that each separate place should have an independent supply for itself.

Take, for instance, my own county of East Lothian. There every town and village has its own independent supply, with separate reservoirs, separate compensation water and separate lines of main pipes bringing the water from the hills to the various points of supply. It would have been infinitely better, and much more economical, if all these places had combined and had one comprehensive scheme dealing with the whole county. Is it too much to hope that in future—and much remains still to be done—the legislature will take care that this question of combination is duly considered before any supply for a comparatively restricted district is sanctioned?

One other point in connection with water supplies, and that is the quantity of compensation water that should be given off. It seems absurd that this should be left to be fought out under every little Bill, and it should be fixed definitely by the legislature. It often happens that the promoters of a scheme—where no landed proprietor has a sufficient interest to oppose it—get off with the provision of far too small an amount of compensation water. This matter is really a national one and should be settled, not in the interest of any individual proprietor, but of the public at large. When the available sources of supply are yearly becoming more and more scarce, it is essential that adequate provision should be made to secure that our rivers and streams have at all times a sufficient supply of water sent down them.

In addition to the supply of water for ordinary domestic purposes, several works have been constructed in Scotland for utilising water-power for commercial purposes. The first of these appropriated the water flowing over the Falls of Foyers on the south side of Loch Ness. This was done by the British Aluminium Company, and although from a commercial point of view it has been successful, there is not the least doubt that the construction of the works there has greatly spoiled the beauty of the scenery, much to the regret of the large number of tourists who frequent Loch Ness, and of all those who have the preservation of the beauties of Scotland at heart.

That supply became quite insufficient for the purposes of the British Aluminium Company, and the Highland Water-Power Company promoted a scheme in 1899 to take the water of Loch Ericht and some smaller lochs, situated in Perthshire, right across Argyllshire, and make use of it at a manufacturing station to be placed at the head of Loch Leven. In the scheme submitted to Parliament the proposed works were too light and the compensation water proposed to be given much too small, while the waters of Loch Ericht were diverted from their natural water-shed into an adjoining county. It was opposed, among others, by the County Council of Perth and the Tay Salmon Fisheries Commissioners, and was rejected by Parliament. In the Session of 1901 the Loch Leven Water-Power Act was passed. It was really part of the former scheme, but without encroaching on Loch Ericht, and provided for the construction of a large concrete dam at the west end of the Blackwater Lochs, and the laying of pipes from it to turbines at the head of Loch Leven. The estimated cost of that scheme was 575,000*l.* The works have been constructed, and are now in full operation for the production of aluminium.

In addition to the use of water for power, several large companies are now working in Scotland producing electricity for power and lighting purposes, and the City of Glasgow has an extensive system for distributing water at high pressure, I believe at something like 700 lb. per sq. in.

The great municipalities in Scotland are also keeping pace with the times, and have been for many years back doing much to improve the cities over which they have control. Tramways are to be found in all the principal cities, and in many country districts as well; and these, with the single exception of Edinburgh, are worked on the overhead electric system. The tramways of the City of Edinburgh, which were originally horse tramways, about twenty years ago, were converted into cable tramways, and they continue to be worked by cable.

Although this system is costly to instal in the first instance, once it is installed, it is worked far more cheaply than any other system. The Edinburgh tramway system costs 1d. per car-mile less to work than any other system in the country. In addition, in a beautiful city like Edinburgh, the public would never have allowed the overhead system, with its network of wires; and that is obviated by the cable system.

The only disadvantage which the cable system has is that it does not readily lend itself to extension into sparsely populated districts. The initial cost is so great that there would be no possibility of any such extensions being commercially successful.

In Glasgow much has been done for the improvement of the amenity of the city. One of the principal works undertaken by the corporation, assisted by the adjoining counties, is the purification of the River Clyde. Provision was begun for that purpose when the railway promoted by the Caledonian Railway Company, running along Argyle-street, was in Parliament, and clauses were introduced into the Act providing for the construction, by the Caledonian Railway Company, of a system of sewers on the north side of the railway and passing underneath it, which were designed to suit the scheme which was then being matured for the purification of the River Clyde.

The whole scheme has been so fully described in papers read before this Institution in 1911-12 by Messrs. McDonald and Taylor, Mr. Easton and Mr. Morton, that it is not necessary to repeat the details here. It deals, and deals satisfactorily, with the sewerage of Glasgow, including the Burghs of Govan and Partick, now included in Glasgow, the Burgh of Rutherglen, the Burgh of Clydebank, and portions of the counties of Lanark, Renfrew, and Dumbarton. The total cost has been about 2,400,000*l.*

The effluent from Dalmarnock Works discharges into the Clyde just about the head of the tidal waters, and it has been decided to install filters at these works. Power was obtained in the last session of Parliament to do this, at an estimated cost of 120,000*l.*

The old Glasgow Bridge, designed by Telford, and built by Gibb in 1833, some years ago showed signs of failure. It was founded on wooden piles, and, owing to the deepening of the river, these became exposed, and began to decay. The bridge was cracked from end to end, and would very soon have become unsafe for traffic. This bridge has been rebuilt by the Corporation of Glasgow with properly-secured foundations, and was opened for traffic in 1899. In rebuilding it the width was increased from 56 ft. to 80 ft. between parapets.

Since that date the congestion in the streets of Glasgow, especially in that neighbourhood, has greatly increased, and only in the past session of Parliament the Corporation got power to build an additional bridge across the River Clyde, in close proximity to Glasgow Bridge, in order to deal with this congestion. Although the bridge just sanctioned will relieve the congestion at that particular place, a larger and more important question must soon be dealt with by the Corporation. Owing to the great extension of the city on both sides of the river to the west, a bridge across the Clyde, considerably lower down than the present bridge, must be provided, either a low-level swing-bridge, or an opening bridge of some sort, or a high-level bridge. The Clyde Trustees have established ferries on the river, and a private company has built a tunnel under the river, but neither of these meets the situation. The kind of bridge to be adopted will necessarily depend to a large extent on the site selected, and this last point will require, and will no doubt receive, very careful consideration.

There are also on the north of the Clyde large cattle wharves and sheds for dealing principally with cattle imported from foreign countries, and there has just been erected a very large grain store, fitted up with the most modern machinery for conveying grain from ships to the store.

In Edinburgh the principal improvement in recent years was carried out in connection with the reconstruction of the Waverley station by the building of the new North Bridge over the valley of the Nor' Loch, and by the widening and flattening of the gradient in North Bridge-street. The old North Bridge consisted of a series of masonry arches with very large and heavy piers, and had been widened by means of iron girders many years ago, but the width of that widened bridge was only 55 ft., the width of the original stone bridge being 42 ft. When the Waverley Station was being reconstructed, the piers of the bridge would have interfered very much with the laying out of the station, and the North British Railway Company were satisfied that if they were to design the station to the best advantage, from a railway point of view, it would be necessary to have the piers of the old bridge altered. They therefore offered the Corporation, who had had for some time under consideration the question of reconstructing the North Bridge, to contribute 30,000*l.* towards the cost of rebuilding it.

This offer was accepted by the Corporation, and the bridge was rebuilt in three steel arched spans, each of 175 ft., and at the same time an opportunity was taken of making a uniform gradient from the south end of the post-office at the north end of the street right up to the High-street, giving a gradient of 1 in 27, in place of a level roadway over the old bridge, and a gradient of 1 in 18 from the south end of the old bridge up to the High-street. The bridge and the new street were constructed throughout with a width of 78 ft. Further, in connection with the remodelling of the Waverley Station, opportunity was taken to make an entirely new system of sewers in the valley of the Nor' Loch, which will be sufficient for many years to come.

Electric light has been installed in Edinburgh, as in other towns, and, like Glasgow, Edinburgh has con-

* Delivered November 3, 1914.

COMPOUND ARTICULATED 2-8-8-8-2 T

CONSTRUCTED BY THE BALDWIN

(For

Fig. 5.

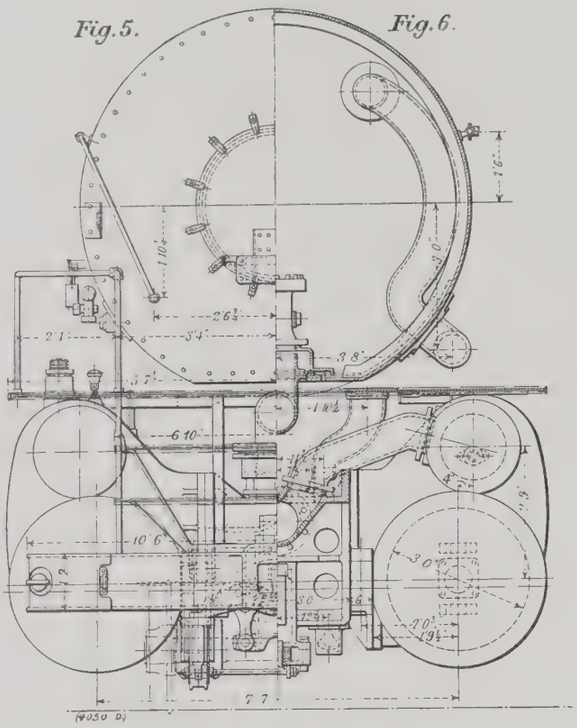


Fig. 6.

Fig. 7.

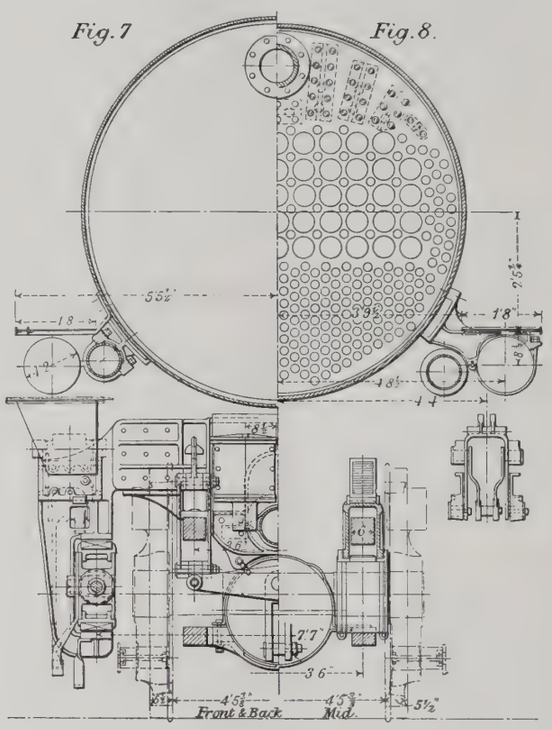


Fig. 8.

Fig. 9.

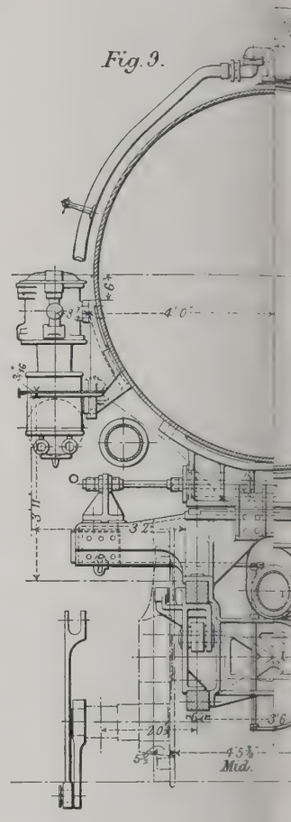


Fig. 16.

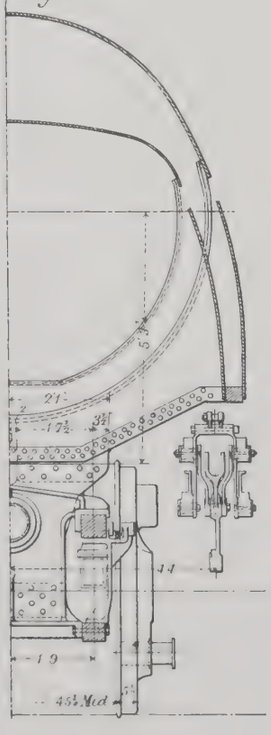


Fig. 17.

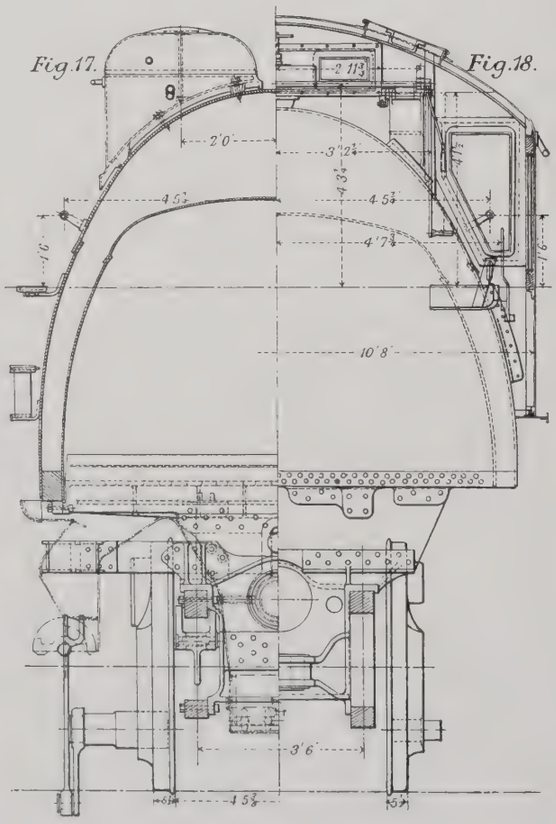


Fig. 18.

Fig. 19.

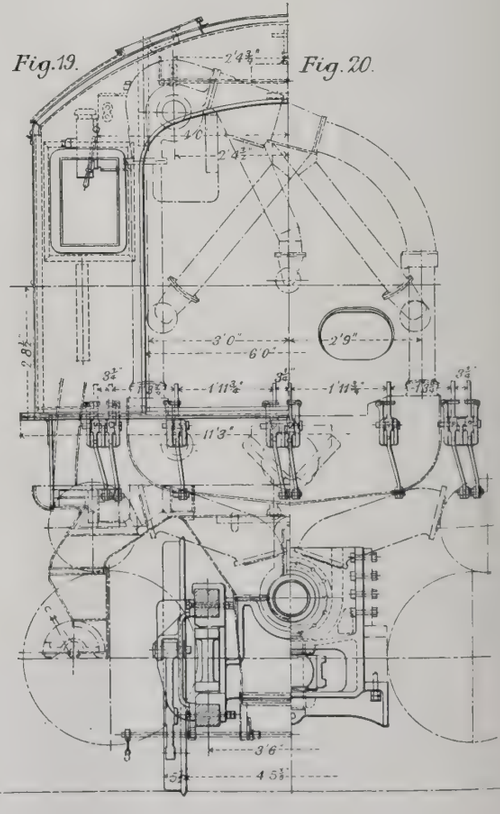


Fig. 20.

OMOTIVE FOR THE ERIE RAILROAD.

ORKS, PHILADELPHIA, PA., U.S.A.

601.)

Fig. 11.

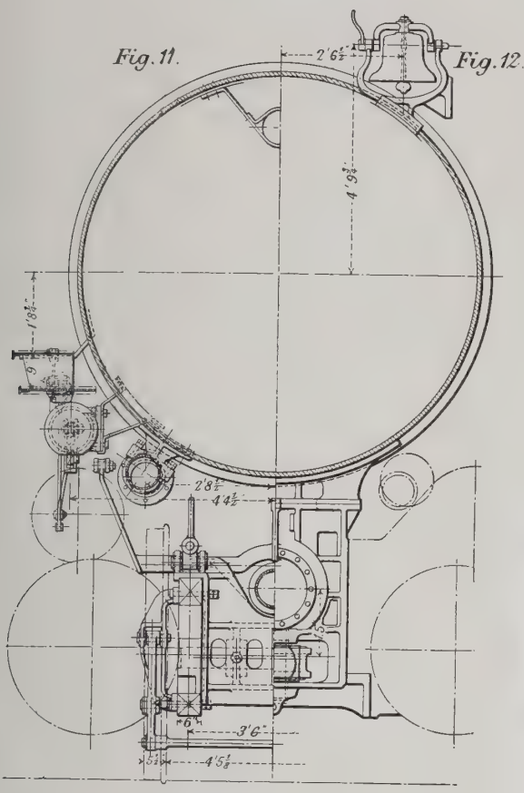


Fig. 12.

Fig. 13.

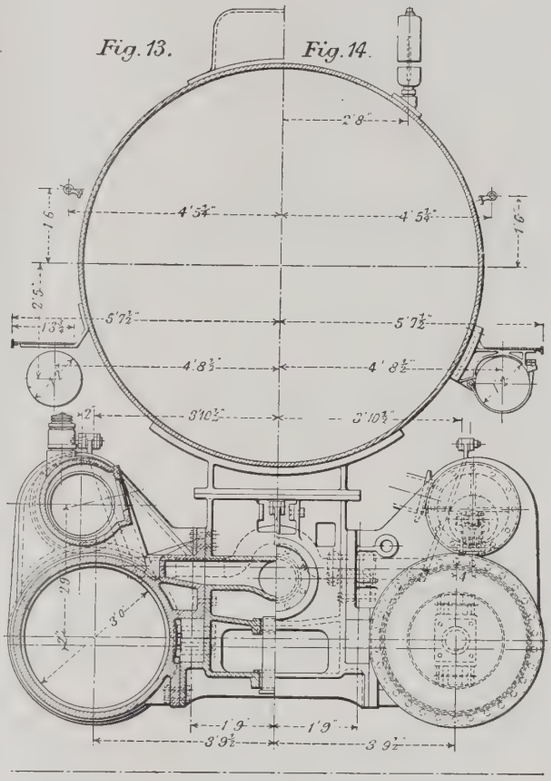


Fig. 14.

Fig. 15.

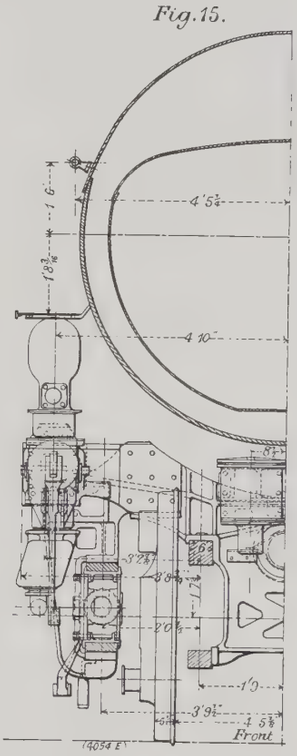


Fig. 22.

Fig. 23.

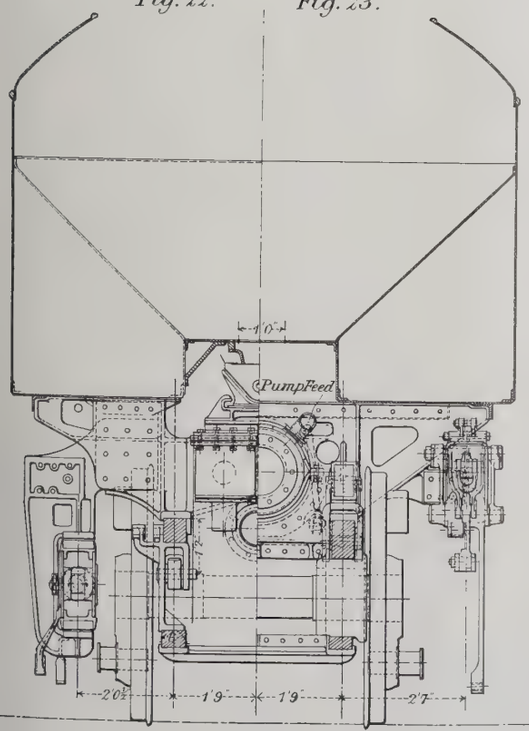


Fig. 24.

Fig. 25.

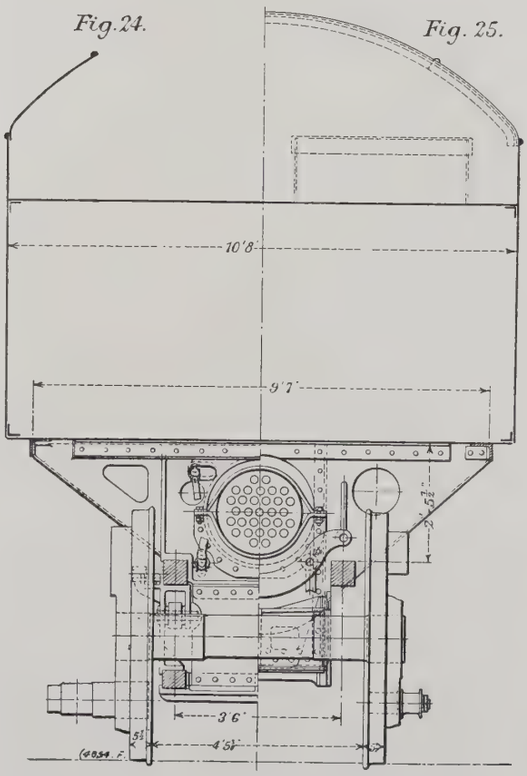
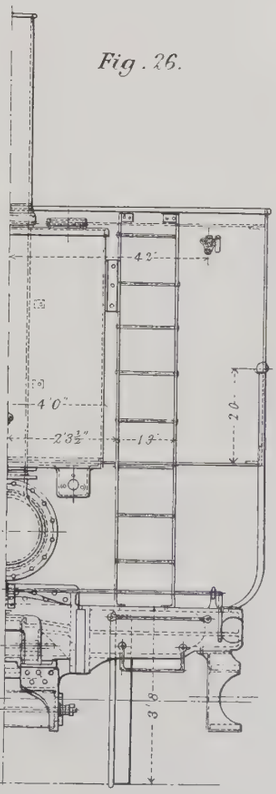


Fig. 26.



COMPOUND ARTICULATED 2 8 8 2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD.

CONSTRUCTED BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA., U.S.A.

(*For Description, see Page* 601.)

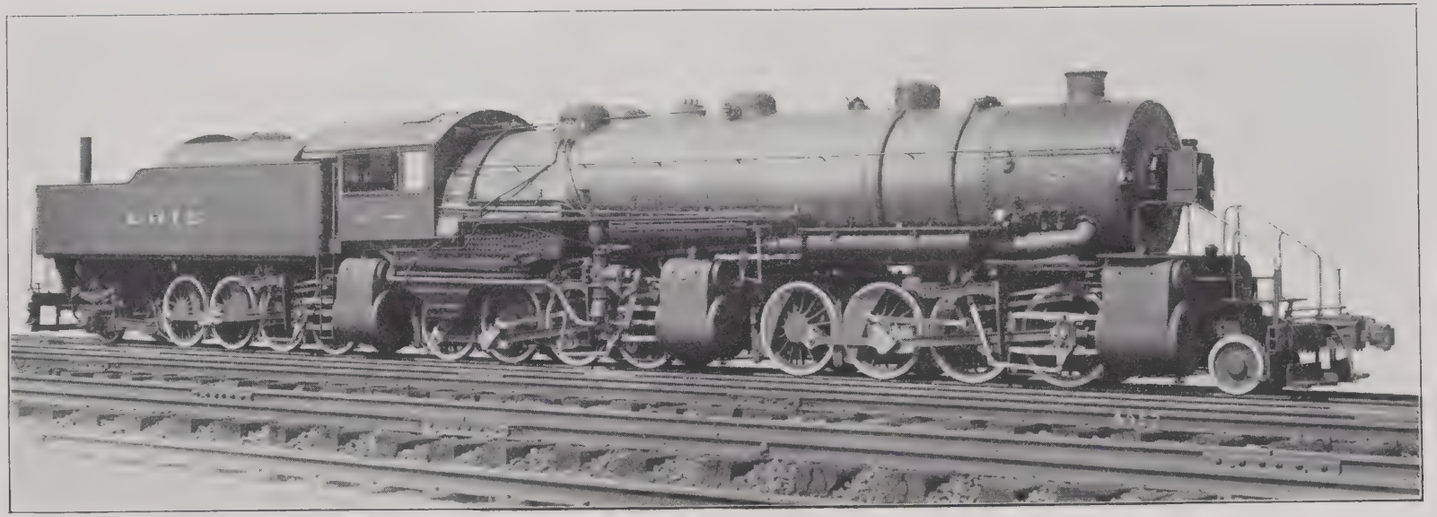
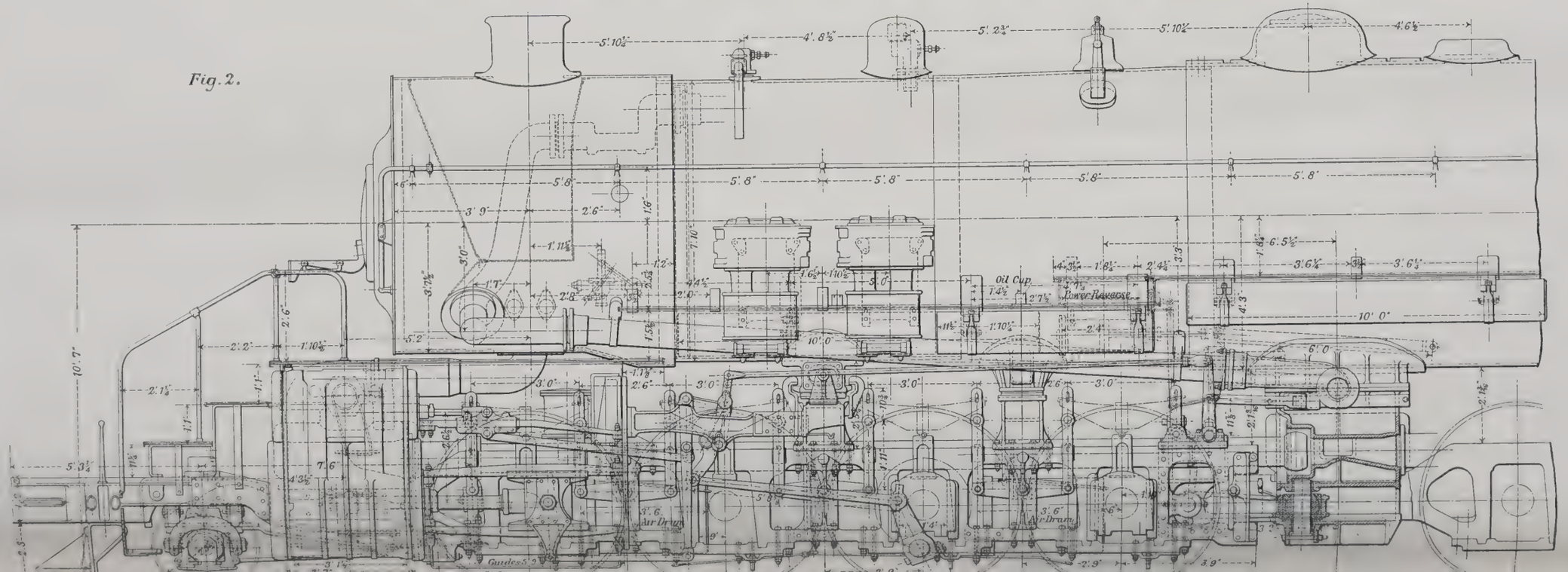


Fig. 1.

Fig. 2.



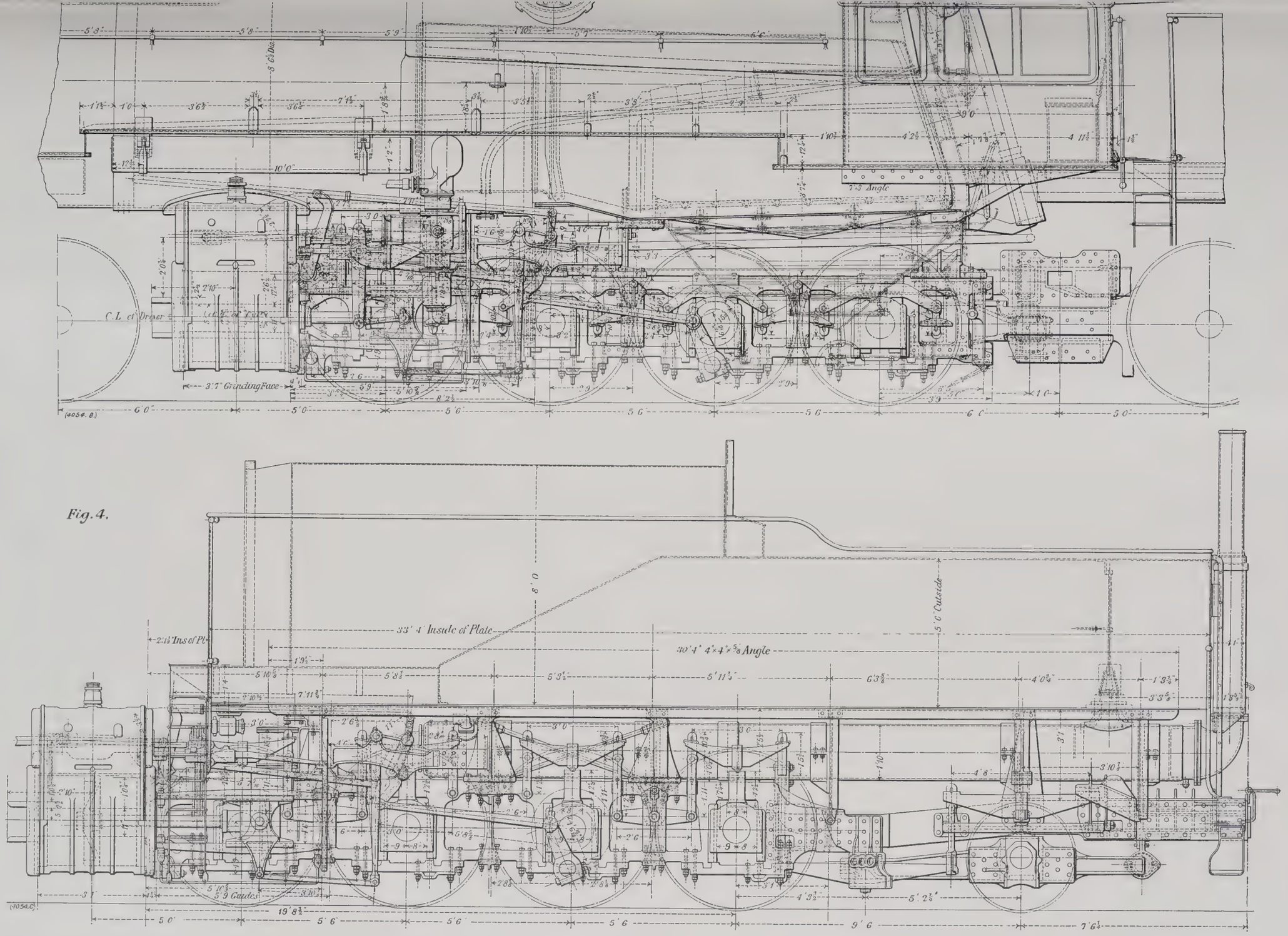

C.L. of Dryer
3'7" Grinding Face
8'0" Dia
10'0"
7'5 Angle
(4054. B.)
6'0"
5'0"
5'6"
5'6"
5'6"
6'0"
5'0"

Fig. 4.

8'0"
5'0" Outside
33'4" Inside of Plate
30'4" 4"×4"×⅝ Angle
2'8" Ins of Pl
5'9 Guides
(4054. C.)
5'0"
19'8½"
5'6"
5'6"
5'6"
9'6"
7'6¾"

structed one of the finest gas installations in the country. And only recently the cattle-markets and slaughter-houses, which formerly occupied a place in a very congested district in the centre of the town, have been removed to the suburbs, and built in accordance with the most modern ideas.

In Aberdeen, in 1880, a new bridge was built over the River Dee, 40 ft. wide. The foundations were carried down to the gravel, and sunk by means of cast-iron cylinders weighted inside. This bridge opened up an entirely new district on the south of the Dee.

Perth, in 1901, constructed a new carriage-bridge across the River Tay, with a width between the parapets of 42 ft., at a cost of 20,000*l.*

In dealing with municipalities one cannot help saying a word about the Town Planning Act, which was passed in 1909. It seems to me that corporations, both in Scotland and England, have quite lost their heads with regard to the administration of that Act. No doubt broad streets and roads and large open spaces in towns of all sizes are of great benefit to the people; but surely the provisions of this Act can be, and are in some cases being, carried much too far.

Take the case of the burgh of Dunfermline, a burgh which has a population of about 28,000, covering an area of 2032 acres, more than half of which is at the present time unbuilt on. It acquired, under the authority of Parliament, between five and six thousand acres of what is purely agricultural land, and it has completed a Town Planning scheme for the whole of that area. Unless something very extraordinary happens, this area of ground cannot be filled with houses for more than a century, and yet the Corporation are going to spend immediately a very large sum of money in laying out roads and sewers for the town-planning of this district.

Again, take the case of the City of Edinburgh. The Corporation own a large area of ground, extending to something like 90 acres, in the neighbourhood of the new cattle markets, available for feuing purposes, and at a recent meeting of the Corporation it was decided by a majority that no building to be put up on that ground is to exceed three storeys in height. The streets are to be wide, and several open-spaces are being provided, and in Edinburgh, which has some old buildings from twelve to fourteen storeys high, it seems absurd to restrict new buildings on this area to three storeys. If the height had been increased to four storeys, it would have meant a saving to the citizens of upwards of 3000*l.* a year. These are only two instances, but all over Scotland this Act is being strained to its utmost extent by corporations in order to make provision far in excess of anything needed in the near future.

There has been no addition to the canals of Scotland during the last fifty years; in fact, one or two, notably the Glasgow and Paisley Canal, have been done away with and replaced by railways.

The Royal Commission on Canals and Waterways, which sat recently, recommended that the Crinan Canal should be considerably improved so as to take larger vessels from the West Coast to Oban, but although that report was issued in 1906-8, nothing has been done in connection with the matter.

There has been a proposal before the public in Scotland for the last few years with regard to the construction of a ship canal between the Forth and the Clyde, wide enough and deep enough to take the largest vessels afloat, whether merchantmen or men-of-war. The saving in distance to be effected by such a canal is so trifling where large vessels with high speeds are concerned that I do not think it is at all necessary, and I am satisfied that if such a canal were constructed it could never prove a commercial success, nor do I think it can be constructed for anything like any of the figures I have seen mentioned as its probable cost.

During this period also much progress has been made with the development of the coal industry in Scotland. Prior to 1864 the great bulk of the supply in Scotland came from Lanarkshire and Ayrshire; and it was to deal to a large extent with these supplies that the Caledonian Railway Company incurred very large expenditure in building the new Grangemouth Docks in 1876 and 1889. More recently, however, the coal-fields in Fife and the Lothians have been developed, and large quantities of coal are now being put out from them.

The total output of coal in Scotland in 1864 was 12,400,000 tons; 1874 was 16,788,661 tons; 1884 was 21,186,688 tons; 1894 was 21,481,554 tons; 1904 was 35,453,009 tons; 1912 was 39,518,629 tons. But while in 1864 only 600,479 tons, or 4.84 per cent. of the total output, was exported to foreign countries, this has gradually increased during each decade until in 1912, 9,702,432 tons, or 24.55 per cent., were exported to foreign countries. This may be all very well for coal-owners, but it is a serious question whether our coal supplies should be so seriously depleted for the benefit of foreign nations.

This brief summary of engineering works in Scotland will show that she is in no way behind the other parts of the United Kingdom in keeping pace with the times, and carrying on the necessary works for the improvement of Scotland itself, and for the benefit of the trade of the country.

I should like to point out to the engineers of the present day how much more easy it is now, from every point of view, to carry out big works than it was at the beginning of the period with which I am dealing. In questions of construction we have now the benefit of pneumatic and hydraulic pressures and of electric energy. We use to an enormous extent Portland cement, which was first used, in Scotland at any rate, in 1870, but then only as a lime in which brickwork was set. The first notice I have of it being used for cement concrete was in 1877, when so little was known about Portland cement itself that no tests were specified with regard to it. Now it is used in great quantities not only for foundations, but as a substitute for stone and brick in quay-walls, retaining-walls, sea-walls, and even for arches. Then there is the substitution of steel for iron, which enables larger spans to be built, yet preserving the same margin of safety. The Greathead shield, for driving tunnels, and steam-navvies have also greatly simplified the construction of works.

Cast iron in under-line railway bridges, in consequence of two or three accidents, and especially of one which took place near Fyvie, on the Great North of Scotland Railway, in 1883, was in 1884 prohibited by the Board of Trade, except in the shape of arch ribs. Again, in the early days of the period I am dealing with, engineers had to specify and supervise the construction of all temporary huts for workmen. Now that is all undertaken by the Local Government Board, and the contractor has to comply with their requirements.

In some of my old specifications, after stating the sizes of the houses and the number of cubic feet, &c., to be provided in workmen's houses, the following clause occurs:—"Each bed to contain not more than two men, and to be at least 6 ft. long and 4 ft. wide inside." That specification was in use for many years, and, as far as I can make out, up to 1874. I am afraid the navvies in those days must have been of a smaller size than many we see about us now.

Apart from the mere question of construction, the whole routine office work is much simpler than in the early days.

Fifty years ago everybody wrote their own letters, there was little shorthand, and typewriting machines were not known. The telephone had not been introduced, and the electric telegraph was very sparingly used. There was no such thing as sun-prints, and for outside work one had either to walk or drive behind a horse, motors being quite unknown.

What has further tended to simplify all engineering works is the standardisation which has been undertaken by the British Engineering Standards Committee. Now, instead of having a long specification with regard to, say, cement or steel, a specification simply provides that these must comply with the requirements of the Engineering Standards Committee.

Ordnance sheets were only just being introduced fifty years ago, and I remember quite well hearing my father say that he thought the introduction of ordnance sheets would be the ruin of civil engineers, a great part of their work in those days consisting in surveying and preparing plans of the estates of landed proprietors. Instead of being the ruin of civil engineers, I suppose there is nothing that has tended more to simplify their work and enable them to lay out railways and other works more efficiently and rapidly than the introduction and use of ordnance sheets. All these appliances mean, just the same as in any other trade or profession, the introduction of more machinery and the consequent employment of less personal labour.

There is one other important point which I should like to allude to for a moment, and that is the introduction in recent years of reinforced concrete. While for certain structures this material may have its advantages, it is in many cases used for ordinary construction where stone or brickwork or steel would be much better, and, as far as I can make out, in most cases would be cheaper. This leads me to observe that, both as regards particular methods of construction in reinforced concrete adopted by individual firms, as well as other constructional and inspecting work undertaken by joint-stock companies, great efforts are continually made to secure the execution of work irrespective of designs which would in the ordinary course be prepared by independent professional engineers.

Unfortunately, men who are members or associate members of the Institution are often also members of, or agents or advisers of those companies, and thus take part in extending the operations of persons who, properly enough engaged in the supplying of materials or erection of structures, seek to include at the same time all the professional functions of advising, designing, and supervising.

Further, as you are aware, the Institution has set its face rigidly against any advertising for professional or advisory work on the part of its members; but while this regulation is adhered to by individual members, companies which contain, or are served by, members of the Institution advertise broadcast for work, frequently using the names of members in the advertisements; and the Council feel that members of the Institution who are acting for such companies are breaking the regulations that have been made. This matter is at the present time receiving the most anxious consideration of the Council, and it is their intention to take some steps to put a stop to the practice I am alluding to.

It is exceedingly difficult to say anything with regard to the future prospects of engineering, especially in Scotland. One thinks, as one has often thought before, that everything is done that can be done, and that little work is left for the engineer to carry out, but if the next fifty years are to see as many and as great changes as have taken place in the last fifty years, then the engineer has a new world before him.

At the present time, when competition is so keen in every walk of life, any new developments in connection with engineering matters which may tend to improve the comfort of passengers or to increase the speed of trains, or to reduce either the charges made for handling goods and merchandise, or the cost of production, must be of immense benefit to the community, and should claim the ardent attention of engineers.

But there is one matter which is urgently calling for the attention of all engineers. I mean the question of road-making, with special regard to the ever-increasing use of motor-vehicles. Many specifications have been proposed up to the present time, but so far I have not seen one that fully meets the requirements of all parties concerned.

Unless we are to have absolutely separate roads in the country for motor and horse traffic, a specification for the construction of a new road must give due weight to the requirements of each of these kinds of traffic, and a road must not be made so that it is fit for motor-car traffic and useless for horse traffic, or fit for horse traffic and useless for motor-car traffic. What is wanted is a road with a strong bottom, but with a certain amount of yield in it, and this must be covered with some special bituminous or non-absorbent material very carefully put on, bound together with tar or some other adhesive substance, so as to give an absolutely smooth surface and minimise the quantity of dust created by the travelling of motor vehicles. I have no doubt that after a few more experiments engineers will be able to construct roads that will give satisfaction to everyone using them.

Gentlemen, I feel that this address is, perhaps, too full of dates and statistics. But this was unavoidable; and if it is of any use or of any interest, even to a small portion of my audience, I shall be more than satisfied.

I wish to thank the engineers of the five Scotch railway companies, of the Clyde Trustees, and Leith Harbour Commissioners, and many others, as well as the members of my own staff, for their valuable assistance in the preparation of this address.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting of the Physical Society of London, held on October 23, at the Imperial College of Science, Professor Sir J. J. Thomson, O.M., F.R.S., President, in the chair, the Presidential Address was delivered by Professor Thomson, the subject being "Ionisation."

Abstract.

Ionisation is the process by which ions—particles charged with electricity—are produced in a solid, liquid or gas. This address is confined to the consideration of ions in gases, and deals with two questions: (1) the nature of the ions, (2) the process by which they are produced. The evidence as to the nature of ions is derived from experiments on their mobility, which have shown:—

α. The mobility of a positive ion depends only on the gas through which the ions are moving, and not on the nature of the gas out of which the ions are formed.

β. The mobility of the ions in a gas at constant density is independent of the temperature.

γ. There are a considerable number of gases in which the mobility is very approximately inversely proportional to the square root of the density of the gas.

δ. In the case of negative ions there is an abnormal increase of mobility when the pressure is reduced below a certain value, and there is some evidence that this is also the case for positive ions at very low pressures.

Two theories of the mobilities of ions were considered, one founded on the view that the action between ions and molecules is analogous to impacts between hard elastic spheres, the other on Maxwell's theory of forces between ions and molecules varying inversely as the fifth power of the distance between them.

It is shown that α follows from the second theory, provided the ion is a cluster whose mass is considerably greater than that of a molecule of the gas through which it is moving. On this supposition it follows also from the first theory if we suppose in addition that all ions in a given gas are of the same size.

(β) follows at once from the second theory; to explain it on the first theory we must suppose that the size of the ion varies with the temperature in a definite way. The necessary relation can be deduced from thermodynamical principles if we suppose that the force between an ion and a molecule is analogous to that between a charged point and a sphere which is either a conductor of electricity or has a high specific inductive capacity.

(γ) requires on theory 1 that the ions in these gases should be of the same size, on theory 2 that the molecules of these gases should exert the same force on a charged point at a given distance.

(δ) follows on either theory if the ion dissociates at low pressures, so that free corpuscles are present in the gas.

With regard to the process of ionisation, the first stage of this in the vast majority of cases consists in the detachment of an electron or corpuscle. Evidence as to the method by which this takes place is afforded by determinations of the velocity with which the electrons are ejected from the body.

In the case of ionisation by light or Röntgen rays, this velocity depends primarily on the wave-length of the radiation, not upon its intensity, nor, at any rate, to any great extent, on the nature of the molecule from which the corpuscle is ejected. This velocity is far greater, even when every allowance is made for resonance, than can be accounted for if we suppose that the energy of the light is uniformly distributed, and that the corpuscle acquires its velocity by the action on it of the electric force in the wave. Another explanation not open to these objections was put forward.

When ionisation is due to the action of moving electrified particles, whether positive or negative, the results are quite different. The velocity of the ejected particles (δ rays, as they are sometimes called) does not seem to vary much, if at all, with the velocity of the particles which eject them, and is of the same order whether these particles are positive rays or the much swifter cathode rays. The method of ejection by the impact of such particles was considered, and suggestions

as to a possible theory and some of its consequences thrown out.

Dr. R. T. Glazebrook, in moving a vote of thanks to the President, said that one expected, when listening to Sir J. J. Thomson, to be carried to the bounds of knowledge by one who had taken no small part in the extension of these bounds, and he was confident that none of those present had been disappointed in that expectation. He asked the President, on behalf of the Society, to allow his address to be published in full in the Proceedings.

Dr. C. Chree seconded the vote of thanks, which was carried with enthusiasm.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

South Africa: The Commercial Intelligence Branch of the Board of Trade is notified that tenders are invited by the Port Elizabeth City Council for the supply of the following plant required in connection with the municipal electric supply undertaking:—Section A, engine-room plant, comprising turbo-generators, high-tension switch-gear, and converting plant. Section B, boiler-house plant, comprising boilers and coal-conveyer. Section C, high-tension and telephone cables. Copies of the specifications and forms of tender, &c., may be obtained from the London agents of the Port Elizabeth City Council, Messrs. Davis and Soper, 54, St. Mary Axe, E.C., on deposit of 5*l.*, which will be returned upon receipt of a *bonâ fide* tender. Sealed tenders will be received by Messrs. Davis and Soper up to noon on November 26.

France: A contractor and engineer, who has hitherto purchased from German firms, wishes to get into touch with United Kingdom manufacturers of contractors' locomotives. A Lyons firm, which has hitherto obtained its supplies from Germany, wishes to hear from United Kingdom exporters of the raw chemicals used in the manufacture of boot-leather dressing. A firm in Lyons wishes to obtain the names of United Kingdom manufacturers of imitation rubber. United Kingdom manufacturers and exporters of the above-mentioned goods may obtain the names and addresses of the inquirers on application to the Commercial Intelligence Branch; but they should address any further communications regarding the inquiries to the British Consulate, Lyons.

Spain: The *Gaceta de Madrid* notifies that tenders for the installation of three electric cranes will be received by the Junta de Obras del Puerto de Alicante, Alicante, up to noon on December 28. Tenders must be accompanied by drawings and full particulars in Spanish; prices must be quoted in pesetas, and weights and measures are to be in the metric system. A deposit of 1500 pesetas (about 55*l.*) is required to qualify any tender. Local representation is necessary. The *Gaceta* also contains a decree authorising the Port Authorities at Santander to carry out wharf improvements at that port at an estimated cost of 140,151 pesetas (about 5190*l.*). The *Gaceta* further contains a decree authorising the Ministerio de Fomento to arrange for the execution of drainage works in the district of Corcovado on the Rio Mula, in the Province of Murcia, at an estimated cost of 1,119,520 pesetas (about 41,460*l.*).

Italy: His Majesty's Consul at Milan reports that a firm in that city desires to get into touch with United Kingdom manufacturers of motor road-rollers (petrol or benzine). United Kingdom manufacturers of motor road-rollers may obtain the name and address of the inquirer on application to the Commercial Intelligence Branch, but they should address any further communications regarding the inquiry to the British Consulate, Milan.

Dominican Republic: H.M. Chargé d'Affaires at Santo Domingo reports that a few years ago there were apparently no roads in the Dominican Republic which were practicable for wheeled traffic all the year round. Good roads, however, are now under construction by the Public Works Department, although progress is very slow. A road from the capital to the north, now a difficult and often dangerous trail, will probably be begun during the current year; when completed, the journey to Monte Cristy will be possible by motor-car in 15 hours, whereas now it requires six or more days of hard riding. Railways are also urgently required. There are at present two small narrow-gauge lines in the north, one from Puerto Plata to Santiago and Moca, and the other from Sanchez to Salcedo and La Vega. It is proposed to connect these two systems by a line from Salcedo to Moca. The construction of a line from Manzanillo Bay to Santiago is contemplated by an American company.

Argentina: The *Boletin Oficial*, Buenos Aires, publishes the text of a law granting to the Compañía Francesa de los Ferrocarriles en la Provincia de Santa Fé a concession for the construction and working of a railway, of 1-metre gauge, starting from the station of Charadai and running in a westerly direction for a distance of 95 km. (about 59 miles), and a branch line in a north-westerly direction about 100 km. (62 miles) long. Plans and estimates relative to the construction of the lines must be submitted to the executive authorities within a year of the signing of the contract; work must be begun within six months from their approval and completed within a further two years.

Personal.—Messrs. Burgon and Ball, Limited, La Plata Works, Malin Bridge, Sheffield, inform us that they have appointed Mr. Edward Pennington, 2, Fen-court, Fenchurch-street, E.C., their London representative.

CATALOGUES.

Insulators.—A catalogue section of porcelain and stoneware insulators has reached us from Messrs. Doulton and Co., Limited, of Lambeth, S.E. The catalogue deals with shackles, cable-insulators, cable-racks, bus-bar supports, fuse-handles, leading-in tubes, cleats, battery-jars, bridge-insulators, resistance-bobbins, and conductor-rail insulators for electric railways. Prices are stated for most of these articles.

Duplex Pumps.—The National Transit Company, of Oil City, Penn., U.S.A., have sent us two bulletins giving full particulars of duplex pumps manufactured by them. The bulletins are placed in a binding-case, to which later publications from the firm can be added as they come to hand. Tables of dimensions and capacities are given, together with illustrated lists of repair parts. Full instructions for setting up and operating the pumps are also included.

Tin-Dredgers.—Messrs. Werf Conrad, Limited, of Haarlem, Holland, have issued a loose-leaf catalogue of bucket dredgers and other plant for recovering tin from river beds, alluvial flats and benches. Several examples of dredgers recently constructed by the firm are illustrated, and each of the main component parts of the dredgers, including hulls, gantries, buckets, screens, elevators, engines, &c., is separately dealt with. Some examples of centrifugal pumping-plant for recovering tin are also included. The London address of the firm is Friar's House, 39-41, New Broad-street, E.C.

Wire Ropes.—A useful catalogue of wire ropes and accessories has been issued by Messrs. W. D. Houghton and Co., Limited, of Sankey Bridges, Warrington. This catalogue is divided into five sections, devoted, respectively, to ropes for mining, engineering, marine, trawling, and steam-ploughing work. Each section gives sizes, weights, breaking stresses, working-loads and other data in tabular form for ropes suitable for different classes of work. The catalogue also contains instructions for splicing ropes and other useful information.

Electric-Lighting Sets.—Messrs. Pooley and Austin, of 25, Victoria-street, Westminster, S.W., have sent us a circular giving particulars of small electric-lighting sets they have placed upon the market for use on yachts and in small country houses and bungalows. These sets comprise a Mawdsley zone-type dynamo, driven by a single-cylinder vertical engine of the two-cycle type, capable of running with either petrol or paraffin as fuel. They are listed in three sizes, with outputs of 300, 400, and 500 watts respectively. Prices are quoted for the engines and dynamos, and also for sets of accumulators and switchboards.

Lock-Nuts.—A pamphlet relating to Larrad's patent Conegrip lock-nuts has come to hand from Cayenne Motors, Limited, of St. Leonards, Sussex. These nuts are made in two parts, of which the lower one is formed with a tapered recess. The upper part is split longitudinally and has a projection which fits into the recess in the lower part. It will be evident that when the upper part of the nut is screwed down, the projecting part will be forced radially inwards by the tapering walls of the recess, and thus the bolt will be gripped very tightly. Several types and patterns are made for different purposes, but all are constructed on the principle outlined above. They can be supplied in steel, iron, brass, and other metals, to fit shafts or bolts from $\frac{3}{16}$ in. to 3 in. in diameter.

Steam-Cranes.—The Bedford Engineering Company, of Bedford, have sent us a copy of their latest illustrated price-list of steam-cranes. A general specification for the construction of the cranes is given, and this is followed by particulars of locomotive cranes for loads ranging from 1 to 10 tons. Fixed cranes, shunting cranes, and cranes with special jibs are also dealt with. The catalogue is fully coded, and, by the use of single syllables representing various features, it is possible, in many cases, completely to specify a crane in a single word. This point, combined with the fact that complete shipping specifications are given as far as possible, will doubtless appeal strongly to foreign buyers. Another useful feature of the catalogue is the inclusion of an illustrated price-list of spare parts. We understand that the firm have Spanish and Portuguese editions of this catalogue in preparation.

Decorations for Ships and Railway Carriages.—We have received from the Tynecastle Company, Albert Works, Tynecastle, Edinburgh, a hand-book illustrating examples of ceiling and wall decoration work carried out by them in the saloons of passenger steamers, and also in railway carriages. These include ceiling and freize decorations in "Tynecastle" canvas, wall decorations in composition and hardened plaster, and ceiling and freize decorations in embossed fine linen. Some examples of ornamental bands for the enrichment of wood mouldings, trusses and capitals for columns and pilasters, cornices and beam-casings, and other decorative work in hardened plaster are also included. Stephen's fireproof bulkheading for the passenger and other accommodation of ships is also dealt with, and an example of a state-room carried out on this system is illustrated.

Alternating-Current Motors.—Copies of their latest catalogue and price-list of alternating-current motors have come to hand from the Langdon-Davies Motor Company, of 110, Cannon-street, E.C. The catalogue contains a general specification for the machines, and illustrates several examples of them; it also illustrates different types of starting apparatus. The price-list gives all necessary particulars of single-phase motors of the squirrel-cage and slip-ring types, for use on 40-cycle to 125-cycle circuits; they are listed in sizes ranging from $\frac{1}{10}$ to 100 horse-power. Polyphase motors are also dealt with. These are also made with squirrel-cage and slip-ring rotors for 25-cycle and 50-cycle circuits. The 25-cycle motors are listed up to 80 horse-power, and 50-cycle motors up to 120 horse-power.

Oil-Engines.—The latest bulletin from the Chicago Pneumatic Tool Company, of Fisher Building, Chicago, Ill., U.S.A., is devoted to their "Giant" oil-engines, which are designed to run on low-grade fuel oils. These engines are of the enclosed, horizontal, two-cycle, low-compression type, and they are provided with cross-heads. Their construction, which includes many special features, is illustrated and described in detail in the bulletin. The charge is first compressed in the front end of the cylinder, instead of in the crank-case, and ignition is effected by means of a thin circular plate attached to the piston. Fuel is sprayed into the cylinder by means of a variable-stroke pump, and coming into contact with the heated plate it is instantly gasified and ignited; for starting, a hot tube is employed. The engines are made in four standard sizes, having capacities of 12, 18, 25, and 45 horse-power. The London address of the firm is the Consolidated Pneumatic Tool Company, Limited, 9, Bridge-street, Westminster, S.W.

Motor-Car.—Messrs. D. Napier and Son, Limited, 14, New Burlington-street, W., have sent us particulars of a trial carried out on one of their 20-horse-power Colonial-type motor-cars, under the auspices of the Royal Automobile Club. The total distance covered was 506.5 miles, spread over five days, the route each day being over a course from London to Byfleet, Ripley, Guildford and the Hog's Back, over Hankley and Frensham Commons, and then back to London. The course included twice fording the River Wey, and a considerable part of each run was over trackless country covered with heather and furze, and including sandy patches, boggy land, and military trenches, as well as many severe ascents. No serious trouble was experienced, and such difficulties as occurred, though sufficient to have completely smashed an ordinary car, were easily surmounted. The average speed of the car (running time only) was 15.1 miles per hour, and the distance covered per gallon of petrol was 14.34 miles, which works out to 26.84 ton-miles per gallon. On the fifth day the car was driven to Brooklands, where it attained a speed of 50.52 miles per hour over the flying half-mile, thus showing that it is capable of running at high speeds as well as of withstanding very rough usage.

Packings.—Messrs. Ronald Trist and Co., Limited, of Coronation House, 4, Lloyd's-avenue, E.C., have sent us particulars of some tests of their well-known "S.E.A." packing-rings carried out at the Conservatoire National des Arts et Métiers, Paris, shortly before the outbreak of the war. The tests were made with a special apparatus, which consisted, essentially, of a cylinder having a stuffing-box at each end, through which passed a steel rod traversing the cylinder from end to end. The first tests were made with steam at a pressure of 8 kg. per sq. cm. in the cylinder. With the stuffing-boxes packed with plaited asbestos, the friction was 3.28 kg. per cm. of the circumference of the rod, while with "S.E.A." rings the fricton was only 1.23 kg. per cm. The average linear velocity of the rod was 40 cm. per second in both tests. Other tests were made with water at the above-mentioned pressure in the cylinder, and in these the friction was 9.01 kg. per cm. with plaited cotton packing, and 1.8 kg. per cm. with "S.E.A." rings. The linear velocities of the rod in these tests were 30 cm. and 34 cm. per second respectively. Slight leakage occurred with the plaited packings in both steam and water tests, but the "S.E.A." rings were absolutely tight in all cases.

Surface Combustion. — A little booklet, giving some useful facts and figures relating to surface combustion and its applications, has recently been issued by Bonecourt Surface Combustion, Limited, of Parliament Mansions, Westminster, S.W. The science of combustion is first dealt with generally, and some useful data on gaseous fuels of all kinds are then given. Following these is the reprint of a lecture on the scientific aspects of surface combustion, delivered by Professor W. A. Bone, before the Royal Institution, and reproduced in Engineering of March 13 last, on page 357. The booklet then fully explains the Bonecourt system, and illustrates and describes the firm's well-known diaphragm heaters. The application of these heaters to sugar-boiling, and other industrial processes, is also dealt with. Examples of enamelling, forging, annealing, glass-melting, and metal-melting furnaces, heated by the surface combustion of various gases, are also included. The remainder of the booklet (nearly a half of it) is devoted to the subject of steam generation by surface combustion. Illustrations of various types of Bonecourt boilers are given, together with particulars of several tests, in which an efficiency of 92.7 per cent. has been obtained. The surface-combustion principle has now been applied to boilers fired with oil fuel. This very interesting and important application is fully dealt with. The booklet is altogether a highly creditable publication. Great care has been taken to ensure the accuracy of the information given, and as the subject of fuel economy is of such vast importance in almost every industry, a considerable demand for copies of the booklet may be confidently expected.

Coal in Iceland.—The fear of a coal famine in Denmark on account of the war has caused the coal deposits at Dufansdale, in the Arnar firth, to be examined, and the results of the investigation is understood to be encouraging. The deposits are likely to prove very extensive, and the quality is satisfactory and improves the deeper one gets. They are right upon a firth with excellent anchorage for vessels.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

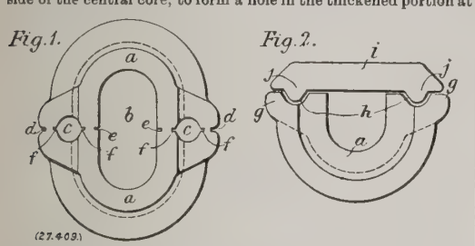
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

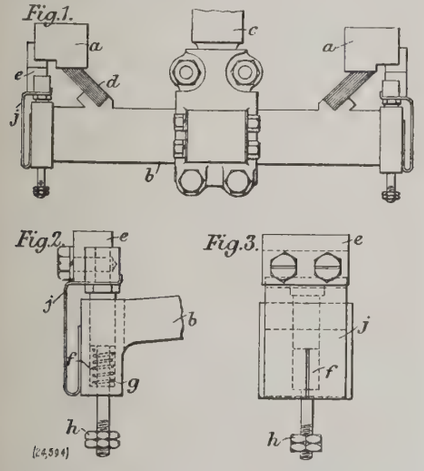
ELECTRICAL APPARATUS.

27,409/13. H. L. Doulton and C. E. Morris, London. Earthenware Cable-Troughs. [2 *Figs.*] November 28, 1913.—This invention relates to improvements in the manufacture of earthenware cable troughs having grooves in their top edges. It is customary to make ordinary earthenware troughs in the form of a tube, consisting of two troughs joined edge to edge, and having the walls partially cut through at the juncture in order to allow the two troughs to be readily separated after the firing process, such tubes being formed by passing clay through dies of a suitable cross-section. According to this invention, the dies are shaped to form a tube having thickened portions diametrically opposite to each other, so as to form troughs having side walls thicker at the top. In order to form grooves in the top edges of the troughs a supplementary core is provided at each side of the central core, to form a hole in the thickened portion at



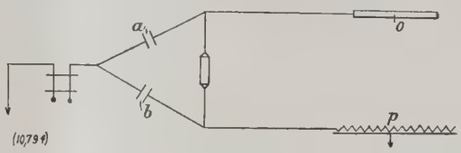
each side of the tube extending from end to end. Cutters are fixed to the dies to form slots in a plane bisecting the holes formed by the supplementary cores. One end of a trough is provided with a socket, and the other end is adapted to enter the socket of another trough. *a*, *a* are two troughs joined face to face, and *b* is the hole made by the central core, whilst *c*, *c* are the holes formed by the supplementary cores. Slots *d*, *d* are formed on the outer sides of the tube by cutters fixed to the die, and *e*, *e* are slots formed at each side of the central hole by cutters on the central core, whilst slots *f*, *f* are formed by cutters on the supplementary cores. After the tube has been fired it is broken into halves and forms a trough, as shown in Fig. 2. The trough *a* has the top of each side thickened at *g*, and a groove *h* is formed in the top of this thickened portion. The cover *i* is provided with lugs *j*, *j* on its under side, which enter the grooves *h*, *h*. (*Sealed October* 22, 1914.)

24,594/13. F. B. Holt, Northwich, and H. Smith, Stretford. Electric Switches. [3 *Figs.*] October 29, 1913.—This invention relates more particularly to switches provided in addition to the main contacts with auxiliary contacts adapted to break contact later than the main contacts, and to which any arcs which may be formed on opening the switch may be confined. Such auxiliary contacts are usually resiliently or movably connected with the movable member of the switch, and are provided with flexible copper shunts. According to this invention, the shunt consists of a strap or plate of good conducting resilient metal, such as phosphor-bronze or well-tempered copper, one end of which is firmly secured to the auxiliary contact, the other or free end making sliding contact with one of the members of the switch. The fixed contacts of the switch are shown at *a*, the



movable bridging member *b* of the switch being carried by an operating rod *c*. The main movable contacts are shown at *d*, and the auxiliary or sparking contacts at *e*. The construction of the latter and of the improved shunt will be more clearly seen from Figs. 2 and 3. The auxiliary contacts *e* are, as usual, resiliently connected with the movable member *b* of the switch. In the present instance the auxiliary contacts slide in slots *f* in the extremities of the movable member *b*, being forced upwards by a spring *g*, their upward travel being limited by stops *h*. The improved shunt is shown at *j*, and consists of a strap of phosphor-bronze or well-tempered copper, one end of which is firmly secured to the auxiliary contact, the other end being doubled on itself and adapted to make sliding connection with the end face of the movable member *b* of the circuit-breaker. In order to improve the electrical contact between the movable member *b* and the shunt *j*, the latter may be provided with one or more saw-cuts at its free end. During the early part of the movement of the movable member *b* of the switch only the fixed contacts *a* and *d* are separated, the auxiliary contacts *e* moving upwards under the influence of their springs *g* in a well-known manner. During this movement of the auxiliary contacts the free end of the metal strap *j* constituting the shunt makes sliding contact with the end face of the movable member *b*. (*Accepted August* 19, 1914.)

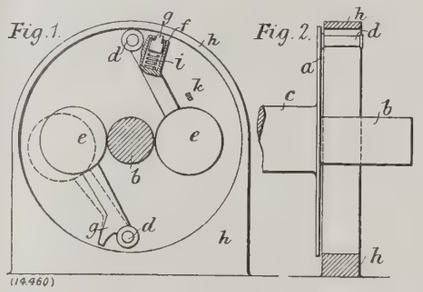
10,794/14. F. Ryan and the Eastern Telegraph Company, Limited, London. Duplex Telegraphy. [1 *Fig.*] May 1, 1914.—Artificial lines used for duplexing submarine cables are made in at least three different patterns as regards the way in which they are affected by change of temperature. For example:—(1) They may vary both in resistance and capacity; (2) they may vary in capacity only; (3) they may be invariable both as regards resistance and capacity. This invention relates to the second class, where the artificial line, though practically constant as regards the resistance, may vary in capa-



city when changes of temperature occur. The invention consists in providing in one arm of a duplex bridge a condenser having a zero temperature coefficient as regards its capacity, and in the other arm a condenser having a negative temperature coefficient and a condenser having a zero temperature coefficient. The diagrammatic drawing illustrates one way of carrying the invention into effect. A plain condenser bridge is used. *a* and *b* represent the capacities of the condensers in the two arms referred to above, *a* being the capacity of zero temperature coefficient leading to the cable *o*, and *b* the composite capacity leading to the artificial line *p*. (*Accepted August* 12, 1914.)

GUNS AND EXPLOSIVES.

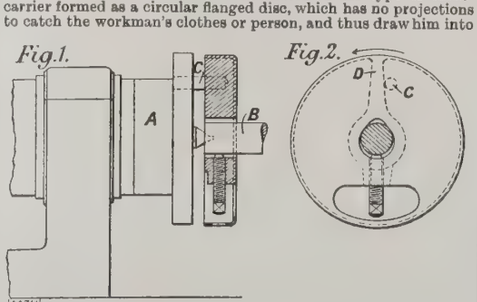
14,460/14. Harle et Cie., Paris, France. Submarine Mines. [3 *Figs.*] June 17, 1913.—This invention relates to a brake for such submarine mines as are provided with an anchor having a lead-line for regulating the depth of immersion of the mine. In such mines while launching—that is to say, during the descent of the anchor—it is desirable that the rope connecting the anchor to the mine should be at a tension sufficient to keep it taut, but not great enough to drag the mine below the surface while the rope is being unwound. With this object it has already been proposed to provide the drum with automatic regulating brakes, so as to correct, as far as possible, accidental variations in the strength of the brake, and to avoid oscillations in level of the mine when thrown into the water. Most of such brakes, however, require regulation or adjustment just before use. According



to this invention, the brake is applied by the movement of a weight due to centrifugal force. *c* is the drum upon which the mooring-rope is wound; it is mounted upon a shaft *b*, and provided with a cheek *a*. *d*, *d* are spindles (two for example) carried by the cheek *a*, about which weighted arms *e* turn. In Fig. 1 the weights are shown in full lines resting against the shaft *b*. When the drum *c* rotates, centrifugal force tends to separate the weights *e*, and cause them to take a position such as is shown in dotted lines. Shoes *g* carried by the weighted arms rub against the internal face of the fixed brake drum *h*. In place of connecting the shoes directly to the weights *e*, a spring *i* and abutment *f* may be interposed as indicated in the drawing, in which a spring *i* thrusts outward a plunger carrying the shoe *g*. The abutment *f* limiting the extension of the spring forces the shoe *g* to separate from the drum *h* when the weight *e* approaches the shaft. The centrifugal movement of the weight may, with a spring, such as *i*, be advantageously limited by a stop *k* to prevent the weights coming into contact with the drum *h*. (*Accepted August* 12, 1914.)

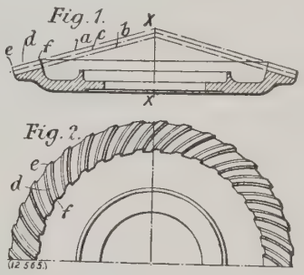
MACHINE AND OTHER TOOLS, SHAFTING, &c.

28,711/13. A. Ransome and Co., Limited, and W. V. Jones, Newark-on-Trent. Lathe-Carrier. [3 *Figs.*] December 12, 1913.—The invention relates to the type of lathe-carrier formed as a circular flanged disc, which has no projections to catch the workman's clothes or person, and thus draw him into



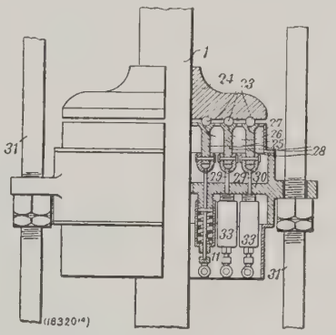
the machine. The invention consists in the particular construction of carrier hereinafter described, in which the circular flanged disc has a boss which may have the usual heart-shaped hole and set-screw for fixing to the mandrel on to which the work is mounted for turning. A rib or projection is formed inside the flange of the disc, against which the pin on the driving-chuck of the lathe bears when turning the work. The outside flange round the disc is made of suitable width to cover the driving-pin, and so form a guard. The hole need not be made exactly concentric with the rim, but the outside of the disc is always made without outside projections of any kind. The drawings show the lathe-carrier made in accordance with this invention, in which Fig. 1 shows a portion of the lathe-headstock with driving-chuck and centre, with the carrier in position ready for use, the carrier being shown in section to show it more clearly. Fig. 2 shows a front view of the carrier with the hole made concentric with the rim. A represents the driving-chuck, B the article being turned or a mandrel for carrying it, C the driving-pin in the chuck, D the projection inside the carrier against which the driving-pin bears when at work. (*Sealed October* 22, 1914.)

12,565/14. L. Renault, Billancourt, France. Bevel-Gear Wheels. [2 *Figs.*] January 7, 1914.—The invention relates to bevel-gear wheels and has for its object to ensure silent meshing and facilitate the machining operations. For the purpose of decreasing the noise created by the running of bevel gears, it has already been proposed to form their teeth helically; but if it is desired to preserve the nature of conical or bevel gears in which the point and the roof of the tooth form conical surfaces the common apex of which is that of the pitch-cone, great difficulties are encountered when cutting these teeth. The cost of manufacture, moveover, is very high. According to this invention, the roots and the points of the teeth, instead of forming two cones having their apices coinciding with that of the pitch-cone, constitute two cones parallel to the pitch-cone for the purpose of affording the teeth a constant height throughout their length. The cone *a* and the cone *b* corresponding to the



point and the root of the tooth respectively, instead of having their apices at the same point in the axis *x*, *x*, are two parallel cones. Both cones are parallel to the pitch cone *c*. In other words, the tooth *d* has the same height at the point *e* as at the point *f*. If the plan view of the gear is considered, the teeth have the helical shape shown in Fig. 2. The constant height of the teeth permits of forming the gear with a milling-cutter or any other shaping tool. The profile of the tooth is constituted by two lines—the flank, that is to say, the part underneath the pitch cone, is constituted by a straight line, and the face, that is to say, the part located above the pitch cone, is constituted by a curve determined in such a manner as to ensure the best meshing with the flank of the corresponding gear-wheel. In practice the faces of two gears which have to mesh are determined in such a manner that the meshing should be perfect for the inner edges of the teeth—that is to say, at the point *f*. (*Accepted August* 12, 1914.)

18,320/14. A. J. Hollick and W. Kneen, London. Thrust-Bearings. [1 *Fig.*] August 14, 1913.—This invention has relation to the anti-frictional mounting of shafts, and has for its object to provide improvements in anti-frictional mountings of such character and nature that the thrust of the shaft is taken up or is resisted in a more advantageous manner than is now the case. The invention, further, has for object to render it possible to employ ball or roller-bearings and to enable such ball or roller-bearings to take up or resist a greater thrust than is now possible in view of the limitations as to thrust governing or pertaining to bearings of the kind mentioned. In a ball or roller thrust-bearing in accordance with this invention, having a plurality of coaxial rows of balls or rollers arranged in one plane or a plurality of parallel planes, one set of the races is combined in a common structure, or the several races on the one side of the balls or rollers are integral or in rigid connection the one with the other or others, and the other set of races, or the several races on the other or opposite side of the balls or rollers, is or are independent the one of the other or others, and each race of the secondly-mentioned set of races is carried, mounted, or supported separately and independently by spring, pneumatic, hydraulic,

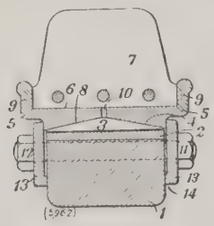


or other bearing-supporting arrangements of the type which are limited as to motion in one direction and are subjected to a stress or load of such magnitude that, under normal conditions, the bearing-supporting arrangements are always in their limiting position, the arrangement being such that each race of the secondly-mentioned set of races is free to give or move separately and independently of the other race or races in the said set and in one direction only when the shaft is subjected to abnormal influences. 1 is a shaft subject to end-thrust, which is taken up by a plurality of ball-bearings. The upper races for the balls 23 are formed in a common member 24 attached to the shaft 1. The lower races 25, 26, 27 are each independent the one of the other, and each is supported by spring, pneumatic, hydraulic, or other bearing-supporting arrangements of the type which are limited as to motion in one direction and are subjected to a stress or load of such magnitude that, under normal conditions, the bearing-supporting arrangements are always in their limiting position, the arrangement being such that each race of the secondly-mentioned set of races is free to give or move separately and independently of the other race or races in the said set and in one

direction only when the shaft is subjected to abnormal influences. Each of the ball-races 25, 26, 27 is provided with downwardly-extending flanges 28, and to each of these flanges is attached a plurality of bolts 29. These bolts 29 extend through holes in a plate 30 carried by shafts 31 arranged longitudinally of and parallel with the shaft 1. The lower face of the plate 30 around each hole is formed with a boss or projection, and this boss or projection is screw-threaded and serves to carry a cylinder 33 within which is placed a spring 11. The spring 11 is confined between the lower inner end of the cylinder 33 and a shoulder attached to the bolt 29. In use, the thrust of the shaft is taken up or resisted by the ball-bearings. Before the shaft 1 is subjected to end-thrust, the cylinders 33 are so adjusted that each spring 11 is subjected to an initial stress of a magnitude greater to a small extent than the load it will have to take up or resist under normal conditions. The spring will therefore exert a greater force than the force due to the thrust of the shaft, and the difference between the two forces will, under normal conditions, cause the shoulders to be always in contact with the bosses or projections, which bosses or projections, therefore, act as limiting devices. When the shaft is subjected to an abnormal end thrust, the ball-bearings or the members thereof are caused to move in opposition to the springs 11. The springs 11 tend to return the shaft to its normal position as the abnormal end thrust is lessened or reduced. (*Sealed October* 29, 1914.)

MOTOR ROAD VEHICLES.

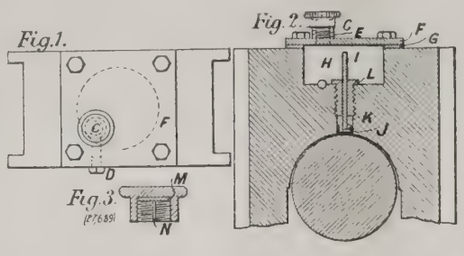
5962/14. P. B. Bosworth, Ohio, U.S.A. Vehicle Wheels. [1 *Fig.*] March 9, 1914.—This invention relates to improvements in vehicle wheels, more especially to the rim portion thereof. A vehicle wheel, according to this invention, is provided on the peripheral portion thereof with a circumferentially-extending broken annulus approximately triangular in cross-section, a pair of annularly-formed tyre-holding members seated on the inclined faces of the said annulus, the inner faces of the said tyre-holding members being fashioned to engage and co-operate with the inclined faces of the said broken annulus and with outwardly-extending portions adapted to engage the base portion of a tyre whereby when the said tyre-holding members are forced towards each other the said broken annulus is clamped on the said wheel, the said tyre-holding members are clamped on the said annulus against movement and the base portion of the tyre is compressed or distorted. 1 indicates the felloe of an ordinary vehicle wheel on which is mounted a peripheral felloe-band 2. Extending circumferentially and seated on the outer face of the felloe-band 2 is a broken annulus 3 approximately conical in cross-section, with a wide base approximating in width substantially to the width of the felloe-band 2 and with a relatively narrow median portion from which the outer face of the band inclines in both directions to the side edges thereof, and with the angles between the base and the faces 4 thereof forming an abrupt and an acute angle. Adapted to be mounted on the faces 4 of the broken annulus 3 is a pair of tyre-holding members 5, each provided with an outer face 6, constituting, when positioned, a seat for a tyre 7, and each also provided with an inclined inner face 8 adapted to engage one of the faces 4 of the broken annulus 3. The lateral portions of the members 5 are provided with outwardly-extending tyre-engaging flanges 9 of a preferred type—that is to say, if the tyre to be engaged is provided with what is known as a straight side, the flanges are shaped accordingly, and if the lateral faces of the tyre 7 are provided with lateral beads, the flanges 9 will be fashioned in the form of the conventional clincher



flanges to accommodate themselves to the curved surfaces of the tyre. The members 5 are so arranged that when seated and with their inner inclined faces 8 engaging the outer faces 4 of the broken annulus 3, the inner or opposing edges of the members will be slightly separated to provide a space 10. The wheel is provided at intervals with suitable transverse apertures in which are mounted bolts 11, provided with nuts 12. In order to force the members 5 towards each other, there is provided on each of the lateral faces of the wheel a circumferentially-extending clamping-band 13, the outer portion of each ring being adapted to engage the side face of its respective rim-forming band 5, and with its inner portion provided with a circumferential lug 14 designed to engage one side of the wheel. The circumferential rings 13 are provided with a series of apertures arranged to be positioned in registering relation with respect to the apertures in the wheel which receive the bolts 11, so that the bolts 11 may be passed through these three registering apertures, and as the nuts 12 are drawn up the bands 13 are drawn towards each other and as their inner portions 14 engage the wheel, their outer portions engaging the members 5 will force the latter towards each other, and as the members 5 are annular and their inner faces 8 engage the faces of the broken annulus 3, the latter is first of all contracted on its seat on the felloe-band, and the wedging action set up by the lateral movements of the rim-forming members 5 towards each other tends to tighten them in position and prevent circumferential movement thereof. At the same time the lateral movements of the members 5 towards each other causes the flanges 9 thereof to compress or distort the base portion of the tyre which is seated on the outer face of these members, so that a duplex result is effected; that is to say, the rim-forming members 5, by being forced towards each other, are clamped on to the member 3, which in turn is compressed or contracted on to the felloe-band, thereby effectually locking the rim-forming members 5 from movement, and the much-desired compression or distortion of the base of the tyre is effected. (*Sealed October* 19, 1914.)

RAILWAYS AND TRAMWAYS.

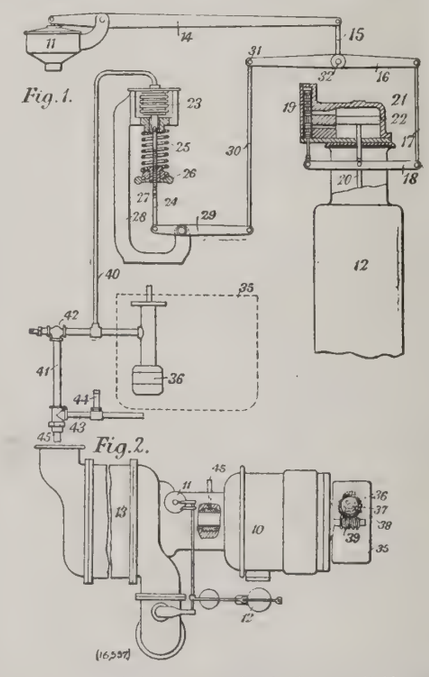
27,689/13. R. Jelley, Swansea. Locomotive Axle-Bearings. [4 *Figs.*] December 2, 1913.—This invention has reference to an improved construction of locomotive axle-box or bearing-brass in which the lubricant is contained in a chamber so constructed that it can be isolated from any foreign substance and also relieved of atmospheric pressure, the lubricant being delivered from the oil-chamber to the bearing surfaces by means of one or more steel needles, the lower ends of which are provided with a brass or other anti-friction metal carrier in direct communication with the axle. Fig. 1 is a plan of an axle-box constructed in accordance with this invention, and shows the method of securing the cover F of the oil-chamber and the position of the filling-tube with cap C. D is a set-screw to remove sediment from the bottom of the oil-chamber. Fig. 2 is a section of the axle-box, and shows the filling-tube E, which may be of any length. F the cover of oil-well, G the leather joint, H the oil-chamber, I the needle with carrier in centre of oil-chamber, K the needle-carrier chamber, and L the needle sleeve in which the needle I fits loosely. Fig. 3 is a half-vertical section of the filling-tube cap C, in which N is an air-passage cut through the internal thread of the cap to admit air to the oil-well when the cap is slightly unscrewed. M is a leather washer which forms an air-tight joint with the end of the filling-tube when the cap is screwed down. The action of this lubricating device is as



follows:—The oil-chamber is filled through the tube E, and the cap is screwed down tightly until the engine is ready for work, it is then slightly unscrewed to admit air through the passage N. When the axle revolves, motion is communicated to the needle and oil is worked down it from the oil-chamber H and spread upon the axle by the needle carrier J, the quantity of oil used being determined by the vibration of the needle and varying as the speed of the engine. After the engine has ceased work, the filling-tube cap C is screwed down and the remaining oil being relieved of atmospheric pressure is retained in the axle-box oil-chamber. (*Sealed October* 1, 1914.)

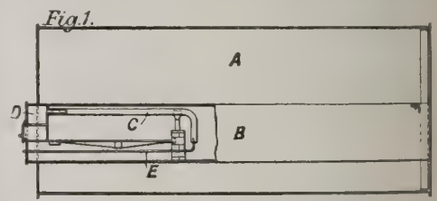
STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

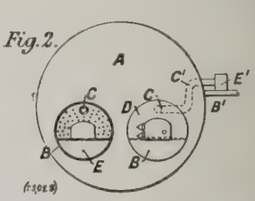
16,557/13. The Warwick Machinery Company (1908), Limited, London (*General Electric Company, Schenectady, U.S.A.*). **Turbines.** [4 *Figs.*] July 18, 1913.—The common practice of to-day with turbine-builders is to provide each turbine with a speed-governor driven by its rotor, and to utilise this governor to control the opening and closing of an admission-valve means as the load changes. Such an arrangement gives a speed range of, say, 3 to 4 per cent. from no load to full load. This invention has for its object to provide an improved governing mechanism which is capable of effectively controlling the turbine over a wide range of speed as the work required thereof varies. The governing mechanism, according to this invention, comprises a regulator admitting elastic fluid to the turbine, subject to the control of a speed-governor, for what may conveniently be termed the "normal" operating conditions. In addition to this, a secondary, or variable, speed-governor is provided that is also responsive to speed changes of the turbine, and which is put into service when the speed is to be maintained below normal. This acts on the regulator, either directly or indirectly, through some intermediary, such as the pilot-valve of the motor, which adjusts the regulator with respect to its seat or seats. 10 indicates a



turbine of any suitable construction having a suitable speed responsive device 11 comprising the usual weights and an opposing spring. This primary governor controls the opening and closing of a valve means or regulator 12 through a system of levers. Driven by the turbine is a compressor or equivalent apparatus 13, whose load is liable to change over a wide range, requiring different speeds of rotation. The governor is adapted for a speed regulation of about 2 per cent. over or under a predetermined speed, and may, for convenience, be designated as a constant speed-governor. Attached to a movable member of the governor is a lever 14 (Fig. 1), to the free end of which is attached a link 15. To the lower end of the link is pivotally attached a floating lever 16, which is connected by a link 17 with the lever 18, the latter being connected to the pilot-valve 19, and to the rod 20 of the motor 21, which actuates the valve means or regulator 12. The motor comprises a cylinder and a piston 22, the rod 20 of which is connected to the valve or valves admitting fluid to the turbine 10. As the load on the turbine changes, a slight but corresponding change in speed of the turbine takes place. This causes the governor-lever 14 to change the position of the pilot-valve 19, the latter to admit fluid under pressure to one side or the other of the piston 22, and thus admit more or less steam to the turbine. By connecting the lever 18 to the piston-rod 20, the movement of the latter will restore the pilot-valve to its initial position. The secondary or variable-speed governor comprises a movable abutment or member, such, for example, as the diaphragm or the like 23. This diaphragm is connected to the rod 24, and its outward movement is opposed by a coiled extension spring 25, whose tension can be adjusted by the hand-wheel 26, the latter being attached to a nut 27 that is threaded to the rod 24. The upper end of the spring is attached to a boss on the frame 28. To the lower end of the rod is attached a lever 29, the right-hand end of which is connected by the rod 30 with the floating lever 16. When the primary governor 11 is controlling the operation of the turbine, the pin 31 connecting the rod 30 and the lever 16 acts as the fulcrum and is stationary; but when the secondary governor is in control the fulcrum 31 is adjusted up and down, and the pin 32 becomes the fulcrum. The lever 29 may be pivotally supported by any suitable means. As shown, it is mounted on the frame 28, which carries the diaphragm. 35 indicates a tank or casing at one end of the turbine, and located therein is a gear-pump 36 of ordinary construction for supplying fluid to the governor and lubricant to the bearings. On the upper end of the shaft 37 of the pump is a gear 38 that meshes with a worm 39 mounted on the end of the turbine-shaft or otherwise driven thereby, so that as the speed of the turbine changes the speed of the pump will correspondingly change and in like manner. Fluid from the pump is discharged through the pipe or conduit 40 leading to the diaphragm 23 and through the pipe or conduit 41 to the bearings of the apparatus. The conduits 40 and 41 are arranged in multiple as regards the discharge of fluid from the pump. At some suitable point in the conduit 41 is arranged a needle-valve 42 which controls the amount of fluid passing through the pipe 41, and hence the pressure in the pipe or conduit 40 leading to the diaphragm for a given speed of the turbine. Connected to the conduit 41 is a conduit 43 that leads back to the supply-tank 35 in which the gear-pump is located. In this conduit 43 is located an adjustable relief-valve 44 which may be set for any predetermined pressure, and when that pressure is exceeded fluid is by-passed from the conduit 41 to the tank. As it is generally desirable to maintain a higher pressure in the conduit 41 than in the conduit 45 leading to the bearings, a perforated disc is interposed between them and at a point beyond the conduit 43. When the turbine is to be operated at constant speed within the limits of the speed-governor 11 it acts through the lever 14 on the pilot-valve of the motor in the ordinary manner, increasing and decreasing the amount of steam admitted to the turbine by the regulator 12. During the time that this primary governor is in service the secondary governor is inactive, the fluid pressure from the pump 36 distending the diaphragm 23 and causing its outer end to rest on the frame 28. This has the effect of fixing the position of the fulcrum 31. The lubricant delivered by the pump now passes from the conduit 41 partly to the bearings by the conduit 45, and the remainder through the conduit 43 and relief-valve 44 back to the supply-tank. The lubricant, after passing through the bearings, is also returned to the tank for further use. (*Accepted July* 22, 1914.)

23,025/13. H. McPhail, Wakefield. Furnaces. [3 *Figs.*] October 11, 1913.—This invention relates to boiler and other furnaces in which a portion of the flue gases is taken from behind the bridge or from a convenient part of the flue or flues, and is led through a collecting pipe or other channel back to the door end of the furnace, and is there discharged upon the fuel. According to this invention, the pipe or channel through which the fuel gases are led is exposed to the full heat of the furnace (or of another furnace), and the gases are thus heated to the highest available temperature before being discharged at the door end of the furnace immediately over the burning fuel so as to meet the combustible gases just as they are distilled from the fuel. It has been found that when flue gases in a highly heated condition are so supplied to the furnace better combustion is obtained, and the production of smoke is prevented, resulting in a substantial economy of fuel and an increase of the heat generated. A is the boiler. B is the furnace-tube with grate and bridge. C is the collecting-pipe for the hot gases. D is the door-plate with door and perforated plate forming an inner casing or chamber in which the pipe C terminates. The collecting pipe C is supported towards its inner end upon the pedestal or standard mounted on the bridge. The pipe is bent down so that it opens at the





back of the bridge, and the hot gases at this point are driven into the pipe by the aid of the steam-pipe E, through which steam at a suitable regulated pressure is supplied. The steam may be derived from the boiler A or from any other convenient source, and it is superheated by causing the pipe E to pass through the furnace below the firebars, or by heating in any other convenient manner either before or while passing through the pipe E, which may enter at the front of the furnace, as shown, or at any other suitable point. The collecting pipe passes, in the arrangement shown, along the top of the furnace so that the gases are highly heated on their way to the front of the furnace. The pipe terminates in the chamber formed behind the door-plate D by the perforated plate (shown in front view at the left-hand side of Fig. 2), through the perforations of which the highly-heated gases are driven so as to impinge upon the upper surface of the fuel, where they meet the combustible gases as they are distilled from the fuel. In place of the perforated plate any other convenient means may be used to direct the hot gases upon the fuel. Fig. 2 shows, at the right-hand side, a modification in which the gases are drawn from an outside flue B^1 through an extension C^1 of the collecting pipe C, in which extension is a fan or blower E^1 that serves instead of the steam-pipe E in the previously-described arrangement. The gases, as before, are highly heated before they are discharged upon the fuel. (*Accepted August* 19, 1914.)

THE BRITISH ASSOCIATION IN AUSTRALIA.

(*Continued from page* 581.)

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE—*continued.*

THE STRUCTURE OF ATOMS AND MOLECULES.

THE joint discussion with Section B on "The Structure of Atoms and Molecules" again crowded the large lecture theatre. This important discussion will be published *in extenso* in the Report. It was remarkable, Sir Oliver Lodge said in his introductory remarks, that such a discussion should be possible. In the past century the atom had been a point or something devoid of constitution; now an astronomy of the atom was being developed. Whether the law of inverse squares really held for the particles of the atom revolving round a central nucleus was not clear. There were theories of the atom; but the nature of the positive electron, if it existed, was a great difficulty, and it had hardly been discussed how the particles of the atom were held together.

Sir Ernest Rutherford, F.R.S., in opening the discussion, remarked that Lodge had given a digest of his (Rutherford's) views; but he did not agree with everything Lodge had said. There was convincing evidence of the independent existence of the atoms, which could be counted, and the atomic theory had now to be regarded as a proved fact The mass of the atom had been determined within a few per cent. by several methods. The idea of the atom being an electric structure had arisen early. The electron must be one of the component parts of the atom for various reasons, and one point was of fundamental importance: the unit nature of negative electricity. There was a definite unit. and every quantity of electricity was an integral multiple of that unit; that consideration limited the possible number of structures of the atom. He believed also in a unit of positive electricity. According to J. J. Thomson, the negative electrons were uniformly distributed through the mass of positive electricity. The inner structure of the atom could be studied in two ways: by the scattering of high-speed α particles by matter, and by the vibrations and radiations. High-speed α particles passing through matter were scattered, and turned off at angles of more than 90 deg. (C. T. R. Wilson), with sudden bends. That bend had to be accounted for, and the energy question was the difficulty of the Thomson atom; the forces inside the structure were not strong enough. Hence his own theory of the atom was that the positive electricity was not diffused, but concentrated in a central nucleus, which was surrounded by rings of electrons; 50 of these rings meant 50 charges, *e.g.* That nucleus, experiments showed, must be exceedingly small, 10^{-12} cm. in diameter, the orbit diameter of the rings being 10^{-8} cm.; the electrons were at relatively enormous distances from the nucleus, and the scale of the customary diagrams exemplifying the structure was quite wrong. A high-speed α particle entering the matter passed through it, being repelled by the nucleus, and was deflected on a hyperbolic path; these paths had been studied by Geiger, Marsden and himself, and they were compatible with the law of inverse squares, to which he would adhere as long as he could. The hydrogen atom carried one charge, and was probably the positive electron. The charge in other atoms seemed to be represented by half the atomic weight; he agreed with Barkla as to this. But it was also possible that the charges of the elements were represented by the consecutive numbers 1, 2, 3 . . ., the atomic numbers of Moseley.

The second method of studying the inner structure was by examining the rate of vibrations with the aid of X rays, as shown by Laue and Bragg, Darwin, Moseley, and others. Each element then showed two strong lines of exceedingly short wavelength, and as the atomic weight of the elements increased, the frequency of those lines decreased, not gradually, but by jumps. Those researches suggested that there was something more fundamental than the atomic weight—*i.e.*, that the frequency of the vibration was determined chiefly by the charge and a little only by the mass, so that the charge on the atom would control its physical and chemical properties. If that charge were so important, the nucleus should itself be complex, and the charge would depend upon that complexity. The most recent researches indicated that atoms might have identical chemical properties and yet be different. Thus, RaD was inseparable from lead, which was not radioactive, and the atomic weights were 214 and 207. Soddy suggested that such bodies, isotopes, should have the same light spectrum and the same X-ray spectrum; the masses available were too small for determining the light spectrum, however. As regards the nature of the forces in the inner structure, nothing definite could be said; they might be electrical or merely residual. Bohr's hypothesis made the hydrogen atom very simple, as consisting of one particle of positive and one of negative electricity only. That view also involved a new idea connected with Planck's quantum, which physicists would have to take seriously; there was something in the atom which could not be explained by old mechanical analogues, and there was something real in Planck's h. But Bohr had great difficulties with complex atoms.

Professor H. E. Armstrong said that chemists had good reason to believe in their structural formulæ, but they were sceptical as to inseparability of the different elements of Soddy and Rutherford. Chemists also believed in carbon having a valency 4, if hydrogen had the valency 1. On that view the body H_3 of J. J. Thomson was impossible, in spite of all paper tricks. Chemists, of course, did not any longer build up their compounds in planes, but in space; the benzene ring did not represent benzene; the ring had to be understood as suggesting the building up of the substance in planes and layers. Some elements had variable valency, and the properties of bodies containing nitrogen as triad differed extraordinarily from those the nitrogen of which was a pentad; chemists could not explain that, but could physicists? Barlow and Pope had followed the external form into the internal structure, with the aid of the novel idea that carbon, having a valency 4, had also four times the sphere of influence of hydrogen. They arrived thus at extraordinary results; the several chlorine (or bromine) substitutes of benzene, for instance, were isomers, but not isomorphous; yet they fitted apparently into the same boxes, even when chlorine was replaced by bromine, although the atomic volumes of chlorine and bromine differed considerably. It was also remarkable that the two hydrogen atoms in H_2SO_4, sulphuric acid, were not of equivalent value. Again, he (Armstrong) had observed that certain strictly isomorphous salt crystals, the benzene sulphonates, of iron, cobalt, nickel, manganese, zinc, magnesium, behaved quite differently in magnetic respects; the iron crystal placed itself in a certain direction between magnetic poles, the cobalt at right angles to that direction, whilst the nickel salt took an intermediate position. All these facts were difficult to explain for the chemists, and the physicists did not help them.

Professor W. M. Hicks, F.R.S., of Sheffield, said that he proposed to draw attention to certain aspects of the problem when approached from the spectroscopic side—*i.e.*, from a consideration of the atom as a configuration capable of emitting definite sets of vibrations. Before doing so, however, he would offer some criticisms with reference to a point raised by Professor Rutherford concerning the effective nuclear charge. Moseley's work indicated that the charges were consecutive multiples for the consecutive elements in the periodic table, and that the number of the charges would be known, if known for one element —*e.g.*, for helium. But whilst Rutherford, Bohr, and Moseley assigned to helium an atomic number 2, Professor Hicks thought that the available evidence pointed to the value 4. It must at least be 2; for there was a double charge in the α particle; but it did not follow that, after two of the movable electrons had been removed, none were left behind with the nucleus. If the atomic numbers of hydrogen and helium were to be 1 and 2, then there could be no intermediate elements between them. But that seemed improbable, for three reasons. Nicholson had given weighty arguments for assuming that the lines observed in the corona and in nebulæ were due to two elements (coronium and nebulium), having atomic weights intermediate between H and He, and as their nuclear charges were 4 and 5, that of helium should be 6. In the second place, Rydberg's theory for the constitution of the periodic table had been justified in one remarkable respect by Moseley's work as to the number of elements missing between krypton and xenon. Discussing Moseley's measurements of the frequencies of the Barkla K and L series (*Philosophical Magazine*, July), Rydberg had further pointed out that the atomic number could only be based on the value of helium, and not on any other value but 4.

Passing to his main question, Professor Hicks stated that three definite facts were recognised as to the constitution of the atom: (1) All atoms contained electrons as part of their constitution; of these electrons the atoms might lose a certain number without altering their chemical identity, whilst the loss of other sets changed them into different elements; that was certainly so for radioactive elements, and the law probably extended to all the elements. (2) There existed also positively-charged nuclei associated with the atomic mass, containing multiples of the fundamental electric charge, and the chemical nature of the element seemed to be determined by this multiple. (3) In the case of certain substances there were found associated magnetic doublets, whose moments were multiples of a definite quantity, the mageton of Weiss; that might apply to other elements, though it was an open question whether the magneton had an independent existence or was a consequence of electronic motion. Any atomic theory had to explain how the atom was built up of those fundamental quantities. So far there were two types of theory:—(1) J. J. Thomson's theory of an extended positive nucleus, within which the electrons revolved in Saturnian fashion; (2) Rutherford's theory of an extremely small nucleus, with electrons in planetary or Saturnian orbits. Neither theory had shown the slightest aptitude in explaining the series laws of spectra, and the actual structure of the atoms, Professor Hicks suggested, must be much more complicated than was assumed.

Unfortunately the complete mathematical treatment of the simplest case was one of extreme difficulty. They might, however, take one important first step as to the direction in which to look for the source of energy emitted as spectral radiations. The energy might arise either from small vibrations about a stable state, or from changes from one stable state to another. In both cases the stable state must be such as not to lose any energy, and must hence represent static equilibrium, and the relative motions must not produce any change in an external field relative to itself; for instance, when a charged sphere was moving with uniform velocity. In the first case the energy would be made up of extremely small amounts from all the atoms, and an increase in intensity would be due to increased amplitude; in the second case the energy would be made up by relatively large amounts from a proportion only of the systems, and an increase would be due to a larger proportion of atoms changing from one state to another. In the first case the constancy of period would follow as a matter of course; but it was difficult to see how the condition of Planck's quanta could be met, and there could be no doubt that the ideas lying at the base of Planck's theory were well founded. In the second case, the energy for each line was transferred in the same amount, and the constancy of the frequency followed at once from Planck's theory. The general conclusion was that one of the main causes of spectral emission was changed from one configuration to another of less internal energy, and experimental evidence pointed in the same direction. Stark had shown that the series lines of spectra were due to molecules which had lost electrons, doublets being due to the loss of one electron, triplets to the loss of two, and so on [Professor Hicks did not refer to the rare case of single-series lines], and it should therefore be expected that the energy emitted was given out by the recombinations to the neutral state.

The general conclusion was supported by the fact that the formulæ to which series lines conformed gave the frequency itself, and not the square of the frequency, which latter condition applied when the forces of displacement were proportional to the displacements. The former case required forces proportional to the velocities (Rayleigh), and hence suggested motion in magnetic fields. Those fields existed, and the only theory which reproduced Rydberg's formulæ (the theory of Ritz) depended only on magnetic fields. Unfortunately, electrostatic fields existed likewise. If they could conceive shells of constant magnetic force, produced by electric charges, moving in such a way that the electric forces between the moving charges themselves were annulled, the first step towards a basis of a satisfactory theory would have been made.

Whilst in all probability, then, the greater por-

BATTERY OF DROP-HAMMERS FOR GREENOCK TORPEDO FACTORY.

CONSTRUCTED BY MESSRS. BRETT'S PATENT LIFTER COMPANY, LTD., ENGINEERS, COVENTRY.

(For Description, see Page 612.

Fig. 1. Complete Battery Erected in Makers' Shop.

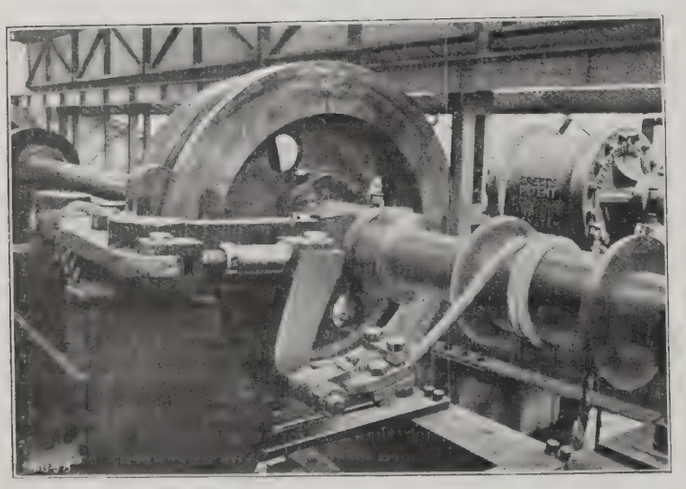


Fig. 2. 5-Cwt. Lifter.

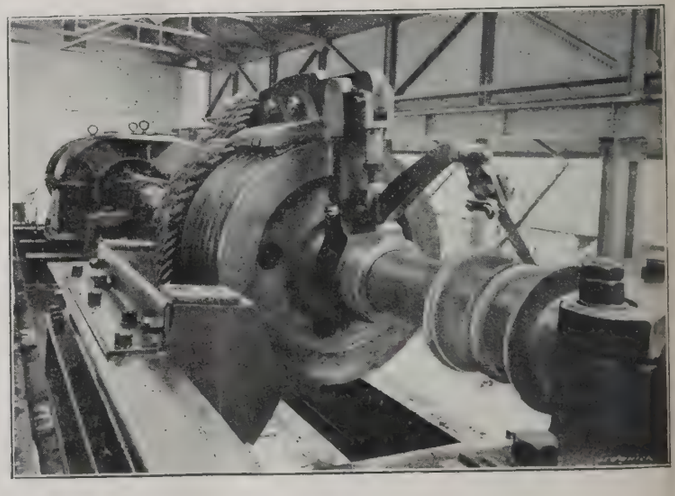


Fig. 3. 40-Cwt. Lifter.

tion of a spectrum was due to changes of configuration, it did not necessarily follow that the lines related to the series were the only ones emitted. In fact, the high-frequency vibrations discovered by Barkla, and quite recently measured by Moseley, were clearly cases in point. Nicholson had recently determined the frequencies of small oscillations of electrons revolving round positively-charged nuclei; these were the coronium and nebulium lines above alluded to, which seemed to be of a very rare type, however. Several attempts had also been made to apply Planck's theory of radiation to the explanation of the laws of spectra. The most ingenious of these suggestions was that of Bohr, which was based on the Rutherford atom ; but it threw no further light on the structure of the atom, and left the mechanism of radiation entirely unexplained. Bohr had, indeed, succeeded in deriving the value of Rydberg's constant from known electric constants and Planck's constant ; that remarkable confirmation of the N of Rydberg's formula (109,675) had certainly caught the scientific imagination ; but Lindemann had shown that a large number of theories would give values into which the various constants entered in the same way. In Bohr's case the exactness of the numerical relation depended upon an apparently arbitrary assumption as to the frequency of the energy emitted when an electron was combined, and Bohr assumed the frequency of an electron to be proportional to its angular velocity, which could hold only for one electron—*i.e.*, for a planetary, but not for a Saturnian system like his own. Bohr had been

BATTERY OF DROP-HAMMERS FOR GREENOCK TORPEDO FACTORY.

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(*For Description, see Page 612.*)

Fig. 4.

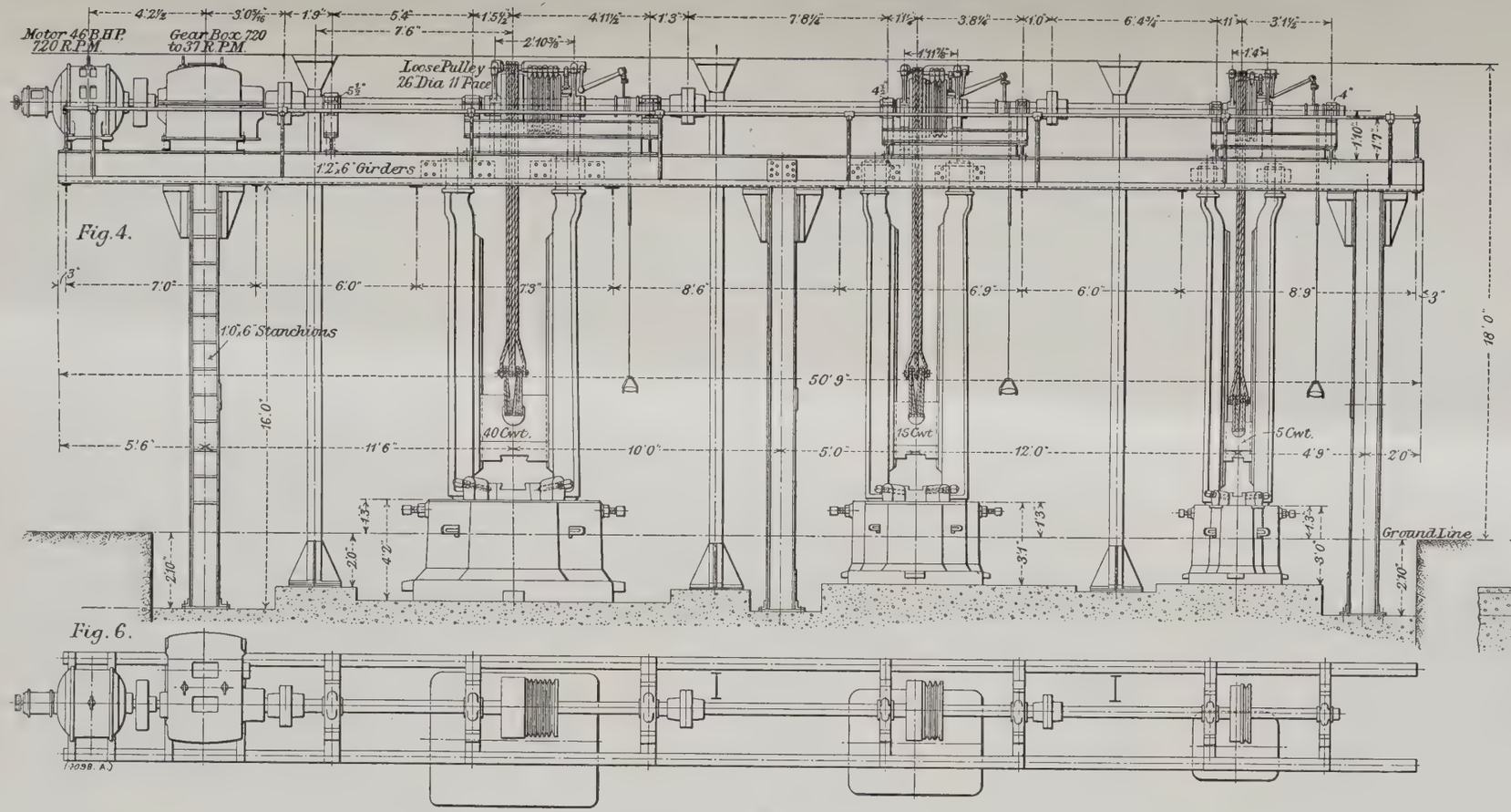


Fig. 5.

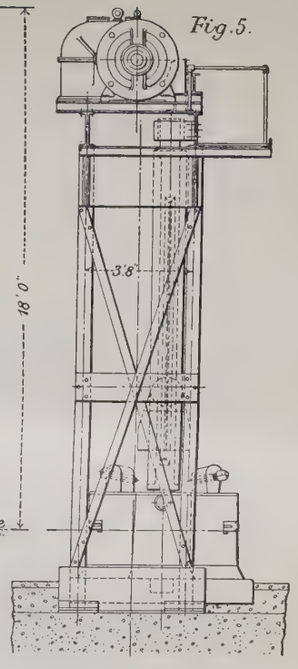


Fig. 6.

Fig. 7.

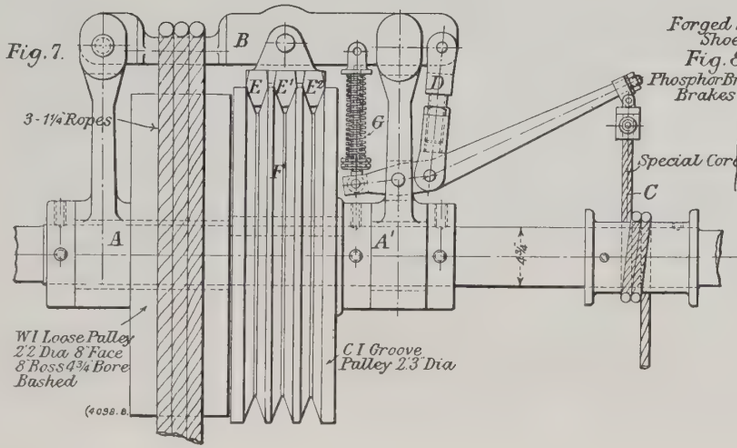


Fig. 8.

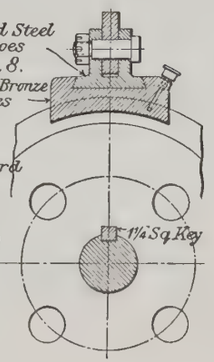
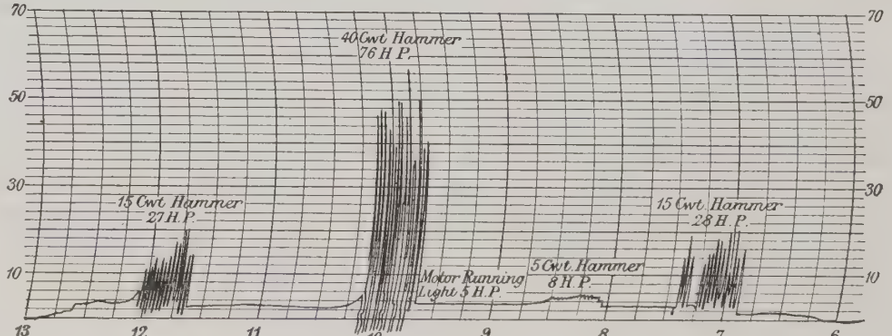


Fig. 9. BATTERY OF BRETT'S FRICTION DROP HAMMERS. 40, 15 & 5 CWT. FOR H.M. DOCKYARD TORPEDO FACTORY, GREENOCK.



2 Kilowatts per Division. July 14th 1914

criticised by Nicholson on other grounds as well, and Bohr's consideration, moreover, led merely to Balmer's type of formula, which was restricted to hydrogen. Bohr's theory, as a matter of fact, did not represent any of the six series of helium, though he postulated that certain lines, hitherto ascribed to hydrogen, belonged to helium, to which he gave two electrons, whilst Professor Hicks (as stated) considered four more correct. Professor Hicks concluded by saying that, though he had criticised Bohr's theory, no one could more admire its ingenuity and suggestiveness.

Professor W. J. Pope, President of the Chemical Section, contented himself with a few remarks. The recent radioactive researches had satisfied the physicist as to the reality of the atomic hypothesis, which chemists had adopted almost a hundred years ago. So physics came back to chemistry. Chemists studied the way of building up molecules from atoms; physicists attempted to take the atom to pieces and to build it up again. Referring to the many isomeric sugars and other compounds, he remarked that chemical theory had predicted the existence of isomers, and chemists had found and synthetised them. Had physicists done anything similar? They should explain the simple laws according to which atoms or radicles were linked together; the work of Laue and of Bragg promised to be of enormous importance.

Mr. H. G. J. Moseley, of Oxford, explained his recent work. When the spectra of X rays were analysed, spectra of two types, K and L, were found, both being far removed in the ultra-violet from any known lines, and from one another. The wave-length of K rays was of the order of 10^{-8} cm., and approximately the law held that the square root of the frequency was equal to A (N − B), where N, the "atomic number," was different for each element, and A and B were constants. If aluminium were supposed to have the atomic number 13 (being the thirteenth element in the periodic table and having the atomic weight 27), then the next element—silicon (Si = 28)—had the number 14. The formulæ calculated gave, on the whole, the atomic numbers N in the order of the elements of the Mendeleieff tube. But there were a few peculiar deviations; *e.g.*, the X-ray order was: iron, cobalt, nickel; whilst the atomic weight order was: Fe, Ni, Co, and there were more atomic numbers missing than chemists counted missing elements. Generally, however, the atomic numbers seemed to be more characteristic for the periodic functions of Mendeleieff's tables than the atomic weights. Rydberg had introduced a similar order of the elements, and had suggested definite mathematical relations between the constants, as Professor Hicks had mentioned. As regards the missing elements, it would perhaps be best to avoid the term "elements." With respect to Bohr, he would point out that Bohr regarded each electron by itself, having an angular momentum. But the Moseley formula contained the square root of the frequency, not the frequency itself or its square, and it seemed that there was something in the atom having the dimension of angular momentum; that would be in favour of Planck's constant h.

Professor Bateson, the President of the Association, called upon by the Chairman, remarked that he had just come from a discussion by zoologists and botanists on the origin of species; physicists and chemists seemed to be discussing something very near that problem. He wished that biologists had the analytical power of his present audience. He had heard that any new substances discovered should not be called elements. What were those bodies? That was their trouble in biology.

Professor J. W. Nicholson, of King's College, London, said he had not desired to take part in the discussion. But he would refer to Hicks and Bohr. The present position of Bohr's theory was that the spectroscopic constant 109,675 did not fit the helium spectrum quite, which might be due to the fact that the electron could take up different positions with regard to the two charges of the helium atom. The lines in nebulæ corresponding to the atomic weights 1.36 and 2.95, intermediate between hydrogen and helium, might not belong to elements in the ordinary chemical sense.

Professor H. Basset, of Reading, suggested that the elements of Mendeleieff's table might be divided into short and long groups, comprising 8, 18, 38 (n, $2n + 2$, $2(2n + 2) + 2$) elements; it was profitable for this purpose to consider hydrogen as head of a special short period and to start with helium; then the two new elements would find their places.

Professor Kerr Grant, of Adelaide, said that, speaking as an outsider, he thought that speakers had neglected several points: the instability of certain systems (radioactivity), the tetrahedral structure of carbon compounds as explicable by spiral revolutions of electrons, the non-magnetism of hydrogen, &c.; magnetism, however, probably depended more upon the molecular than upon the atomic structure.

Professor Rutherford, in replying, said that the inseparability of certain elements was indeed derived from experiments with very small quantities, but their methods were very delicate. There was a prize of 10,000*l.* for the discoverer of a method for separating RaD and lead; there were probably several kinds of lead metal. He did not worry as to the position of magnetons in the atoms at present. Bohr's theory, started in his laboratory, need not be correct in details; it was highly speculative, but was the only attempt so far made If the theory of radiation and that of atoms were not in harmony, there was something wrong about the radiation theory. he would say. The whole matter was, as Sir Oliver Lodge had remarked, in its infancy; they need not go too fast. but might leave something to further generations. The nucleus of hydrogen might again have a nucleus. In any case the atom was very complex—a universe in itself.

High-Frequency Spectra.

In a subsequent paper on "High-Frequency Spectra," Mr. Moseley gave some further particulars of his work and of its experimental side in a systematic research on elements and a search for missing elements. Using the method of Kay, he took a highly evacuated glass globe of 2 litres capacity and placed the substance to be examined in a trough, the position of which could be shifted from outside, so that the stream of cathode rays just hit the desired spot. Behind the trough was a diaphragm with a slit 1 mm. wide, and the characteristic rays observed, analysed by Rutherford's method, appeared as images of the slit. The spectra so obtained were all very similar, and consisted mostly of two lines, one of very high frequency, the other of much lower frequency and much softer; sometimes only one line was found, but the investigation was, of course, incomplete. The appearance of more than two lines suggested composition or impurity; brass, for instance, gave the two lines of copper and the two lines of zinc. Mr. Moseley showed diagrams plotting the elements in their order on the ordinates, and the square roots of the frequency as abscissæ; the lines of different elements then appeared to follow a very simple law, and missing elements betrayed themselves by blanks. Mr. Moseley dwelt particularly on the examination of the rare earths, which, on his numbering, bear atomic numbers 57 to 73. Some of these rare-earth metals may, as chemists have long suspected, be mixtures of several elements; their separation, generally by fractionation (lately studied by Urbain in Paris particularly) is exceedingly difficult.

Salts Coloured by Cathode Rays.

Professor E. Goldstein, of Berlin, the discoverer of the "canal" or positive rays, gave an account of his resumed researches on "Salts Coloured by Cathode Rays." It had long been known, he said, that salts bombarded by cathode rays became discoloured, and the colours had by Giesel been ascribed to a partial decomposition of the salt—*e.g.*, sodium chloride—resulting in the reduction of some metal (the electro-positive component), and the formation of a sub-chloride. Giesel had, in fact, imitated some of the colours by preparing salts containing reduced metal; but these preparations did not behave like the cathodically bombarded salts, and the after-colouring, as Professor Goldstein called it, was also noticed in the absence of all metals and in inorganic compounds containing chlorine, bromine, &c. It was improbable that the effect should sometimes be due to the electro-positive and sometimes to the electro-negative element. It appeared more probable that both the components had their share in the effect, and Professor Goldstein suggested that there was no real reduction, but that the compounds were "distended"—*i.e.*, that the bonds between them were loosened. This "distension" was discussed by Professor Goldstein as a new condition of matter. In this condition, which seemed to be a general property common to all the elements, matter had a high absorptive power for light. The colours were produced by a very short exposure to cathode rays or to β rays, or to ultra-violet light, and Professor Goldstein believed that the real effect was due to ultra-violet rays. Sometimes the colours were very brilliant (pink, green, deep blue—not bright red so far); they might last for years, or be destroyed in a few days or even minutes; the different elements differed much in these respects, and the tests might be used for delicate analysis, as small quantities of the salt, in solid solution in another salt, were sufficient. In the cold the colours were long preserved, but heat destroyed some of them rapidly, and for that reason Professor Goldstein had not been able to bring some of his best specimens (KCl, which turns deep blue; KBr, violet) over to Australia. Daylight was also destructive, and while the exposure to daylight lasted, and for some time afterwards, the respective substance phosphoresced. Professor Goldstein's chief new point was that a connection appeared to exist between these phenomena and the therapeutic effect of radium and mesothorium in the treatment of skin and other diseases.

The Scattering of Light.

The paper by Professor A. W. Porter and Mr. E. Talbot Paris, B.Sc., of London, on "The Scattering of Light by Small and Large Particles of Conducting and Non-Conducting Substances," was a continuation of an investigation by Porter and Keen on the diffraction of light by particles (sulphur suspension) comparable with the wave-length of light. In that case the observations had been confined to transmitted light. In the recent experiments, Professor Porter explained, the polarisation in different directions of silver and copper suspensions had been studied by means of a double-image prism and a nicol; the suspensions were prepared after the method of Pieroni. In working with silver the size of particles could be determined (which was not possible with sulphur) by chemical analysis combined with counting the number of particles per unit volume; the determination could also be made, after Perrin, by counting the number of particles in two layers of a vertical column; the two methods had practically given the same results.

The following table gives a summary of the observations made on silver suspensions for light of wave-length 550 $\mu\mu$:—

Diameter of Particle.	Direction of Maximum Polarisation.	Relative Electric Conductivity.
$\mu\mu$	deg.	
80	90	—
98	90	$2.96 \cdot 10^{-4}$
108	98.36	$3.70 \cdot 10^{-4}$
131	109.54	$4.12 \cdot 10^{-4}$
164	113.36	—
310	130.30	—

According to J. J. Thomson, the direction of maximum polarisation for perfectly conducting particles should make an angle of 120 deg. with the incident light. From the above table it would appear that the angle was 90 deg. for very small particles, as it would be for dielectric particles (as Threlfall observed in 1894), but that the angle increased as the diameter of the particle increased to a value above the theoretical limit. Measurements of the electric conductivity were likewise made with solutions containing the same amount of silver per unit volume; the two conductances should be the same, unless there were a difference in the specific conductivity of the silver particles. Now the conductivity of the suspensions increased as the size of the particles increased. Thus there would appear to be a real change with size in the resistance of the silver particles, a change which was not simply a consequence of the fact that Thomson's theory was limited to the cases for which the specific resistance was sufficiently small. Thomson's equations would, however, apply for large particles when η, defined by 2π radius/λ, was comparable to unity. For large particles calculations had not, so far, been made; by transforming Rayleigh's equations, however, they had made calculations for perfectly conducting particles for which η was $= 1_1$, and their maximum polarisation corresponded to an angle of 108 deg., whilst their experiments gave values between 110 deg. and 120 deg. It was not difficult to suggest a reason for this diminution of the conductivity with size. Separated particles of silver were non-conducting, like vapours, because

no free electrons escaped into the medium. In aggregates of such molecules, owing to the mutual forces between them, free electrons were forced out in greater proportionate quantity, as the size of the aggregates increased. But a colloid particle was surrounded in its medium by a double layer of polarised molecules of the medium, and it was quite possible that this double layer of a dielectric medium modified the optical properties of the silver.

Professor Porter also communicated some notes on "The Change in Thermal Conductivity During the Liquefaction of a Metal," being a preliminary account of experiments recently entered upon by Mr. F. Simeon, B.Sc., and himself.

Photographic Action of Euphorbia Juice.

Dr. H. G. Chapman, of Sydney, stated in a paper by Professor J. M. Petrie and himself, on "The Action of the Juice of Euphorbia Peplus on a Photographic Plate," that in studying the properties of indigenous plants they had discovered that when letters were written with the milky juice of this euphorbia, which resembles the common European species, on glass, and the glass fixed close to a sensitive film, sharp impressions of the letters were produced, faint impressions in one day, deeper impressions in three days, and darker prints still, and yet quite sharp, after exposure of one month. When the separation of the plates exceeded 12 mm., no impression was observed; the edges of the letters were slightly diffused. The interposition of black paper, paraffin paper, thin aluminium or gold foil, thin glass, made little or no difference, nor did a strong air-current between the plates. The action did not appear to be radioactive; for there was no scintillation of the juice when examined with a sulphide screen, nor any discharge of an electroscope. On the other hand, the juice might be heated to 200 deg. Cent., charred and even incinerated without losing its activity completely. The activity was observed with all plants of euphorbia peplus from distant localities, but not with any other kinds of euphorbia.

Photo-Electric Effect in Selenium.

Professor O. U. Vonwiller, of Sydney, gave a preliminary account of some experiments on "The Photo-Electric Effect of Selenium," undertaken for the purpose of deciding whether the photo-electric effect shown by the conducting, not the vitreous, insulating selenium depended on the mode of preparation. He had prepared his selenium by distillation *in vacuo*. Temperature certainly had an influence; for selenium heated to 260 deg. had ten times the conductivity of the substance heated to 109 deg. only. The most effective rays in the photo-electric action were the red, moreover; the action of red rays seemed to penetrate to a depth of 0.1 mm., whilst ultra-violet rays merely affected the surface. Scraping made a difference only when there was also exposure to light. The photo-electric currents were sometimes as great as those from bright zinc. The fatigue of selenium disappeared again in the dark; mere exposure to the atmosphere, unless accompanied by heating, did not cure the effect.

(To be continued.)

PROGRESSIVE SPEED TRIALS OF MOTOR-BOATS.

By A. H. Burnand, A.I.N.A.

Progressive trials hitherto recorded have been confined almost exclusively to steam-propelled craft, and very few of these have related to vessels under 50 ft. in length, or of a total horse-power below 70 to 100. This is readily explained by the fact that in steam-engines, the measurement of power by the use of the indicator becomes increasingly difficult, and the accuracy more doubtful, as the engine becomes smaller and the rotational speed higher. In addition to this, the staff of observers necessary for conducting a trial is virtually the same for a small as for a large vessel, if the operations are to be carried out, and the records made, simultaneously. For ordinary measured-mile trials, each lasting from, say, four to seven minutes, according to the speed attained, the skill and accuracy required is of the highest order if the results are to be of any real scientific value. In many steam vessels of the size mentioned above the space available for observers, and the conditions of working, are such as to make simultaneous records impossible, and when this is the case, estimated values have often to take the place of actual recorded figures.

The use of the internal-combustion engine of the small, high-speed type, with from two to eight cylinders, puts the ordinary indicator out of the question for power measurement during trial runs; while to use other methods for measuring the power between engine and propeller is far from easy, and certainly cannot be done without extensive preparations, while in most cases of small craft the passengers are limited to the helmsman and one observer.

Although at first sight the difficulties in the way of making progressive trials of motor-boats may seem unusually serious, yet the importance of obtaining reliable data at the present day is so great that a reasonably accurate and, at the same time, simple method of carrying out such trials single-handed is urgently needed. In the design of new boats, in the present struggle for greater speeds, and in the continually-recurring problem of propeller efficiency, as well as the determination of the most economical speeds for various types of hulls, may be found the arguments for special exertions in this direction. In what follows the author proposes to describe a method of making

Fig. 1. CURVES OF POWER OBTAINED FROM ENGINE ON TEST BENCH. THE POINTS A.B.C.D. REPRESENT THE REVOLUTIONS OF THE PROPELLER WHEN 4, 3, 2, & 1 CYLINDERS WERE FIRING.

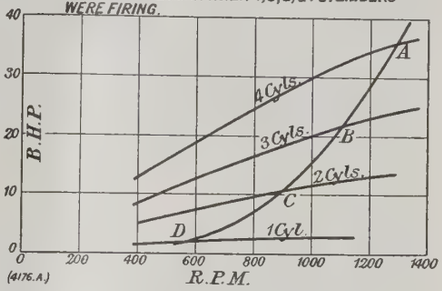
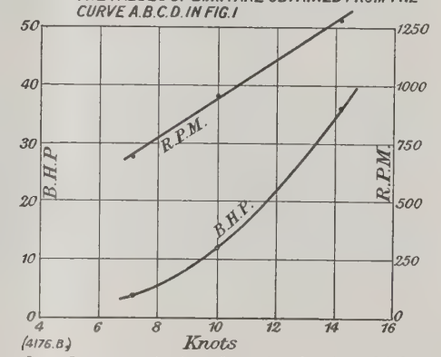


Fig. 2 THE VALUES OF R.P.M ARE OBTAINED FROM THE ACTUAL TRIALS. THE VALUES OF B.H.P. ARE OBTAINED FROM THE CURVE A.B.C.D. IN FIG. 1



speed and power tests of motor-boats which has been in use for the past three years, and has proved uniformly successful, not the least of its good points being that all the work and observations can easily be done by one man. It cannot be used with single-cylinder engines, and its value is limited with two or three cylinders, but beyond this number excellent results can always be obtained

The first stage commences at the test-bench, on which the engine must be thoroughly "run in." A power curve is then obtained over the whole working range, from the lowest possible speed to something beyond that at which the engine will be run in the boat. When this has been done, similar curves are obtained, also over the whole range of revolutions, by cutting out cylinder by cylinder until only one is left. If all the cylinders are not of uniform power, the weaker ones must be "brought up" before carrying out these tests. If any doubt of their equality exists, careful note should be made of those cut out on each power curve, so that the same conditions may be subsequently reproduced in the boat. The method of carrying out these tests on the bench presents many important and interesting features, and requires great care to execute if considerable accuracy is desired. A series of curves from a four-cylinder engine are shown in Fig. 1.

When the engine is installed in the boat a reliable speed-indicator is a necessary adjunct on the engine, and unless the friction clutch is combined with a positive drive, some means of counting the revolutions of the propeller-shaft also is absolutely essential. The author's experience of revolution-indicators has always been such as to make the use of the ordinary counter desirable as a check.

After the preliminary runs afloat have been made, and the highest speed of boat, engine, and propeller ascertained, the next step is to cut out successively the cylinders corresponding with those cut out during the power measurements on the test-bench. This cutting out must extend for a sufficiently long interval of time to ensure the boat settling down to its speed due to the power then being developed, the corresponding revolutions being carefully noted. It is essential that the adjustments of both throttle and ignition should be such as to obtain the highest revolutions the engine will give under these reduced powers, so that the test-bench conditions may be correctly reproduced.

Having obtained the necessary data of the revolutions, the power co-ordinated can be picked off from the chart obtained on the test-bench, and the engine can then be run normally with all cylinders firing. It is unnecessary to carry out trials over the measured distance with any cylinders cut out. Further trials are next carried out at reduced powers, the engine being run as nearly as possible at the revolution speeds obtained by cutting out the various cylinders. If intermediate speeds are required, the power developed may be estimated as follows. On a base of revolutions per minute, horse-powers as obtained by cutting out cylinders in the manner just described should be plotted. A fair curve drawn through these points will enable powers due to other propeller speeds to be closely estimated. This is shown in the curve A B C D, Fig. 1.

By a combination of the data thus obtained a curve of horse-powers at various speeds of boat may be plotted. A curve of revolutions plotted on a base of speed in knots supplies some of the necessary data for the analysis of the propeller. These curves are shown in Fig. 2. In boats having speeds of 20 knots and over, it is desirable, if possible, when running as low as 5 knots, to reduce proportionately the measured distance run. Thus, while a nautical mile is none too great for accurately timing at 20 knots, its length is liable to vitiate results at 5 knots unless the weather is absolutely calm and the currents uniform.

The errors which may occur by this method of estimating powers relative to speeds are not of a nature to be a serious bar to future calculations or deductions for other boats. In the first place, the engine, if well "run in" on the test-bench, is not likely to develop more brake power when in the boat than while on the bench, while actually the power delivered to the screw will be less by reason of losses in the reverse gear, tail-shaft bearings, and stuffing-boxes. These, however, will naturally be greater when the boat is first launched than when, after a few hours' running, all these parts have become "worked in." In the next place, such losses will occur in all installations, so that the question of total brake horse-power of the engine is, for future calculation, more important than net power to the screw. Errors due to a slipping clutch are more serious, but the provision of a counter on the propeller shaft, as well as on the engine, is a check to this.

The author, while quite aware that the method just described cannot be considered as one of absolute scientific accuracy, has thoroughly satisfied himself of the utility of the method and its value in designing new boats and installations.

The curves in Figs. 1 and 2 relate to an early type of speed boat of 26 ft. in length, with a set of four-cylinder engines installed, but they are given to show the process rather than for any special information which they contain. The author has made a series of trials of boats, which he hopes shortly to publish, with some deductions therefrom as to the relationship of speed and power. One thing may be added to the above. The most valuable information which can possibly be obtained in progressive trials is what is, fortunately, the most easy to observe—namely, the relationship between revolutions per minute of the screw and speed of the vessel. Many years of study of the screw-propeller have shown the author that very definite laws are associated with this relationship.

The New Army.—106 members of the Institution of Automobile Engineers are serving in His Majesty's Army, or considerably over 10 per cent. of the total membership.

DROP-HAMMERS FOR GREENOCK TORPEDO FACTORY.

On pages 608 and 609 we illustrate a battery of friction drop-hammers which has recently been supplied to the Greenock torpedo factory by Messrs. Brett's Patent Lifter Company, Limited, of Foleshill Works, Coventry. The complete battery erected in the makers' shops is shown in Fig. 1. It consists of three hammers of 40 cwt., 15 cwt. and 5 cwt. respectively, operated from an overhead shaft driven by an electric motor. The lay-out of the plant is clearly shown in Figs. 4 to 6. General views of the 5 cwt. and 40 cwt. lifters are given in Figs. 2 and 3, while outline drawings of the 15-cwt. lifter are given in Figs. 7 and 8. In all essentials the lifter mechanism is the same for all three sizes, and the operation may best be described by reference to these two latter figures.

The main shaft, which runs continuously while the battery is in use, carries a grooved pulley F, which is keyed to it. This pulley is furnished with a set of phosphor-bronze brake-blocks, E^1, E^2, and E^3, which are secured to a forged-steel shoe, pinned to a shackle B. The shackle is pivoted at one end in the fork at the end of arm A, while towards the other end it is free to slide in the forked end of arm A^1. Arms A and A^1 are fitted with phosphor-bronze bushes in the bosses and are quite free to move round the shaft. The driving-lever, to which is connected the cord C by which the hammer is operated, is pivoted on the arm A^1, and is connected to the shackle B by a link D and an adjustable spring G. The spring normally pushes the brake-blocks E^1, E^2, and E^3 clear of the pulley F, but when the cord C is pulled, the blocks are drawn down on to the pulley and the whole arrangement is propelled round. The main lifting-ropes for the hammer, which are guided by a loose pulley on the shaft, are fastened to the shackle B, so that the rotation of the arms and shackle lifts the hammer. It can be instantly released at any time by releasing the cord C, which is carried round a small pulley secured to the shaft. This gives a sort of capstan arrangement, so that a light pull on the end of the cord is sufficient to raise the hammer. The release when the cord is loosed is immediate. The cord, as shown in Fig. 4, is fitted with a handle at the lower end.

As will be clear, the control of the hammer is entirely by slip, and the arrangement allows of lubricant being applied to the frictional parts in contact. In practice it is found even after a hard day's work the brakes do not get unduly hot. The constant rotation in the air of the pulley grooves tends to keep them cool. It will be clear that the whole arrangement is of a simple type with an absence of complicated parts. Tools in a smithy do not as a rule get a great amount of consideration, and the simple and massive construction is of much value in enabling the tool to stand up to the severe duties it has to perform. The blow necessary to stop the heavy levers on the down stroke is taken by buffers carried on the main frame, as is shown in Figs. 2 and 3. As an illustration of the class of work heavy hammers of this type can turn out, it may be mentioned that the levers A and A^1, shown in Fig. 7, are mild-steel stampings made in one piece under a 3-ton drop-hammer.

As has been said, the battery is driven by an electric motor. As the speed of the main shaft is only 42 revolutions per minute, it has been necessary to introduce gearing. This is of the enclosed type, running in an oil-bath. The motor is coupled up direct to the high-speed shaft of the box by means of an expanding centrifugal clutch, which allows the motor to start up without load, and gradually transfers the power to the lifter shaft as the speed increases. The centrifugal clutch will also slip, when necessary, if an undue load is put on, thus safeguarding the motor. In some cases ordinary open spur-gearing is fitted, in which case the motor is simply fixed on to the standard, and drives up to a fly-wheel fixed on the back shaft. This system is satisfactory, but is, of course, noisier and less efficient than the enclosed gear. With a drop-hammer battery there is always a certain amount of spring of the main horizontal girders when the hammers are working, and whereas a gear-box ensures proper meshing under such circumstances, there is no such certainty with open gears.

Our final illustration, Fig. 9, is a copy of a chart from a recording wattmeter giving the power taken to drive the hammers lifting and also running light. For the largest hammer—*i.e.*, 40 cwt.—the maximum torque is 76 horse-power, for the 15-cwt. 28 horse-power, and for the 5-cwt. 8 horse-power. The power consumed in running the lifters light, *i.e.*, for driving the gear, and all overhead mechanism when the hammers are not being actually lifted, is 5 horse-power.

MECHANICAL GEAR FOR OPERATING BOAT-DAVITS.

The outstanding feature of the ordinary bent boat-davit is its simplicity. There is nothing in it which can go wrong, and as long as there are plenty of men to operate it its action is perfectly satisfactory. It came into existence in the days of the sailing-ship, when crews had to be large to deal with the canvas, and when passengers were few, and consequently there was plenty of strength available to turn it, even if it had rusted in the bearing or the footstep, or if it had been slightly bent by the impact of the sea. The day of large crews has now passed, however, while passengers have increased in numbers enormously. The result is that while there may be a thousand people on board a ship, there probably are not among them thirty really trained seamen capable of skilfully dealing with a boat that has to be moved by main force. It is this condition of affairs which has favoured the introduction of newer forms of davits which can be manipulated by stewards and stokers, and even by passengers. But as yet such davits are only found upon higher-class vessels, while the ordinary bent davit can be counted in tens of thousands. Its existence is, however, threatened in all vessels carrying passengers, for in the Report of the Departmental Committee on Boats and Davits [Cd. 6846, 1913] the following recommendation appears:—"In passenger and emigrant ships there should be an efficient mechanical gear which can be made readily available for completely controlling the slewing and turning out of the boats against a considerable list." Although there are bent davits which comply with this requirement, there are hundreds, if not thousands, which do not, and therefore this recommendation promises to bear hardly on large numbers of steamship-owners whose vessels carry passengers and yet are not furnished with the latest type of fittings.

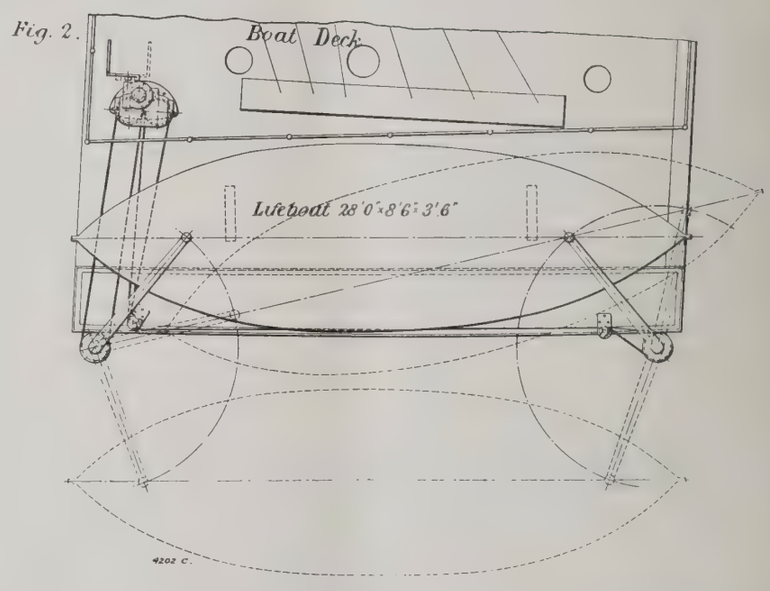
It is, of course, not a difficult matter to design mechanical gear for application to existing round davits, but, unfortunately, these are not standardised, nor are the vessels which carry them, and therefore, unless the device were in a manner independent of the position of the davits in relation to the bulwarks, it would be necessary to alter the design for each ship, involving considerable delay and increased expense. In some cases it would be cheaper to scrap the existing davits and instal others of a more complex character. What is wanted is a gear which can be bolted to the deck and connected to the davits by flexible means capable of being adapted to all likely conditions on the spot. One method of attaining this result, due to the Welin Davit and Engineering Company, Limited, of 5, Lloyd's-avenue, London, is illustrated on this and the opposite page.

The figures show two modifications. In the first (Fig. 1) the davits are fixed at a distance apart greater than the length of the boat to be handled, a condition which lends itself to a very simple arrangement, as the boat will swing outboard, keeping parallel to the bulwark all the time. All that is necessary, therefore, is to rotate the two davits simultaneously. In this case the davits should be high enough to prevent

MECHANICAL GEAR FOR OPERATING BOAT-DAVITS.

CONSTRUCTED BY THE WELIN DAVIT AND ENGINEERING CO., LTD., LONDON.

Fig. 1.



MECHANICAL GEAR FOR OPERATING BOAT-DAVITS.

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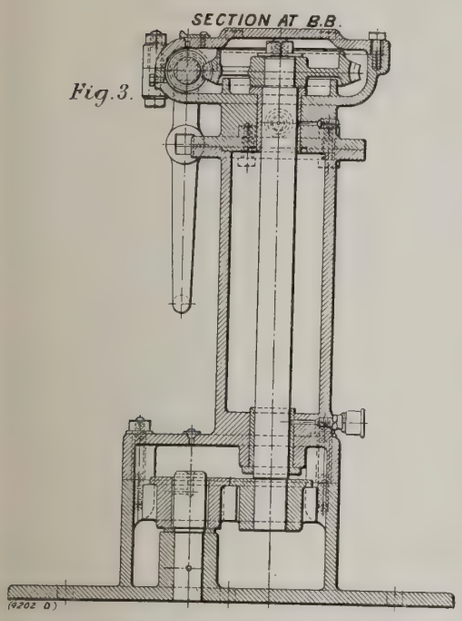
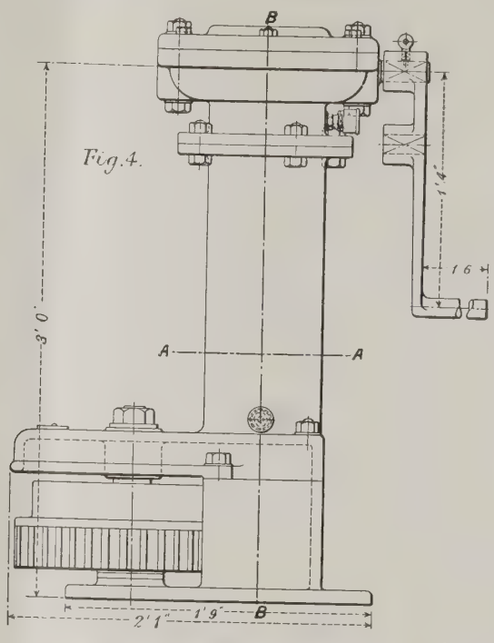
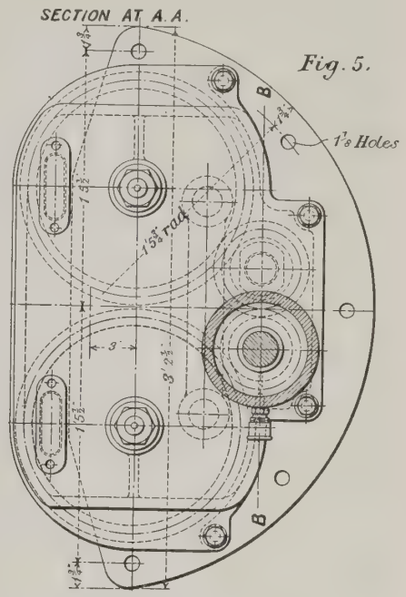






FIGS. 6 TO 11.

undue obliquity of the falls, or else the lower blocks should be fitted to travellers in the boat.

The tackle is very simple. A cast-iron standard is bolted to the deck, and in it there is a vertical spindle, carrying a worm-wheel at the upper end. This wheel is rotated by a worm and handle, and can be turned in either direction. At the lower end of the spindle is a pinion gearing with a spur-wheel which forms part of a drum rotating on a stud. The motion of this drum is conveyed to the two davits by a pair of wire ropes, these ropes acting substantially as connecting-rods, compelling the davits to turn in unison with the drum, except that they turn in opposite directions. Upon the shank of each davit, as shown in Fig. 1, there is a rope drum made in halves, so that it can be applied without unshipping the davit and does not need to be bored. The ropes are fixed at one point to the drums, so that there is no fear of them slipping. When the handle of the gear is turned, the wire ropes are drawn in at one side and paid out at the other, with the result that the davits both turn at the same angular velocity. Of course, one rope is crossed, so that the davits both turn inwards at first and then both outwards. The whole arrangement is very clearly shown in Fig. 1.

The second design provides for the commoner case, in which the distance between the davits is less than the length of the boat which they carry. Simultaneous motion will not then put the boat outboard, as it will foul the shanks of the davits. The proper motion can be followed in Fig. 2. When the boat is lifted off the chocks, the left-hand davit is first rotated clockwise, and at the same time the right-hand davit is also rotated in the same direction. The left-hand end of the boat is thus moved until it is over the bulwarks, while the right-hand end is swung inwards, past the right-hand davit. But when this motion is complete, the motion of the right-hand davit is reversed, and it then carries its end of the boat over the bulwarks. Further motion of the davits transfers the boat completely outboard, ranging it parallel with the bulwarks. The various positions can be followed in Fig. 2, in which the inboard position of the boat is shown in full lines. The dotted outline of the boat crossing the full lines shows one end of the boat over the rail and the other further inboard, while the final outboard position is also shown in dotted lines. It is clear from this that the angular velocity of the two davits is not uniform, and, indeed, the right-hand davit has its motion reversed during the operation, while the left hand becomes practically stationary before the other completes its stroke. The means by which these results are attained are shown in Figs. 3 to 11.

Figs. 3 to 5 show the turning-gear, which is very similar to that in Fig. 1, except at the base. There are two drums (Fig. 5) which do not necessarily rotate at the same speed. One of these is driven direct by a pinion at the bottom of the vertical shaft (Fig. 3) of the hand-driving gear. The second is driven partly by gearing and partly by a link, the arrangement being shown in Figs. 6 to 11, and it is this combination of partial gears and a link which effects the required movements of the right-hand davit.

In Fig. 6, the top left-hand view in the group of photographs, will be seen four wheels, corresponding to the four in Fig. 5. The two large wheels are connected to the rope-drums (Fig. 5); one of the small wheels is on the vertical shaft (Fig. 3), and the remaining small wheel is an intermediate pinion. Both the small wheels rotate constantly at a uniform angular velocity, while the large wheels have an irregular motion corresponding to the required motion of the davits.

Let us assume that Fig. 6 corresponds to the position of the boat shown in full lines in Fig. 2, and that the two pinions are set in motion by the hand-gear. The left-hand wheel commences to rotate anti-clockwise, and at the same time it pushes the right-hand wheel in an anticlockwise direction by means of the link. Evidently one davit is moving outboard and one inboard, until the wheels attain the position shown in Fig. 7. As the motion continues, the link ceases to push, and begins to pull, and now the wheels rotate, one in an anticlockwise and the other in a clockwise direction, and both davits move outboard, until the position of Fig. 9 is reached. Here the right-hand wheel is in gear, and the left-hand is just out of gear, and is being rotated by the link, which now pushes from the right-hand end. The motion is continued through Fig. 10, but at that point the link again comes into tension, drawing back the right-hand wheel until its teeth again come into gear with the pinion. The davits are now in the position corresponding to the outboard position of the boat in Fig. 2.

It will be realised that the manipulation of davits from a single rotating spindle is a matter of very considerable difficulty, and that the problem has been solved by the gear just described in a very ingenious manner. This gear only needs to be bolted to a ship's deck, and a couple of drums clamped on the davits, to make the boat-lowering gear comply with the latest requirements. Should it be at any time considered preferable to use a fore-and-aft shaft instead of the wire drive above described, this can easily be arranged without alteration to the mechanism proper; in fact, we are advised that considerable orders for the P. and O. Company are at present in hand arranged in this way.

OUR COAL ABROAD.—Mainly in consequence of war with Germany, Austria, and Turkey, our coal exports, which have continuously increased of late years, will show a very appreciable reduction in 1914. Shipments to the following countries to October 31, this year, have exceeded 2,500,000 tons:—Russia, 3,086,032 tons; Sweden, 3,580,692 tons; Denmark, 2,581,186 tons; Germany, 5,256,765 tons; France, 10,046,810 tons; Spain, 2,659,286 tons; Italy, 7,262,616 tons; and Argentina, 2,535,790 tons. Our coal exports have fallen off heavily to Russia and Sweden, but they show a moderate increase in the case of Denmark. The decline in our coal shipments to Germany this year has been 2,362,648 tons. Shipments to France, Spain, Italy, and Argentina all show decreases this year. Our coal deliveries to Egypt also declined in the first ten months of 1914 to 2,361,658 tons, as compared with 2,488,330 tons in the first ten months of 1913. Our aggregate coal exports to October 31, this year, were 52,060,848 tons, as compared with 61,257,261 tons and 52,550,191 tons. Shipments of bunker coal declined to October 31, this year, to 16.037.409 tons, as compared with 17,434,411 tons and 15,020,522 tons.

INDUSTRIAL NOTES.

The Director of the Department of Labour Statistics, in an article on the state of the labour market in October, published in the *Board of Trade Labour Gazette*, gives the following information :—Employment continued to improve in October both as regards the numbers of workpeople employed and the amount of short time reported. The improvement was largely accounted for by war contracts, and was especially noticeable in the engineering, miscellaneous metal, woollen, worsted, hosiery and dyeing trades. The boot, leather and clothing trades continued to be very active, and employment in shipbuilding yards was good generally. Carpenters and woodworkers were busy in connection with the erection of huts for the new army. The pig-iron, iron and steel, printing, pottery and glass trades also showed an improvement. The cotton trade improved slightly, but a large amount of short time still prevailed. The curtain branch of the lace trade improved, but the other branches continued to be depressed. The silk and carpet trades showed some recovery. Coal-mining remained about the same as in September, and there was a seasonal decline in the brick-making industry.

Compared with a year ago there was a decline except in the trades most affected by war contracts. It should, however, be noted that the boom in employment reached its zenith about the middle of 1913, and that for some time before the outbreak of war several trades had declined considerably from the high level then attained.

The changes in rates of wages taking effect in October affected 67,000 workpeople, and resulted in a net increase of 2100*l.* per week. The number of workpeople who received increases was 58,000, and included 16,200 coal-miners, &c., in Cumberland, Bristol, and Somerset, who received a seasonal advance ; 6690 building trade operatives at Birmingham ; 11,500 ironstone-miners and limestone quarrymen in Cleveland and Durham ; 5850 workpeople in steel works in West Scotland ; and 5000 workpeople in engineering works in Sheffield and district. The principal decrease affected 6250 blast-furnacemen and iron and steel workers in South Wales and Monmouthshire.

The number of disputes beginning in October was 27, and the total number of workpeople involved in all disputes in progress during the month was 20,677, as compared with 13,025 in September, 1914, and 79,859 in October, 1913. The estimated total aggregate duration of all disputes during the month was 192,500 working days, as compared with 229,800 in September, 1914, and 1,007,400 in October, 1913.

Cases dealt with during the month include painters, Chesterfield; carpenters, Ballykinlar Camp, co. Down; shipwrights and joiners, Southampton ; packing-case makers, Aberdeen; block-printers, Dartford.

The average weekly number of vacancies notified to all Labour Exchanges for the five weeks ending October 16, 1914, was 31,981, as compared with 29,339 in the four previous weeks, and with 23,045 in the five weeks ending October 17, 1913. The average weekly number of vacancies filled during the same periods were 24,729, 23,107, and 17,158 respectively.

The October number of the *Reichs-Arbeitsblatt* (the journal of the German Labour Department) states that "the revival in the labour market which began in August, after the initial sharp decline in the level of employment consequent upon the outbreak of hostilities, not only continued in September, but became apparent in nearly all branches of industry. It was possible to discontinue to a considerable extent the short time which had been introduced in many instances in August. The improvement was especially noticeable in mining, and particularly in coal-mining, as also in the engineering, electrical, and clothing trades. Certain trades worked more briskly than in times of peace."

Returns relating to unemployment in September were furnished to the German Labour Department by thirty-four trade unions, with an aggregate membership of 1,162,614. Omitting branches which failed to make returns, the membership covered was 1,010,283, of whom 161,164, or 16 per cent., were stated to be unemployed at the end of September, as compared with 22.4 per cent. in the previous month and 2.7 per cent. in September, 1913.

The Board of Trade has issued the following information :—The average change in retail food prices during October was an advance of less than 1 per cent. ; this advance was mainly due to an increase in the price of eggs, partly attributable to seasonal causes. Milk and butter also showed slight rises in price, as is usual during October. The price of sugar at October 31 averaged about 5 per cent. lower than at the beginning of the month. Margarine prices fell by about 5 per cent. on the average, and those of fish and bacon by 3 per cent. Potatoes also were lower in price. Meat, bread, flour, cheese, tea, cocoa, and coffee showed little or no change.

Taking all these articles together, and allowing for their comparative importance in working-class household expenditure, the average increases in price since July amounted to about 13 per cent. in the large towns, and 12 per cent. in the small towns and villages.

Dr. E. S. Reynolds, Professor of Clinical Medicine, a few days ago delivered a lecture at the Medical Session, Manchester University, on "The Industrial Diseases of Greater Manchester." He drew attention to the great improvement in, and the greater use of, dust-removing appliances in cotton factories, and the great diminution in the danger to health arising from the presence of dust in the mills, since 1908. Except in the case of strippers and grinders, the amount of mechanical bronchitis among cotton operatives was not now excessive. The amount of tubercular phthisis, though high as compared with that among agriculturists, was not much above the average existing in other indoor occupations. Infectious diseases might be conveyed by raw cotton, as in the recent slight outbreak of smallpox, and it was interesting to notice that in 1606 and again in 1646, the plague was introduced into Manchester by raw cotton from Smyrna. Heat, humidity, dust, bad ventilation, and the monotonous work of a cotton-mill, were conditions which increased the mortality of cotton operatives as compared with that of the average population, and which caused respiratory troubles, rheumatism, and dyspepsia ; but as an indoor occupation it did not strike him as being among the really dangerous trades, nor yet among those which might be classified as specially unhealthy. Supposing a cotton-mill in a pure atmosphere free from smoke, the operatives well housed, with plenty of air-space and sunlight, and of temperate habits, then there would not be among the workers any excess of tuberculosis. The detrimental effects of foul air, lack of sunlight, and low wages were obvious. A few words, he added, were needed concerning alcoholism. "Drinking" in industrial communities might be due to the habits of a trade, or to the heat, dryness, dustiness, or monotony of certain occupations ; but it certainly caused diseases which the occupation itself was not responsible for. Though industrial diseases made a long list, the health of the worker was now much better than formerly, and the chief causes of this important improvement were to be found in the long lists of Acts for the improvement of industrial conditions which stretched from Peel's time down to the Workmen's Compensation Act of 1906. He suggested that the next important step in legislation to improve the health of the people of Greater Manchester should be an Act for the total removal of the smoke nuisance.

Statistics dealing with the working of the Workmen's Compensation Act and the Employers' Liability Act in 1913 have been issued as a Blue Book. In regard to seven industries—mines, quarries, railways, factories, harbours, docks, &c., constructional work, and shipping—compensation was paid in 1913 in respect of 3748 cases of death and 476,920 cases of disablement, the gross total of compensation amounting to 3,361,650*l.* If to this figure there be added the cost of management, commission, legal and medical expenses, &c., it is estimated that the total charge borne by the seven industries in question cannot have been less than 5,000,000*l.* In 1912 there were 3599 fatal cases and 424,406 non-fatal, the total compensation amounting to 3,174,101*l.* The gross total of persons employed in the seven industries was 7,509,353. There had been a steady increase since 1908 in the actual number of cases in which compensation had been paid, and 1913 showed a further increase.

In regard to industrial diseases, compensation was paid in 27 fatal cases to the amount of 4147*l* , and in 8233 disablement cases to the amount of 130,251*l.* The number of "continued cases" was 2485, or 30 per cent. of the total number (in the case of accidents the proportion is only 7.7 per cent.), and they accounted for 67,148*l.*, or more than half the total disablement compensation.

In regard to cases under the Employers' Liability Act, of the 39 cases in which judgment was given for the plaintiff, only two were fatal cases, the compensation awarded being 159*l.* 12s. in one case, and 400*l.* in the other ; 29 were returned as cases of total incapacity, the total compensation awarded being 1314*l.*, an average of 45*l.* a case ; eight were returned as cases of partial incapacity, the total compensation awarded being 568*l.*, an average of 71*l.* a case.

The Board of Trade has forwarded a letter to West Riding manufacturers of khaki materials inquiring the extent to which they can increase their output of these materials. They are asked to state the extent of their weekly output, whether all machines are working day and night, and, if not, what difference in the output it would make if they were ; also what additional labour would be required to work the machines day and night. They are also asked to say what increase in plant is possible. In the factories where shortage of labour has been reported, strong recommendations have been made that cotton operatives who are suffering from slackness of trade in Lancashire should be imported, and employed in khaki weaving. In some cases this suggestion has been already followed out.

Speaking at Firth College a few days ago, the Vice-Chancellor of Sheffield University, Mr. H. A. L. Fisher, pointed out that unemployment still existed, though it showed no increase on the figures for 1860. Unemployment might be divided into three classes —seasonal, due to transformation of machinery, and cyclical. With regard to the first, the remedy might either be to educate those liable to seasonal unemployment in subsidiary trades, or by regulating the demand so that it was not exclusive to one season. The transforming of machinery could never be eliminated as part of industrial progress, and the only efficient remedy he could find for this was in well-directed charity towards the deserving mechanic thrown out of work—the charity which aimed at providing a new job, or in the provision of industrial training.

Cyclical unemployment was very troublesome to deep thinkers, because its cause was so difficult to find. It recurred every seven or ten years, and had been attributed to the spots on the sun, and, perhaps more reasonably, to too great investments in fixed capital, leaving an insufficient supply in circulation. It had been proposed to remedy this by a very highly-developed system of progressive taxation, relieving the very wealthy of their surplus riches.

His own impression was that this cyclical unemployment arose as the result of economic competition. No progress could be secured without competition, though these recurring cycles showed that it was, as George Eliot said, the pain of progress. One efficient remedy was insurance against these bad times. Society ought to be strong enough to provide this through direct State action, or by the private insurance companies, so that the poor might be tided through the bad seasons.

Unemployment, even for a very brief time, was deleterious to the life of the whole country, even for a day it was the waste of force, for industrial quality unquestionably deteriorated in idleness. Productive quality was best helped by optimism, courage, and faith, such as were very difficult in times of bad trade. There was one general remedy for unemployment, the improvement of the mechanism for the mobility of labour, and for that reason they should welcome the institution of Labour Exchanges throughout the country.

We are informed that for the first time since hostilities broke out full time is being worked at a number of Oldham cotton-mills. The returns show that 30 per cent. of the spinners are working full time, while 5 per cent. are totally unemployed. At the remaining mills, with few exceptions, the machinery is run during daylight only. Employment amongst card-room workers also shows an increase. At many mills difficulties have arisen owing to strippers, grinders, and blowing-room operatives having enlisted.

NICKEL AND THE WAR.

The world's production of nickel during recent years has been steadily increasing, as shown by the following figures :—

	Tons.	Tons Increase.
1913	30,000	1500
1912	28,500	4000
1911	24,500	4400
1910	20,100	—

During the recent six or seven years there has been a remarkable expansion in the industrial uses of metallic nickel. Two-thirds of the world's supply is produced in Canada ; the remaining third comes from New Caledonia and is controlled by France. As the main supply is obtained from Canada, the suggestion was made some years ago, and obtained considerable support there, that the export of Ontario nickel ores, mattes or metal should be prohibited, or limited, to all countries other than Great Britain. The question at the time was considered of great importance. A large quantity of nickel is used in the nickel-plating industries. The shutting off of the metal from this field would probably not cause such serious consequences to ensue as would follow should the sources of nickel be shut off from nickel-steel industries, also from the nickel coinage of several countries. Besides its use in bridges, nickel-steel is much used in the manufacture of armour and other war products ; the prohibition of nickel exports from Canada to non-British countries is therefore an important point.

The question has been again discussed as a consequence of the war, and a Government order was issued in Canada, at the end of October, prohibiting the export of nickel to enemy countries. The Order in Council is worded : "To all foreign parts in Europe and on the Mediterranean and Black Seas, save Great Britain, France, Russia (except the Baltic ports), Spain, and Portugal." The Canadian nickel deposits

differ from the German potash deposits in so far as the latter appear to have no competing sources of supply; the former has no such monopoly. The Canadian contraband of war prohibition will act as an incentive to the opening out of new deposits and re-opening of old ones, several of which are situated in the United States, Greece, and other countries, all well known.

Norway possesses extensive deposits of nickel ore, much of it containing as high as 2 per cent. of the metal. In former years nickel-mining was of some importance there, but competition with the richer ores of Canada and of some mines now shut down in the United States, could not be maintained, and most of the mines ceased operation. Towards the end of the last century the annual production of nickel sank to 7 tons. It is now stated that the mines have been reopened. On a small scale the Norwegian nickel ore-mining industry was revived some years ago, with an annual output of 70 to 100 tons, nearly all of which is used within the kingdom; one mine was worked at Eije with an ore output of 5770 tons, producing 58.27 tons of nickel. In the smelting works 2.77 tons of matte is obtained from 100 tons of ore, and this contains 40 per cent. of nickel and 25 per cent. of copper. It is refined in the electrolytic works at Christiansand, which are equipped for an annual production of over 400 tons of the metal. The production of electrolytic nickel is a much more complicated operation than are those yielding aluminium or sodium. The electrolytic nickel has a high degree of purity, and is fairly compact. The total consumption of electricity is relatively large, and the process can be employed with advantage only where the cost of the current is exceptionally low, as is the case in Norway.

The United States may be considered a non-producer of nickel, although a very limited recovery of this metal is made as a by-product in the electrolytic refining of copper. The States depend practically entirely on the nickel-ore mines of Sudbury, Ontario, for their supplies of the metal. The production of the Sudbury mines during 1913 reached 750,000 tons of ore, most of which was smelted to matte containing about 24,000 tons of nickel. In 1912 the production of these mines amounted to 737,320 tons of ore, whilst the matte produced 22,421 tons of nickel. There are several important companies associated with this industry:—The International Nickel Company, the Mond Nickel Company; the British-American Nickel Company was engaged also early last year, The New Caledonian mines output of ore in 1913 was 75,300 tons, and 6000 tons of matte.

The Canadian output during the last three years has been as follows:—

	Lb.	Tons.	£
1913 ...	49,676,772	22,177	3,104,800
1912 ...	44,841,542	20,018	2,802,600
1911 ...	34,098,744	15,222	2,132,171

The Ontario deposits occur in a saucer-like arrangement of rocks of volcanic character, 35 miles across one way and 15 miles the other. The mines are grouped along the outer edge of the saucer, most of them near Sudbury on the south-east side. The central portion of the saucer is filled in with non-metallic rocks, in this case sandstones and slates. It was stated about fifteen months ago that nickel properties near Sudbury were sold to French capitalists for 1,875,000*l.*, but that a very large outlay of capital would be necessary to obtain an output. It is stated that the International Nickel Company has spent approximately 2,083,000*l.* in the development of its Sudbury mines.

For the purpose of obtaining the nickel output given above, it was necessary to mine and treat 823,403 tons of nickel-copper ore during 1913 and 725,065 tons during 1912. The companies turning out these ores are the Mond Nickel Company, the Canadian Copper Company, also owning smelters, and the Dominion Nickel Company. The quantity of Bessemer nickel-copper matte shipped out of Canada in 1913 was 47,150 tons, as compared with 41,925 tons during 1912. This matte carries small gold and silver values, as well as metals of the platinum group.

Considerable changes have been made in some of the details of smelting practice, although the general method remains the same—that is, the ore is roasted, smelted, and converted to a Bessemer matte, containing from 77 to 82 per cent. of the combined metals, copper and nickel, the matte being shipped to Great Britain and the United States for refining. The quantity coming to this country, however, is extremely limited. We import some nickel oxide from the United States in the following small quantities:—

	Cwt.	£
1913	17,965	90,120
1912	23,679	116,975
1911	15,117	74,310
1910	17,294	86,135
1909	19,455	96,325

A portion of the matte made by the Canadian Copper Company is used for the direct production of monel metal, an alloy of nickel and copper, without the intermediate refining of either metal. Of the metallic output of Canada, nickel is second in quantity and third in value, as shown below:—

		£
Nickel	49,676,770 lb.	3,104,800
Copper	76,975,830 ,,	2,448,600
Silver	31,750,618 oz.	3,955,000
Gold	784,525 ,,	3,378,300
Lead	37,662,700 lb.	365,500

The province of Ontario has the largest mineral production, 40.75 per cent.; British Columbia coming next with nearly 20 per cent., and Nova Scotia third with 13.40 per cent. The output of the other six provinces is very limited, in no case reaching 10 per cent.

THE LATE MR. FRANK PEARN.

We regret to announce the death of Mr. Frank Pearn, which took place at his residence at Heaton Moor, Stockport, on the 11th inst. Mr. Pearn, who was in his 64th year, was a member of the firm of Messrs. Frank Pearn and Co., Limited, West Gorton, Manchester, well-known as makers of pumps and pumping machinery. He served his time with John Cameron, of Salford, a firm still in existence as John Cameron, Limited, and engaged in the production of a similar class of machinery. In 1870 Mr. Pearn conceived the idea of a double-action pump with an external packed ram. With a view to making this new machine, he started in business for himself, taking premises for the purpose in Hulme, a district of Manchester. Success followed his efforts, and in 1873 his brother, Mr. Sinclair Pearn, joined the firm and took over the commercial side of it, and has been associated with it ever since. The demand for their special class of pumps and pumping machinery continued to grow, and in 1878 new works were built in West Gorton, where they have since been located. In 1894 the firm was turned into a private limited company, with the title Frank Pearn and Co., Limited. Since first erected, in 1878, three additions have been made to the works, and at the present time they occupy an area of 8000 square yards. The late Mr. Frank Pearn was actively connected with the works until about six months ago, when he had to absent himself on account of his ill-health. He was thoroughly practical, and was responsible for a number of improvements applied to the various machines made by the firm. Many large pumping installations were laid down under his supervision in various parts of this country and abroad, the size ranging from 1000 ft. to 2000 ft. head. Many of these later installations were electrically driven. In conjunction with his brother William he invented the surface and boring-machine now known as the Pearn-Richards surface and boring, milling, drilling, and tapping-machine. There is a constant demand for this machine, particularly at the present time. Some years ago an excellent book on "Workshop Costs" was published by Messrs. Sinclair and Frank Pearn. Full of remarkable yet simple detail, it showed how costing could with little trouble be made of immediate and permanent value, and although one class of machinery is taken as an example, the methods demonstrated can be readily employed in almost any class of industry. This book was written, among other objects, to demonstrate the fact that at least one costing method was in existence equal, if not better, than any importation from the United States, of which there were several at that time.

Personally, the late Mr. Frank Pearn was universally respected, and his genial temperament made him many friends both in and out of business.

ECONOMICS OF ELECTRIC RAILWAY DISTRIBUTION.*

By Horace Field Parshall, D.Sc., M. Inst. C.E.

Practically all modern traction systems of the larger class are referable to the same class of power-house and transmission system, and these are not affected to any important extent by the sub-station arrangement, which is determined with reference to variations in the operating result occasioned by the spacing and the capacity of the individual sub-stations.

In the book by Mr. Hobart and the author on "Electric Railway Engineering" most of the problems entering into the design of electric-railway installations have been dealt with. The question of the economic arrangement of sub-stations and the distribution conductors was not dealt with at length, because at the time the book was written sufficient operating data were not available to furnish a basis for different calculations. Such a wide difference of opinion existed between different engineers as to the cost of operating and maintaining a system of sub-stations that it did not appear advisable to treat the subject except on general lines. Since the publication of that book a great deal of experience has been gained, as a result of which engineers have come into more general agreement as regards sub-station practice. The present paper is written with a view to assist towards the standardisation of electric-railway sub-station practice. Many years ago Lord Kelvin formulated a law as to the economic use of conductors in transmission systems, The number of independent variables when a complete system with sub-stations has to be dealt with is so great that the mathematical expression, from which might be deduced the minimum cost, would in practice be open to some suspicion. In this paper a complete balance-sheet embodying every item has been worked out for each case, and the tabulated result is included as a part of the paper; hence, for different conditions it would be possible for an engineer to make the necessary corrections, so that, without any great amount of labour, the methods and results of the paper may be applied to practically any class of electric-railway installation. The paper has not been extended to include the electric-traction installation as a whole, since the process of standardisation in respect of motor equipments is still proceeding, and conclusions that might be drawn under present conditions would in another short time be incorrect. So far as the distribution is concerned, the conclusions are likely to be lasting, since the operating conditions on which the general results are founded are likely to obtain for a considerable time to come.

With the given energy consumption per unit of length of line that follows from a given train movement, the capacity of the sub-stations increases directly with the distance between them. The energy loss in distribution-conductors of a given section varies with the cube of the distance between sub-stations. The cost of attendance is within wide limits independent of the size of the sub-station. The cost of the plant per kilowatt falls off with the size of the units, but the maintenance and renewals per kilowatt are more or less constant. The paper embodies a series of curves showing graphically the arrangements of sub-stations that will operate different train services on different electrical systems and at various voltages with a minimum total operating cost. With rotary-converter sub-stations and a working voltage of 600 volts, and for certain assumed average conditions of train-weight, speed, and energy-consumption, the most economical sub-station spacings are 8½, 5½, and 3½ miles for train services of six, twelve, and twenty-four trains per hour respectively. For a working voltage of 1200 volts, the sub-station spacings are 11, 7½, and 5 miles respectively, while when 2400 volts is adopted, the most economical sub-station spacings are 16, 12, and 8½ miles for the three train services respectively. Curves are also given illustrating the advantage gained by working at higher voltages, and these confirm the author's view that with the present arrangement of rotary-convertor sub-stations, there is little advantage in a higher voltage than 2400 volts for the track-conductor. The economy of higher voltages is shown to be approximately the same whatever the train service. As between 600 and 1200 there is a saving of 14 per cent. in the total annual costs of the distribution system; as between 1200 and 2400 volts there is a further saving of 7 per cent., or 21 per cent. as between 600 and 2400 volts. If the working voltage is further increased to 3600 volts, there is a decrease in total annual expenditure on sub-station and overhead-conductor equipment of only 3 per cent., which will be less than the additional cost of the rolling-stock.

For single-phase distribution at 5000 volts the most economical sub-station spacings are 31, 24, and 16 miles for train-services of two, three, and six trains per hour respectively. At 10,000 volts single-phase, the most economical sub-station spacings are 45, 34, and 26 miles for the same three train-services respectively. With three-phase distribution at 5000 volts, the most economical distances between sub-stations are 38, 31, and 18 miles for the same respective train-services. In most of these last cases, however, the economical distance between sub-stations thus determined is greater than would be permissible in practice from considerations of both traffic-operation and voltage-drop. Further, in the case of single-phase operation, the lower pressure of 5000 volts is found to be the most economical for certain services, and the higher pressures of 10,000, 12,000, and 15,000 volts in vogue on the Continent are explained by considerations of voltage-drop.

An Appendix to the paper summarises the sub-station operating costs of the Central London Railway, which have been used to a large extent as a basis for the calculations embodied in the paper.

* Abstract of a paper read before the Institution of Civil Engineers on Tuesday, November 17.

Contracts.—The list of contracts just to hand from Messrs. Ed. Bennis and Co., Limited, Little Hulton, Bolton, seems to indicate that very little difference, if any, has taken place in the amount of business being done. Among the export orders is one for India, consisting of a Bennis elevator arranged to elevate the coal from a storage-bunker below the ground-level to the mechanical stoker-hoppers on two water-tube boilers. Their other orders are for thirty-five of their various stokers for all classes of manufacturers in this country, the great majority of which are repeat orders, and for three coal-elevating and conveying installations complete, two for this country and one for India, above referred to. —Messrs. Glenfield and Kennedy, Limited, of Kilmarnock, have just received orders from the Colne Valley Water Company for one compound-condensing beam-engine with bucket and plunger-pump, to pump 2,000,000 gallons of water per 24 hours against a total head of 300 ft., and from the Cowes Urban District Council for one set of 10-in. diameter by 22-in. stroke three-throw well-pumps driven by a tandem compound steam-engine, and complete with boiler, &c. They have also received orders for sluice and reflux-valves up to 72 in. in diameter, and for a large amount of work for the British Government.

EXPERIMENTAL MARINE-TYPE QUADRUPLE-EXPANSION ENGINE AT THE SOUTH SHIELDS MARINE SCHOOL.

CONSTRUCTED BY MESSRS. W. SISSON AND CO., LIMITED, ENGINEERS, GLOUCESTER.

(*For Description, see opposite Page.*)

Fig. 1. FRONT ELEVATION.

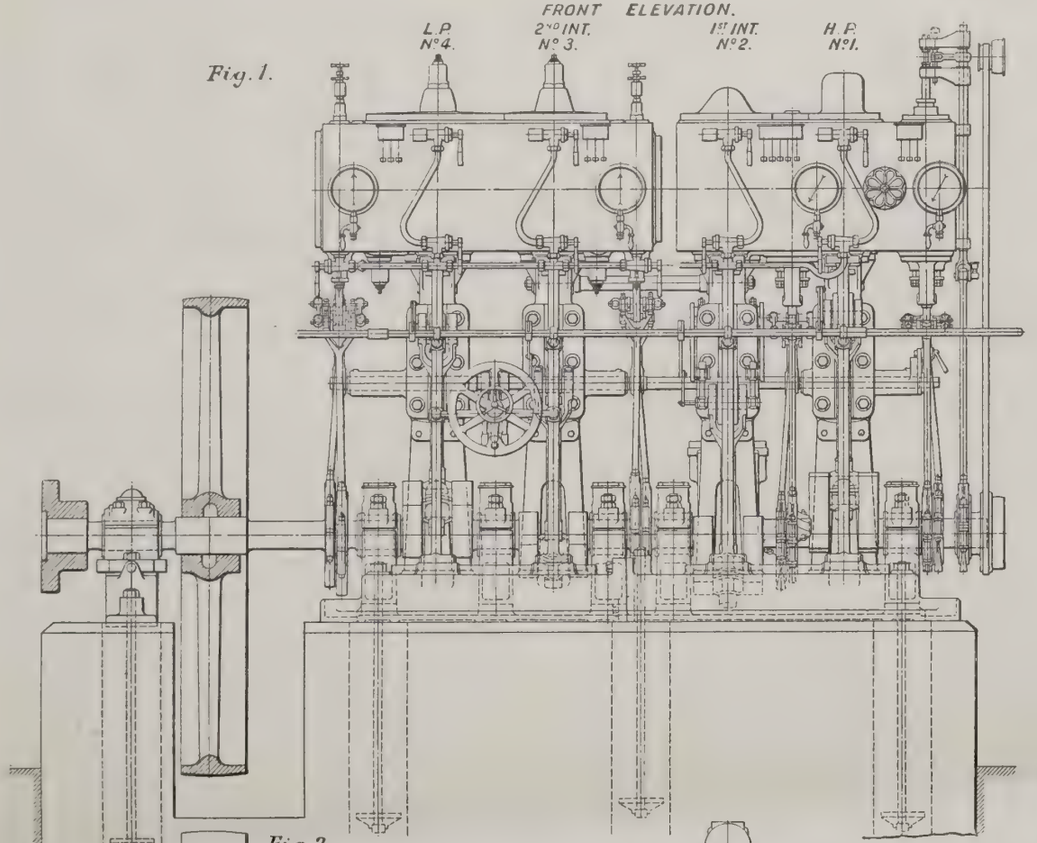


Fig. 3. H.P. END ELEVATION.

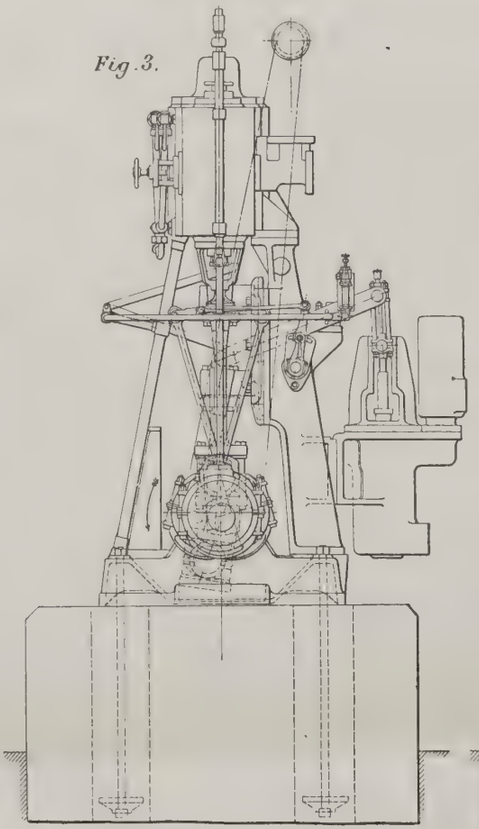


Fig. 4. L.P. END ELEVATION

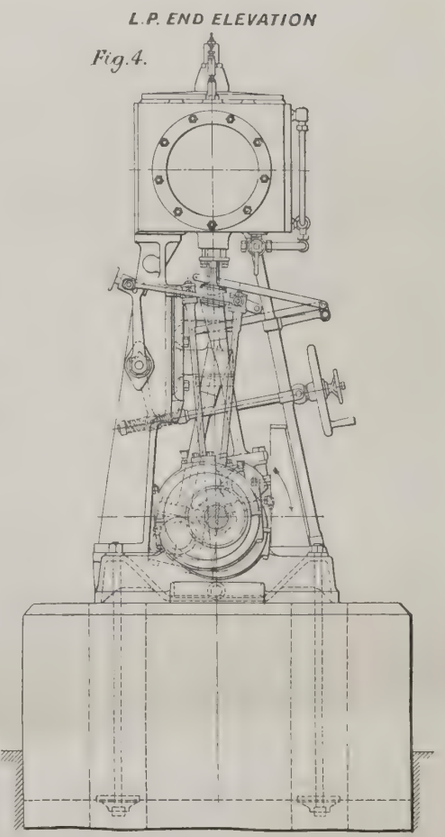


Fig. 2.

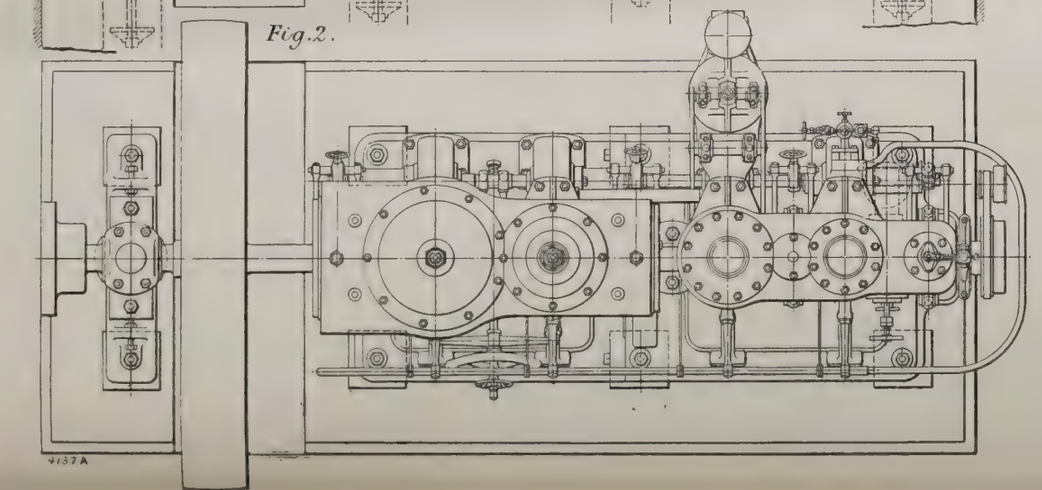


Fig. 5. N°2 VALVE GEAR.

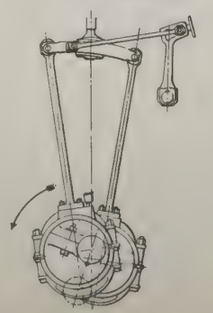
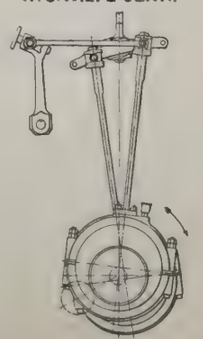


Fig. 6. N°3. VALVE GEAR.



EXPERIMENTAL MARINE-TYPE ENGINE AT THE SOUTH SHIELDS MARINE SCHOOL.

CONSTRUCTED BY MESSRS. W. SISSON AND CO., LIMITED, ENGINEERS, GLOUCESTER.

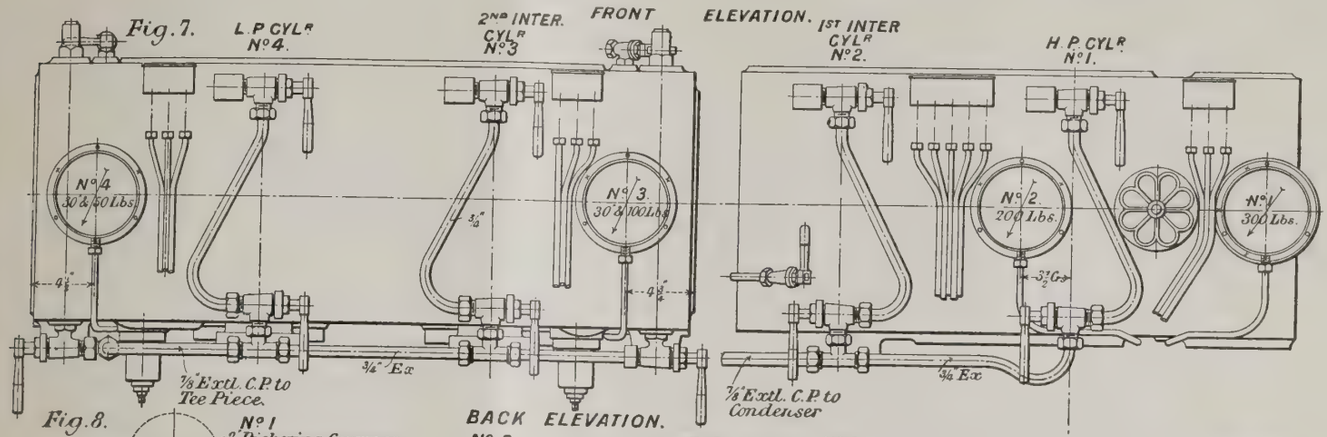
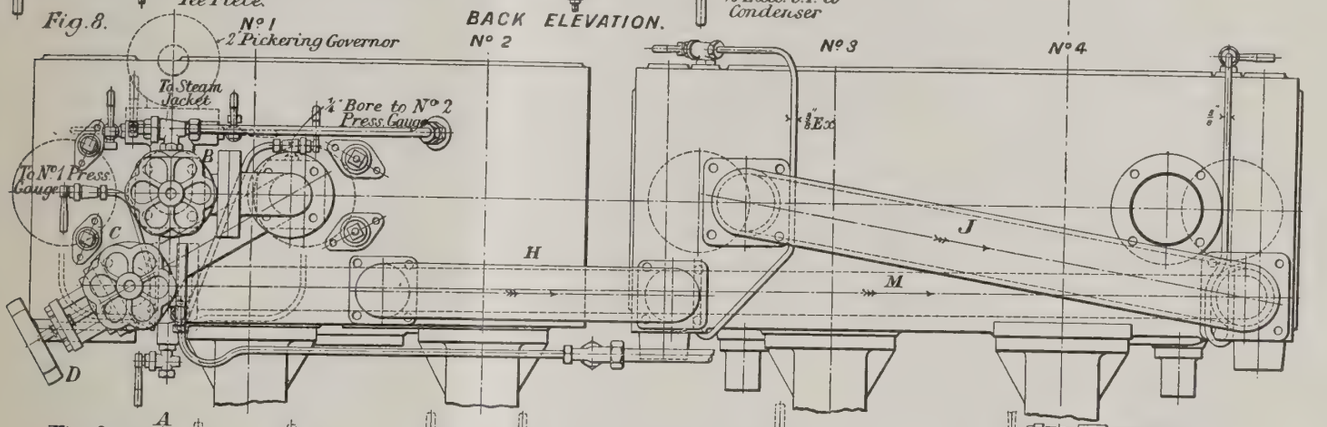
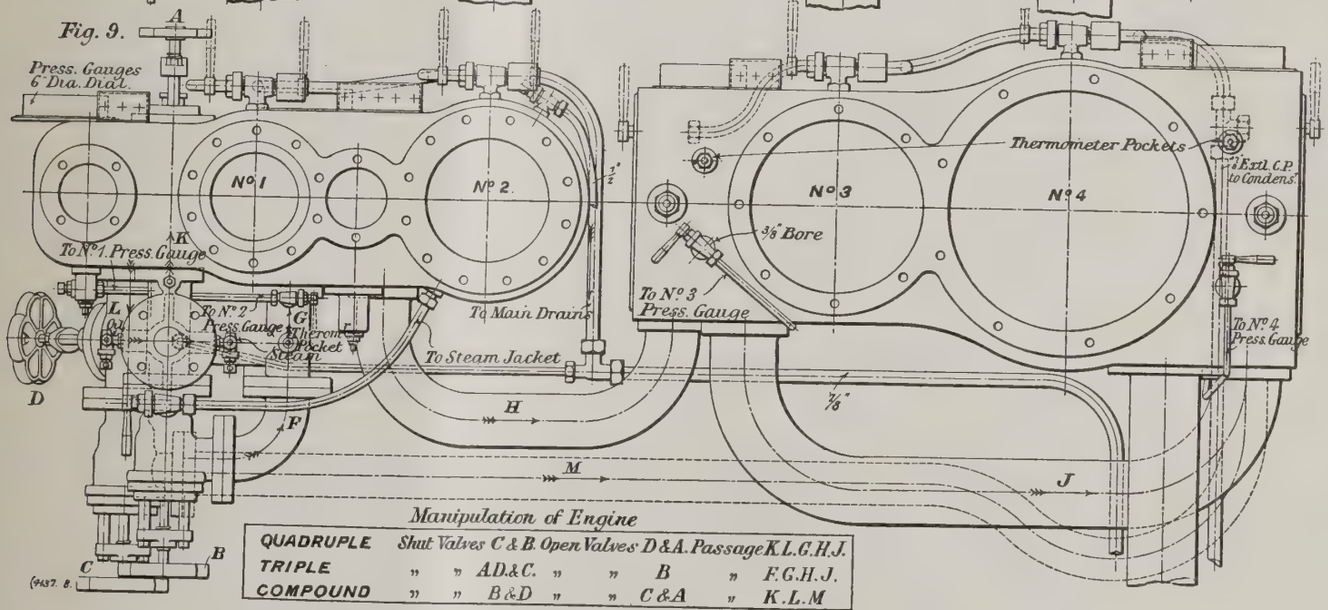


Fig. 7.
FRONT ELEVATION.
L.P CYL.R No. 4.
2ND INTER. CYL.R No. 3
1ST INTER CYL.R No. 2.
H.P CYL.R No. 1.
No. 4 30 & 50 Lbs.
No. 3 30 & 100 Lbs.
No. 2 200 Lbs.
No. 1 300 Lbs.
⅞" Extl. C.P to Tee Piece.
¾" Ex
⅞" Extl. C.P to Condenser
¾" Ex





Manipulation of Engine

QUADRUPLE	Shut Valves	C & B.	Open Valves	D & A.	Passage	K.L.G.H.J.
TRIPLE	"	"	A.D.& C.	"	"	B	"	F.G.H.J.
COMPOUND	"	"	B & D	"	"	C & A	"	K.L.M

A VERY interesting example of an experimental steam-engine and accessories has just been supplied to the Marine School, South Shields, by Messrs. W. Sisson and Co., Limited, engineers, Gloucester. As shown by the illustrations on the present and opposite page, and also on page 620, this engine is of the usual vertical inverted open-front marine type, and has four cylinders on four cranks, Fig. 1, set at such angles as to give the best balancing results. The cylinders are respectively 6 in., 8½ in., 12 in., and 16⅜ in. in diameter, with a 12-in. stroke, arranged to work on the usual quadruple-expansion series. Suitable by-pass valves and pipe connections are provided for working triple-expansion with the high-pressure cylinder shut off, and boiler steam admitted to the first intermediate ; also, by simply removing the exhaust-pipe from the second intermediate cylinder to the low-pressure cylinder, and substituting one direct from the high-pressure exhaust to the low-pressure chest, the engine can be worked as "high ratio" compound. The engine is designed to take steam from the boiler at 200 lb. per sq. in., and when working quadruple-expansion and running at about 150 revolutions per minute the output is 60 brake horse-power. As will be seen, the cylinders are arranged in two pairs (Fig. 11, page 620), the high-pressure and first intermediate forming one portion, and the second intermediate and low-pressure the other (Fig. 4, page 616, and Fig. 9, page 617), there being a stay between the two portions placed at the top of the back standards (Fig. 1). The high-pressure and the first and second intermediate pistons are of cast iron, the low-pressure of cast steel, all of dished form, and each provided with three self-spring rings of the makers' special iron alloy. The pistons and connecting-rods are all similar, the former having solid forged crossheads (Fig. 1), with slipper attached at the inner side, and working on the face arranged on each back standard, to which are attached the front plates for taking the go-astern pressure. The connecting-rods have double eyes at the top ends, with the gudgeon-pin shrunk in, and T-feet, and bronze bearings with distance-pieces and mild-steel bolts at the bottom end. The four sets of reciprocating parts are made of such relative weights as to give the best balancing effect ; and to secure this without making very awkward high-pressure and first intermediate pistons it has been necessary to attach a weight to the crosshead of each of these two rods.

The high-pressure cylinder is steam-jacketed, and provided with Meyer expansion-gear, the main valve being cylindrical and annular to receive the cylindrical cut-off valves, which are driven and the relative positions determined by a special arrangement of gear. There is the usual eccentric (Figs. 1 and 3) with straps and rod, but this is attached to a bar or spindle working in guides outside the cylinder and having levers or projecting fingers threaded on, one of which has the solid spindle of the lower cut-off valve attached to it, and the other the hollow spindle of the upper cut-off valve. The relative position of these two cut-off valves or "bobbins" is varied by a right and left-hand screw carried by an arm rigidly attached to the vertical spindle or bar, and engaging with the two fingers referred to, and the rotation of this screw separates the fingers or brings them closer together ; this, of

course, having the same effect upon the cut-off valves or bobbins attached to the spindles. The main valve is driven by Stephenson link-motion of double-bar type, the eccentric-rod ends being placed between the bars, so that in the full gear ahead or astern they do not come in line with the valve-spindle. This latter has the usual solid forged cross-head with bronze link-block. The weigh-shaft arm is carried on a separate sector-piece (Fig. 3), by means of which its position in relation to the weigh-shaft arms of the other cylinders can be altered so as to vary its gear position in relation to them. A high-speed throttle-governor is provided for the high-pressure cylinder, and driven by a pulley having two steps, so that, together with the speed-adjustment gear attached to the governor itself, the engine speed may be varied from 100 to 200 revolutions per minute.

The first intermediate cylinder is also steam-jacketed, and has a piston-valve of the makers' special "labyrinth" type, driven by link-motion, similar to that of the high-pressure cylinder, excepting that the weigh-shaft arm has a slot at the outer end with a sliding-block (Fig. 5), to which the draw-bars are attached, and by means of which the gear position can be altered. The second intermediate and low-pressure cylinders both have single-ported, flat-faced slide-valves, driven by Stephenson link-motion of the double-bar type, arranged according to usual marine-engine practice (Figs. 4 and 6), the eccentric-rods having double-top ends with bolted bearings for attachment to the link-pins, so that in full gear the eccentric-rod top end comes into line with the valve-spindle. The weigh-shaft arms have the same draw-rod adjustment as that of the first intermediate. The reversing is effected by a screw engaging with a nut (Fig. 4) having trunnions working in the ends of two arms attached to the weigh-shaft, the other end of the screw being carried in a swinging cross-bar spanning the two front pillars of the second intermediate and low-pressure cylinders. The reversing-screw has a hand-wheel and locking-wheel, as usual.

Each cylinder has a complete set of relief-valves and drain and indicator-cocks and pipes, so that the top and bottom of each may be indicated (Fig. 7, page 617). Steam-pressure, compound, and vacuum-gauges and a reciprocating counter are provided. The cylinders are lagged with asbestos and hair-felt, encased by blued-steel sheets. The main crank-shaft is in two parts, united by solid-forged coupling-flanges, with spigot and faucet and turned-steel bolts, as usual, and an extension-shaft is similarly connected at the after end, carrying a belt fly-wheel, which drives a dynamo when required. This extension-shaft is carried in a self-oiling bearing, and has a half-coupling secured beyond this for attachment to a Heenan and Froude dynamometer (Fig. 1). The eccentrics of the second intermediate and the low-pressure cylinders are mounted on the coupling flanges of the shaft, as is so customary in marine engines. The bed-plate is of strong box-section with close bottom for collecting the oil drip; a shallow trough is cast at each end to take the drip from the eccentrics, suitable arrangements being provided for drawing off. There are five main bearings, each having a bored seat with circular bearings of anti-friction bronze, held down by cast-iron caps with studs and lock-nuts. There are also capacious oil-boxes cast on for siphon lubrication and closed by polished hinged brass lids.

The air-pump (Figs. 2 and 3) is of the ordinary single-acting type with suction, bucket and delivery-valves, the case being of cast iron, the barrel of gun-metal, the bucket, guards, and glands of brass, and the rod of delta metal. It has a capacious air vessel, and is attached to the back standard of the first intermediate cylinder and driven from its cross-head by levers and links with adjustable bearings, as usual. Arrangements are made for connecting an indicator so that diagrams may be taken from top and bottom of the pump.

A double-connection, wet-tube, sight-feed lubricator is provided for the steam-pipe, and flushing lubricators where necessary, also a complete system of lubrication by means of brass oil-boxes with sight-drop and shut-off connections piped to each of the important working parts. The connecting-rod top-ends are milled out to form oil catch-boxes for lubricating the cross-head gudgeon and the crank-pin by means of a hole bored down the body of the rod for this purpose, and according to the makers' standard practice. High splash-plates edged with polished brass tube are attached at the front of the engine.

The surface condenser is independent of the engine, and consists of a cylindrical steel-plate shell with angle iron rings securely riveted thereon, also a capacious exhaust-box riveted to the crown, and the whole galvanised after completion. The exhaust-box has an inlet for the exhaust steam from the engine and from a steam-turbine which may be provided later on, the latter connection being blanked at present. The tube-plates are of rolled yellow metal, and the tubes of seamless brass, secured therein by screwed glands and cotton packing, the doors being of cast iron. The condenser is carried by wrought-iron supports arranged so that the height admits of a suitable exhaust-pipe, while at the same time giving good drainage down to the air-pump suction.

In conclusion, it ought to be mentioned that this engine and accessories were designed and arranged throughout in accordance with the specification and requirements of the Principal of the college, Mr. Harold R. Cullen, M.A., who will shortly be conducting a series of tests, and we hope in a future issue to give particulars of the results obtained.

The Royal Institution.—The eighty-ninth Christmas course of Juvenile Lectures, founded at the Royal Institution in 1826 by Michael Faraday, will be delivered this year by Professor C. V. Boys, F.R.S., his title being "Science in the Home." The lectures will be experimentally illustrated, and the subjects are as follow:—"Mechanics in the Home," Tuesday, December 29; "Chemistry in the Home," Thursday, December 31; "Fluids in the Home," Saturday, January 2; "Heat in the Home," Tuesday, January 5; "Electricity in the Home," Thursday, January 7; "Light in the Home," Saturday, January 9. The lecture hour is 3 o'clock.

The Royal Society of Arts.—The session of the Royal Society of Arts commenced on Wednesday, the 18th inst., with an address from Sir Thomas Holdich, Chairman of the Council. All the usual arrangements have been made for meetings, &c., and the ordinary programme has been issued to the Fellows. Three of the papers to be read before Christmas deal with the chemical industries as affected by the war. The first of these is by Sir William Tilden, on "The Supply of Chemicals to Britain and Her Dependencies;" and the second by Dr. W. R. Ormandy, on "Britain and Germany in Relation to the Chemical Trade." The third paper is by Dr. Mollwo Perkin, on "The Indian Indigo Industry," which has, of course, been very seriously affected by the production of synthetic indigo in Germany. The other two papers to be read before Christmas are by Sir William Abney, K.C.B., D.Sc., F.R.S., on "Permanent Pigments," and Mr. W. A. Young, on "Metal-Work in the Eighteenth Century." A certain proportion of the papers announced for reading after Christmas also refer to the effect of the war upon British trade, while others are concerned with the usual variety of topics proper to the Society's ordinary work.

The Transmission of Power by Chains. — Last Saturday a paper with the above title was read before the Birmingham Association of Engineers by Mr. H. T. Hildage, M. Inst. C.E. He said that about a year ago Messrs. Hans Renold, Limited, introduced the multiple-bush roller-chain, which is built up of the inner combinations of the bush roller-chain, threaded upon a stud which is entirely independent of any of the links, and is consequently perfectly free to rotate. Its power-transmitting capabilities can be increased by increasing the width. For example, an ordinary ½-in. pitch cycle-chain can be made to transmit about 7 horse-power at about 3000 revolutions per minute. A multiple-bush roller-chain, 5 in. wide and of 6 by 6 combinations, would readily transmit 20 horse-power at 2000 revolutions per minute, and be in every way satisfactory. This is better than could be done with a silent chain, because a ½-in. pitch silent chain to transmit 20 horse-power would have to be about 12 in. wide, and would consequently be made up of several strands. The general object of the paper was to give information which would enable every engineer to make his own chain-wheels, as he now makes his own spur-wheels. It also contained some discussion of the limiting numbers of teeth that should be used.

The Repair of Motor Vehicles in the War.—Already the Mechanical Transport Department of the Army has despatched several thousand motor vehicles to the front, where they are doing most excellent work in many ways. For example, in some places they are carrying ammunition right up to the guns, although it was originally intended that the final distribution should be by horses. The work is arduous in every way, and naturally the wear and tear is heavy. To enable repairs to be executed on the spot a number of motor-repair shops have been sent out. These vehicles have been constructed by Messrs. Dennis Brothers, Limited, of Guildford, and the tools supplied by Messrs. Drummond Brothers, Limited, of the same town. The power equipment for driving the machine-tools is a 3-horse-power "Aster" petrol-engine, to which a dynamo is directly coupled, while the line-shaft is driven by belt from the engine pulley. A very adequate number of lamps are provided, twelve of them being portable ones, and two, duplex roof lights. These are supplied from a direct-current "Crypto" dynamo having an output of 700 watts; this also supplies current for a small electric grinder and a portable drilling-machine. The chief machine-tool is a 6-in. Drummond lathe, a feature of which is its ability to deal with milling, boring, and drilling work, in addition to ordinary turning and screw-cutting. It is provided with treadle gear for use should the engine fail. Another important tool is a sensitive radial drill, also of Drummond make. It is arranged to do ordinary sensitive drilling and similar delicate work, while it is also capable of tackling quite heavy or awkward jobs. As this drill is capable of drilling to the centre of a 44-in. circle, it will be seen that it has a very wide range of utility. Other equipment consists of a portable bench and vice, forge, anvil, and a full range of small tools.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with a quiet tone, and no dealings were recorded. At the close sellers of Cleveland warrants quoted 49s. 6d. cash and 49s. 9½d. one month. The afternoon session was also idle, and prices showed no change. On Friday morning Cleveland warrants were steady, but the turnover was limited to 1000 tons at 49s. 8d. nineteen days, and closing sellers again named 49s. 6d. cash and 49s. 9½d. one month. In the afternoon there was no change in the tone of the market, and business was at a standstill. Sellers of Cleveland warrants quoted prices as in the morning. On Monday morning there was again no dealing in Cleveland warrants, but sellers' quotations were a turn firmer at 49s. 7d. cash and 49s. 10d. one month. The afternoon session was quite idle and prices were unchanged. There was a little activity on Tuesday morning, when 2000 tons of Cleveland warrants were done at 49s. 5½d. and 49s. 6d. cash, and 50s. 0½d. January 20. The closing quotations were 49s. 6½d. cash and 49s. 9½d. one month. In the afternoon the tone was stronger, and one lot of Cleveland warrants changed hands at 49s. 9½d. one month, with closing sellers naming 49s. 7d. cash and 49s. 10½d. one month. When the market opened to-day (Wednesday) a firm tone was in evidence, and Cleveland warrants marked a little advance. The turnover was 1000 tons, at 49s. 8d. and 49s. 9d. cash, and the closing quotations were 49s. 9½d. cash and 50s. 1d. one month. The afternoon session was quite idle, but Cleveland warrants maintained their strength, being quoted by sellers at 49s. 11d. cash, and 50s. 2d. one month.

Scotch Steel Trade.—Little change falls to be reported in the state of the Scotch steel trade, especially in the heavy departments, which are still short of specifications for ship-plates and angles. The local demand generally is poor, but orders for odd lots are always coming in and assisting to keep the mills running. In the lighter kinds of material there is a fair amount of business passing, much of it being on Government account. Black-sheet makers have been securing a little more work, and so also have those turning out galvanised sheets. In both cases there would seem to be prospects of an improved demand, particularly in the latter at any rate, as Government requirements are likely to increase in the near future. The export trade is slow but promising, and some fair tonnage inquiries have come to hand of late. Prices are without change, and, except when something good turns up, they remain firm. Taken all over, there is a decidedly better feeling in the trade, and the fixing up of more shipbuilding contracts on the Clyde has had a strengthening effect.

Malleable-Iron Trade.—The difficulty of securing specifications is still the chief complaint of the malleable-iron makers in this area, and the result is that nine shifts per week is very general. New work is indeed scarce, both locally and for shipment. Prices are unchanged, and are still based on 7*l.* 12s. 6d. per ton, less 5 per cent., for "crown" bars, local delivery.

Scotch Pig-Iron Trade.—Although business in the Scotch pig-iron trade has not greatly increased with the recent reduction in prices, there has been, nevertheless, a little more doing, and a better feeling all over. Buying is confined within rather narrow limits, and is mostly for more immediate requirements. Shipments are being very well maintained. The demand for hematite iron is not heavy, owing to the quieter state of things in the steel works. The following are the market quotations for makers' (No. 1) iron:—Clyde, 67s. 6d.; Calder, Gartsherrie, Summerlee, and Langloan, 68s. (all shipped at Glasgow); Eglinton, 62s.; and Glengarnock, 69s. 6d. (both at Ardrossan); Shotts (at Leith), 68s.; and Carron (at Grangemouth), 68s. 6d.

Clyde Shipbuilding.—Although nothing had leaked out, the shipbuilders on the lower reaches of the Clyde have recently been very fortunate in securing new work to fill up the fast-decreasing order-books. Certainly they could each do with a great many more contracts, but these will come along all right in the near future, as foreign business begins to open out, and the war situation becomes clearer. The following nine contracts, which have just been reported, are very acceptable. Messrs. Ferguson Brothers, Port Glasgow, have received orders to build a dredger a duplicate of the Ponrabbel, which was sunk by the German cruiser Emden, while outward bound for her destination at Tasmania. Messrs. Ferguson have also received an order for a small steamer for Sierra Leone. Messrs. W. S. Miller and Co., Glasgow, have ordered four cargo steamers of about 6000 tons each. Two of these are to be built by Messrs. Russell and Co., Port Glasgow, and two by Messrs. Robert Duncan and Co., Limited, also of Port Glasgow. Messrs. William Hamilton and Co., Port Glasgow, have contracted to build a meat-carrying steamer for Messrs. Furness, Houlder and Co., London. She will have a keel measurement of 450 ft. They have also secured the order for a cargo steamer of 400 ft. keel measurement for Messrs. J. Chambers and Co., Liverpool. Messrs. Gow, Harrison and Co., Glasgow, have placed a contract with the Greenock and Grangemouth Shipbuilding Company, Greenock, for a steamer—a repeat order of the Vitruvia.

Structural Engineering at the London County Council School of Building, Brixton.—The Thursday evening class affords training in the practical design of reinforced concrete and steel work. The lecturer is Mr. R. Graham Keevill, A.M.I. Mech. E., M.C.I., of the Works Department, Admiralty, who is also the lecturer on ferro-concrete at the Northern Polytechnic.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—Business in the house-coal section was slack for a month, following an all-round elevation of values, but a decided improvement has taken place during the past week as a result of the advent of frosty weather. Buying is larger on all sides, local and country inquiries being particularly brisk. In addition, full deliveries are being made to gas companies. House-coal pits are consequently working at greater pressure to provide for a larger output. In the course of the next week or so full time is likely to become the general rule. No improvement can be reported in the condition of the hard steam-coal trade. Exports appear to be continually on the decline, and though the wants of allied nations are assisting South Yorkshire producers, the general position is most unsatisfactory. Fortunately home trade keeps good. Prices are weak, though no quotable change has been made. An improved trade in the market for smalls is attributed to a better demand from the Lancashire cotton area. Coke is quiet at unaltered rates. Quotations:—Best branch hand-picked, 16s. to 16s. 6d.; Barnsley best Silkstone, 12s. 6d. to 13s. 6d.; Derbyshire best brights, 12s. 6d. to 13s. 6d.; Derbyshire house, 10s. to 11s. 6d.; best large nuts, 11s.; small nuts, 9s. to 10s.; Yorkshire hards, 10s. to 11s.; Derbyshire hards, 9s. 6d. to 10s. 6d.; best slacks, 7s. to 8s.; seconds, 4s. 9d. to 5s. 9d.; smalls, 1s. 9d. to 2s. 9d.

Iron and Steel.—There is an absence of activity in the raw-material market, which is somewhat remarkable, having regard to the enormous output of finished goods in the heavy sections of the finished trades. On the week, however, the market is firmer. Heavy tonnages of hematite are going into consumption in the armament factories, but owing to the weakness of the demand in other districts, values are mostly unchanged. Common irons are quiet, with business chiefly confined to small purchases for current delivery. West Coast hematites are quoted at 80s., East Coast at 70s., Lincolnshire No. 3 foundry at 56s. 8d., Lincolnshire No. 3 forge at 55s. 8d., Derbyshire No. 3 foundry at 55s. 6d., and Derbyshire forge at 53s. 6d. Transactions in the cheaper brands have been effected at a reduction of 6d. to 2s. There is no change in the position of the finished-iron trades, except that more orders have been received on general account to supplement the special requirements of Goverment contractors. In the steel and engineering trades, British and foreign War Offices are supplying the bulk of the orders, but a considerably larger volume of diverted German business is being booked, and a more confident feeling prevails among manufacturers of "peace" products. Steel foundries are working full time, and work is more plentiful at the forges. The outlook in railway steel has improved owing to a slightly better demand from abroad. The requirements of tramway concerns are also on a larger scale, but there is room for a much bigger improvement. One of the least satisfactory features is the pronounced shortage of Siemens-Martin steel. Additional furnaces are being erected to supplement the already record output, but the quantity required by shell and gun-makers is so large that little is left for general trade purposes, and that at prices which are considered excessive, having regard to the decline in raw-material values. The tool works are devoting most of their resources to the manufacture of picks, shovels, axes, crowbars, and other entrenching tools for military engineering purposes. Billet prices favour producers, and no reduction appears likely at the present heavy rate of consumption.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Notwithstanding the unprecedented difficulties with which trade is confronted, a sound, steady business is passing, and the state of the pig-iron market must be described as satisfactory. There is a good demand within the limits imposed by the war, and upward movements in values have been readily followed by buyers. More disposition to operate is shown, and buyers' and sellers' ideas of values now differ very little. The stringent Admiralty regulations are restricting shipments; but traders, whilst regretting that the step stops business, approve of the measure as absolutely essential. Loadings are still proceeding for customers in Norway, Sweden, and Italy. Shipments to Scotland have fallen off considerably, and larger supplies are now being sent by rail to pig-iron buyers north of the Tweed, the difference between freights by sea and rail rates having been reduced to almost vanishing point. No. 3 g.m.b. Cleveland pig is once more 50s. for prompt f.o.b. delivery, and for delivery over periods early next year the price is now fully 50s. 6d. No. 1 has become 52s. 3d.; No. 4 foundry, which is scarce, 49s. 7½d.; No. 4 forge, 49s. to 49s. 1½d.; mottled, 48s. 6d.; and white, 48s. 3d.—all for early delivery. Hematite is rather unsteady, but makers declare that with cost of production much increased by ore becoming dearer, prices must advance. There is a good deal of vexatious delay in connection with obtaining license for shipments, rendered essential by the declaration of hematite as contraband of war, and for the present shipments are practically at a standstill. Mixed numbers of East Coast hematite are no longer offered freely at 61s. 6d. Possibly some second hands would still accept that figure, but up to 62s. is also asked. Foreign-ore values have risen rather rapidly. Buyers are in the market on the basis of 18s. 9d. ex-ship Tees for best Rubio, and sellers quote up to 19s. 3d. Freights Bilbao-Middlesbrough have advanced to 6s. 3d. Coke is in good request for local consumption, and supply is none too plentiful.

Stocks and Shipments.—The stock of Cleveland pig-iron in the public warrant stores now stands at 144,055 tons. Since the beginning of the month it has been reduced by 913 tons. Shipments of pig-iron from the Tees to date this month average 2330 tons per working day, the total despatches being returned at 34,950 tons, 32,785 tons of which have gone from Middlesbrough and 2165 tons from Skinningrove. To the same date last month the loadings were given at 31,139 tons, or a daily average of 2075 tons, and for the corresponding part of November a year ago the clearances reached 52,198 tons, or an average of 3479 tons per working day.

Manufactured Iron and Steel.—There is little new to report concerning the manufactured iron and steel trades. Most branches are busily employed, and some departments would have larger makes if more men were available. Several firms are being pressed for delivery. A fair number of inquiries for joists, plates, and angles are reported. Principal market quotations stand:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 5s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 8*l.*; iron ship-rivets, 8*l.* 7s. 6d.; iron girder-plates, 7*l.* 5s.; steel bars (basic), 7*l.* 10s.; steel bars (Siemens), 7*l.* 15s.; steel ship-plates, 7*l.* 5s.; steel ship-angles, 7*l.*; steel boiler-plates, 8*l.* 5s.; steel strip, 7*l.* 5s.; steel hoops, 8*l.*; steel joists, 7*l.* 2s. 6d.—all less the customary 2½ per cent. discount; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.* 5s.; heavy steel rails, 6*l.* 7s. 6d.; steel railway sleepers, 7*l.*—all net at works; galvanised corrugated sheets, 24 gauge, in bundles, 14*l.* f.o.b.—less 4 per cent.

PERSONAL.—Mr. P. Walter d'Alton, M. Inst. C.E., M. I. Mech. E., M. I. E. E., for many years chief mechanical engineer on the staff of Messrs. Dick and Co., has opened offices at Cross Keys House, 56-58, Moorgate-street, and begun practice as a consulting and inspecting engineer.

ELECTRIC SHIP PROPULSION.—According to the daily Press, the United States Navy Department has authorised the statement that the new battleship California is to be fitted with a system of electric drive, consisting of steam-turbines driving dynamos which in turn will drive main propelling motors. This decision presumably follows on the success which has been obtained with the United States Navy collier Jupiter. We have dealt with this latter ship from time to time, but may mention that she arrived at the League Island Navy Yard on October 19 last, after an entirely successful voyage from one coast of the United States to the other through the Straits of Magellan. Mr. W. P. Durtnall, who has done so much to advocate this form of propulsion, informs us that on the trials of the Jupiter the coal consumption for all purposes was 1.662 lb. per shaft horse-power, and the saturated-steam consumption 11.68 lb. per shaft horse-power. Other figures in reference to the trials will be found in our recent description on page 506 *ante*.

THE INSTITUTE OF MARINE ENGINEERS.—At the meeting of this Institute on Monday, the 9th inst., presided over by Sir James Mills, the Hon. Secretary, Mr. James Adamson, prefaced the business of the evening by making a presentation to Sir James Mills, on behalf of the engineers of New Zealand. The presentation took the shape of a gift of silver plate to Sir James and Lady Mills. Mr. Adamson observed that during the many years of service which Sir James Mills had given to the Dominion, there had been ample opportunities of forming opinions of his influence in directing the affairs of the Union Steamship Company of New Zealand. It was never a simple and easy matter so to hold the balance amid many interests as to win the approbation of all. Yet this was what Sir James Mills had achieved. One of the results of his wise administration of the Union Company's affairs had been the desire of the marine engineers to place on record in a tangible form their esteem and high regard.

ARMOUR-PLATES AND SHELL FOR THE UNITED STATES NAVY.—We read in the *Iron Age* that contracts for the armour-plates for the three new battleships of the California class are to be divided as follows:—

To the Midvale Steel Company.

7374 tons, at	435 dols.	=	3,207,690	dols.
401 ,,	486 ,,	=	194,886	,,
290 ,,	466 ,,	=	135,140	,,
63 ,,	376 ,,	=	23,688	,,
8128 ,,			3,561,404	,,

To the Bethlehem Steel Company.

14,748 tons, at	435 dols.	=	6,414,380	dols.
802 ,,	486 ,,	=	389,772	,,
580 ,,	466 ,,	=	270,280	,,
126 ,,	376 ,,	=	47,376	,,
16,256 ,,			7,121,808	,,

The E. W. Bliss Company was the lowest bidder for the 4-in. shells, with an offer of 9.50 dols. a shell; whilst the Bethlehem Company's bid was 9.80 dols.; the Tredegar Steel Company, 9.95 dols; the Washington Steel and Ordnance Company, 10 dols.; and the American and British Company, 10 dols. The E. W. Bliss Company and the American and British Company were the lowest bidders for the 5-in. shells, the price being 12 dols. a shell, compared with 13.75 dols., the bid of the Washington Steel and Ordnance Company. The Bethlehem Steel Company was the lowest bidder for the 14-in.; its bid was 415 dols. a shell, compared with 425 dols. by the Crucible Steel Company and 426 dols. by the Washington Steel and Ordnance Company.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Tonnage arrivals over the week-end were delayed by stormy weather, and there were serious complaints of a lack of vessels ready to load. Colliery stoppages, through failure to clear trucks, were also reported, and some sellers showed willingness to make concessions in order to stimulate buyers. Values of all large description sshowed weakness, but smalls were steadier, as numerous pit stoppages have reduced supplies. Upon the whole, prices have shown little change. The best Admiralty large has made 20s. to 22s. per ton; best secondary descriptions have brought 18s. to 19s.; other secondary qualities, 17s. 6d. to 18s. 6d.; best bunker smalls, 8s. 6d. to 9s.; and cargo smalls, 5s. to 7s. per ton. The best household coal has been quoted at 19s. to 20s.; good households, 17s. to 18s.; No. 2 Rhondda large, 12s. 6d. to 14s.; and No. 2 smalls have realised 6s. 6d. to 7s. 6d. per ton. Patent fuel has been quoted at 16s. 6d. to 17s.; special foundry coke has made 27s. to 30s.; good foundry coke, 22s. to 24s.; and furnace coke, 17s. 6d. to 18s. 6d. per ton. As regards iron ore, Rubio has realised 16s. 6d. to 17s. 6d. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Dowlais.—Bessemer and Siemens furnaces have been busy. The Goat Mill has been turning out tin-bar, cogging-steel, heavy steel rails, steel sleepers, &c. The Big Mill has been occupied with fish-plates, tram-rails, &c.

Newport Bridge.—The question of the rebuilding of Newport Bridge has again come before the Newport Town Council. Mr. Alderman Canning said that steps had been taken to regulate heavy traffic on the bridge, and there was no need for alarm, since any instability which had shown itself was of a gradual character, and its progress had been carefully watched.

Barry Graving Dock.—At the annual meeting of the Barry Graving Dock and Engineering Company, Limited, the directors' report showed a net profit of 17,030*l.*, and a disposable balance of 44,601*l.* Final dividends making 5 per cent. for the year on the preference and 10 per cent. on the ordinary shares, were proposed, leaving 29,333*l.* to be carried forward. Through an engineering strike and the war, the profits for the year were reduced 4725*l.* The report was adopted.

Sharpness New Docks.—For the past year the tonnage receipts of the Sharpness New Docks and Gloucester and Birmingham Navigation Company declined to 10,692*l.* Grain declined by 37,818 tons, and timber by 81,809 tons, while there was some falling off in sundries. For the whole of last year grain imports were 83,989 tons lower, timber imports 110,225 tons lower, and sundries 2679 tons lower. The reduction is attributed to the war.

Labour at Avonmouth.—A shortage of labour which has prevailed at the Bristol Docks for some weeks is still causing inconvenience, particularly at Avonmouth, where numerous arrivals and exceptional conditions prevailing at the docks have made great demands upon the labour available.

Newport.—The coal trade has shown an easy tendency at Newport, in consequence of heavy stocks and shortage of tonnage for prompt loading. Under the circumstances, buyers have exhibited little eagerness to do business, as they are looking for concessions. The best Newport Black Vein large has made 16s. 6d. to 17s.; Western Valleys, 16s. to 16s. 6d.; and the Eastern Valleys, 15s. 6d. to 16s. per ton. Smalls have been quoted at 5s. to 7s. per ton, according to quality. Iron-ore imports declined in October from 39,171 tons to 31,997 tons; pit-wood from 36,268 loads to 21,607 loads; and bars, angles, blooms, billets, &c., from 28,191 tons to nil. Foreign coal exports fell from 318,238 tons to 307,801 tons, but coastwise exports increased from 57,078 tons to 58,013 tons.

THE JUNIOR INSTITUTION OF ENGINEERS.—At a recent Friday meeting of the Junior Institution of Engineers, Mr. F. D. Evans, A.M. Inst. C.E., Executive Engineer, Public Works Department, Federated Malay States, discoursed on the topic, "The Engineer and Malaria." The definite association of the mosquito with malaria was discovered by Sir Ronald Rose (then of the Indian Medical Service) in 1897, and had been conclusively proved by many workers since that date. All attempts to transmit malaria in any other natural way had failed, and the radical measure to prevent malaria was obviously mosquito destruction. The mosquito is a water-breeding insect, and Mr. Evans explained that anopheles mosquitoes generally bred in shallow pools and swamps, but that other species which have been shown to transmit other diseases, such as yellow fever and filaria, commonly bred in stagnant water, especially in the collections of water in tins, refuse and water-holding receptacles, always to be found near habitations. The most certain way of getting rid of mosquitoes was to do away with all water containing refuse in vessels or to properly screen in or close in such vessels and thoroughly drain land. As an alternative to thorough drainage, oiling of pools by covering with a thin film, and poisoning of pools with a lardacide, had been extensively tried, but this method required extraordinary care and frequent application to be successful. It was most necessary for engineers carefully to consider the probable effects of malaria on the labour force to be employed on any new work in a malarious country, and to employ what precautionary measures were practicable, as otherwise they might be faced with an appalling death and wastage rate when the work was in progress.

EXPERIMENTAL MARINE-TYPE ENGINE AT THE SOUTH SHIELDS MARINE SCHOOL.

CONSTRUCTED BY MESSRS. W. SISSON AND CO., LIMITED, ENGINEERS, GLOUCESTER.

(*For Description, see Page* 617.)

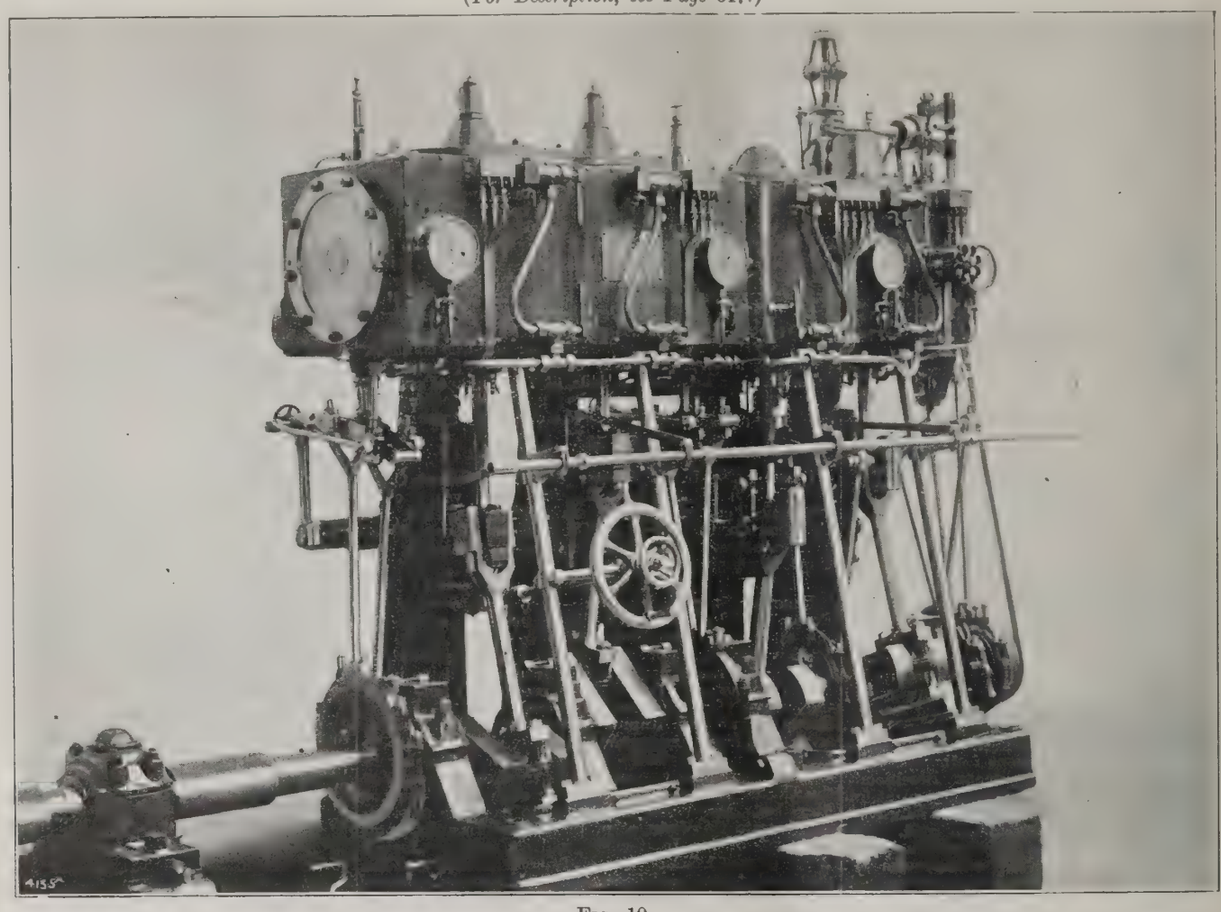


FIG. 10.

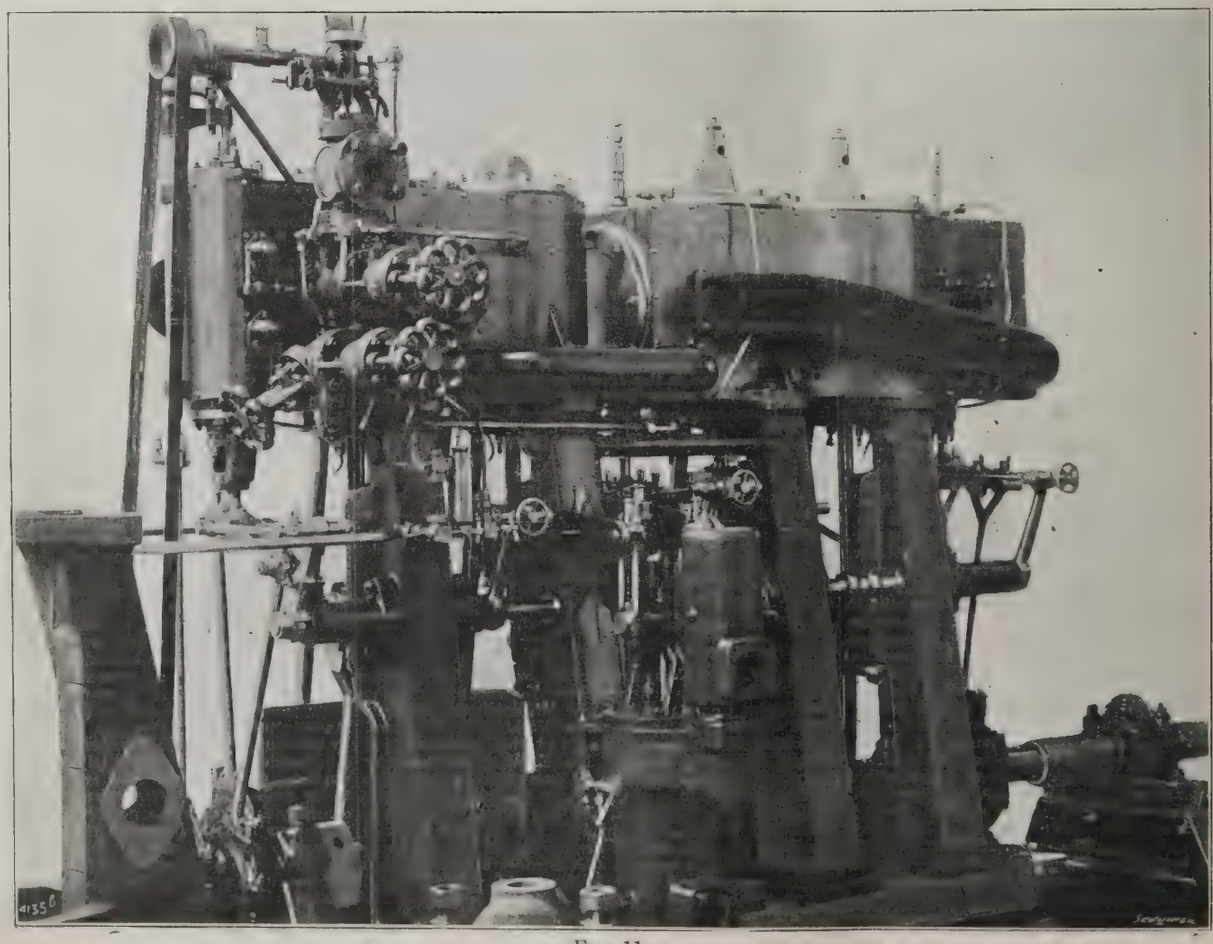


FIG. 11.

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TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.
UNITED STATES, New York: W. H. Wiley, 432, Fourth Avenue. Chicago: H. V. Holmes, 957-958, Monadnock Block.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" can be supplied direct from the Publisher post free, for twelve months, at the following rates, payable in advance:—

For the United Kingdom	£1	9	2
For Canada—			
Thin paper copies	£1	11	6 ($7.65)
Thick ,, ...	£1	16	0 ($8.75)
For all other places abroad—			
Thin paper copies	£1	16	0
Thick ,, ...	£2	0	6

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

READING-CASES.—Reading-cases which will hold twenty-six numbers of "ENGINEERING" may be had of the Publisher or of any newsagent. Price 6s. each.

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NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS—Friday, November 20, at 8 p.m., a paper on "The Effect of Vacuum on Steam-Turbines" will be read by Mr. G. Gerald Stoney, F.R.S., Member, of Newcastle-on-Tyne.

THE ASSOCIATION OF MINING ELECTRICAL ENGINEERS (NOTTS AND DERBYSHIRE BRANCH).—Saturday, November 21, at the University College, Nottingham, at 3.30 p.m. Discussion on paper, "Power-Factor and its Improvement," by Mr. L. G. F. Routledge, A.M. Inst. E.E., president of this branch.

THE SURVEYORS' INSTITUTION.—Monday, November 23, at 8 p.m., a paper will be read by Mr. Edwin Savill, on "Our Wheat Supply."

THE ROYAL SCOTTISH SOCIETY OF ARTS.—Monday, November 23, at 8 p.m., in the Hall, 117, George-street, Edinburgh. Mr. Andrew Wilson, M. Inst. C.E., F.R.S.E., Vice-President, will occupy the chair. The following communication will be made:—"On Some Industrial Applications of Hydraulic Power," with lantern illustrations, by Mr. J. T. Wight, A.M.I. Mech. E., Assistant Professor of Engineering, Heriot-Watt College.

THE ROYAL SOCIETY OF ARTS.—Monday, November 23, at 8 p.m. Cantor Lecture: "The History and Practice of the Art of Printing," by Mr. R. A. Peddie (Lecture I.) Wednesday, November 25, at 8 p.m. "The Supply of Chemicals to Great Britain and her Dependencies," by Sir William A. Tilden, D.Sc., F.R.S., F.C.S. Sir William Ramsay, K.C.B., LL.D., Sc.D., F.R.S., F.I.C., F.C.S., will preside.

THE FARADAY SOCIETY.—Monday, November 23, at 8 p.m., in the rooms of the Chemical Society, Burlington House, Piccadilly, W., when a general discussion on "The Hardening of Metals" will take place. The President, Sir Robert Hadfield, F.R.S., will preside, and will deliver an introductory address. Contributions to the discussion will be made by:—Dr. G. T. Beilby, F.R.S., "Some Recent Papers on Hardening and Overstrain in Metals, and the Bearing on these of the Author's Amorphous Theory of the Hardened State;" Professor Ernst Cohen (Utrecht), "The Influence of Allotropy on the Metastability of Metals and its Bearing on Chemistry, Physics, and Technics;" Professor H. C. H. Carpenter, F.R.S.; Professor J. O. Arnold, F.R.S.; Professor C. A. Edwards, "The Hardening of Metals by Quenching;" Dr. Walter Rosenhain, F.R.S.;" Mr. Andrew McCance, "The Inter-strain Theory of Hardening;" Mr. J. C. W. Humfrey "The Part Played by the Amorphous Phase in the Hardening of Steels;" Dr. C. H. Desch, (*a*) "The Hardness of Solid Solutions;" (*b*) "A Note on Twinnings and the Martensitic Structure;" Dr. T. Martin Lowry, F.R.S., and Mr. R. G. Parker, Note on "Metallic Filings;" Professor H. M. Howe and Mr. A. G. Levy will communicate a paper on "The Hardening of Manganese Steel." Mr. H. L. Heathcote will demonstrate instruments for testing hardness. The subject will then be open for general discussion. The Council invites contributions to the discussion from those unable to be present at the meeting.

THE INSTITUTION OF MECHANICAL ENGINEERS: LOCAL MEETING.—Tuesday, November 24, at 8 p.m., in the main room of the Portico Library, Mosley-street, Manchester, for the presentation and discussion of the paper on "The Effect of Vacuum in Steam Turbines," by Mr. G. Gerald Stoney, F.R.S. (Member). Mr. Michael Longridge, Vice-President, will preside.

THE INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, November 25, at the University, Edmund-street, at 7.30 p.m., a paper on "Power-Plant Testing" will be read by Mr. W. M. Selvey.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 26, at 8 p.m. "Power-Plant Testing," by Mr. W. M. Selvey, Member.

THE PHYSICAL SOCIETY OF LONDON.—Friday, November 27, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. Agenda: (1) "Note on the Conduction of Electricity at Point Contacts," by Mr. A. F. Hallimond; (2) "Thermal Conductivity of Badly-Conducting Solids," by Mr. T. Barratt, B.Sc.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 27, at 8 p.m., at 39, Victoria-street. "A Model Drawing-Office System," by Mr. C. E. Ford.

THE MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.—Friday, November 27, at 3.30 p.m., at the University, St. George's-square, Sheffield. The following papers will be read: "A Fire-Damp Indicator," by Mr. H. R. Webster; and "The Case for the Electric Miner's Lamp," by Mr. Wm. Maurice. The following paper will be open for discussion:—"Electric Miner's Lamps Compared with the Combustion-Tube Oil-Lamp," by Mr. E. A. Hailwood.

THE INSTITUTION OF MUNICIPAL ENGINEERS.—Saturday, November 28, the sixth annual general meeting at noon, at 4, Southampton-row, London, W.C., for routine business. Minutes of last meeting; presentation of annual report of Council; announcement of result of ballot for election of Council, for the year 1914-15; any other business. 1 p.m., adjourn for lunch. At 2.45 p.m., the presidential address will be delivered, and will be followed by a discussion on the following papers:—"A Plea for the Better Remuneration of Municipal Surveyors and Inspectors of Nuisances in Small Urban and Rural Districts," by Mr. G. Belson Chilvers, M.R. San. I. (Member); "Housing of the Working Classes," by Mr. Edward Whitwell (Member); "The Future Control and Maintenance of Rural Roads," by Mr. J. S. Wooddisse (Member).

ENGINEERING.

FRIDAY, NOVEMBER 20, 1914.

WORKERS' ENCOURAGEMENT OF COMMERCIAL EXPANSION.

THE possible expansion of industry in consequence and as a result of the operations of the war has been the theme of many discourses; but it is questionable if the attitude of the worker in relation to this important question has been adequately considered. Yet few will doubt that the worker has a special duty in this particular juncture in our industrial history. No one who considers the matter, even superficially, can fail to realise the value to the worker of such a reorganisation of our supplies and demands as will compensate fully and satisfactorily for the dislocation due to the war, as well as provide for a quickening of our commercial enterprise in order to make good war losses. This, like the general prosperity of the nation, and consequently its greatness amongst the countries of the world, is dependent upon the realisation of high ideals, whether regard be had to international integrity, commercial morality, or industrial efficiency. It is the third quality with which we are for the moment concerned, and as we have dealt in previous articles with the phase of the question affecting the enterprise of the employer, in respect of fertility in invention, efficiency in equipment, and adaptability in commercial propagandism, we propose to devote attention for the moment to the responsibility and attitude of the workers in the achievement of the same end—namely, the furtherance of our industrial supremacy and commercial enterprise.

The primary aim of the industrialists is to achieve (1) continuity of employment for the workers; (2) ensurance of a satisfactory rate of remuneration; (3) a reduction in the cost of output; and (4) the expansion of the purchasing market. It follows that, these desiderata being achieved, the prosperity of the working classes is promoted, because not only is the income of each unit made more constant and greater, but the purchasing power of the wage is augmented by reason of the cheapening of production. At the same time, industrial efficiency, with cheapened manufacture and an extended market, increases the demand for labour, so that the burden placed on the community for the maintenance of the less fortunate is reduced. These are truisms, but few think deeply enough to realise the action and reaction of the efficiency of labour upon national and individual prosperity. It is therefore desirable that the national aim to extend markets should be considered from the standpoint of the worker.

There are many manufacturers who are dependent upon imported supplies, and while there may be natural and economical difficulties in meeting the requirements of some manufacturers, it is possible for this country to meet the wants in the great majority of cases. Capital is ever necessary, and unfortunately the worker does not fully recognise the claims that capital possesses. There is, therefore, a natural reluctance on the part of those with available financial resources to embark on new enterprises without the assurance that whatever success may be attained will be permanent after the war, when other countries resume production at present checked because of hostilities. We refuse to believe that the British capitalist lacks enterprise. We have no convincing evidence that the inventive faculty of Britain is unable to devise processes or mechanical appliances to achieve an efficiency corresponding to that of any foreign nation. But we are not so certain that the organisations of labour will adapt themselves to principles more in consonance with those obtaining in countries whose manufactures we desire to displace, and with which new industrial developments must ultimately compete. The war has undoubtedly affected our lines of thought in many directions, and the dislocation of supply and demand, to which we referred recently, has shown that we must create new lines of attack industrially. Much has got to be changed, not only in Government and municipal administration, but also in industrial organisation. It would be well, therefore, if those responsible for the organisation of labour would address themselves to this problem, with the view of finding a policy which, while ensuring the desiderata already enumerated, gives a greater reward for commercial enterprise.

It is idle to speak of the capturing of the trade of any country unless improved tactics are adopted. None of our competitors has secured trade which ought to have come to us without excellent reasons. They have met a demand by supplying the article exactly as required at a cheaper price; or the article produced at a given figure has been more profitable for the sum demanded; or success has been attained in the selling department by greater adaptability to the conditions of a country; or, finally, the convenience of buyers has been consulted in packing consignments, or by quoting at a price inclusive of transport, import charges, and warehousing at the port of discharge. Some of these causes of success are attributable to the commercial management of a factory, but others, of great importance, are due to methods of manufacture. Many of our competitors in foreign countries have greatly improved their mechanical appliances, encouraged thereto by the greater output and economy consequent upon the willingness of the workers to make the most of new machine-tools. The time is therefore oppor-

tune for trade unions to recognise their responsibility for the encouragement of the flow of capital for the benefit of industry generally, and of the increased effort of the selling departments.

This subject of the relationship of labour to economy of output may be said to be hackneyed, but in the present industrial crisis it is important that it should be once more enforced, and that support should be given to a great body of opinion amongst the working classes that the true and underlying principles of industrial economics should have greater play than heretofore in the settlement of the relation between employer and employed. Perhaps the first difficulty of the estimator in a factory in connection with all prospective contracts is the absence of any fixity of the rate of wage. We admit that of late years agreements have been made between employers and unions, and even between federations of employers and great groups of unions, whose members contribute collectively to the creation of some of the mighty products of modern manufacture. These agreements, too, have in some cases been made to continue in force for as long a period as three years. We regret to note, however, that there is an inclination towards shorter periods. Unfortunately, too, even in the presence of such agreements, there is scope for the crafty agitator. Agreements, as a rule, are based on broad questions of remuneration and hours of employment, and, in some cases, on the relation of the proportion of overtime to the working week or day. There are, however, many details in ordinary contracts of employment between worker and employer, and often some of these subsidiary and generally trivial details are made the cause of dispute. We may instance, for example, the allowance for working away from the factory. Surely the object aimed at by the employer and worker in arriving at these agreements is continuity of work. Consequently the organisation of a strike on such subsidiary details may be worthy of the statesmen who regard international agreements as "mere scraps of paper," but unworthy of those who are capable of excellent work as mechanics. The enforcement of such agreements has ever been a difficult question, but for the future there must be some guarantee that there will be fixity of wage on any given contract during the existence of the agreement. For this reason there is much to be said in favour of the principle that such agreements should be legally registered, and that employers and trade unions alike should be called upon to deposit with the Courts financial guarantees against their violation in spirit as well as in letter.

For success in international competition in the future, it is important, not only that new factories should be organised and equipped to meet demands hitherto covered by foreign factories, but that existing establishments should be improved by the introduction of new processes and new mechanical appliances, in order to reduce the cost of production. The difficulty here is that there is no surety that the possible increased output, or the lowest attainable cost in labour, will be realised from the new machines. We have always contended that high wages are generally economical, but it is not easy to make the worker realise that he is responsible for the economy of the high wage which the employers are always anxious and willing to pay. It is an axiom that there can be no equality in remuneration without equality in the value of the product. The incapable or indolent worker, who receives the same wage as the intelligent and industrious employee, is a drag on the latter, because he increases the cost of production, and handicaps the selling department, and consequently tends to reduce the extent of employment available in any community. If new machine-tools are to be introduced and old appliances scrapped, the work produced must be augmented so as to cover the charges on the increased capital involved, while at the same time maintaining or increasing the wage earned.

The rate of wage must depend not so much upon the man as upon the value of the output from the machine. It matters little how this result is obtained, whether by time-rate or premium-bonus system, or by the older piece-work rate of pay. The rate of production on most machines is easily ascertained, and the remuneration to the worker may vary with the output. At the same time the degree of responsibility on his part must be taken into consideration. If we take a lathe engaged on repeat work, the responsibility of the attendant is reduced to a minimum, and it will be accepted at the same time that the remuneration possible is limited, because the competition for orders for such repeat work requires that the selling price should be low. In the case of a turning lathe we have the same condition in modified degree; but where the turner is engaged, for instance, on large turbine-rotors, it necessarily follows that he requires to exercise greater experience and skill, so that his remuneration deserves to be higher. Moreover, it can be higher, because in such work, requiring greater skill, competition is not so keen, and the possibility of serious expense due to wastage or fault is great. In other words, it will be recognised that all turners in a large factory cannot be regarded as equal if sound economical conditions are to prevail. The same illustrations might be drawn for almost every class of work, not only in engineering, but in other departments of industrial activity. It is therefore illusory for the trade unionist to expect that industrial improvements and commercial enterprise can be encouraged by the principle of equality.

The national need at the moment is not only for greater effort on the part of the selling department in capturing foreign markets, and of the business department in securing improved mechanical accessories as well as more efficient administration; the workers themselves should realise that in this peaceful contest for industrial supremacy they must play an important part. The reward of success will be largely reaped by them, because the aim, as we have said, is to ensure continuity of employment, the utilisation of a greater number of workers, and the cheapening of the cost of production, all necessarily contributing to better income on the part of the working classes. The improvement in trade resulting from higher efficiency necessarily tends towards a greater demand for labour, and possibly higher rates of remuneration. Apart altogether from this, there can be no doubt that improvements in producing facilities tend to enhance the weekly income, even although the rate per unit of output may be decreased. On the other side of the ledger we have cheapening of the cost of living, because reduction in the cost of output is immediately operative in this country in lessening the selling price; so that the development of industry, which is so much desiderated at the present time, will be a great advantage to the workers from every standpoint, and will, at the same time, enhance our position amongst the nations of the world, an ideal which is worthy of the collective effort of all who to seek maintain British traditions.

LLOYD'S REGISTER AND THE MERCHANT FLEET.

Lloyd's Register occupies a unique position in relation to the world's fleet. They are the guardians in the public interest of the safety of all who go down to the sea in ships, and the confidence with which the public view their survey of new ships, and their periodical resurvey of existing ships, is proved by the approach to unanimity with which shipowners classify their vessels with them with a view to such survey. The primary object is, no doubt, associated with the underwriting of the vessels against loss; but, from the public point of view, the surety of seaworthiness which is established as a consequence of the issue of Lloyd's certificate carries great significance. The annual report, issued this week, is therefore of wide interest, as it shows not only the ramifications of Lloyd's, but the developments which are taking place in connection with the merchant marine under their watchful care. It is to be noted that there are now registered at Lloyd's 10,621 ships, of 23,870,655 tons; of the latter, more than 22½ million tons are steamships either of iron or steel. During the year ended with June 30, Lloyd's assigned classes to 713 new vessels, of a total of 2,020,185 tons, the highest total for any one year recorded in the history of the Society. Practically all the vessels were steamers, the sailing tonnage being only 5788 tons, and of the total 60 per cent. was built for the British Empire, the remaining 40 per cent. being for other countries. During the year, too, plans for 749 new vessels, representing 1,650,000 tons of shipping, were passed by Lloyd's Committee. That the interests of all concerned are fully recognised is proved by the representative character of the Committee, including representatives of all the technical institutions concerned with marine construction. Thus, in addition to shipowner- and underwriters from the principal maritime dis, tricts, there are a large number of shipbuilderss engineers, steel manufacturers, forge-masters, and others embraced in the organisation, and, in addition to the Committee of Management in London, there are local committees at Liverpool and Glasgow. The surveyors on the staff, too, have won the confidence of all. This year regret is expressed in the report at the death of Dr. Thearle, who was for long chief ship surveyor, and at the retirement of Mr. Charles Buchanan, a member of the chief ship surveyor's staff. Mr. W. S. Abell has already proved his ability to maintain the traditions of his new office as chief ship surveyor, and Mr. James T. Milton, chief engineer surveyor, continues his policy of safety associated with the encouragement of new developments in marine engineering.

In regard to the developments in construction, it is pointed out that an unprecedented number of vessels of over 5000 tons have been classified during the year—namely, 163; 19 of these were over 10,000 tons, ranging up to the Aquitania, of 45,647 tons. Fifteen vessels exceeding 12,000 tons are in course of construction, in addition to a large number between 10,000 tons and 12,000 tons. Among special types of vessels built or building, mention is made of the largest lumber-carrying vessels under the American flag, the Atlantic and the Pacific, two vessels for the Russian Government, and one for the Government of the Commonwealth of Australia, to carry oil in bulk and specially strengthened in view of having to supply warships with fuel-oil at sea. An auxiliary schooner yacht is building for owners in Boston, in the construction of which alloy steels of high tenacity have been employed in order to enable the scantlings to be substantially reduced and still fulfil Lloyd's requirements concerning the structural strength of the vessel. During the year seventy-two vessels, of 429,384 tons, were built under the Isherwood system of longitudinal framing, and there are in course of construction now 226 vessels, totalling 1,182,200 tons. Seventy-two vessels, of 402,033 tons (five of which are over 10,000 tons), were built for carrying oil in bulk. This is the largest output of such vessels in any one year. During the year 1,215,467 tons of ship and boiler steel were tested by the surveyors of the Society, as well as 406,131 fathoms of chain-cable and 9284 anchors. The inspection of refrigerating machinery installations, both on board ship and in ports, is now an important department of the surveyors' work. There are 176 vessels having Lloyd's certificate in respect of refrigerating machinery, and 32 vessels are at the present time being constructed which are to be fitted with such installations. This is not surprising in view of the fact that during the year there were imported into the United Kingdom in steamers fitted with refrigerating installations 3½ million quarters of chilled beef, 2½ million quarters of frozen beef, 7¼ million carcases of frozen mutton, and nearly 6 million carcases of frozen lamb, in addition to dairy produce, fruit, &c. Insulated barges, too, are now being utilised on the Thames for the distribution of such cargoes. Another point brought out in the report is that there are now recorded in Lloyd's Register Book 2750 vessels fitted with wireless telegraphic installations, as compared with 1932 at the corresponding date last year. There are also now afloat 930 vessels with submarine signalling apparatus, as compared with 806 a year ago.

As regards developments in connection with machinery, the chief feature has been the number of vessels fitted with geared turbines of the Parsons type. It is pointed out that there are twenty-three vessels being built to Lloyd's class with such machinery. In addition, there are six vessels under construction in which direct-coupled turbines are to be used, and six in which triple-expansion engines are associated with turbines for the use of the exhaust steam from these engines. The economy of the geared turbine is clearly recognised in the report, and reference is made to the accuracy with which it is now possible to cut helical gearing by a special machine introduced by the Parsons Company. As regards the combination of reciprocating and turbine engines, it is pointed out that the machinery can by such an arrangement be worked at reduced power with practically the same efficiency as at full power. The speed of the reciprocating engines is reduced by linking up, so that the full steam pressure may be utilised in the

cylinders. "With ordinary steam-turbines the speed can only be regulated by varying the steam pressure, so that when less than full power is required, the steam pressure has to be reduced, and a corresponding loss of efficiency is incurred." It is remarkable, however, that the geared turbine seems now, with very few exceptions, to be preferred to the combination of reciprocating and turbine engines. As the superintending engineer of all companies regards economy on the round voyage as the dominant consideration, this preference is at least most significant. There is probably too much tendency to think of the economy of the geared turbine at reduced speed, because in a merchant ship the speed is practically constant from the beginning to the end of the voyage, the number of times that reduced speed requires to be resorted to, and the duration of these periods, being almost negligible.

The progress of the internal-combustion engine is naturally a matter of considerable interest to Lloyd's Register, and it is interesting to point out that new rules are under consideration for the construction and survey of Diesel engines and their auxiliaries, as well as for the pumping arrangements of vessels fitted with internal-combustion engines other than those of the Diesel type. There are in service 27 vessels propelled with Diesel engines registered at Lloyd's, the collective horse-power being approximately 50,000 indicated horse-power, while 20 others are in course of construction. In addition there are 36 vessels with oil-engines other than the Diesel type, and several others are in course of construction. The East Asiatic Company, which uses for the most part Burmeister and Wain's engines (either built at Copenhagen or at Messrs. Harland and Wolff's, at Glasgow), are probably the most noted advocates of the Diesel engine. Lloyd's quote as worthy of notice the fact that the earliest of this company's vessels — the Selandia — has eight cylinders per shaft, each being $20\frac{7}{8}$ in. in diameter and $28\frac{3}{4}$ in. stroke, the total power being 2500 horse-power, whereas the latest engines have six cylinders per shaft, each $29\frac{1}{8}$ in. in diameter and $43\frac{5}{16}$ in. stroke, the power being 4000. These are the largest cylinders which have so far been used for Diesel engines in merchant ships. Several Diesel-engined vessels, ranging from 5000 to 8000 tons, are in course of construction on the Clyde, and of these, four are intended for British owners. The use of the oil-engine for small vessels is also extending, and to ensure economy in construction it has become usual to build such engines in batches of standard dimensions. As regards the flash-point of oil permitted by Lloyd's, the rules revised some time ago provided for a flash-point not lower than 150 deg. Fahr., but under special conditions the Committee have approved plans making suitable provision for the safe use of oils of even lower flash-point. Fires have occurred in vessels the fittings of which were only suitable for high flash-point oil, and as these fires might perhaps have been caused by the employment of oil-fuel having a flash-point lower than 150 deg. Fahr., the Committee felt it to be their duty to call the special attention of the owners of vessels in which oil-fuel is used to the importance of seeing that the vessels are supplied with fuel of suitable quality.

ELECTRIC-CABLE FAULTS.

Apart from trouble due to bad jointing or external mechanical damage, the whole question of the faults which at times develop in insulated electric cables is somewhat obscure, and perhaps beyond the range of many engineers who have to do with the maintenance of networks. In practice this is not important, since an intimate acquaintance with the physical and chemical effects which may build up to a fault in a cable is hardly necessary to a colliery electrician, a works engineer, or a mains superintendent. None the less the matter indirectly concerns all these workers, and the information bearing on it which was contained in the paper read before the Institution of Electrical Engineers on the 5th inst., by Mr. C. J. Beaver, should be of interest and value to them. We cannot undertake to review the whole of Mr. Beaver's paper, which bore the comprehensive title "Cables," but may deal with some of those parts of it which threw light on various troubles which at times arise in practice. In considering what he described as "working vicissitudes of insulated cables," Mr. Beaver dealt independently with the three common classes of insulation—paper, rubber, and vulcanised bitumen. He also considered the troubles which might arise with each class, under those due to the physical and chemical properties of the component parts of the cable, and those due to conditions external to the cable.

Dealing with the properties of paper insulation, Mr. Beaver began by referring to the well-known fact that the chemical stability of pure manilla paper, and the durability resulting therefrom, are offset to some extent by its hygroscopic properties, necessitating careful sealing where the dielectric is exposed. No degree of impregnation would render paper water-proof enough to comply with the requirements of cables. In connection with impregnation, Mr. Beaver referred to "one or two erroneous impressions" which, he stated, required correction. These had reference, in the main, to the so-called "overdrying" of paper during cable manufacture. As paper contains no constitutional or chemically-combined water—*i.e.*, as its structure consisted of celluloses, not cellulose hydrates—it could not be overdryed. The idea that high insulation resistance was due to this overdrying, or, in other words, to some sort of manufacturing accident, and was consequently undesirable, was probably a legacy from the early days of impregnated cotton and jute cables. Even with such cables, however, it was doubtful if the higher insulation obtained with long heating was due to heating *qua* heating. It was probably due to the supersaturation of the absorbent dielectric with the impregnating medium. High insulation in a paper cable did not necessarily indicate overheating. It depended on the specific insulation resistance of the dry paper and compound used, and on their relative proportions. Uniformity was an important matter, and was secured by impregnating the paper before applying it to the cable. This system rendered overheating (which was not the same thing as overdrying) impossible.

With careful construction there was little likelihood of troubles owing to internal causes in paper cables, and it was to external conditions that one must generally look for reasons of deterioration. Among such causes, expansion and contraction effects due to overloading sometimes appeared, but were not common. This matter was altogether independent from the question of safe working temperature. Much could be done to guard against trouble by making suitable arrangements for expansion at joints and adopting special procedure in laying bends. In the main runs little could be done. Mr. Beaver described an interesting experiment on expansion and contraction which he had carried out. Two 95-ft. lengths of 0.5-sq.-in. concentric low-tension paper-insulated lead-covered cable were used. The two cables differed only in the spacing and gauge of the wires comprising the outer conductors. This resulted in a difference in the total rigidity of the cables and a difference of a few mils. in the over-all diameters. The difference in longitudinal rigidity was insufficient to have the slightest effect on flexibility. The cables were mounted separately on rollers on each side of a central beam. Twelve experimental runs were carried out with the rollers fixed so that they could not revolve, the frictional resistance to movement thus being uniform throughout the cable lengths. One end of each cable was fixed, and the other ends were sweated into brass blocks free to move in guides, and geared to graduated dials. At intermediate points, such as one-third and two-thirds from the fixed end, the rollers were left free and pointers were fixed to them. A continuous current of 750 amperes was fed into the cables at the fixed ends, cross-connections being made to put the four conductors in series without interfering with the movements at the free ends. The length of each run was determined by the time required to attain maximum expansion. It averaged $3\frac{1}{2}$ hours, and the temperature rise averaged 112 deg. Fahr. The general behaviour of the two cables was entirely different. The more rigid tended to take up a permanent and increasingly expanded position, while the other did just the reverse. An interesting feature in both cases was that the net result of the cycles and expansion and contraction produced the maximum effect at a part about two-thirds from the fixed end. In practice movements of this sort pulled conductors out of joints, fractured lead sheaths, &c.

Apart from questions of expansion, temperature rise in cables increased the natural rate of deterioration of the insulating material. The effect of the type of insulation, form of cable, and method of laying, on such temperature rises in underground cables had not been sufficiently appreciated until recent years. Useful work was now being done by the Institution Research Sub-Committee which was investigating the matter. An important point in connection with the present Institution figures for current density, which bore on this matter, was that single paper-insulated lead-covered cables used at considerably higher densities than those given in the Wiring Rules did not attain such high temperatures as would be found by extrapolation of data obtained at lower current densities. Mr. Beaver quoted an experiment illustrating this. Joints could be taken as the next cause of trouble. They had always been the weak spots of networks, although in recent years the standard of jointing work had greatly improved. The best results had been obtained by making the joint as much like a specially reinforced part of the cable as possible. One good reason for this was that there was a much better chance of making a lead-sleeve joint water-tight on a lead-covered cable than there was of making a water-tight joint with a cast-iron compound-filled box. The question of avoiding concentration of stress and weak paths became very important at working pressures of 20,000 to 30,000 volts. The conductor ferrules should be designed in bold curves, and should accurately fit the conductor before sweating. Any excrescence of solder at the ends of the ferrules after finishing off would be a source of danger. In Mr. Beaver's experience, wrappings of tape or paper for the insulation of the joint were inadmissible at high pressures owing to the risk of electrostatic discontinuity and weak paths. He favoured a form of joint in which the conductors were supported on porcelain spiders, the whole thing being embedded in the compound.

Further causes of trouble were the electrolytic and chemical corrosion of lead coverings. Electrolytic corrosion had been fairly common, though, thanks largely to the Board of Trade rule for permissible potential gradients between tramway rails and earth, and also owing to our insular ideas, it had not been experienced here to anything like the extent it had in other countries. Continuity bonding and cross bonding at suitable points had usually been the means of checking or preventing such corrosion. Chemical action was sometimes blamed for the corrosion of lead coverings, a notable instance being that of the wooden bridges which used to be universally used in the solid system of laying cables. Mr. Beaver had, however, examined many cases of this kind, and had invariably found them to have been due to electrolytic action, the wood having formed the path for the current. Apart from exceptional cases it could be taken for granted that simple chemical action, as distinct from action assisted by the current, was a negligible cause of trouble with lead-covered cables. A final "working vicissitude" of lead-covered cables was mechanical damage. The causes were usually obvious, but Mr. Beaver had recently come across a form of such damage which was novel, in that it arose from quite modern traffic conditions. It referred to a piece of single-core lead-covered paper cable laid 4 ft. below the road surface in iron troughs. The development of heavy motor vehicles during the last few years had depressed the cable at the joints of troughing and led to faults.

In the next group—rubber-insulated cables—Mr. Beaver had not much to say about the physical and chemical properties of the components. He pointed out, however, that efforts to co-ordinate the physical and electrical properties of vulcanised rubber have not so far been successful. If rubbers specially designed for insulating purposes were modified by the introduction of ingredients commonly used for mechanical rubber goods, an addition of as small a part as 0.5 per cent. might reduce the insulating resistance by 50 per cent. This might be harmless sometimes, but at the same time the molecular structure was so modified that after immersion in water for a few hours the insulation fell very appreciably. With insulating rubbers there was no such effect. Another aspect of the matter was that in rubbers designed purely for insulating purposes it was possible to get critical stages in vulcanisation between which there were great differences in the dielectric strength. For instance, it was easy to vulcanise a thick high-grade rubber dielectric, such as is used for extra-high-tension cables, to a stage at which, by com-

parison with standards, its insulation resistance would give no evidence, and mechanical tests very little indication, of under or over-vulcanisation. Yet the breakdown point might be only one-fourth of the value obtainable when vulcanisation was carried a little further or not quite so far. In normal manufacture these critical stages were usually passed, but there was a wide field open for investigation, and a series of curves connecting coefficients of vulcanisation with dielectric strength and physical properties would be of great interest.

With regard to rubber-cable troubles, the first cause was the natural deterioration common to all rubber goods. Mr. Beaver said it could be taken as an axiom that, other things being equal, the natural rate of deterioration was slowest in rubbers made from fine hard Para. Plantation rubbers of the same botanical origin (*Hevea brasiliensis*) would undoubtedly in time reach the same level. Professor Schwartz, who was present at the meeting, seemed to think plantation rubber had already reached it. Troubles due to external factors were mainly the result of chemical influences arising from direct contact with alkaline solutions, acid vapours, oxidising agents, oils, solvents, &c., or indirect chemical attacks consequent on osmotic and electrolytic actions where incipient weaknesses in the dielectric allowed such actions to arise. Under this category came effects due to leakage current along damp fibrous coverings. These happened largely near ends which had been badly trimmed when connections were made. Access of moisture to the strands of a vulcanised-rubber cable by way of exposed ends was a fruitful source of trouble. Acid products were formed when the moisture came in contact with the free sulphur, which was always present to some extent in the rubber next the strand, leading to corrosion of the conductor. Powerful oxidising effects occurred on extra-high-tension rubber cables where the production of ozone and oxides of nitrogen on the external surface of the dielectric was caused by brush discharge. Preventive measures against any of these external influences were best applied in the form of special coverings. The internal cause of trouble due to the well-known deleterious effect of copper, by its catalytic oxygen-carrying properties, on rubber, was met by tinning the copper wires which came in contact with the rubber.

Turning to the last group—vulcanised bitumen cables—Mr. Beaver suggested that there was a general idea that vulcanised bitumen had a general similarity to rubber. This was partially true. The cohesion between the particles of the material, however, was much less than in rubber, so that such properties as resilience, elasticity, &c., had considerably lower values. The differences between the materials, might be regarded as differences of degree. The physical properties of vulcanised bitumen varied considerably with temperature. At about 32 deg. Fahr. it tended to yield to sudden shock. At temperatures up to about 100 deg. Fahr. it was toughly plastic, and had considerable resilience, and resistance to mechanical stress. At from 100 deg. to 130 deg. Fahr. it began to lose its toughness, and at still higher temperatures its cohesion disappeared to a considerable extent, although its resilience appeared to increase. Its manner of yielding to mechanical forces at high temperatures bore a general resemblance to that of gelatinous materials and had no parallel in the behaviour of rubber. It did not yield by softening or by any process resembling the melting of bituminous, waxy or resinous substances. The rate at which any given stress was applied had a great effect, while the manufacture might be varied to give various physical properties in relation to a given temperature range. A material intermediate as regards softness or hardness, possessing maximum toughness at medium temperatures, wide limits of temperature range and approximately equal resistance to all kinds of stress at low temperature, was the most desirable for cable work. In manufacture it was usual to apply shock, bending, and penetration tests to samples of the material.

Trouble with vulcanised bitumen cable was not usually likely to follow from direct chemical action. The substance was chemically remarkably stable, and was not appreciably subject to natural deterioration under normal conditions of atmosphere and temperature. In this respect it was comparable with paper rather than with rubber. It was exceptionally inert to acids, but was susceptible to the action of alkaline substances. The direct action of such substances was usually, however, only superficial, and it was a fact that even such severe conditions as continual exposure to coal-pit waters (which were usually alkaline) had no appreciable effect on vulcanised bitumen; waters of a brackish character had no effect on it. Mr. Beaver also stated incidentally that the idea—recently perpetuated in a Board of Trade Report—that vulcanised bitumen was softened by contact with coal-gas was not correct. The statement was true for natural bitumens and pitches, but decidedly not so for vulcanised bitumen. The fact that the material was subject to alkaline attack had great influence under continuous-current fault conditions, which could produce electrolytic action. In most soils it was possible not only to form alkaline substances at parts which constitute the virtual negative electrode of the leakage circuit, but to force such substances by osmotic pressure through the dielectric of the negative conductor. Under these circumstances both the direct action on the vulcanised bitumen of concentrated alkaline substances, and the aggravated conditions due to the passage of current (producing continuous supplies of deleterious matter and forcing them to the best position of attack) came into play. This led to a type of softening of the dielectric known as saponification. Experience had, however, brought Mr. Beaver to the conclusion that there was a second physically similar, but chemically different, type of softening. This had been proved to depend on leakage currents, and to be greatly dependent on moisture, temperature, and time. It had been found that this second type of softening could, for practical purposes, be eliminated by adding some 5 to 10 per cent. of rubber to the vulcanised bitumen.

THE THERMAL PROPERTIES OF STEAM.

Up till ten or fifteen years ago steam-tables, based on Regnault's experiments, which were for the most part made before 1847, sufficed for all the needs of the practical engineer. The introduction of the throttling calorimeter for the estimation of the quality of steam had, however, led to doubts whether the accuracy of Regnault's results was as great as had been assumed, and these doubts were confirmed when the increasing use of superheated steam showed in many cases gains substantially in excess of the theoretical. Further researches, both theoretical and experimental, on the properties of steam were accordingly undertaken in many countries, and led to the publication of new steam-tables, such as those of Marks and Davis, or the new edition of Professor Peabody's tables, which fully satisfy the present requirements of engineering practice. Further experimental data have, however, been secured since the publication of these tables, and a very complete discussion of the thermal properties of steam, in which cognisance is taken of these newer results, has just been published by Professor G. A. Goodenough.*

In this pamphlet the whole of the available data are brought into consideration and new formulæ established, which, whilst fitting the experimental results with great accuracy, are also consistent with each other and with thermodynamic principles, a matter of which Professor H. L. Callendar seems to have been the first to recognise the importance.

The relation found between the pressure and temperature of the steam is as follows :—

$$\log p = 10.5688080 - \frac{4876.643}{T} - 0.0155 \log T$$
$$- 0.00406258\ T + 0.00000400555\ T^2$$
$$- 0.00002 \left\{ 10 - 10 \left(\frac{t-370}{100} \right)^2 + \left[\frac{t-370}{100} \right] \right\},$$

where p is the pressure in pounds per square inch, and T the absolute temperature in Fahrenheit units, whilst t is the temperature in Fahrenheit degrees. The absolute zero is taken as -459.6 deg. Fahr. For the specific volume of the steam Professor Goodenough gives the expression :—

$$v - 0.017 = 0.59465 \frac{T}{p} - (1 + 0.05129\, p^{\frac{1}{2}}) \frac{C_1}{T^4}$$

where v denotes the volume in cubic feet per pound, and $\log C_1 = 10.82500$. The "heat content" of steam at different temperatures and pressures is :—

$$i = 0.320\ T + 0.000063\ T^2 - \frac{23583}{T}$$
$$- \frac{C_3\, p\, (1 + 0.0342\, p^{\frac{1}{2}})}{T^4} + 0.00333\, p + 948.7,$$

where

$$\log C_3 = 10.79155.$$

The entropy of superheated steam is given by the relation :—

$$s = 0.73683 \log T + 0.000126\ T - \frac{11.791.5}{T^2}$$
$$- 0.25355 \log p - \frac{C_4\, p\, (1 + 0.0342\, p)}{T^5} - 0.08085.$$

where

$$\log C_4 = 10.69464.$$

The thermal properties of steam at very high pressures and temperatures are stated to be as follow :—

Temperature.	Pressure.	Volume of 1 Lb.	Weight of 1 Cub. Ft.	Heat Content of		Latent Heat.
				Liquid.	Vapour.	
deg. F.	lb. p. sq. in.	cub. ft.	lb.	B.T.U.	B.T.U.	B.T.U.
600.0	1540.4	0.272	3.68	604.5	1164	560
620.0	1658.7	0.241	4.15	633.0	1151	518
640.0	2056.6	0.187	5.35	663.0	1136	473
660.0	2360.8	0.151	6.63	700.0	1112	412
680.0	2699.1	0.118	9.86	745.0	1080	335
700.0	3074.5	0.080	12.46	823.0	1016	193
706.3	3200.0	0.048	20.92	921.0	921	0

THE LATE MR EDWARD BAYZAND ELLINGTON.

As announced in our last issue, Mr. Edward Bayzand Ellington, whose portrait we give on the opposite page, died suddenly at his residence, 73, Addison-road, Kensington, on the 10th inst., at the age of sixty-nine. Mr. Ellington had been severely crippled by an attack which he had last Easter, but he had so surprisingly recovered that he was able to be at business, and also to attend at the Institution of Mechanical Engineers on the afternoon of the day of his death.

Mr. Ellington was born in London in the year 1845. He served a pupilage of five years, from 1862 to 1867, at the works of Messrs. John Penn and Son, Greenwich, during which time he went through the various shops and the drawing-office. He remained in the latter one year longer, down to 1868, then for twelve months he designed and superintended the erection of the building known as the Glengall Wharf, Old Kent-road, and the special machinery in use there. Mr. Ellington served his apprenticeship with Messrs. John Penn and Son at a time when that firm were at the full zenith of their success in marine-engine construction, especially for naval purposes; but he did not limit his energies in the early days of his engineering career to the designing and construction of steam-engines alone, but made a study of the other developments of the science, especially those relating to hydraulic machinery, which he ultimately made his own particular branch of work.

As bearing upon this point, we may state that when delivering his Presidential Address before the Institution of Mechanical Engineers, in March, 1911, he referred to hydraulics as being the branch of engineering to which he had attached himself some forty years before, and to which he and a few of his compatriots had devoted themselves ever since. "He did not know," he added on the occasion to which we refer, "what might be the fate of the distribution of hydraulic power in the future, but one fact remained clear, and that was that hydraulic power itself, apart from a particular method of application, was, after the sun, the most lasting source of energy, and the most easily adapted to the wants of mankind, of any of the great forces of Nature."

Reverting to the earlier period of Mr. Ellington's activity, we may state that from 1869 to 1874 he was a partner with Mr. Bryan Johnson, in the firm of Johnson and Ellington, having engineering works at Chester. Mr. Johnson had been a constructor of machinery used in mills and mining work, but when Mr. Ellington entered into partnership with him the firm increased its specialities, and gradually devoted its energies, almost exclusively, to the designing and construction of hydraulic machinery. It was in the latter year, 1874, that Messrs. Johnson and Ellington acquired the right to manufacture the Brotherhood three-cylinder hydraulic engine, subsequently so largely used for hydraulic-capstan work, and the firm became known as the Hydraulic Engineering

* "Thermal Properties of Steam," by G. A. Goodenough. University of Illinois Bulletin. London: Chapman and Hall, Limited. [Price 35 cents.]

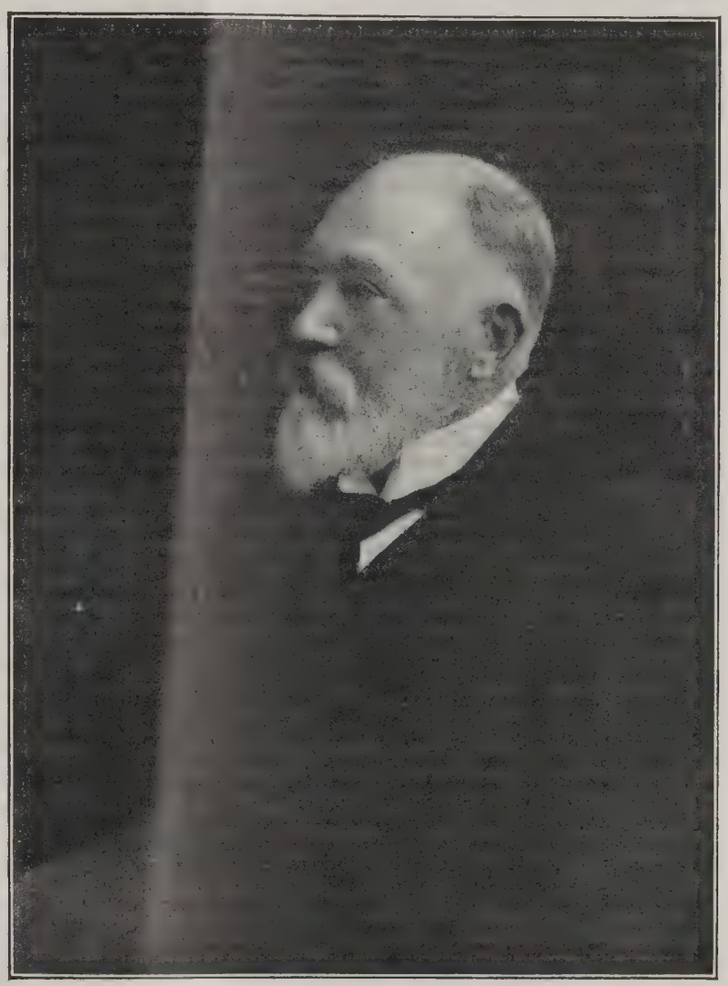
Company, Limited, Chester, of which company Mr. Ellington was managing director, with full professional and technical charge and responsibility. The firm actively developed the construction of hydraulic machinery in general, and in this connection we may specially mention their direct-acting lifts with balance arrangement, a device due to Mr. Ellington, and which led to a marked improvement in the matter of smoothness of working and speed, besides effecting a material saving in water consumption of both passenger and goods-lifts. This hydraulic balancing arrangement was described in a paper on "Hydraulic Lifts," read by Mr. Ellington before the Institution of Mechanical Engineers in the year 1882, when we published it in full* in ENGINEERING, together with a report of the discussion to which it gave rise.

During the early years of his connection with the Chester firm, an Act of Parliament was passed, mainly owing to Mr. Ellington's efforts, for the establishment in large towns of a public supply of water under high pressure, for distribution to private concerns, thus furnishing them with the necessary power for working passenger and goods-lifts. In his capacity as managing director of his company, he was occupied in the early seventies of the last century with the design and construction of the hydraulic machinery for the Hull Hydraulic Power Company and the Hull Docks, also with the hydraulic machinery for other towns in the United Kingdom, for the British Admiralty, and for Continental cities. Mr. Ellington was engineer to the Hull Hydraulic Company from 1871 to 1875, and in the latter year was appointed a director. The Hull scheme was carried out on a small scale compared with later work of the same nature, but it proved invaluable in regard to the data which it supplied, and it led Mr. Ellington to devote his energies to the development of similar work in London. It was a pioneer scheme which conclusively proved the practicability and adaptability of the public supply of hydraulic power on the lines previously occupied exclusively by gas and water undertakings.

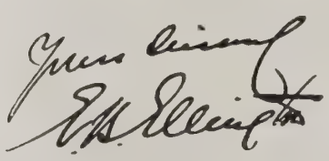
In 1882 Mr. Ellington negotiated the purchase of the Act of Parliament passed for the supply of hydraulic power in London, when a sum of 100,000*l.* was raised to carry out the scheme. In this connection, Mr. Ellington had the cordial support of his friends, among whom we may mention the late Mr. Henry Chapman and Mr. (now Sir) Corbet Woodall. This action marked the commencement of the General Hydraulic Power Company, Limited, of Southwark, London, S.E., a company which now has a capital of 1,000,000*l.* Sir Corbet Woodall's professional association with Mr. Ellington commenced in 1882 and terminated about the year 1900. During that period the public supply of hydraulic power underwent considerable developments. The London Hydraulic Power Company was formed in 1884, and commenced operations in 1885, a similar supply being given in Liverpool in 1889. The two supplies were under the control of the General Hydraulic Power Company, of which company Mr. Ellington was, from 1900 down to the time of his death, the chief engineer and general manager. The development of the London scheme is indicated by the following figures:—The company has now five pumping-stations, the engines of which last year delivered on an average 22,600,000 gallons of water per week, under a pressure of 750 lb. per sq. in. This water—supplied through 177 miles of mains—served for operating 7200 machines scattered throughout London, and comprising lifts, cranes, presses, vacuum cleaners, &c.

The Manchester Corporation supply was commenced in 1894, and that of the Glasgow Corporation in the following year. The former was entrusted to Sir Corbet Woodall, as engineer, but Mr. Ellington's experience and advice were largely drawn upon, and his share in the work was a considerable one.

We have referred above to a paper on "Hydraulic Lifts," read by Mr. Ellington before the Institution of Mechanical Engineers, and in 1890 he contributed to the same Institution a paper in which he described at length the hydraulic installations at Hull, London, Liverpool, Melbourne, Birmingham, Sydney, Antwerp, Manchester, and Glasgow, the general arrangement of the works, the leading particulars in the design of engines and accumulators, the amount of water delivered, the sources of supply, methods of registration, the construction of mains and joints, and the efficiency obtained.* These two papers give a very interesting review of Mr. Ellington's life-work.



A. G. Gabell and Co., Photographers.



Mr. Ellington was elected a member of the Institution of Mechanical Engineers in 1875, and after serving for many years on the Council, first as ordinary member and subsequently as Vice-President, he was in 1911 elected to the office of President, a position which he held for two years. In the summer of 1911 the Institution held a meeting in Switzerland, where the members met with a most cordial reception from the leading Swiss engineers. The gathering proved—largely owing to Mr. Ellington's great tact and powers of organisation—most successful, and it will long evoke pleasant recollections in all who took part in it. In 1912 another very successful summer meeting was held at Belfast. During Mr. Ellington's tenure of the office also a visit was paid to the new pumping-station of the London Hydraulic Power Company at Grosvenor-road.†

The most notable event, however, in connection with Mr. Ellington's presidency of the Institution of Mechanical Engineers was the introduction of the system of examinations for candidates for admission as Graduates or Associate Members. In his presidential address, delivered on March 16, 1911, Mr. Ellington dealt at length with the question of the education of engineers, and urged forcibly the necessity which existed for ensuring that young engineers entering the Institution should be suitably trained. These remarks led to the subject being seriously taken up by the Council, and resulted in the system of examina-

* See ENGINEERING, vol. xxxiii., pages 128, 153, and 420.

* See ENGINEERING, vol. lx., pages 154, 362, and 402.
† *Ibid.*, vol. xcii., page 77.

tions now in force, a system which promises excellent results.

It was during Mr. Ellington's presidency, too, that the important extension of the Institution building was put in hand; and in connection with this work Mr. Ellington, who acted for a long period as chairman of the Building Committee, rendered most valuable services. Mr. Ellington was, in fact, untiring in his devotion to the interests of the Institution, and his sound common-sense and excellent judgment, combined with his business ability and great tact, ensured him the high esteem of all his colleagues, by whom, and by a large circle of friends, he will be most sincerely missed.

Mr. Ellington was elected a member of the Institution of Civil Engineers in 1882, and at the time of his death had been for some years a Member of Council of that body. For contributions to that Institution he had been the recipient of a Watt Medal and a Trevithick Premium. He was also a Governor of the Imperial College of Science and Technology. His name will ever be associated with the introduction and development of public hydraulic-power supplies, and especially with the General Hydraulic Power Company, to whose prosperity he devoted his scrupulous and whole-hearted care from its foundation to the end of his life, and whose progress and success were very largely the result of his efforts.

Mr. Ellington leaves a widow, two sons, and two daughters, to whom the most sincere sympathy will be widely offered. We may add that his eldest son, Major E. L. Ellington, is now on active service with the British Expeditionary Force. Major Ellington was mentioned in one of Sir John French's recent despatches, and has received the Cross of the Legion of Honour. His second son, Captain Noel Ellington, who has for some years been associated with his father professionally, is also on active service with the 5th Battalion, Cheshire Regiment.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. XII.

By Frederick William Lanchester, M. Inst. C.E

The Naval Air-Scout. The Flying-Boat Type.

The work of scouting, or reconnaissance, will undoubtedly be the first and most important duty of aircraft in the service of the Navy. Whether it be in connection with the work of coast defence, in giving timely warning of the approach of hostile vessels of war, or in searching out and reporting the whereabouts of an enemy's battle fleet, in locating the enemy's commerce-destroyers on the high seas, or in directing gun-fire during a bombardment, the employment of aircraft cannot fail to be of signal value. So far as the coastal work is concerned, there appears to be no present difficulty in the way of effectually patrolling the whole of the home waters to a distance of some 200 miles from our shores, other than the want of the necessary number of machines and the requisite organisation—that is to say, there is no difficulty of a technical or engineering character. To some extent, as touching points of especially strategic importance, aircraft are already occupied in this duty; the extension of the system is mainly a matter of increase in material and *personnel*. Unfortunately the demand and pressure for increase are felt in all branches of the aeronautical services, and it cannot but take some considerable time to build additional machines, apart from the time that must be expended in the training of the *personnel* and in accumulating the experience necessary to determine what types and establishment are really necessary.

In connection with the work of reconnaissance of home waters, where the "base" is a station situated on or in the region of the coast-line, it is well understood that the length and extent of the coast-line is a matter of considerable importance. If, on the one hand, the base be situated on a small island or promontory in the vicinity of hostile or neutral country, a dirigible or other similar low-velocity machine would be unsuitable. In the event of a high wind it would frequently be impossible for it to return to its base; it would, in fact, be blown away. If, on the other hand, the base be situated on a long stretch of coast line (such as the East Coast of Great Britain) with a number of well-placed stations, the risk is comparatively small; since, unless the wind is directly off shore, or nearly so, it will always be possible to make some other "port" than that of origin; the chance of being blown away will be remote.

When the operations in contemplation are far removed from home, beyond the radius of action of aeroplanes operating from a coast station or from friendly territory, we find ourselves confronted with difficulties of a kind for which there is no parallel in land operations. As pointed out in the preceding article, two solutions are possible. Either the machine must be capable of alighting in, and rising from, the water, and of riding in safety on the surface of the sea or ocean under ordinary weather conditions, and so be able to accompany and act as an auxiliary to a warship or squadron at sea, or some kind of sea-going pontoon vessel must be devised from which machines can be launched and on whose deck they may alight. Both these schemes are evidently practicable, and each has its advantages and difficulties.

For the former scheme the most suitable type of machine would appear to be the "flying boat"—that is to say, the type in which the flotation, when riding at anchor, is derived from a hull of boat shape and of seaworthy design, with the usual "hydroplane" stepped bottom to give the necessary lift to cause the craft to rise on the water and "skim" whilst acquiring the speed necessary for flight. It is by no means certain that this single hull or boat will oust the double float at present more generally adopted, but for the larger naval aircraft, weighing probably upwards of 2 tons, the single boat may be reasonably expected to prove the more seaworthy job, especially in heavy weather. In discussing the question recently* the writer made the suggestion that, for the sea-going aeroplane (such as now under discussion), it may be found advantageous to make arrangements for the abandonment of the flight organs, and to provide a marine propeller, so that in case of emergency the hull may be navigated as an ordinary motor-boat. The flying boat will thus, it is anticipated, be found the most suitable type of machine to act as sea-going air-scout to the cruiser or battleship. It is a type that may be so designed as to be readily stripped and carried in davits, the flight organs being fitted, and the boat otherwise made ready for air service, when required. For the commerce-raider, or the cruiser or cruiser squadron detailed for the destruction of the hostile commerce-raider, an air-scout capable of being carried in this manner would prove of the greatest value. In really bad weather it would not be possible to launch or fly a machine of this type; but so far as present experience goes, it is impossible to fly any aeroplane which has to rise from the water under these conditions. However, if it should prove possible to fly, as an average, on but half the total days in the year, the extended range of vision obtained (even by such limited use of the air scout) would frequently prove of decisive value. In the case, for example, of the recent pursuit of the Emden and Königsberg, if our cruisers had been able to sweep a belt of some 200 or 300 miles in width (instead of about one-tenth of that), the result would have been achieved in far less time. A cruiser, well served by its air scouts, in pursuit of an enemy, if not fast enough or strong enough to give battle, would be able, having located the enemy, to warn merchantmen of their danger and at the same time to call for the requisite reinforcements. It would be no longer possible for an enemy cruiser to secure concealment amongst the islands of an archipelago or in a river mouth or estuary.

Advantage of the Double-Float Type.

For the duties of bomb and torpedo air-craft, discussed in detail in the preceding article, the boat-type of machine is ill-suited, the conditions being such as to indicate the two-float type as necessary. The latter admits of the bomb-magazine or torpedo-cradle being arranged centrally beneath the fuselage, from which position, by suitable release mechanism, the missile or torpedo can be readily let fall. It is doubtful, on the other hand, whether the two-float type will prove as convenient to handle aboard a vessel not especially fitted out for its reception, and it is further doubtful whether it will prove as seaworthy a job when compelled to depend on its own resources. However, there are authorities who are disposed even to give it preference on the latter count, and certainly for the smaller craft there is something to be said in favour of the fact that, so long as the floats are intact and uninjured, the machine is virtually unsinkable—it cannot be swamped, as is the case with the boat-type.

A serious disadvantage under which the sea-going aeroplane at present labours, whether it be of the single boat or double-float type, is that its speed is essentially limited by the fact that it has to alight and take off from the water, and this involves designing to a comparatively low minimum flight velocity. Whilst this does not necessarily limit the mean or maximum in like degree it tends in that direction.

The Aeroplane Pontoon Base.

Passing now to the alternative scheme—the aeroplane pontoon-ship, we have opened up possibilities of quite a different kind. We are no longer concerned *of necessity* with the limitations imposed by rising from or alighting on water, and the vessel will be expressly designed to suit the aeroplane service, instead of the aeroplane requiring to adapt itself to the vessel. Any land type of machine could be used from the pontoon-ship, but by preference floats would be fitted, and so far as practicable, machines would be rendered "amphibious." Whilst it is evidently desirable that all machines in the service of the Navy should be able to rise from the sea, the conditions are evidently altered when an immersion is to be regarded as an accident rather than as part of the regular routine.

For the primary function of the aeronautical arm in the Navy, whether it be scouting, or attack on the submarine, or torpedo work, there is no particular advantage in employing machines in great numbers. For the latter duty (when the machine for this class of work has been developed), it may be found desirable to attack by squadrons or flights rather than by individual machines. But even this is doubtful, since the advantage gained by simultaneous attack from different points of the compass, as preventing the enemy from concentrating his fire on any one machine, may be more than outweighed by the greater risk of the impending attack being detected and reported by the enemy's air service or torpedo craft. When, however, we have to consider the demands that will be made on the naval air-service for the performance of its secondary function, in addition to the occasions when it will be required to act in connection with land operations, it is evident that provision must be made for transporting and handling machines in large numbers, and this, as far as can be made practicable, irrespective of ordinarily bad weather conditions, and independently of any land station or base. It is here that the need for the floating base or pontoon-ship will be felt.

We may anticipate that, apart from such mechanical detail as alighting gear, relative petrol capacity, &c., the requirements of the naval and military machines for the destruction of hostile aircraft will not differ greatly. Each will rely mainly on the gun in some shape or form for its power of offence, and will depend upon its speed to force the enemy into engagement. Both types will be sent into action in the greatest numerical strength that circumstances permit, or as limited by the number that can be handled or manœuvred without undue danger to themselves, in order to bring the heaviest fire concentration upon the enemy, and to take full advantage of the n-square law. To this end the whole subject of *formation flying* will need to be studied exhaustively and practised assiduously both in time of peace and in time of war. For the time being, however, we are concerned with the question of the floating base—whose object is to render it possible to mobilise an air fleet, as contemplated, complete with repair dépôt and supplies of every kind, at any point required, in the shortest possible space of time.

Conditions to be Fulfilled; Specifications.

The conditions which it is desirable that the air-service pontoon-ship shall fill are, briefly, as follow:—

(1) To act as storage and transport for a fleet of *at least* three squadrons, say fifty or sixty machines, complete with spares, fuel and oil supplies, and *personnel*, together with all guns, ammunition, bombs, torpedoes, &c., necessary for complete equipment.

(2) To carry a workshop fully equipped, together with the necessary mechanical staff to deal with

* James Forrest Lecture, Institution of Civil Engineers, 1914. (See Engineering, May 8, 15, and 22, 1914.)

repairs, &c., such as are reasonably required to maintain an air fleet in fighting order.

(3) To provide an upper deck of sufficient area to act as an "alighting ground" completely free from any obstruction—*i.e.*, there may be no masts, funnels, ventilators, cranes, searchlight platform, or wireless apparatus such as would form a permanent projection above the flying-deck level. The conditions as to deck area, &c., must be such as to give ample room for alighting or getting off to a pilot of ordinary skill.

(4) It must have a speed capacity of 20 knots in order that it may be able to accompany a battle fleet at sea, or to render it able to save itself by flight from an enemy battle squadron.

(5) It must have a gun armament of sufficient power to protect it from attack by the light, fast cruisers of the enemy.

(6) It must be of comparatively light draught, as light as is consistent with its sea-going qualities and other requirements, in order that it may be able to act in rivers, harbours, or estuary regions in support of land operations, and incidentally to enable it to evade pursuit and destruction by war vessels of heavy draught and gun power (such as the battle-cruiser) by taking refuge in shoal water.

The above list of requirements indicate at once that the pontoon vessel will need to be a ship of very large size, comparable to that of a first-class battleship, at least as to length and beam. Beyond this, taking the requirements in order, there appears to be nothing really difficult or impossible of fulfilment. Thus, conditions (1) and (2) could be met without difficulty by a specially-designed vessel of a few thousand tons displacement. Condition (3) is more exacting, and requires that the vessel should be of the maximum beam admissible—say 90 ft.—with a water-line of not less than 500 ft.; also the need for doing away with funnels probably means that the internal-combustion engine will have to be considered as the means of propulsion. This, for the horse-power required—about 15,000 indicated—is rather beyond anything yet attempted; however, it can be by no means deemed impossible. The conditions could be met by employing six propeller-shafts, each driven by a Diesel unit of 2500 indicated horse-power; this is not considered to-day by any means beyond the limits of commercially sound engineering. The present-day uses of the *masts* of a warship are mainly for signalling (by wireless and otherwise), to serve to carry searchlight and look-out platforms, and as an anchorage for jib-cranes. All these various requirements will need to be met without hampering the flying-deck with any permanent obstructions. Thus it is well understood that the "aerial" for a wireless installation may be arranged horizontally; in the present case it could be carried on spar outriggers, some 10 ft. or 15 ft. away from the gunwale, being shipped and unshipped as needed. Searchlights could, without difficulty, be mounted on telescopic pillars dropping flush into the deck, operated by hydraulic power or other means, and taking but a few seconds to raise or lower; cranes also can be provided in such form as to be rigged only when needed. Altogether there is nothing in these detail requirements likely to prove of insuperable difficulty. Condition (5) would be adequately met by a powerful broadside armament of 6-in. guns, in addition, perhaps, to guns of heavier calibre mounted in a single turret astern, all arranged below the level of the flying-deck. With a ship of the size contemplated there should be no difficulty in providing a sufficient weight of armament for the purpose specified. The gun-deck would be the main upper structural deck of the vessel, with only the comparatively light flying-deck above it.

The pontoon-ship as an aeroplane base possesses certain and obvious disadvantages; an area for alighting such as is presented by the deck of a ship, although it may be, say, 90 ft. beam by 400 ft. or more in length, is none too large under really bad conditions of weather for even a skilled pilot, especially if the vessel be rolling in a heavy seaway. Without doubt, under extreme conditions operations will become frankly impossible; but, under similar conditions, it will be also impossible to employ a machine designed to rise from the water. The conditions in the case of the pontoon-ship, however, are not really so unfavourable as might be thought; the vessel can always be brought head to wind, when the relative velocity of the machine on alighting will be reduced by the velocity of the wind; it may also be still further reduced by maintaining the vessel under power; these two effects in combination, assuming the wind to be 40 miles per hour and the vessel at full speed, will result in a machine, flying through the air at 60 miles per hour, taking the deck without any relative motion whatever—a most favourable state of things, permitting it to be instantly secured and made fast. Beyond this, under the said condition—*i.e.*, head to wind—it is only in the exceptional case of a heavy cross sea that the rolling could be serious, and with the modern methods of steadying sea-going vessels (gyroscopes and ballast-tanks) it would require a quite exceptional state of weather to keep the air fleet imprisoned. There is one constructional point that is worthy of mention; the flying-deck will require to "run out" at the bows of the ship in easy lines, to avoid setting up eddies or dead regions, such as might affect the stability or buoyancy of machines landing or leaving the deck; to some extent it may be found necessary to extend this precaution to where deck joins gunwale abeam.

It is also worthy of note that the proposed pontoon-ship, being of comparatively light draught and great beam, will possess naturally the type of stability of a raft rather than that of an ordinary ocean-going vessel, and will thus tend in a seaway to follow the changing slope and motion of the long ocean waves. Now this slope and motion, as is well known, are so co-ordinated that the normal to the wave slope is always the *apparent plumb*, and so it may even turn out that the flying-machine, on taking the deck of a vessel studied as a raft rather than as a ship, will (even when the motion is severe) have no tendency either to side-slip overboard or turn turtle.

The same conditions that are favourable to alighting, as from the point of view of relative motion, are also favourable to the machine when getting away. Thus, with a 40-mile-per-hour wind and the vessel at full-speed, head to wind (as already assumed), a machine will be able to leave the deck with a relative motion of only some 10 or 20 miles per hour and a flight velocity of 70 or 80 miles per hour. Taking all the possibilities of the situation into account, it is probable that the machines to operate from a pontoon will, on the whole, be constructed as faster fliers than those designed for rising from the water, and to that extent at least will be better fitted for combatant duties.

THE IRON AND STEEL INSTITUTE.

As we announced on pages 300 and 558 *ante*, a meeting of a purely formal character of the Iron and Steel Institute was held in the offices of the Institute, 28, Victoria-street, Westminster, yesterday, the 19th inst., at 11 A.M., when Dr. Arthur Cooper occupied the chair. In the opening proceedings, Dr. Cooper said that the reason for his taking the chair was the enforced absence of their President, Dr. Adolphe Greiner. The last news they had received from the latter stated that he was practically a prisoner in his own house, which was occupied by the German military. He was, however, in good health, but had very much aged. The Council, Dr. Cooper added, would take the very first opportunity after the meeting to assure Dr. Greiner of their heartfelt sympathy with him and his family for the distress they were going through. The minutes of the last spring meetings were taken as read. Scrutineers were appointed for the examination of voting-papers for the election of new members; all the candidates who had sought election were duly elected. Dr. Cooper then stated that all the members present were conversant with the circumstances which had led to the meeting. It had been arranged with the Comité des Forges that this year's autumn meeting should be held in France. All was in readiness for their reception in Paris and in the French Lorraine iron-mining districts. Early in August, however, it became apparent that the meeting in France could not take place. The Council of the Institute communicated at the time with the Secretary of the Comité des Forges, who confirmed the impossibility, owing to the war, of their receiving the Institute, kindly adding that the pleasure they would have experienced on that occasion was only deferred, and also the hope that the meeting in France would take place at some future date. The time being short for making other arrangements, the Council decided that the papers which had been prepared for the meeting in France should be taken as read, circulated amongst the members, and discussed by correspondence. The papers and the written discussions will appear in the second volume of the Institute's Proceedings for the current year, which will be issued in the early months of 1915. The war, Dr. Cooper further stated, owing to the international character of the Institute, was going to affect it more seriously than other institutions in this country. The Iron and Steel Institute counted 32 Belgian members, 61 French, 21 Russian, 11 Japanese, 71 German, and 30 Austrian. Of the 101 German and Austrian members, 12 had already sent in their resignation. He hoped, however, that they would be able, in the near future, to record increases in the number of Belgian, French, and Russian members. At the Council meeting, which had been held earlier in the morning, a very strong view was expressed to the effect that a list should be prepared giving the names of all the members of the Institute who were on active service with the British, the French, and the Belgian armies, and Dr. Cooper asked that the names of these members should be sent in to the Secretary. A list of such members would be published in the next volume of the Proceedings. The Council had also provisionally arranged that the next spring meeting should be held in London on May 13 and 14; also that the next autumn meeting should be held in the week ending September 27, probably in London also. Further information concerning both meetings would be sent to the members later on.

ALL-STEEL RAILWAY EQUIPMENT.—The types of all-steel equipment on the Pennsylvania Railroad developed at the company's car-shops in Altoona now include a steel caboose for the use of the crews of freight trains. Only one such car has been made at present; it will be used on the different divisions of the system before work is started on others. The Pennsylvania Railroad Company was the first to adopt all-steel passenger equipment in 1906; now it has all-steel passenger cars, mail and postal cars, express cars, refrigerator cars, luggage cars, freight box cars, and coal cars.

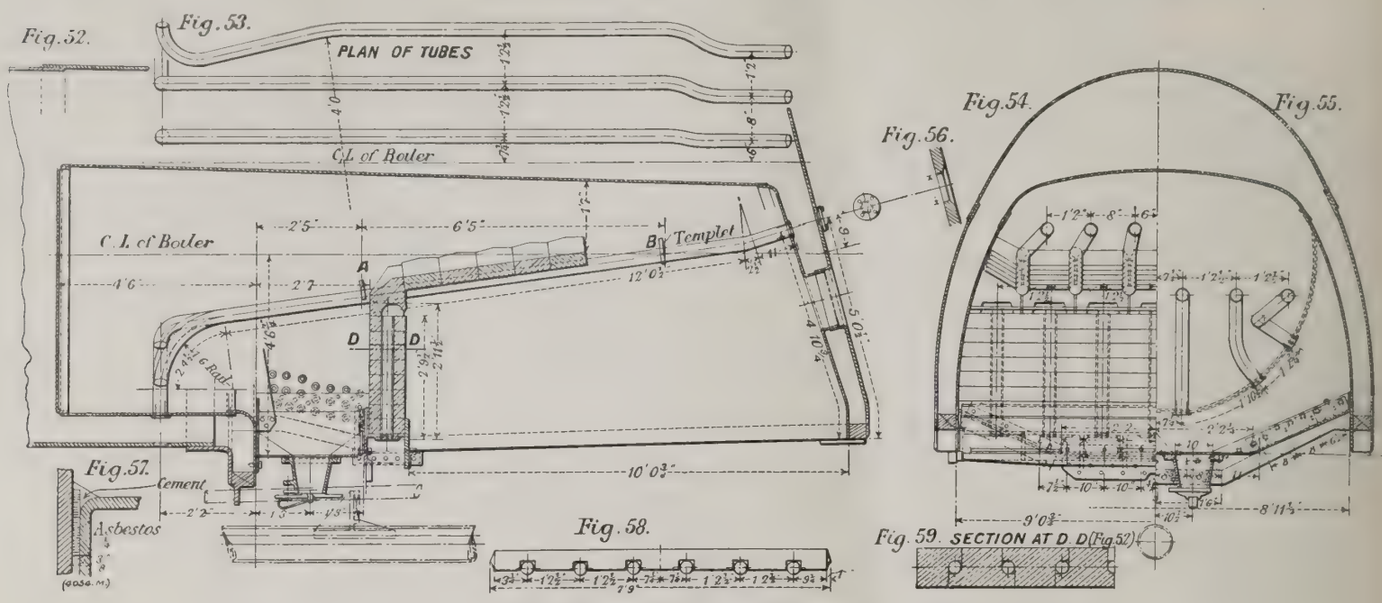
OFFICIAL FIRE-TEST WITH TREATED WOOD.—The British Fire-Prevention Committee have just issued their report No. 193, regarding a test carried out on July 1 with a match-boarded deal partition, in which the deal was impregnated by a proprietary process, with the object of making it fire-resisting. The partition comprised studs with §-in. grooved, tongued, and beaded match-boarding on both sides, and it measured 10 ft. wide by 9 ft. high. The test was conducted under the Committee's usual conditions, and was a forty-five minutes' test at temperatures that rose to 1630 deg. Fahr., whereupon water was applied from a steam fire-engine. The main features in the official "Summary" of the test are that smoke appeared freely through several joints after thirty-eight minutes, and that after forty minutes scorching appeared at several joints; further, that after forty-four minutes a glow was seen at four points. Upon the application of water, water came through several of the vertical joints. The fire-resistance was thus considerable for wood-work, although the minimum classification as to such a partition affording "Temporary Protection" under the British Fire-Prevention Committee's Standards—necessitating resistance for forty-five minutes—was not obtained by a few minutes. It would have been interesting if the partition had been tested side by side with a match-boarded deal partition which had not been impregnated.

POST OFFICE TELEGRAPHS.—The Post Office still continues to work with a closed capital account, a policy which, while it helps to keep down the national outgoings, exhibits the postal telegraph system as being worked at a loss, while it is probably realising a profit, properly so called. Further information is, however, required before a definitive opinion can be pronounced upon the subject. As regards the construction of new lines and buildings, the cost should certainly be charged to capital, but the information supplied is confused with the question of maintenance and "other expenditure," so that it is difficult to arrive at a final conclusion. As matters now stand, a deficit is admitted year after year in the working of the Government telegraphs. This is shown by the following statement of the annual receipts and expenditure since 1903-4:—

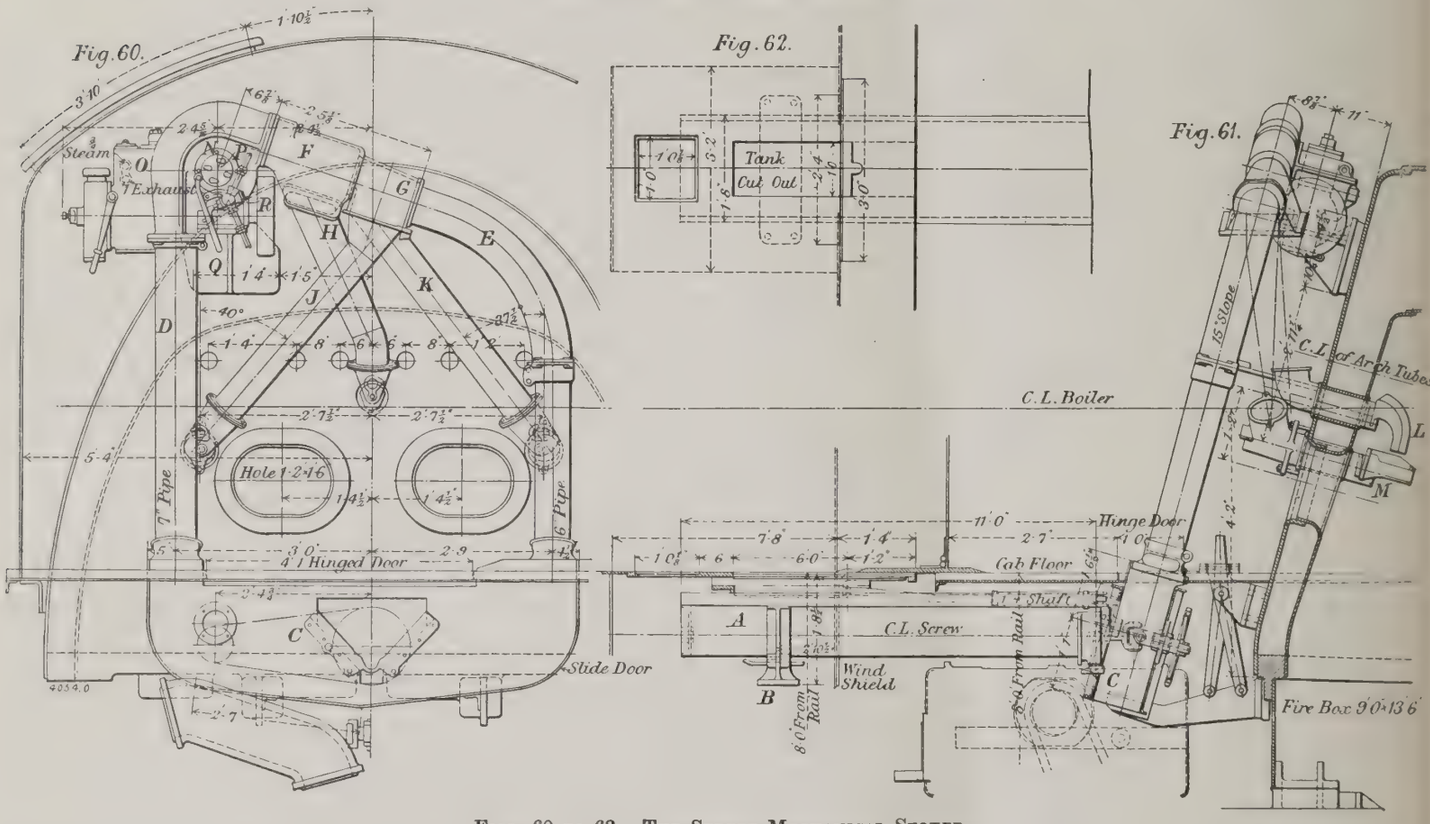
Year.	Receipts. £	Expenditure. £
1903-4	3,736,115	4,972,382
1904-5	3,920,023	5,111,150
1905-6	4,151,380	5,163,890
1906-7	4,369,227	5,283,616
1907-8	4,484,120	5,608,234
1908-9	4,622,169	5,767,704
1909-10	4,917,183	6,047,189
1910-11	5,121,341	6,352,281
1911-12	6,110,441	7,177,513
1912-13	8,953,111	9,602,144

When Parliament and the Government have more time to attend to questions of telegraph administration, it might be well for matters to be set out in greater detail, so that the country might know what is the real financial position of the Government telegraph network.

DETAILS OF 2-8-8-8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD.



FIGS. 52 TO 59. GAINES' FIREBOX.



FIGS. 60 TO 62. THE STREET MECHANICAL STOKER.

COMPOUND ARTICULATED 2-8-8-8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD.

(*Continued from page* 602.)

CONTINUING the description of the powerful 2-8-8-8-2 type locomotive on the Erie Railroad, which we commenced in our issue of last week, when we gave longitudinal drawings and sections of the machine and details of the tender tank, we now turn to details of the boiler, &c. These we illustrate in Figs. 33 to 51, on Plate XLI., with this week's issue, and on the present and opposite page. Of these, Fig. 33 shows the completed boiler in the works of the builders, the Baldwin Locomotive Works of Philadelphia. Fig. 34 shows the fire-box shell with, for contrast, the shell of a small locomotive fire-box alongside. Fig. 35 shows the fire-box foundation ring. A general drawing and details are shown in Figs. 36 to 41, while Figs. 42 to 46 relate to the fire-box. The front tube-plate is illustrated in Fig. 47, and the smoke-box arrangements are shown in Figs. 48 to 51. Our illustrations, Figs. 52 to 59, annexed, give details of the fire-box arch, while Figs. 60 to 62 show the machine stoker. It has been thought well to include at this stage a description of the boiler-feed system, and Figs. 63 to 80, page 629, relate to the feed-water heater.

From the reproductions of photographs given in Figs. 33 to 35 some idea of the size of the boiler may be obtained. It is of the wide fire-box type, with a single taper course in the barrel. The barrel is 28 ft. $2\frac{1}{16}\frac{3}{16}$ in. long. Its internal diameter at the front course is 94 in., the taper course bringing the largest internal diameter up to $102\frac{7}{8}$ in. The thickness of the barrel-plates is $\frac{1}{16}\frac{3}{16}$ in., stiffened at the position of the bearers underneath with $\frac{3}{4}$-in. liners. The longitudinal seams for the front two courses are butt-joints, with inside and outside cover-strips, the former being $23\frac{5}{8}$ in. wide by $\frac{1}{16}$ in. thick, and the latter $8\frac{1}{4}$ in. wide and $\frac{1}{16}$ in. thick. The longitudinal seam for the front course is welded for a length of 36 in. at the front end, and 26 in. at the back. The second-course seam is welded for 13 in., front and back. The seam for the third, or dome, course is welded for the full length, and a $\frac{7}{8}$-in. liner surrounds the dome openings on the under side. On the upper side the flanges of the steam and safety-valve domes cover the joint except for a small length provided with outside cover-plates. The steam-dome is pressed out of steel plate, $\frac{3}{4}$ in. thick. The longitudinal seams of the first and second courses have $1\frac{3}{8}$-in. rivets at $3\frac{1}{2}$-in. pitch. The two circumferential seams between the three courses of the barrel are lap-joints, with three rows of $1\frac{3}{8}$-in. rivets. The smoke-box tube-plate is circular, and flanged to go inside the barrel, as is always done in American practice. It is $\frac{5}{8}$ in. thick, and is riveted to the barrel by a single row of 1-in. rivets. It is supported by fourteen stays, attached to the upper part of the first and second courses of the barrel.

The fire-box has a width inside at the grate level of 108 in., and a length of no less than 172 in., the grate area being 90 sq. ft. The foundation-ring is 4 in. deep, and at the sides and back of the box is 5 in. wide. At the front the ring is 6 in. wide, so that liberal water spaces are provided. The shell and fire-box plates are double-riveted to it with $\frac{7}{8}$-in. counter-

COMPOUND ARTICULATED 2-8-8-8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD; DETAILS OF BOILER, &c.

CONSTRUCTED BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA., U.S.A.

(*For Description, see Page* 628.)

Fig. 33.

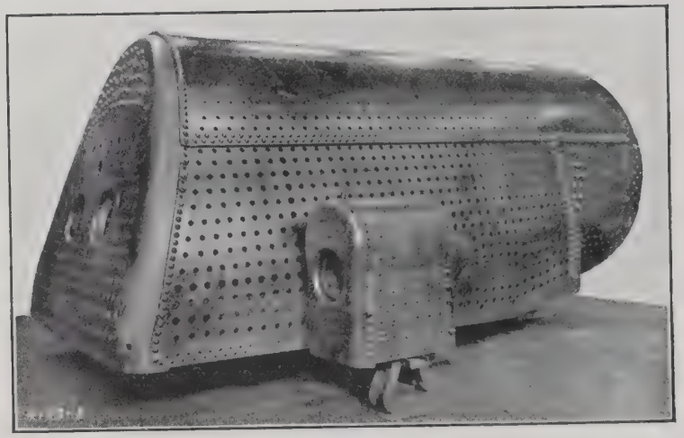


Fig. 34.

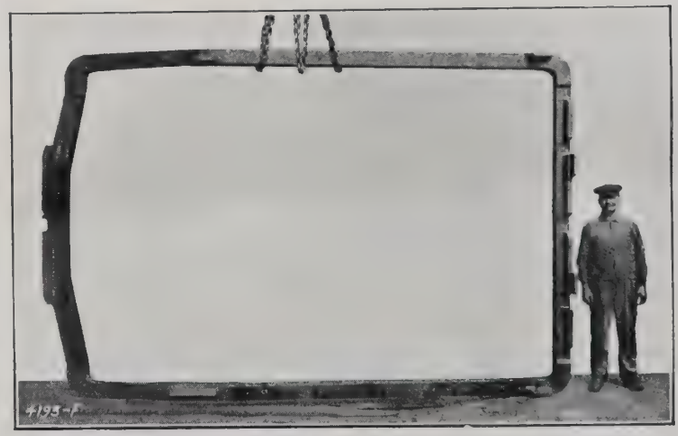
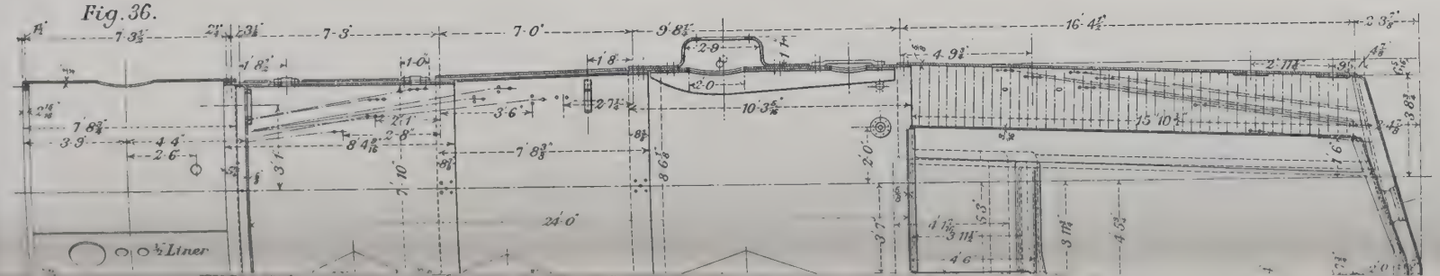


Fig. 35.

Fig. 36.



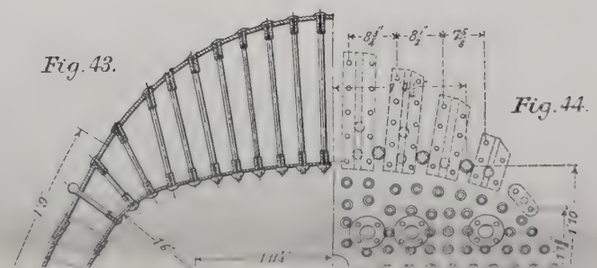


Fig. 43.

Fig. 44.

Fig 42.

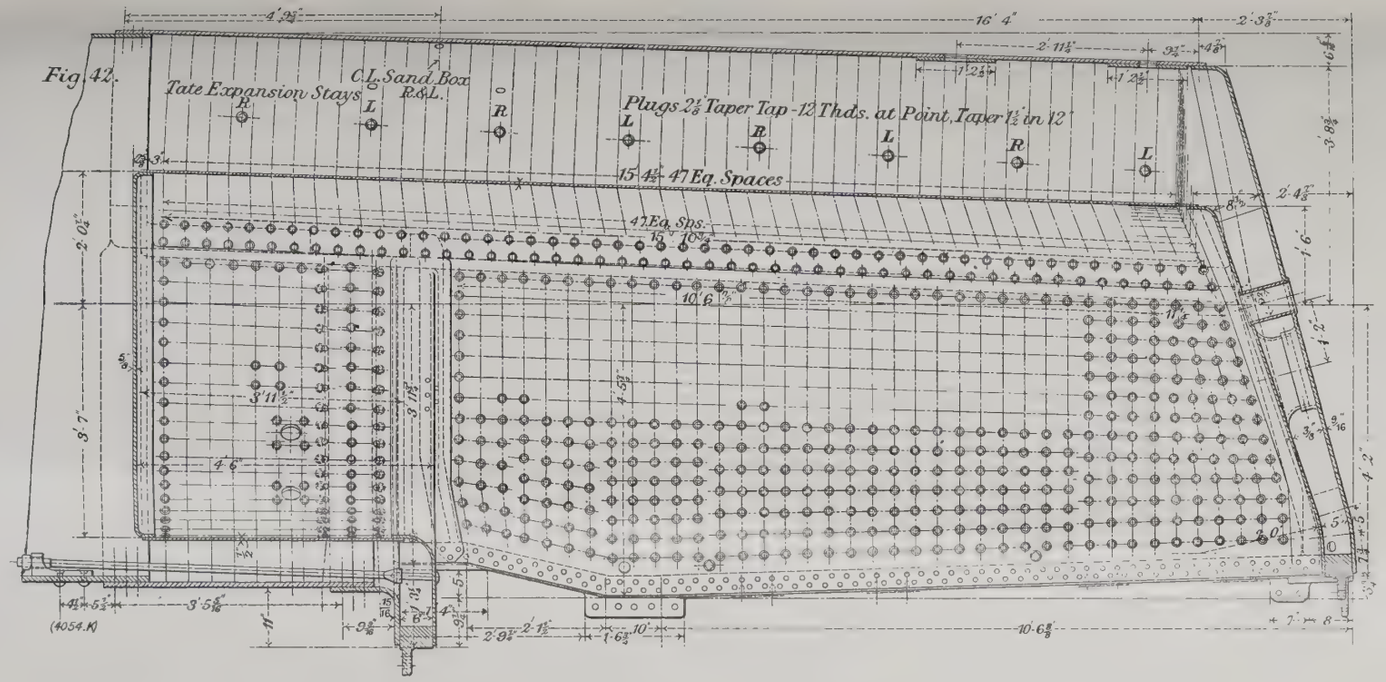


Fig.45.

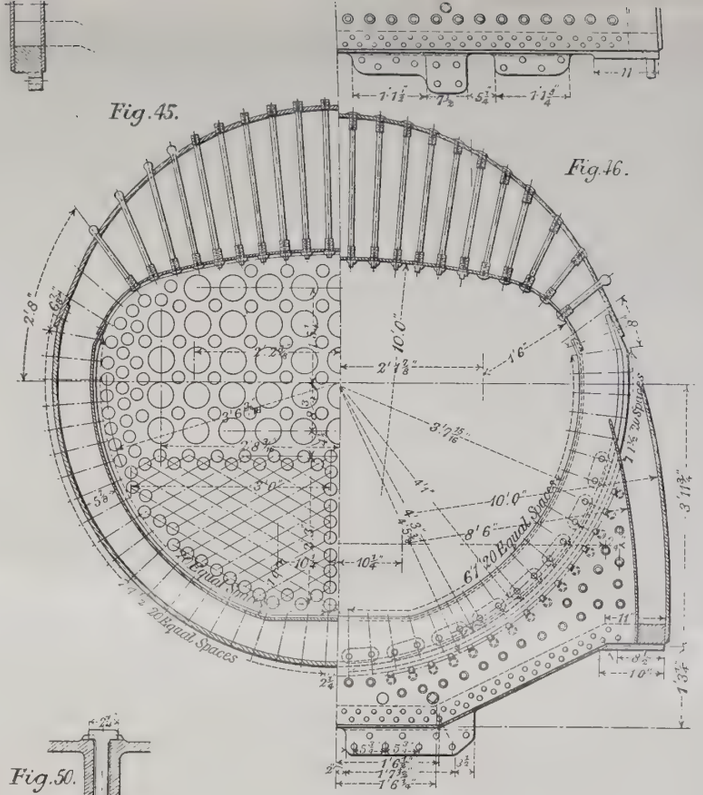


Fig.46.

Fig.48.

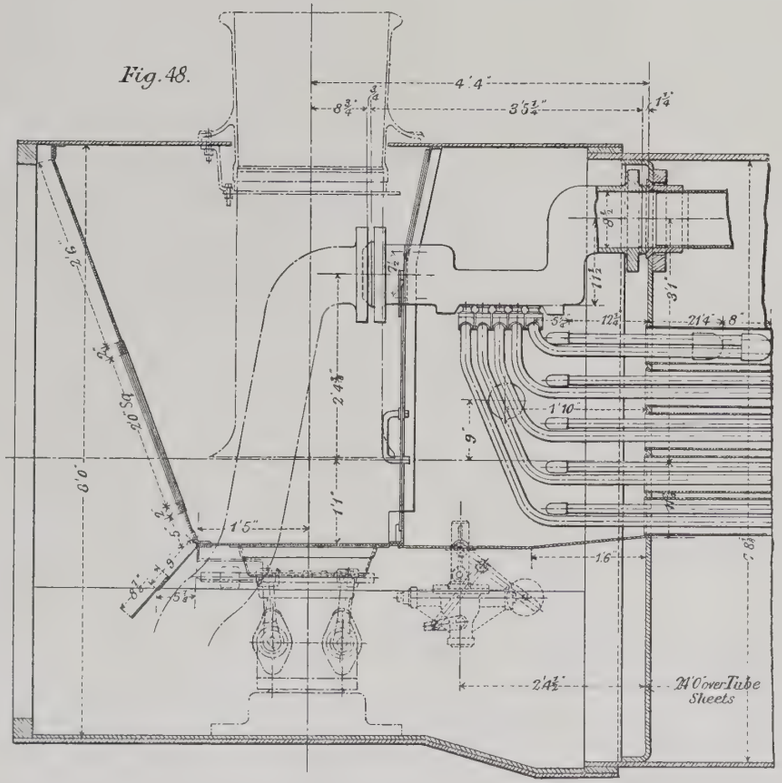


Fig.50.

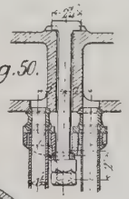


Fig.49.

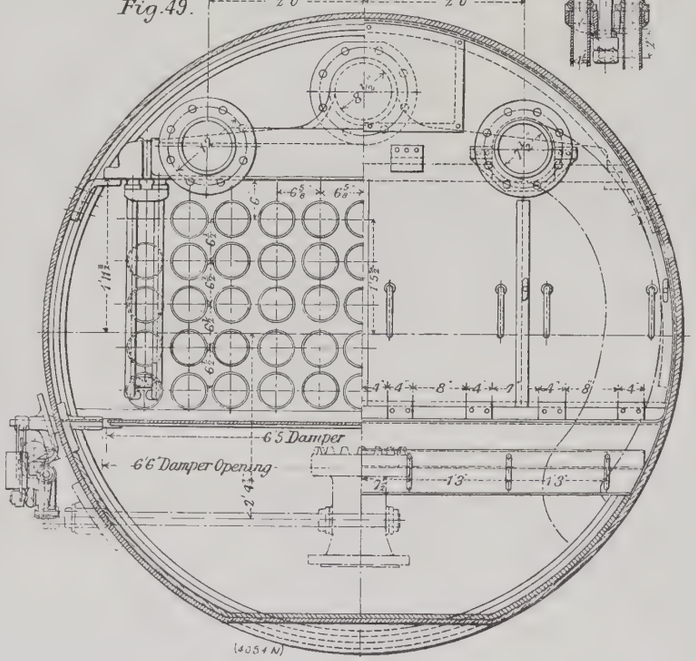
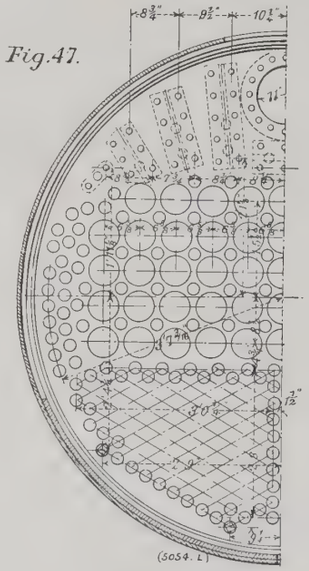
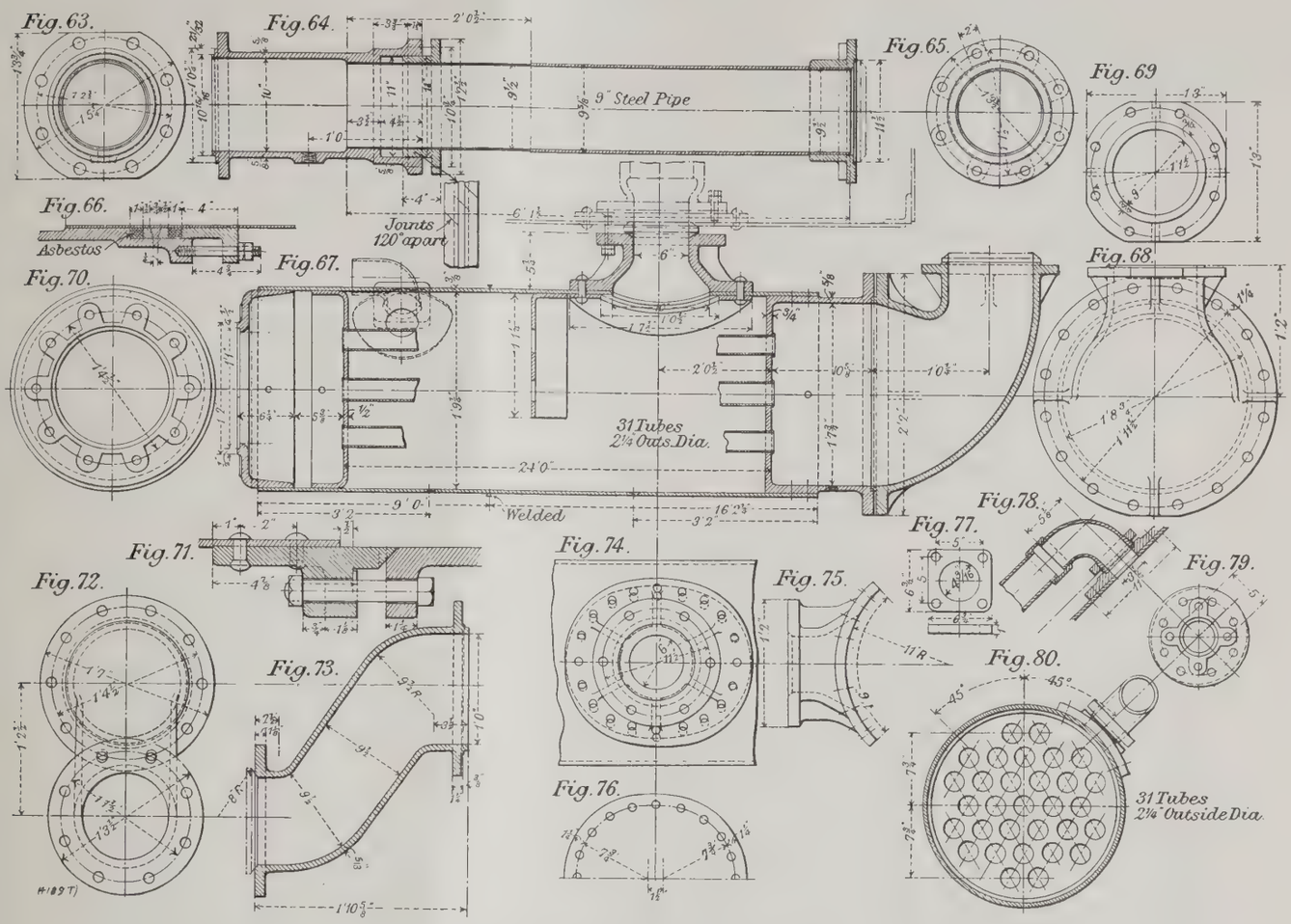


Fig.47.



DETAILS OF 2-8-8-8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD.



FIGS. 63 TO 80. FEED-WATER HEATER.

sunk rivets. The fire-box shell consists of three sheets, the crown-sheet and two side sheets. The crown-sheet is one large plate, $\frac{5}{8}$ in. thick, extending some distance along the barrel over the combustion-chamber. The side plates are $\frac{1}{2}$ in. thick. The back head of the boiler is $\frac{9}{16}$ in. thick. It is sloped forward, as is usual in modern American practice. The throat-sheet of the shell is very shallow. It is $\frac{15}{16}$ in. thick, and is riveted up to the wrapper-plates and to a $\frac{13}{16}$-in. plate forming part of the barrel below the combustion-chamber. Fourteen stays extend between the crown-sheet of the shell and the back head.

The fire-box embodies a combustion-chamber 4 ft. 6 in. long, extending into the barrel. The box is built up of a crown-sheet, two side sheets, back and throat-sheets, a single plate forming the underneath and sides of the combustion-chamber, and the tube-plate. All these are of steel. The crown-sheet extends over the box and combustion-chamber. It is $\frac{5}{8}$ in. thick and is lap-jointed to the side sheets, which are likewise $\frac{5}{8}$ in. thick. The back plate is $\frac{5}{8}$ in. thick and the tube-plate $\frac{5}{8}$ in. thick, while the combustion-chamber plate is $\frac{1}{2}$ in. thick, as is also the throat-sheet. The fire-box plates are stayed to the shell, &c., by 3025 stays, all but 832 being of the Tate flexible pattern, described in ENGINEERING some time ago.* All these, except 160, are 1 in. in diameter. There are 326 flush Tate stays in the sides, &c. The 160 stays just referred to are $1\frac{3}{16}$ in. flexible crown-stays connecting the crown sheet of the combustion-chamber with the shell crown-sheet. The remaining crown-stays are of the usual plain radial type, also $1\frac{3}{16}$ in. in diameter. In all the water-spaces 1-in. flexible bolts are used. There are sixteen T-headed palm-stays, extending from the fire-box throat-sheet to the barrel. These are expansion-stays running through brackets fixed to the barrel-sheet, while the T-head is connected to the throat-sheet by two screwed stays.

Figs. 42, 45, and 46 show the shape of the combustion-chamber, which adds 108 sq. ft. to the fire-box heating surface of 272 sq. ft. The front and back tube-plates are shown in Figs. 47 and 45 respectively. They are 24 ft. apart. The boiler contains 326 $2\frac{1}{4}$-in. tubes, and 53 tubes $5\frac{1}{2}$ in. in diameter; the latter accommodate the superheater elements. The former are of No. 11 W.G., the latter of No. 9 W.G. thickness; they are all of steel. The tubes provide a heating surface of 6418 sq. ft. There are, in addition, six arch-tubes in the fire-box. These will be referred to later. They add 88 sq. ft. to the heating surface, making the total 6886 sq. ft.

The locomotive is fitted with a Schmidt superheater, consisting of fifty-three elements, extending from 21 ft. 4 in. to 22 ft. down the tubes, thus leaving about 2 ft. of the large tubes at the fire-box end unoccupied. It provides a heating surface of 1584 sq. ft. Steam is brought to the superheater header through an $8\frac{1}{2}$-in. pipe. The general arrangement of the header and superheater in the smoke-box will be clear from Figs. 48 and 49. The header is supported on brackets, shown in Figs. 49 and 50. The connection of the elements with the header is illustrated in Fig. 51. From the header the steam is taken to the cylinders through two pipes of $7\frac{1}{2}$ in. internal diameter. The superheater is enclosed in a large compartment, in the bottom of which is a mechanically-operated damper, 6 ft. 5 in. long by 20 in. wide. The front of the superheater compartment is provided with large doors (Fig. 50). The smoke-box is of the self-cleaning type, the blast-pipe opening above a deflector-plate of adjustable depth. The blast-pipe nozzle is rectangular, surrounded by a blower-ring, cast with the blast-pipe. The nozzle-area is adjustable by means of two flaps. The gear for working these flaps is shown in Figs. 48 and 49. It is a right and left-handed screw-gear, operated from the cab, and by means of it the rectangular opening may be reduced from 7 in. by 9 in. to 7 in. by 3 in. The smoke-stack is 22 in. in internal diameter. The petticoat pipe, which is separate from the stack, extends down to the centre line of the boiler.

The interior arrangement of the fire-box is shown in Figs. 52 to 59, in which, however, the complete details of the fire-box construction are not reproduced. In addition to providing additional fire-box volume in the combustion-chamber, which, at the same time, permits the use of flues of a reasonable length, the design embodies an interesting form of brick arch, which has now attained considerable popularity in the United States. This arch is a development of one originally introduced by Mr. F. F. Gaines, Superintendent of Motive Power of the Central of Georgia Railway. The original Gaines fire-box was designed with a normal grate area, at the front end of which was placed a vertical brick wall. Between the latter and the tube-plate was a space, which practically formed a combustion-chamber. The bottom of this chamber was provided with a hopper, in which cinders collected, and from which they were easily removed. The brick wall contained vertical passages, up which air passed into the fire-box above the fire.

A number of objects were satisfactorily attained with this box. Much work has been carried on in America of late years, both on testing plants and in the form of general observations in service, with regard to the high value of fire-box volume and heating surface. The Gaines fire-box increases both these. With fire-boxes which have only a short front water-leg, the only type of arch possible is either a wall placed some way back of the tube-sheet, or at any rate an arch forming part of such a wall. The wall adopted by Mr. Gaines was the first attempt made to increase the length of the flame path in large shallow fire-boxes. The value of the arch as a baffle from the point of view of thorough mixing and complete combustion of the gases is, of course, well appreciated in this country, and our readers will also readily recognise that the absence of an arch would leave the upper back portion of the box practically untouched by the flames, which would then be drawn direct from the grate to the flue-sheet. The above features of the Gaines fire-box tend to improve combustion, while the provision of a secondary supply of air previously heated, in its passage up the interior of the brick wall, to a temperature which renders possible immediate combination with the constituents of the furnace gases, is also clearly a step in advance of the usual method of admitting cold air through the fire-hole door, with possible injury to the tube-sheets, and the certain lowering of the temperature of the gases. Lastly, the sparks and cinders, instead of blocking the tubes, fall into the hopper, whence they are easily removed. The original Gaines wall was subsequently advantageously combined with a regular arch, which still further prolongs the flame-path, and ensures the hot gases reaching the crown and upper part of the back of the box. For some years the combustion-chamber extending into the

* See ENGINEERING, vol. xciv., page 336.

barrel has been regarded favourably by American designers as providing additional fire-box volume and ensuring more complete combustion before the flames are extinguished by passing down the tubes. From the practical point of view, such chambers have objections. The water underneath them is rather dead unless the space is very liberal, an arrangement for which it is often impossible to provide. Often, therefore, the combustion-chamber impedes the circulation of water to the water-legs of the fire-box, and coincidently serious stresses are placed on the plates, with resultant troubles from cracks and broken stays.

Ordinarily in America the firebrick arch is supported on arch tubes running diagonally from the tube-sheet to the back plate. The well-known "Security" arch of the American Arch Company, New York, is supported in this way. When this arch is combined, as in Fig. 52, with the Gaines fire-box and combustion-chamber, the arched tubes are carried from the lower side of the combustion-chamber diagonally up to the back plate. They are set parallel between the points A and B to template. The template for this box is shown in Fig. 58. At the ends the arch tubes are beaded over. These arch tubes are extremely good steam-producers, and the water circulates through them rapidly. Their supply is drawn from the dead space at the bottom of the barrel, and therefore a strong current sets towards this part, much of the water passing on to the legs of the fire-box. The arch tubes are shown in plan in Fig. 53, and in elevation towards the front end in Fig. 55. The brick arch and wall are shown in section and elevation in Figs. 52 and 54. The vertical wall is shown in horizontal section in Fig. 59. It contains vertical air-ducts consisting of 3-in. wrought-iron pipe. These air-ducts open into the fire-box just at the head of the wall under the arch. The wall is supported by a cross-bearer attached to the foundation ring. In front of the brick wall the space is floored with plate covered with firebrick and fireclay cement. There are two hopper-pockets. Fig. 57 shows a detail of the joint between the cinder hopper floor-plate and the fire-box throat-sheet.

The ashpan is of the deep-hopper type, and was shown in Figs. 3, 17 and 19, Plates XXXIX. and XL. *ante*. It is composed of three hoppers arranged longitudinally. Two of these are outside the driving-wheels, while the third extends down between the third and fourth pair of drivers of the central group. An Inter-state regulation requires that all ashpans shall be capable of being cleared without the necessity of the fireman going under the engine. The hand-levers working the dumping-doors of the side and central hoppers are shown in Figs. 17 and 19 above referred to.

The mechanical stoker fitted to this locomotive is of the Street pattern, developed by the Locomotive Stoker Company, of Schenectady. Some time ago we gave in ENGINEERING* a description of the Crawford stoker employed on the Pennsylvania Railroad. These two stokers are the most widely used of any in the United States. At the last Railway Master Mechanics' Association Convention figures were reported which would make the total number of Street stokers in use at the present time about 500. The Crawford and Street stokers are designed on totally distinct principles. The former, it may be remembered, is of the underfeed type. The latter is of the scatter type, the coal being fed into the box above the grate. The essentials are illustrated in Figs. 60 to 62, page 628. The machine consists of a conveyor supplying coal from the tender to an elevator on the back head of the boiler, which in turn supplies the distributing apparatus.

The conveyor is of the screw type, and is accommodated in the trough A, extending from the engine to the tender. At the front end, this trough is pivoted under the foot-plate ; at the back, it is carried in the support B fixed to the tender, and in which it is free to slide. Above the conveyor-trough is an oscillating grid, over which is a rectangular opening in the tender-floor. This opening is furnished with plates, which can be drawn forward so as to move the opening further back over the trough as the coal is used up. Originally a crusher was furnished on the tender with this class of machine, but now prepared coal is commonly supplied to the tenders. The screw-conveyor works the coal forward into the hopper C. An endless chain of small elevator-buckets works in this hopper, moving from the right to the left and then up the trunk D, down through the trunk E, and back to C. On arriving at the upper left-hand corner, the buckets turn over and pass through the compartments F and G. These form part of the distributing gear. In the first there is a circular screen, perforated with different-sized holes in each quarter circumference, so that, according to the setting, coal of various sizes, and consequently various amounts, may be passed through to the chute H. The coal which does not pass through this screen is carried on by the buckets to the compartment G, where it falls into the chutes J and K. The coal is divided between these two chutes by a distributor, which may be set to deflect the coal in any desired proportion to one or the other. The deflector is a plate set in line with the axis of the conveyor, so that the lurching of the locomotive does not disturb the proportionate distribution. From these chutes the coal passes to distributors projecting into the interior of the fire-box. The central one, L, is different from the others, one of which is shown at M. These distributors are furnished with steam-jets, which blow the coal into the fire-box. The steam is supplied in intermittent spits. The small coal passing through the screen in F is fed to the central distributor L. This is curved downwards, and all this coal is fed to the back of the box. It is therefore not so likely to be carried away over the arch partially burnt, as it would be if it were thrown a long way down the box, The two distributors M supply the remainder of the grate. By the adjustment of the screen in F and the deflector under G, the amount of coal fed to any particular portion of the grate may be regulated within a very wide range. The elevator is operated by a sprocket, over which the bucket-chain works at N. This sprocket is driven by a small steam-engine at O. The conveyor is driven through a universal joint by chain off a sprocket in mesh with the elevator chain. This is at the left-hand side of the hopper C, in which are also sheaves to keep the chain of buckets down into the coal. The steam for the jets is supplied in puffs or spits, which are regulated by a cam-plate P. There are four cams on this plate, any or all of which can be thrown into use. These cams force outwards the upper end of the lever Q, which is supported on a bracket attached to a small steam-valve R. The movement of the lever by the cam depresses the valve and admits steam through a pipe (shown broken off) to connections on the distributor-heads. The lever Q is furnished with a sliding striker, which, if needed, may be pulled down, when no steam is passed to the jets. The stoker will supply 11,000 lb. of coal per hour to the fire-box.

Having considered above the steam-generating part of this locomotive, we may complete this portion of our description with a reference to the boiler-feed apparatus. The boiler can be fed either by injectors or by pumps, or by both. There are two Hancock injectors, each of a capacity of 7500 gallons per hour. They draw water from the tender-tank and force it into the boiler through a clack mounting on the top of the front part of the barrel. In addition to the injectors there are two pumps which draw and deliver to the boiler feed-water heated, to about 200 deg. Fahr., in the feed-heater illustrated in Figs. 63 to 80. This heater is placed under the tender-tank in the position shown in our illustrations of last week. It is supplied with steam from the exhaust of the rear pair of low-pressure cylinders. The heater is a steel cylinder containing 31 tubes 2¼ in. in diameter and 24 ft. long. It provides 436 sq. ft. of heating surface. The heater is shown in section in Fig. 67. Details of the heads are given in Figs. 68, 69, and 70. The bend at the back end is cast iron. The heater heads proper are cast steel. Water is supplied to the heater through an inverted saddle mounting attached to the underside of the tank, and shown in detail in Figs. 74 to 76. It is drawn off by the pumps by two outlets near the other end of the heater, details of which are illustrated in Figs. 77 to 80, and delivered to the boiler through clacks mounted on a small dome on the top of the first course of the barrel. Steam from the rear low-pressure cylinders passes through the 9-in. steel pipe, shown in Figs. 63 to 66. To the end of this pipe is coupled the cast-steel double bend illustrated in Figs. 72 and 73. The joint between these two is made with a brass cone-ring (Fig. 71). The other end of the double bend is attached to the left-hand end of the heater (Fig. 67). The exhaust passes up the right-angle bend at the other end of the heater to a vertical exhaust-pipe. The steam-pipe is furnished with an expansion-joint. The short part attached to the cylinder-saddle is of cast steel, fitted with a gland, in which slides the 9-in. steel pipe. The packing in the gland consists of three cone-shaped brass rings, with braided asbestos rings at the back and front of them. In subsequent articles we shall deal with the framing cylinders, &c., of this interesting locomotive.

(*To be continued.*)

* See ENGINEERING, vol. xcvii., page 558

THE INSTITUTION OF AUTOMOBILE ENGINEERS: SCOTTISH CENTRE.—The first general meeting of the newly-formed Scottish Centre of the Institution of Automobile Engineers will be held on Monday, November 23, at the Institution of Engineers and Shipbuilders in Scotland, Elmbank Crescent, Glasgow, at 7.30 p.m., when Messrs. A. Ludlow Clayden and Harold Burchall will read a paper entitled "Retail Transport," being a summary of the conditions governing the retail delivery of household goods, and a plea for the adoption of the lighter type of commercial vehicle of 5 cwt. to 6 cwt. in preference to the heavier 20-cwt. to 30-cwt. type. The paper will be followed by a discussion. This meeting will be open to all interested in the subject on presentation of their cards at the door, and a good attendance is confidently anticipated.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on a number of colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further particulars concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

South Africa: With reference to the call for tenders by the Johannesburg Municipal Council for the supply of a tramway lay-out (points, crossings, rails, &c.), the office of His Majesty's Trade Commissioner for South Africa reports that certain alterations have been made to the specifications, and that the time for the receipt of tenders has been extended. Sealed tenders, on the proper forms, will now be received by the Town Clerk, Municipal Offices, Plein-square, Johannesburg, up to noon on January 5. It will be observed that the time for the receipt of tenders is limited, and owing to forms having to be obtained from South Africa, this intimation will be of use only to firms having agents in the Union who can be instructed by cable.

Canada: His Majesty's Trade Commissioner for Canada reports that a firm in New Westminster, British Columbia, intends to erect immediately a new grain-elevator and warehouse. The elevator will have a capacity of 51,000 bushels, and will be built so as to allow for the doubling of its capacity by extension of the building.

Italy: H.M. Consul at Milan reports that a firm of agents in that city wishes to secure the representation of United Kingdom manufacturers of iron and steel railway material, railway wheels and axles, fireproof bricks, retorts, crucibles, &c.; iron and steel tubes, pipes, and fittings; iron and steel bars and rods, machine-tools, brass and brass wares, stoneware, earthenware, and chinaware, &c.

Argentina: The *Boletin Oficial* contains a decree authorising the Empresa del Ferrocarril del Sud to carry out irrigation works in the valleys of the rivers Negro and Neuquen, at an estimated cost of 406,928 pesos currency (about 35,600*l*.). A further decree authorises the same company to construct two new canals for the Rio Negro Superior irrigation system, at an estimated cost of 42,500 pesos currency (about 3720*l*.).

France: The British Chamber of Commerce, 9, Rue des Pyramides, Paris, has a demand for British manufacturers of cardboard-making machinery and for manufacturers of perfumery machinery.

THE AURA HYDRO-ELECTRIC INSTALLATIONS IN NORWAY.—A considerable amount of work has already been done in connection with these very important installations, in which much English capital is interested. Most has been done in the Litledale, which adjoins the Sundale. The temporary power-station was within a fortnight of its completion, when the stoppage caused by the war put an end to the work; it is built to supply 2000 horse-power for use in the construction of the large installations. A narrow-gauge railway, 5 miles long, was in use some weeks before the stoppage, for the transport of materials, and the large bridge across the Driva was nearly ready. The railway higher up, leading to the Osbu Lake, had also been commenced, and the 11-mile tunnel from this reservoir had been started at four of the sixteen shafts. Of four rope-lines, one is ready, and the other three nearly so. Above Krogshavn, on the west side of the firth, a distribution basin, 800 metres above the sea, is being constructed, necessitating the excavation of about 18,000 cubic metres of rock, about half of which has been blasted. Several pipe-lines are to lead from the reservoir to the power-station, and the preparatory work for their installation is about ready. Two large quays had also been taken in hand, one having been contracted for at about 40,000*l*. The employees, when the work had to be stopped, numbered 1300 men for the company, 400 for contractors, 16 engineers, &c., and quite a town was in existence.

CANADIAN DOCK PROJECTS.—A dry dock is to be constructed at Owen Sound by the Canadian Shipbuilding and Dry Dock Company, Limited. The company has a capital of 2,000,000 dols., and an Ontario charter. The headquarters are at Owen Sound, which has decided to grant a subsidy to the company in the shape of a cash bonus of 10,000 dols. per annum for a term of twenty years. This bonus is contingent upon the fulfilment of an agreement by which the company must employ at least 200 men daily for an average of 300 days in each year. A site for the dock and plant has been secured upon the bay shore of the city. The dock will be 775 ft. long from caisson groove to head peak, and 104 ft. wide at the top and 21 ft. over the sills. The Dominion Government has passed an Order in Council authorising a subsidy to the Amalgamated Engineering Works, Limited, of British Columbia. The subsidy is to amount to a maximum of 5,500,000 dols., bearing interest at 4 per cent. per annum for a period of thirty-five years. The subsidy is to be granted for the purpose of enabling the company to construct a dry dock at Vancouver, to cost 6,500,000 dols. The Lake Superior Dry Dock Construction Company, Limited, with an authorised capital of 1,000,000 dols., and a bond issue of 785,000 dols., was originally organised to build a dry dock at Sault Ste. Marie, Ontario. The City of Sault Ste. Marie has voted a subsidy to the company of 20,000 dols. per annum for a term of twenty years, subject to the payment by the company of taxes on a fixed assessment, which would return to the city about 10,000 dols. annually. The Dominion Government has also granted a subsidy of 3 per cent. per annum upon 1,386,528 dols. for a term of twenty years.

NOTE ON THE TRANSFORMATIONS OF STEELS.*

By H. De Nolly and L. Veyret (Saint Chamond, Loire).

I. Reversible, or Almost Reversible, Transformations.

Two theories have been put forward to explain the variations in properties which correspond with the transformation point in steels.

1. *The Carbide Theory*, which attributes these variations to a single phenomenon—the solution of carbide in an excess of the metal, with the formation of a solid solution (Arnold).

2. *The Allotropic Theory*, which assumes a dual phenomenon: (*a*) an allotropic transformation of iron (α iron into β or γ iron), and (*b*) the solution of more or less dissociated carbide in the γ iron. γ iron either does not dissolve the carbide, or the carbon, or dissolves it only to a slight extent (Osmond).

The authors, on the other hand, believe that there is a more or less complete dissociation of the carbide accompanied by the solid solution in the γ iron, of the carbon liberated by this dissociation.† They reserve, however, further explanations on the subject to the end of the present paper.

The first-named theory is seductive by reason of its simplicity, but it would seem to explain, rather indifferently, certain facts observed on close examination of the dilatation curves on different steels.‡ On the other hand, the second theory can, without much difficulty, be made to square with the observed facts. It is only needful to admit that the allotropic transformation of α iron into γ iron produces a shrinkage, whereas the dissociation of carbide, accompanied with solution, causes dilatation, which agrees, besides, perfectly well with the authors' own theory, as it is difficult to admit that solution, pure and simple, should be accompanied by an increase in volume—a fact which is indeed observed but very seldom—whereas dissociation is nearly always accompanied by increase in volume. To show that this hypothesis satisfactorily explains the phenomena actually observed, let us study the dilatation curves of reversible carbon steels of varying degrees of hardness.

Dead-Soft Steel (*Carbon, Traces*).—According to the carbide theory, the variation in volume of a dead-soft steel should be very small, seeing that the proportion of carbide is very small. According to the allotropic theory, on the contrary, a considerable shrinkage should be observed, seeing that the transformation of α iron into γ iron which causes this contraction is at its maximum, while the carbide, the passage of which into solution tends to produce dilatation only, exists as traces. This is just what is found; shrinkage is much more marked in dead-soft steels than in hard steels (Figs. 1, 2, 3, and 4).

Eutectic Steel (*Carbon about* 0.9 *per Cent.*)—The phenomenon is a double one, as the second theory enables one to foresee. There is, to begin with, a shrinkage B C, Fig. 2, on heating, due to the transformation of α iron into γ iron; this shrinkage is less marked than in the dead-soft steels—(1) because the steel contains less γ iron, and (2) because the carbide commences to dissociate and to dissolve in proportion as γ iron is formed, and occasions a dilatation which tends to attenuate the contraction due to the allotropic transformation. During the allotropic transformation the carbide does not have time to pass into complete solution; the excess of carbide continues to dissolve once this transformation is finished. There may be seen, as a matter of fact, on the curve a portion C D corresponding with an abnormal dilatation. From the point D onwards the whole of the carbide is dissolved, and the steel dilates in a normal manner.

On cooling, the reverse phenomenon is observed. There is a dilatation F G corresponding with the transformation of γ iron into α iron, a dilatation limited by the precipitation of carbide, which has not become complete at G, and continues along G H, accompanied by shrinkage. Beyond the point H all the carbide is precipitated, and the steel contracts normally* (see Fig. 4 and Fig. 2).

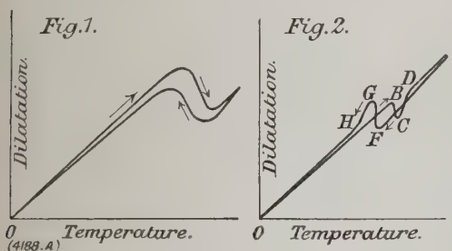
Only one shrinkage is observed if the heating be gradual enough to allow the carbide time to dissolve during the transformation. After rapid heating a slight dilatation is observed after the transformation, owing to the solution of the excess of carbide, which has not had time completely to dissolve during the transformation. This dilatation is weaker the softer the steel, and becomes nil in dead-soft steel (see Fig. 3).

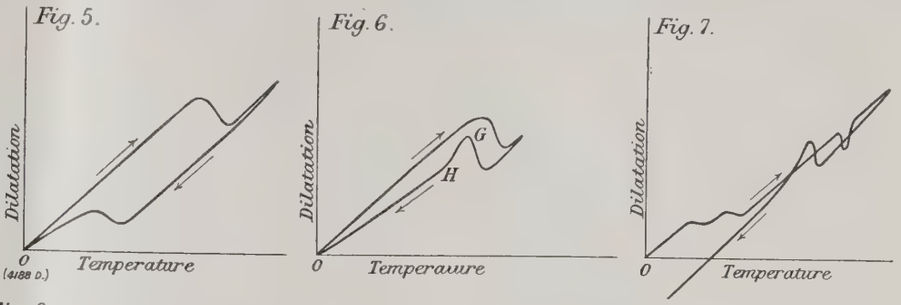
Hypereutectic Steel.—The curve is similar to that of eutectic steel; the portion of the curve C D is more prolonged because it corresponds with the solution of the whole of the hypereutectic carbon.

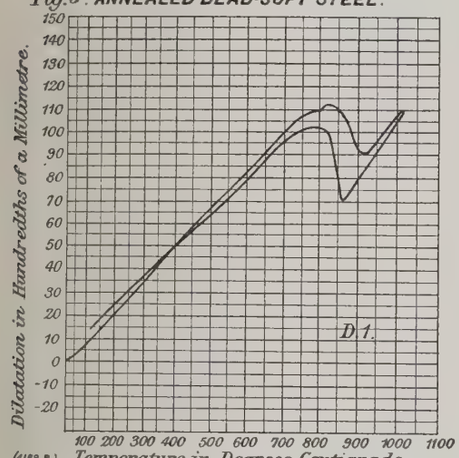
II. Irreversible Transformations.

The true phenomena just investigated do not always occur with the same ease; the curves relating to the eutectic steel show clearly that the solution or precipitation of the carbide lags behind the allotropic transformation of the iron both during heating and during cooling.

It may therefore be foreseen that by sufficiently







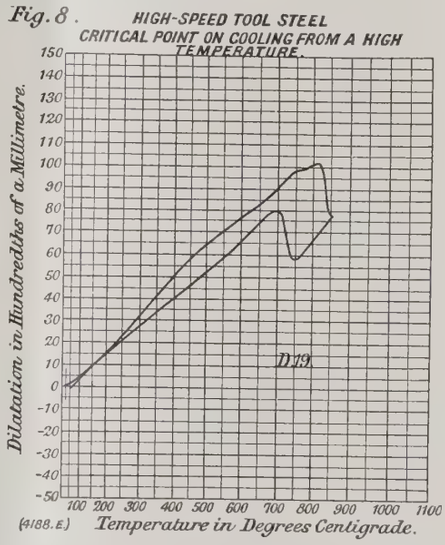


Fig. 8. HIGH-SPEED TOOL STEEL
CRITICAL POINT ON COOLING FROM A HIGH TEMPERATURE.
Dilatation in Hundredths of a Millimetre.
D.19.
(4188.E.)
Temperature in Degrees Centigrade.

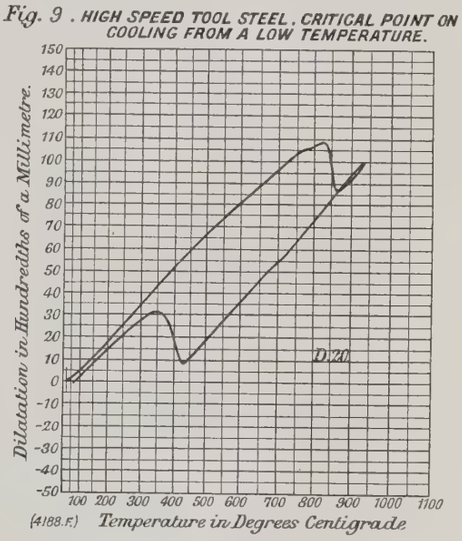


Fig. 9. HIGH SPEED TOOL STEEL. CRITICAL POINT ON COOLING FROM A LOW TEMPERATURE.
Dilatation in Hundredths of a Millimetre.
D.20.
(4188.F.)
Temperature in Degrees Centigrade

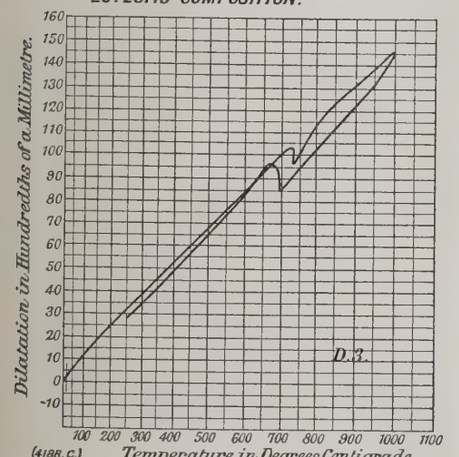


Fig. 4. VERY HARD STEEL ANNEALED. PERCENTAGE OF CARBON SOMEWHAT HIGHER THAN THE EUTECTIC COMPOSITION.
Dilatation in Hundredths of a Millimetre.
D.3.
(4188.C.)
Temperature in Degrees Centigrade.

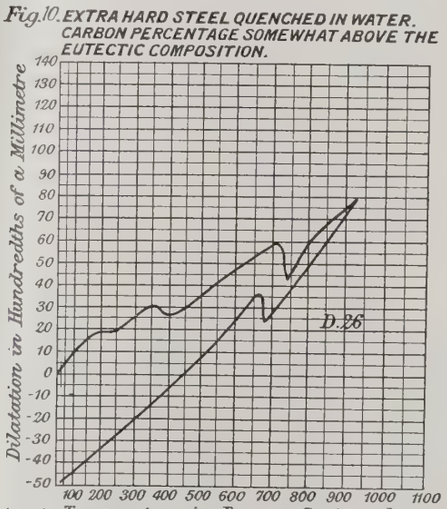
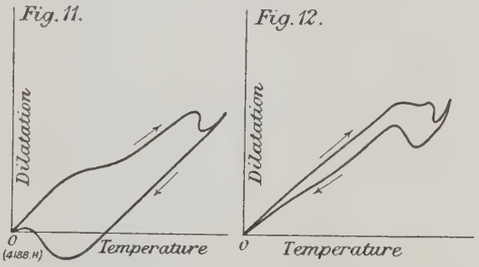


Fig. 10. EXTRA HARD STEEL QUENCHED IN WATER. CARBON PERCENTAGE SOMEWHAT ABOVE THE EUTECTIC COMPOSITION.
Dilatation in Hundredths of a Millimetre
D.26.
(4188.G.)
Temperature in Degrees Centigrade



* Paper contributed to the Iron and Steel Institute.

† See Guillet, *Etude Industrielle des Alliages Métalliques.*

‡ In the figures interpolated in the text the authors have purposely exaggerated the bends observed on the curves. On the other hand, the different diagrams grouped together at the end of the paper reproduce the dilatation curves just as they were obtained on the recording instrument.

* Mr. Le Chatelier long ago pointed out the presence of a dilatation following the shrinkage which occurs at the critical point on heating. The authors believe themselves to have found herein a plausible explanation of this fact.

rapid heating (carbon steel), or by carrying out the transformation as a temperature artificially lowered (special steels), the precipitation of the carbide may be obviated. The γ iron will certainly be transformed into α iron, but the carbide will remain dissolved in a state of supersaturation in the α iron. This solution of α iron supersaturated with carbide in a more or less dissociated state, would be "martensite."* Several facts appear to confirm this hypothesis :—

1. The shrinkage G H (Fig. 2), due to the precipitation of carbide being suppressed in a hardened eutectic steel, this steel should possess a lower density than the annealed steel. This is just what is found.

2. In the cooling curves of self-hardening steels the shrinkage G H should not occur, seeing that the carbide remains dissolved. This, as a matter of fact, is what the authors have found in all the curves relating to self-hardening steels which they have taken, no matter what

Fig. 13. ANNEALED CHROMIUM NICKEL STEEL.

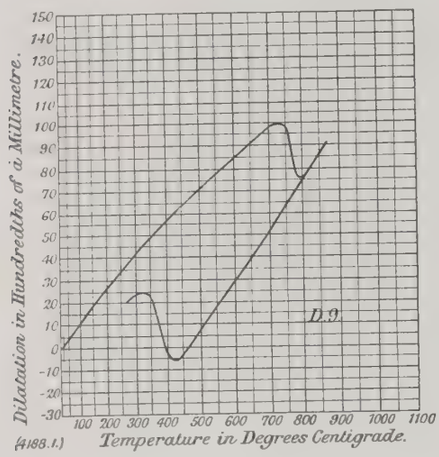


Fig. 14. CHROMIUM NICKEL STEEL QUENCHED IN WATER.

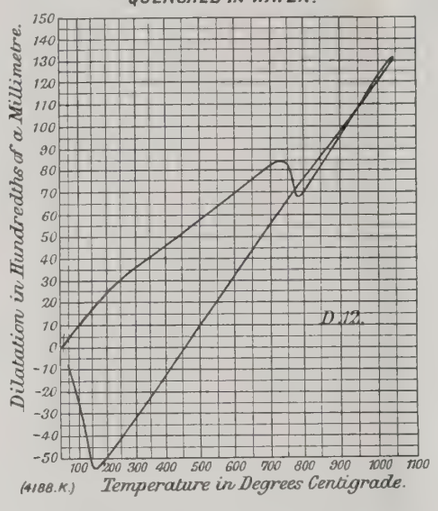


Fig. 15. ANNEALED HIGH-SPEED TOOL STEEL.

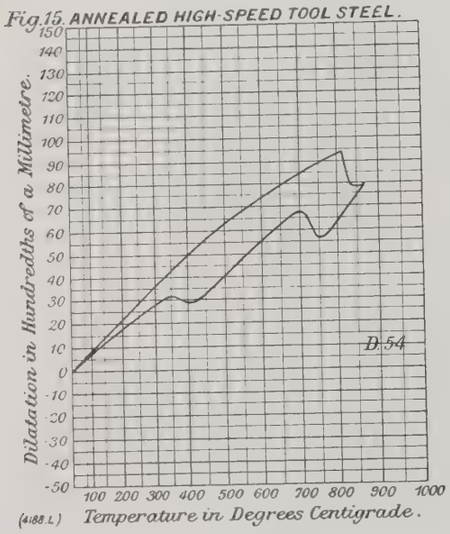
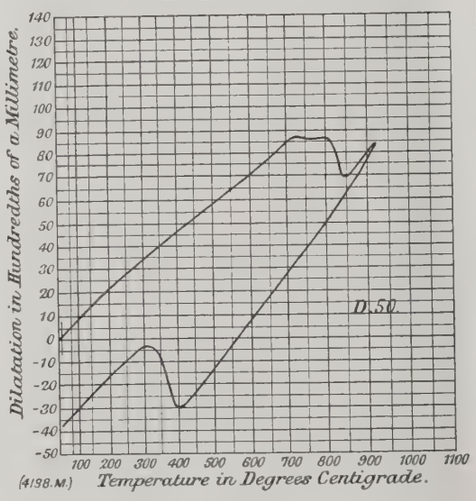


Fig. 16. HIGH-SPEED TOOL STEEL QUENCHED FROM A HIGH TEMPERATURE IN OIL.



their composition. In high-speed steel especially there may be seen fairly clearly the bend G H in the curve, when the critical point on cooling occurs at a high temperature (Fig. 6). In the opposite case (Fig. 5) this bend is completely suppressed. The first-named steel is pearlitic ; the second is martensitic (see Figs. 8 and 9).

3. The precipitation of the carbide on tempering, after quenching (transformation of martensite into troostite), should correspond with a shrinkage of the steel. This the authors have observed in all the martensitic steels.

In the hard carbon steels quenched in water (Fig. 7) this shrinkage takes place between about 200 deg. and 400 deg. Cent.† (see Fig. 10). In some self-hardening chromium-nickel steels this shrinkage, somewhat less marked than in the preceding instance, occasions nevertheless a well-marked bend in the curve, between 200 deg. and 400 deg. Cent. (Fig. 11, see also Figs. 13 and 14). In high-speed steel this shrinkage does not occur until about 700 deg. to 750 deg. Cent., which agrees closely with the softening point of these steels (Figs. 12, 15, and 16).

Notes on the Dissociation of Cementite.—The question of the dissociation of the carbide has given rise to a certain number of controversies. Some authors believe that the carbon becomes dissolved in the state of carbide ; others, that the carbide dissociates, and that it is the carbon which dissolves in the γ iron. These two views are, perhaps, somewhat extreme. The first-named hypothesis does not adequately explain the separation of graphite which is observed in silicon steels after prolonged heating,* while, on the other hand, the second hypothesis does not square with the cementite precipitation of ordinary carbon steels. It seems to the authors more reasonable to allow that the carbide undergoes a partial dissociation. The austenite would be composed of a solid solution of iron, carbon, and iron-carbide in a state of chemical equilibrium ; the relative proportions of the various constituents corresponding with equilibrium would vary with the temperature and the composition of the steel. There would thus be a homogeneous system analogous to the system hydrogen and iodine vapour. According to the respective solubility of carbon and carbide (Fe_3C) in the γ iron, it would be possible, on cooling, to obtain either graphite or carbide.

In ordinary steel the carbide would be the first to attain its saturation point ; it would commence to separate, and at the same time there would be formed in the solid solution a partial combination of iron with carbon, in order to re-establish the chemical equilibrium destroyed by the precipitation of Fe_3C. It can be understood from this how it is that only cementite is obtained on slow cooling, the carbide reforming the solid solution, at the expense of the carbon present, in proportion as the crystals of cementite separate out.

If the steel contain a high proportion of silicon the solubility of the carbon in the γ iron is considerably reduced, and it will then be the carbon which will, first of all, attain saturation point. A deposit of graphite, and at the same time a further dissociation of carbide in the depths of the solid solution, will be obtained to adjust afresh the chemical equilibrium. Slow cooling carried out under these conditions could lead therefore only to the separation of graphite by itself. It might be, besides, that an intermediate system is formed, which would allow of either carbon or graphite being deposited according to the temperature. The same theories can be applied to the consideration of molten cast iron.

PHYSICAL APPARATUS.—The Council of the Physical Society have decided not to hold the usual exhibition during the present session.

* Several authors admit that martensite is formed by a solution of carbon or of carbide in α iron.

† Maurer, *Revue de Métallurgie*, October, 1908.

* Charpy and Cornu, *Comptes Rendus*, May 26, 1913.

CATALOGUES.

Oil-Engines.—A new catalogue of stationary and portable oil-engines has reached us from Messrs. Marshall, Sons and Co., Limited, of Gainsborough. These engines are of the horizontal, two-cycle, semi-Diesel type, and will work with crude, refined, and residual oils as fuel ; the consumption of good crude oil is given as 0.6 pint per brake-horse-power hour at full load. The catalogue explains the system of working, and gives a complete general specification covering the construction of the engines. They are made in ten sizes, ranging from 6 to 50 horse-power, in both the stationary and portable types. Tables of weights, dimensions, and other data are included in the catalogue.

Aerial Ropeways.—We have received from Messrs. John M. Henderson and Co., of King's Engineering Works, Aberdeen, a booklet illustrating and describing some interesting examples of aerial ropeways constructed by them. One of these, at Clee Hill, Shropshire, has a length of $3\frac{3}{4}$ miles, and is used to carry granite from a quarry to the railway. Its capacity is 60 tons per hour carried in individual loads of 10 cwt. each, at a speed of 300 ft. per minute. Another, at Loch Leven, Scotland, has a length of $4\frac{1}{2}$ miles, with a difference in altitude of 1100 ft. against the loads. Individual loads of 6 cwt. each are carried at a speed of 300 ft. per minute, and the capacity of the line is 700 to 1000 tons a day. Several other ropeways erected in this country or abroad, and handling timber, stone, ore, town refuse, colliery refuse, and other materials are illustrated in the booklet.

Drying Plant.—The Sturtevant Engineering Company, Limited, of 147, Queen Victoria-street, E.C., have issued a small catalogue relating to their system of drying, which is applicable to all kinds of materials. The drying is usually effected by the circulation of warm air, the air being heated by passing it through a bank of steam-pipes of comparatively small diameter. The catalogue illustrates examples of plants for drying skins and hides, laundry work, wool, rags, fibre, yarns, timber, and other goods, all these plants being constructed on the above-mentioned principle. A rotary drying-plant, and a plant for drying the interiors of casks by the rapid circulation of cold air are also illustrated in the pamphlet. Illustrations of different types of fans, steam-traps, and other accessories are included, together with a useful table and chart, from which the quantity of moisture in air at different temperatures can be obtained.

Fans.—The Alldays and Onions Pneumatic Engineering Company, Limited, of Great Western Works, Birmingham, have issued a catalogue giving prices and particulars of their "Sertus" propeller-fans. The special feature of these fans is the boss of the propeller, which is designed so as to prevent the return of air which takes place at this part in propellers of the usual design. Another point worth mentioning in connection with these fans is that the frame is square instead of circular, as usual. The fans are thus simpler to fix, and the corners do not require to be filled in, as is necessary with circular fans. They are supplied either with electric motors or belt-pulleys for driving, and are listed with capacities ranging from 950 cub. ft. to 50,000 cub. ft. of air per minute. "Serlano" open-running wall-fans are also dealt with in the catalogue. These fans are of the centrifugal type, and are intended for use where large volumes of air have to be moved against a greater resistance than can be overcome by fans of the propeller type. Sizes, weights, capacities, and other particulars of these fans are given, but prices are not stated.

Metal-Working Machinery.—A very useful and attractive catalogue of presses and dies, shearing-machines, rolling-mills, and other metal-working machinery has been issued by Messrs John Hands and Sons, Limited, of Cardigan Works, Birmingham. Full particulars are first given of single-ended and double-ended direct driven presses especially suitable for hot clipping and trimming of drop-forgings and other work of this class ; they are made in many different sizes and patterns. Grooving and nibbling presses, geared presses, self-feeding presses, overhung and inclinable presses, shearing-presses, drawing-presses, fly-presses, forging-presses, and coining-presses, are similarly dealt with. The catalogue also includes particulars of planishing-hammers, seaming and curling-lathes, spinning-lathes, shearing-machines of all types (including circular shears and heavy billet shears), slitting-machines, and rolling-mills. In conclusion, numerous examples of presswork produced by the firm's machines and dies are illustrated. The catalogue is extremely well printed and illustrated, and very conveniently arranged ; it is, in fact, in all respects, a highly creditable publication.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Since the reading of Mr. Pomeroy's paper on "Automobile Engineering and the War," the Institution has been endeavouring to arrange a conference between automobile engineers and steel-makers of this country, but no success has attended these efforts up to the present owing to the enormous volume of work the steel-makers already have in hand. The Council have now arranged to hold a meeting in the Midlands at which Mr. Pomeroy will read another paper, dealing in somewhat greater detail with the needs of automobile engineers in the direction of stampings, forgings, and castings. The desire is to get together those who can supply such parts, or might be prepared to undertake the supply of such parts, and to talk the whole question over with automobile manufacturers who are at present in difficulties. It is hoped that this paper will be read early in December, and that a large muster of those interested will be present.

GRANARY AT GLASGOW HARBOUR.

(*Continued from page* 585.)

Having in previous articles illustrated and described the granary, which is specially interesting not only for its size and for the combination in the one building of ordinary construction and ferro-concrete work, which latter is on the Considère principle as designed by the Considère Construction Company, Limited, London we now turn to the ship-discharging, conveying, and distributing machinery. As mentioned in our introductory article, this embodies the fullest experience and latest practice, having been constructed by Messrs. Spencer and Co., Limited, Melksham, Wilts, who have made grain-handling machinery a speciality for many years. The drawings illustrating the complete installation at the Glasgow Granary, the publication of which we begin this week, are therefore of great interest. But first a general idea of the arrangement of the plant may be given.

The granary is built practically parallel to, but at a distance of about 220 ft. from, the quay on the river side, and on the quay there is laid for a length of 900 ft. a rail-track of 20-ft. gauge for two travelling ship-discharging elevators. A subway is provided in the back of the quay-wall for two lines of band-conveyors. The two elevators are each capable of taking 250 tons of grain per hour from a steamer, and each is provided with two 4000-lb. automatic machines for weighing the grain as elevated. After being weighed it is discharged on to the longitudinal band-conveyors running parallel to the quay, and delivered by them to transverse band-conveyors, running in an underground subway connecting quay and granary, which carry it to the bottom of the main elevators inside the granary. Two main elevators, each capable of dealing with 250 tons per hour, raise the grain to the conveyor gallery at the top of the building and discharge it on to longitudinal band-conveyors for distribution. Two of these conveyors extend over the silo portion of the granary, and enable grain to be deposited in any one of the 150 separate bins. The other two conveyors, which extend over the floor-storage portion of the granary, can deposit grain on any of the eleven storage-floors by means of vertical down-spouts, spaced at 12 ft. apart centres, all over the floor granary. The arrangement for turning over grain within the granary and delivering it into barges, railway-wagons, or road vehicles, in bulk or in sacks, will be dealt with in our next article.

Fig. 75.

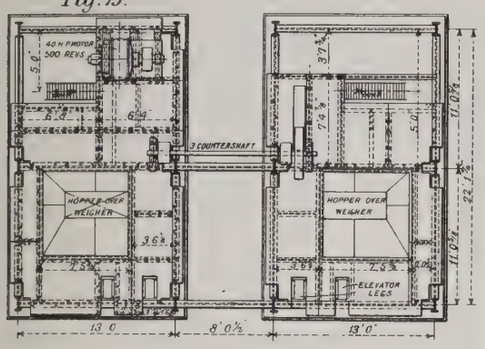


Fig. 76.

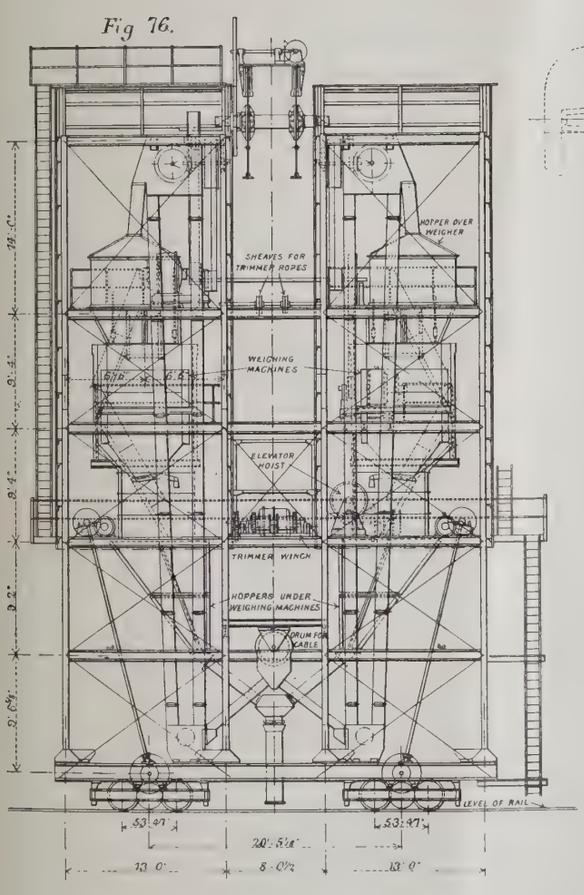
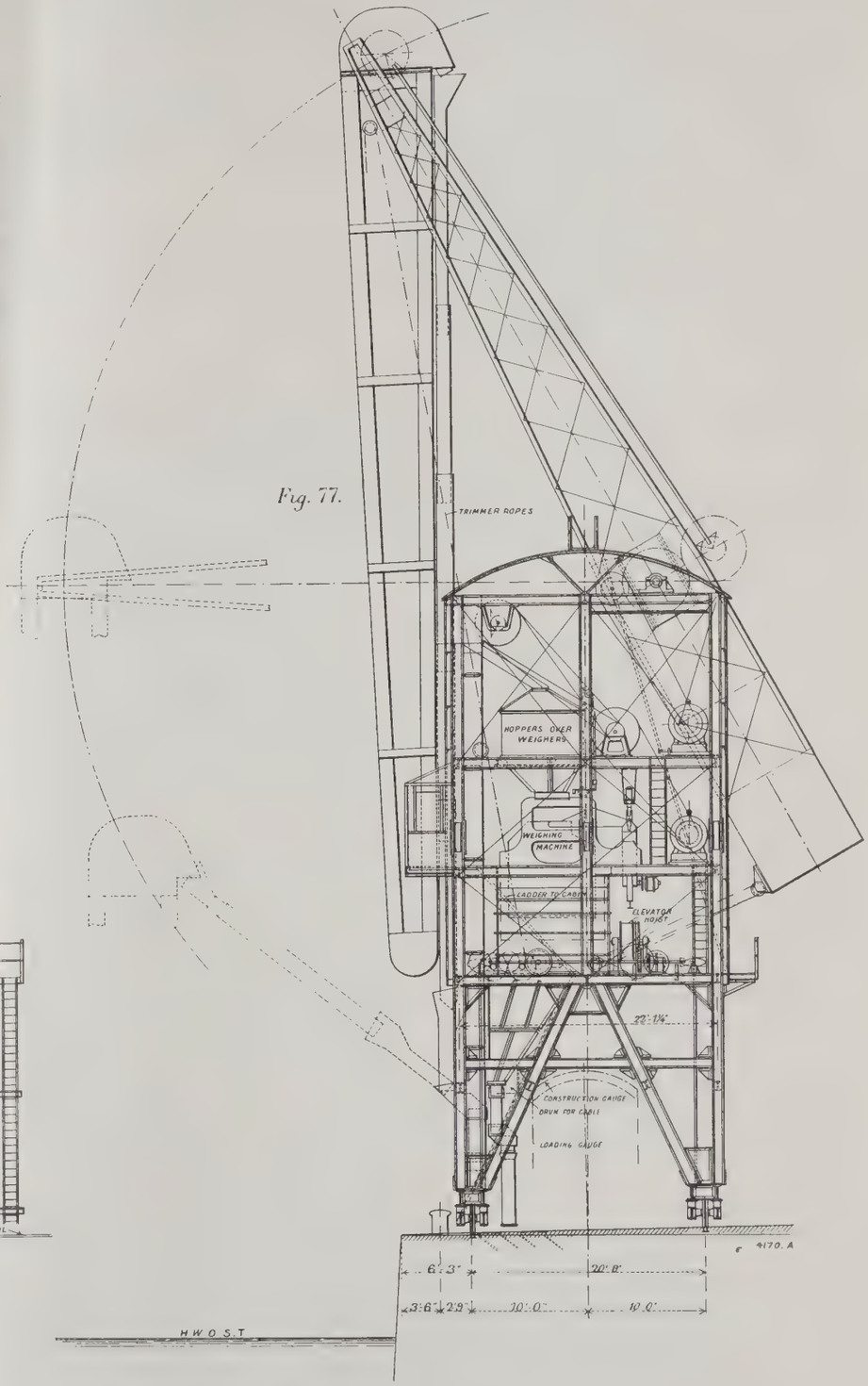


Fig. 77.



Figs. 75 to 77. Travelling Elevator on Quay for Discharging Grain from Ships.

One of the two travelling ship elevators, running on rails on the quay, is illustrated above. These elevators are traversed electrically along the quay at a speed of 20 ft. per minute, and each is capable of discharging grain in bulk at the rate of 250 tons per hour. Fig. 75 is a plan, Fig. 76 a front elevation, and Fig. 77 a cross-section through the travelling structure carrying the ship elevator, which is shown in the housed position. The approximate weight of the structure is 200 tons. The extreme working positions of the elevator are denoted on

Fig. 77 by the dotted lines, and this range covers the largest and smallest vessels at all states of the tide. The telescopic shoot is shown delivering the grain into the hoppers at the bottoms of the two weighing-elevators. By referring to Fig. 76 it will be seen that the maximum intake can be dealt with expeditiously by means of the two weighing-elevators mentioned above, which are placed on the sides of the structure, each delivering into an automatic weighing-machine, capable of dealing with 4000 lb. of grain at each weigh, without retarding in any way the continuous flow of grain.

The grain, after being weighed, is discharged through the fixed shoots in the quay on to either of the two conveyors in the subway at the back of the quay-wall. Details of these conveyors in the subway are shown in Figs. 78 to 81, on Plate XLII. accompanying this issue, and a perspective view is given in Fig. 88, on page 640. The shoots are to be seen in Figs. 80 and 88. These conveyors are in duplicate, and each is capable of dealing with 250 tons of grain per hour, so that both ship-elevators can work at the same time. The quay is on a curve of 1 mile radius, and the conveyors are arranged in a series of tangential straights; the junction between one set of conveyors and the next is clearly shown by Figs. 78 and 81, which, with Fig. 79, show the motors driving them. The hand-wheels and mitre-gear for taking up the slack of the conveyor-bands are also shown in Figs. 78 and 81.

The quay-side conveyors deliver on to two intake conveyors running at right angles to them, and placed in a subway leading to the elevator-pit in the centre of the granary. The intake subway machinery for passing the grain from the conveyor to the elevators is illustrated by Figs. 82 to 86, on Plate XLII., and by Fig. 87, annexed. The intake conveyors will be seen on the left-hand side of Figs. 82 and 86, delivering into shoots feeding the main intake elevators.

The two main intake elevators are of the continuous-bucket type, each with a capacity of 250 tons per hour. Perspective views of the elevator-heads and the buckets are given in Figs. 90 and 91, page 646. The grain is raised to the top of the tower and delivered on to four longitudinal troughed band-conveyors, which we will illustrate in detail in our next article. Figs. 82, 83, and 86 also indicate the loading-out bulk and sack band in the intake subway, the bands in the longitudinal basement subways of the granary, and the short transverse band at the north end of the intake subway, the latter bands being for the purpose of turning over grain in the granary or loading out to barges at the quay. Fig. 89, page 646, gives a perspective view of one of the longitudinal basement subways, with band capable of conveying 100 tons of grain in bulk or 500 sacks per hour. These we will deal with in our next article.

(To be continued.)

GRANARY AT GLASGOW HARBOUR.

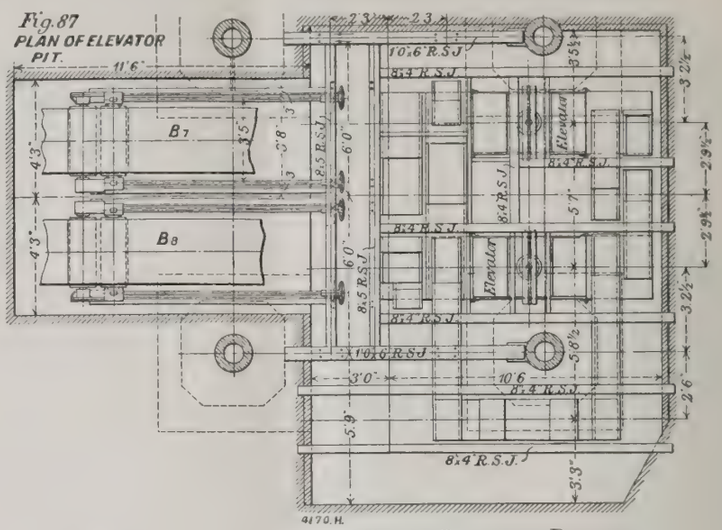


FIG. 87. PLAN OF ELEVATOR-PIT IN CENTRE OF BUILDING.

THE INSTITUTION OF MECHANICAL ENGINEERS

AN ordinary general meeting of the Institution of Mechanical Engineers was held on Friday last, the 20th inst., at Storey's Gate, Westminster, the chair, in the unavoidable absence of Sir H. Frederick Donaldson, being occupied by Mr. Michael Longridge, Vice-President.

THE LATE MR. E. B. ELLINGTON.

In opening the proceedings the Chairman referred to the heavy loss which the Institution had sustained in the recent death of their Past-President, Mr. Ellington, whose duties in the chair had been conducted with such dignity and courtesy, as well as tact and sound judgment in dealing with difficult and delicate situations. Few outside the Council knew how great and constant had been his work for the Institution, and how diligently and wisely it had been done. The record of that work would be adequately dealt with in the memoir which would be published in the Proceedings. One matter might be referred to in the meantime—namely, the Institution Building. The burden of the work in connection with the enlargement of the building fell upon Mr. Ellington, and it would stand as a memorial of him. The President had written to Mrs. Ellington expressing how greatly the Council of the Institution honoured her husband in his life and the regret that all felt at his death. He was sure that the meeting would be glad to pass the following resolution :—

"The Council and members of the Institution hear with the keenest regret of the decease of their late esteemed Past-President, Mr. Edward Ellington, who, by his business ability, his tact, and his unfailing readiness to forward the progress, prestige and usefulness of the Institution, leaves a mark and example to his successors which will undoubtedly bear fruit for the further progress of the Institution. They resolve that the heartfelt expressions of sympathy be conveyed to Mrs. Ellington and her family in the loss they have sustained."

GARRISON ARTILLERY.

The formal business of the meeting having been next despatched, the Chairman remarked that since the last meeting the Institution had been asked to find men for commissions in the Garrison Artillery, to serve in England, and possibly in Malta. A number of names had been sent up, and he was glad to say that from among those names the required number of men had been selected and put forward for commissions.

EFFECT OF VACUUM IN STEAM-TURBINES.

A paper entitled "The Effect of Vacuum in Steam-Turbines," by Mr. G. Gerald Stoney, F.R.S., Member, was then read in abstract by the author. This paper we print in full in another part of this issue.

After passing a vote of thanks to the author, the Chairman said that to those who had not had to do with the design of turbines and their condenser plant the paper might appear to be an amplification of the well-known home truths that a reduction of back pressure increased the power of the turbine, and that an increase in the quantity of cooling water and in condenser surface, as well as in the efficiency of air-pumps, reduced the back pressure. The paper, however, made a very serious attempt to correlate broadly the effects produced and the conditions producing them. He considered Figs. 1 and 2 of the paper to be a set of very useful and reliable curves. They showed the increase in power expressed in thermal units, or, perhaps, increase in the quantity of heat convertible into work per pound of steam expanded adiabatically from 175 lb. and 15 lb. pressure to various degrees of vacuum. In a turbine the expansion was very approximately adiabatic, and therefore he thought that the curves might be considered fairly reliable. The only point he would suggest about them was that, instead of using the expression "British thermal units available per pound of steam," the words "power per pound of steam" or "heat convertible into work per pound of steam expanded adiabatically" should be adopted. That was really what was meant. The B.Th.U. available were the B.Th.U. which could be converted into work in adiabatic expansion. He thought it would be advantageous if a foot-note were added showing the formula by which the curves were obtained. The formula was a common one, but not known to all, especially with regard to superheating. He was not so certain with regard to the curves in Figs. 3 and 4. They were got out, in the first place, on the supposition that the transmission was proportional to the difference of temperature between the steam outside and the water inside the tubes, and that, doubtless, was a fairly true assumption. He did not, however, consider it quite true that the temperature of the water leaving the condenser to go to the pump was always the same as the temperature of the steam. There were many cases in which it was a good deal colder, and he had found cases in which the temperature T was not by any means constant, but higher at the top of the condenser than at the bottom. That was due to steam not getting freely through the tubes, but the point was rather a small one. The important point about the curves was that the quantities the designer wanted were the amount of water X which had to be passed through the condenser, and S, the reciprocal of the surface, or the number of pounds of steam condensed per square foot of surface. That depended upon K, which was a very variable quantity; it depended not only upon X and S, but certainly also upon the speed with which the water went through the condenser. One other point. Mr. Stoney had given the proportionate weight of various parts of a turbine plant; it would, he thought, be a great advantage if the comparative prices could also be given. The cost of working a plant was important, and the cost of amortisation of the capital was no small a proportion of the total expense of working.

Mr. D. B. Morison, who spoke next, observed that the turbine appreciated vacuum to a greater extent than any other steam-engine. The commercial turbine of the present day was bladed for the highest vacuum that could be obtained with the condensing water available. The effect of vacuum on a turbine bladed for, say, 26 in. of vacuum was also considerable, provided the exhaust-chamber was suitably designed. An ideal exhaust-chamber was one in which the steam issuing from the last row of blades was conducted to the condenser by a diverging nozzle, suitably directed and adequately proportioned; in practice that was very difficult to attain. Designers of turbines were giving more and more attention to the contour of the exhaust-chamber, as they realised that on its correct proportions depended the degree of vacuum which could be responded to by the turbine. Perhaps the most interesting turbine on the marine side was the geared turbine. The geared turbine was of such a design as would enable the highest attainable vacuum to give almost the theoretical economy due to that vacuum. Consequently the marine geared turbine should be bladed for the highest vacuum that was obtainable in the coldest water in which the vessel traded. It was quite an easy matter to ascertain what was the limiting vacuum in any turbine plant; and it was not only easy, but exceedingly instructive, because if a higher vacuum were carried than the turbine would respond to, the effect or the loss would be twofold, in that the turbine efficiency was sacrificed; the condensate was lowered in temperature, and therefore the efficiency of the boiler was sacrificed. As far as the condenser was concerned, the controlling

GRANARY AT GLASGOW HARBOUR; GRAIN-CONVEYING MACHINERY.

MR. W. M. ALSTON, M. INST. C.E., ENGINEER TO THE CLYDE NAVIGATION TRUST, GLASGOW; MR. G. H. BAXTER, M.I. MECH. E., MECHANICAL ENGINEER;
MESSRS. SPENCER AND CO., LIMITED, MELKSHAM, WILTS, CONSTRUCTORS.

(*For Description, see Page* 633.)

Fig. 78. LONGITUDINAL SECTION ON LINE A.A. LOOKING TO RIVER

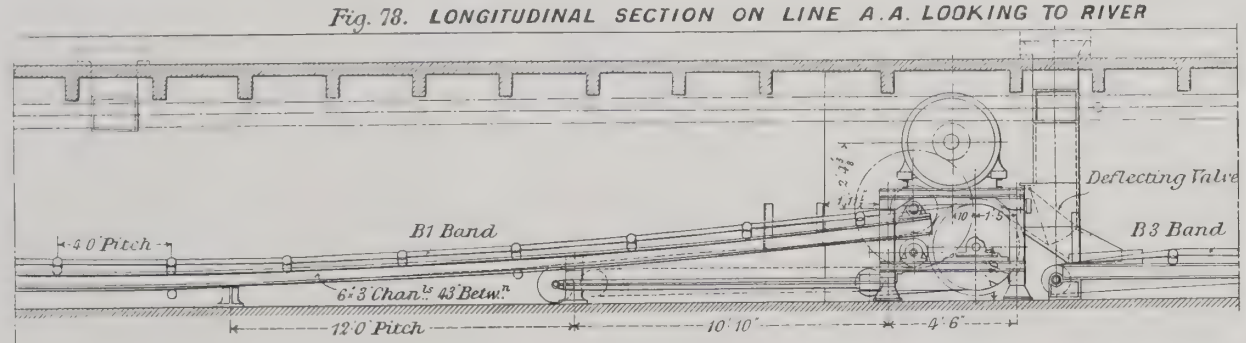
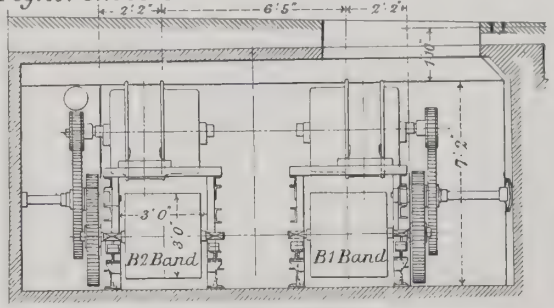


Fig. 79. CROSS SECTION ON LINE B.B.



SECTION ON LINE C.C.
Fig. 80.

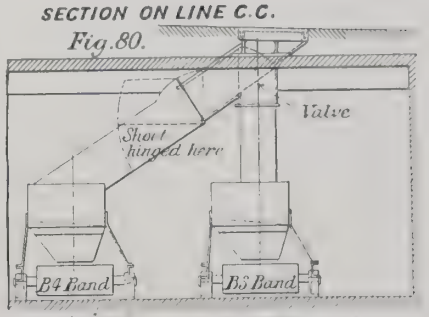
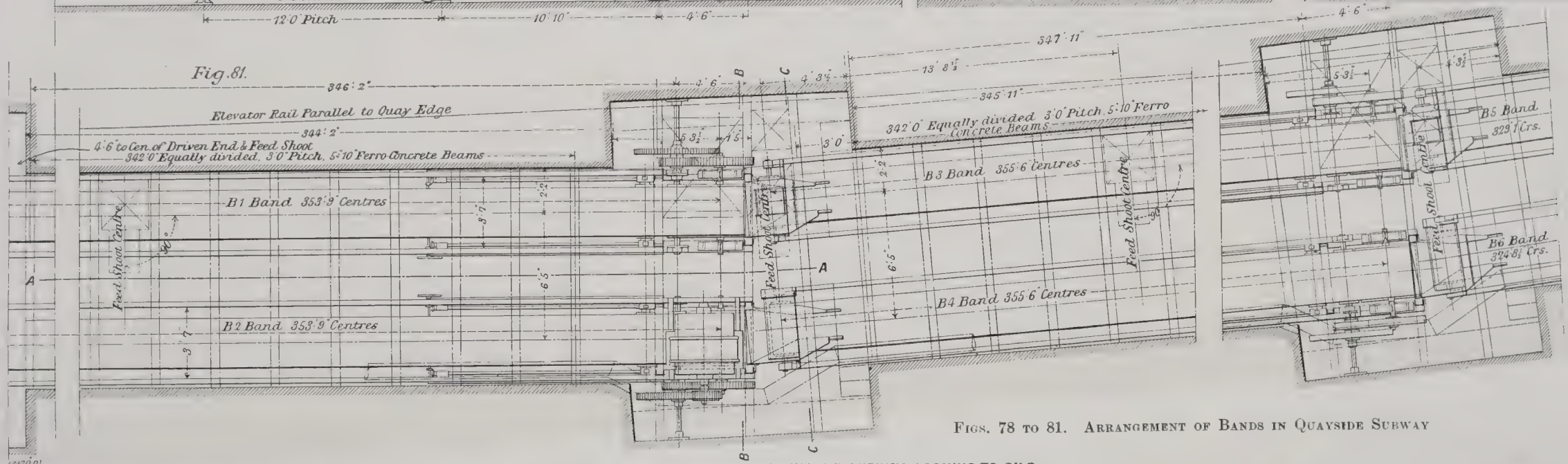
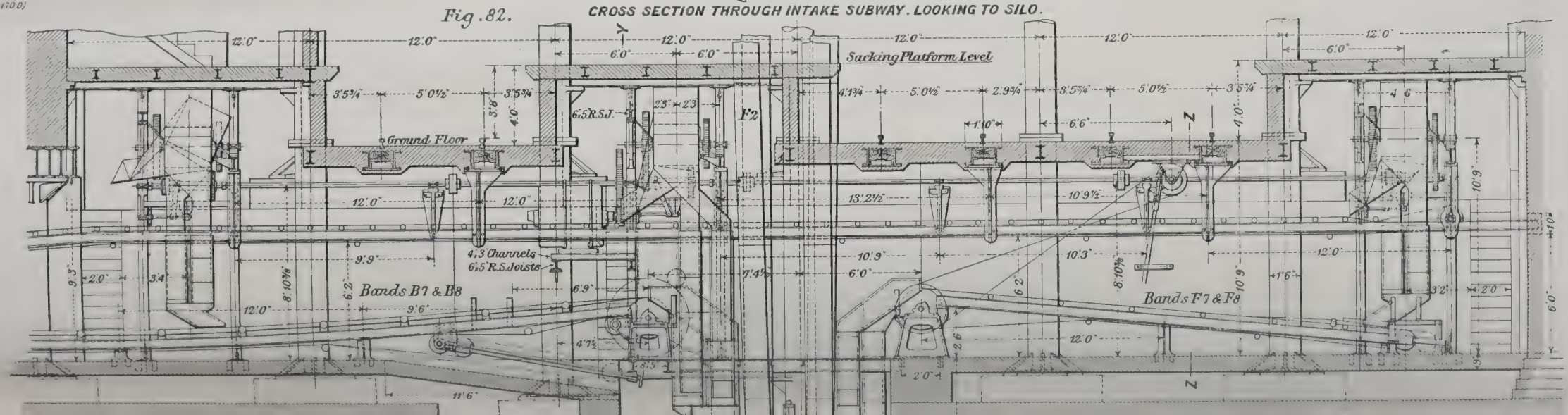


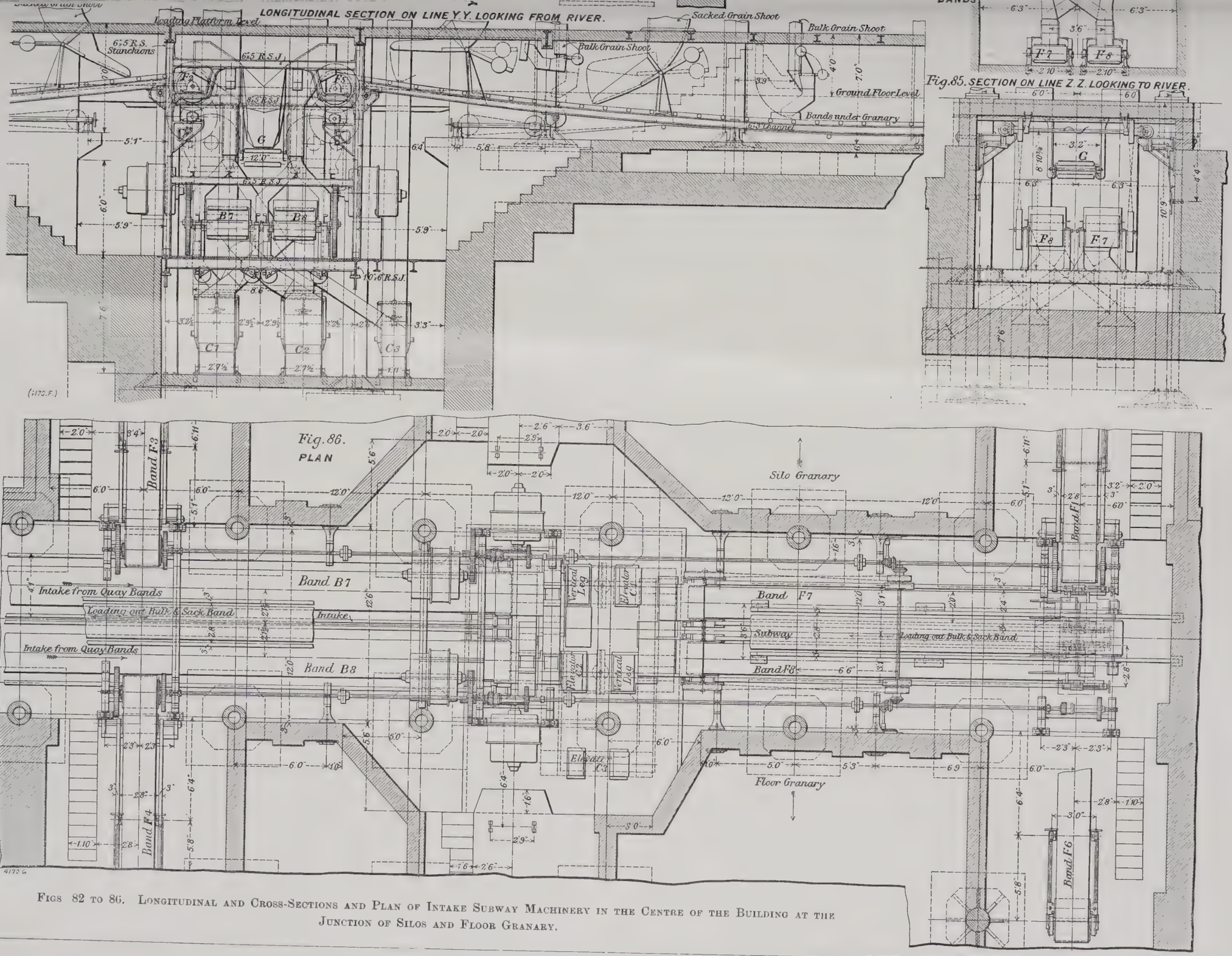
Fig. 81.



FIGS. 78 TO 81. ARRANGEMENT OF BANDS IN QUAYSIDE SUBWAY

Fig. 82. CROSS SECTION THROUGH INTAKE SUBWAY. LOOKING TO SILO.





FIGS 82 TO 86. LONGITUDINAL AND CROSS-SECTIONS AND PLAN OF INTAKE SUBWAY MACHINERY IN THE CENTRE OF THE BUILDING AT THE JUNCTION OF SILOS AND FLOOR GRANARY.

vacuum was that carried in the steam space above the tubes, and it was futile to record any other vacuum in that condenser. The resistance of a condenser was very low indeed, and was the difference in vacua between the top above the tubes and in the air-pump suction-pipe. It was necessary, in order to establish a true resistance, that the air-pump should be one of very high efficiency. The most efficient apparatus for the production of the highest attainable vacuum was undoubtedly a steam-jet. The credit of introducing that apparatus to condenser-designers was due to Sir Charles Parsons. It had been used for creating an initial vacuum in a condenser, and, either alone or in series, in water-coolers for taking the vapour away from the surface of the water to be cooled. But Sir Charles Parsons gave to the world an apparatus by which a vacuum could be obtained in a surface-condenser higher than had ever been obtained before in a commercial plant, and, he thought, by any air-pump apparatus. Mr. Stoney had referred to the importance of a high-efficiency air-pump when a turbine was running below its full load, and consequently when the condenser was lightly loaded. If a condenser were lightly loaded, the condensation took place on a few upper rows of tubes; below that was a large volume of highly aerated vapour — very difficult to condense — prevailing over a large amount of the surface. The only way to bring the temperature which prevailed at the top lower down was to remove that aerated vapour below the condenser-tubes. No apparatus would do that so effectively as a steam jet.

Mr. H. Fothergill remarked that in the case of a modern battle-cruiser, the horse-power at full speed was about 100,000. At cruising speed the horse-power would be about 4000, or 4 per cent. of the full load. At full load there was so much condensate that it might be possible to condense the whole of the auxiliary exhaust steam in the feed-water; but at cruising speeds that was obviously impossible. It was therefore necessary, in order to recover part of the power in the auxiliary steam, to turn it into the turbine. To obtain the maximum economy a high vacuum should be maintained at all speeds. To obtain that high vacuum under full-load conditions would require for driving the air-withdrawing apparatus about $\frac{1}{2}$ per cent. of the steam consumed. At cruising speeds that figure increased to about $7\frac{1}{2}$ per cent. The question was, then, whether that high vacuum was worth the extra percentage of power. Mr. Stoney had said that "much more careful attention was required in the future as to the shape of the exhaust." Till recently, the exhaust passage was not considered; so long as the exhaust was got into the condenser, that was considered as quite sufficient. There was therefore often a battering effect, due to sharp elbows and corners, and the kinetic energy of the steam flowing from the turbine was to a great extent lost; it was only the potential energy, due to the difference in pressure between the inlet to the condenser and the air-pump suction, that caused the flow of steam over the tubes. Those conditions necessitated a very great difference in pressure. As a result, a high vacuum at the exhaust inlet to the condenser was unobtainable. If the steam were guided, or directing-plates were put into the exhaust-steam inlet into the condenser, the kinetic energy of that steam could be utilised for carrying it into the condenser and over the cooling surface, thereby reducing the loss of pressure between that and the outlet. The results given by Mr. Stoney in regard to vacuum in tropical waters seemed excellent. He would like particulars of the arrangement by which that high vacuum had been made obtainable. He was glad that the author had taken up the question of weights. There was a great deal of hesitation as to whether the increase in weight of a condenser due to high vacuum was worth the general increase of weight in the engine-room. It was rather discountenanced by some engineers; but those engineers, as Mr. Stoney had pointed out, seemed to overlook the fact that the size of the boilers could be reduced by this means.

Mr. H. Wheatley Ridsdale asked the author whether he could not differentiate to some extent between the figures which were purely theoretical and due to calculation and those that had been verified by direct observation, not so much for turbines bladed for high vacua as for those bladed for a comparatively low vacuum, such as 26 in., which were and had been worked at higher vacua. It was very important that the exact place where the vacuum was measured should be specified or referred to. He had found it a matter of extreme difficulty to measure the real vacuum at the exhaust from the last row of blades; he had never been able to get satisfactory concordance between pressure and temperature measurements at that position. He thought the point deserved attention. With the tortuous and restricted exhaust-passages imposed upon the designer in many marine installations, which worked frequently under more steam or overload than the designer intended, there must be inequalities of pressure round the annulus of the blades, some blades having a much freer exhaust than others. It was really necessary to know what happened all round the annulus of exhaust-blades close up to them. It was not sufficient merely to say that such and such a vacuum, which was measured at the top of the condenser, affected a turbine in such a way. That was, of course, the proper place to measure vacuum when talking about condenser performance, but the turbine itself might know nothing about what happened there. In his experience of marine practice he had never known a case of a turbine which, however overloaded or inadequately bladed or restricted in its exhaust, did not respond, in the shape of increased revolutions, to any increase in vacuum for a given initial steam pressure. That was a matter which could be easily tested simply by speeding up the circulating pump on one side of a ship, while the other pump was kept at constant revolutions. He had had some opportunity of observing what feed-heaters could do in warships, and he had never known of a case in which the quantity of exhaust steam from the auxiliaries was not greater at full power than the heaters could handle; that being so, it was quite evident that the feed was being given to the boilers at the highest possible temperature, whatever might have been its temperature as condensate. In the case of lower loads, the trouble did not arise so much from not having enough auxiliary exhaust to heat the feed, but from having a great deal more than could be used for the purpose. He had no hesitation in making a general statement that the best vacuum for every marine turbine was always the highest obtainable. It would always be wise to design, in the case of warships, for the very highest vacuum, the reason being that if a warship had to do her work in the warmer seas, the conditions of the temperature and of available space on board might make the upper limiting vacuum which it was possible to obtain so low that the working was not on the most profitable part of the range. It would cost about the same in weight to obtain the last $\frac{1}{2}$ in. of vacuum, whether from 27 in. to $27\frac{1}{2}$ in., or from $28\frac{1}{2}$ in. to 29 in. But the last half inch was nothing like so profitable in the case of the low-vacuum plant as in the case of an installation in which the vacuum was much less restricted. On a vessel he had in view, by cutting down the vacuum from an already low figure, it was possible with the weight saved to increase the boiler plant by no less than 8 per cent.; the steam consumption was, of course, 8 per cent. greater. The power developed, however, was from 2 per cent. to 3 per cent. greater than would have been possible had the 8 per cent. of weight been applied to improving the condensers rather than to increasing the boiler power. In the case of such a vessel, belonging to the destroyer class, the problem was not economy, but of getting the maximum power at full load out of a given weight of machinery. The radius of action at full speed was, of course, reduced by the increased fuel consumption to about 8 per cent. But at lower powers, where the condenser plant became adequate to the lowering of the load, the radius of action was just as great as it would have been had the condenser plant been more liberally proportioned.

Professor H. Hubert, of Liége, desired, in the first place, to take the opportunity of expressing his thanks for the welcome which he, personally, had received, as also for that which had been accorded to his countrymen in England. He would like to direct the attention to one interesting matter—namely, the utility of a high working vacuum for a turbine working with exhaust steam. His friend, Professor Rateau, had, as was known, succeeded in considerably augmenting the output of rolling-mill engines.

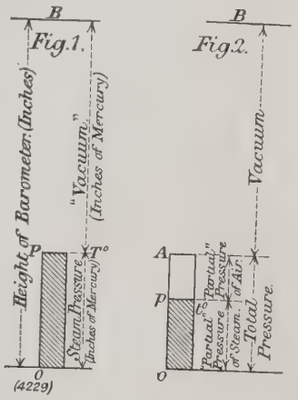
Professor Rateau increased the output of an 800-horse-power reciprocating rolling-mill plant by some 250 horse-power by introducing an exhaust-steam turbine working with steam at a pressure of 1 atmosphere, the water being heated in the accumulator to 100 deg. Cent. For that sort of thing, however, it was essential for the turbine to have a very good condenser; the turbine would be of no use without that. The question was an interesting one for mine-owners and also for the rolling-mill works, because these engines did not use condensers, or used them only with difficulty. He knew of a case in which a rolling-mill engine in Germany had a very good vacuum, but the engine, nevertheless, used the same quantity of steam as when there was no vacuum, because the vacuum never arrived at the engine, on account of the great distance between the engine and the condenser. It was of importance to have a perfect vacuum to work the turbine, and the condenser should accordingly be very near the turbine.

Mr. C. Humphrey Wingfield, who followed, agreed with Professor Hubert as to the importance of making the exhaust-pipe as short as possible, but had found that (with reciprocating engines of destroyers) there was not the same necessity as regarded the height of the air-pump suction.

Mr. Wingfield made two sketches (Figs. 1 and 2 herewith) on the blackboard to show that air mixed with the steam caused the temperature of the exhaust to be lower than that given in steam-tables as corresponding to the observed pressures.

In Fig. 1, which illustrated the case of steam with no admixture of air, the absolute pressure was the difference O P between the height of the barometer and the vacuum shown by a vacuum-gauge. In this case the temperature T would agree with that given by steam-tables for a pressure O P.

In Fig. 2 air was present, and as its pressure was added to that of the steam, or vapour, it followed that if their sum O A were the same as



before (viz., O P, Fig. 1), the steam pressure, O p, must be less than before, as shown in Fig. 2. The temperature in that case would be t deg., corresponding to the pressure O p, instead of T deg., corresponding to the pressure O P. The diagram thus showed that, with equal vacua, the temperature must be reduced when air was present. Anything which reduced the quantity of air would lower the point A (Fig. 2), bringing it nearer p, and the vacuum would be increased by the same amount.

As withdrawal of air reduced the heat insulation, condensation would proceed with greater efficiency, and p would be lowered. As this would cool the feed-water below t, it would probably be best to regulate the circulating water so as to maintain the pressure at p, or even to raise it. If this were done, there would still be a gain if A were lowered more than p was raised. This illustrated the author's frequently-repeated insistence on the necessity for adequate means of removing air.

Mr. A. K. Bruce said he had experience of certain triple-expansion engines, with a steam-pressure of 190 lb. and a superheat of about 80 deg. condensing, employed for driving a mine mill in Australia, combined with an impulse turbine, a surface-condensing plant, and a cooling tower. The cost per unit, with coal at 36s. a ton, was fractionally over 1d. in the case of the triple-expansion engine. With the turbine plant added, although the output was materially increased, the coal cost was not much affected, being reduced to a fraction under 1d. per unit. With a better vacuum at the turbine the coal cost might have been considerably more favourable, and the increased output might have been obtained with increased efficiency and economy. With regard to auxiliary exhaust, the report of the Committee

on Water-Tube Boilers (1900-2) showed that the cruiser Hyacinth, with the auxiliary exhaust turned into the receivers of a four-crank triple-expansion engine, gave at high powers an economy less than with open exhaust. Presumably the steam consumption of the auxiliaries was so much increased by the back pressure that the total consumption per horse-power for propelling purposes was increased. Some interesting data on the utilisation of auxiliary exhaust in heating feed-water was derived from the United States Navy Department. Some time ago the results of tests of three oil-fired destroyers had been published. The vessels ran a standard speed of 29 knots throughout. In one ship the auxiliaries exhausted to the feed-heater, in the second to the low-pressure turbine, and in the third in parallel to both. With the exhaust to the feed-water the economy in oil was 15.2 per cent. better than in the case of the vessel with closed exhaust turned into the low-pressure turbines. With the boat in which feed-heating and closed exhaust were both employed the advantage was 8 per cent., or just between the two. French engineers had reverted to the use of the compound engine in combination with the low-pressure turbine, usually on four shafts. The arrangement was not only very economical, but should be made more so by the use of the most efficient type of turbine and blading, and ordinary compound engines with a fairly small cylinder ratio. These engines exhausted well above atmosphere straight into the turbine.

Mr. Wm. H. Patchell, who spoke next, said we had apparently reached the "condenser age." In power-station construction there had been various ages. At one time the station had to be designed round a given engine ; then round a given boiler. The author's paper touched the bed-rock of the matter. The safest vacuum was taken consistent with the cooling water available, the best turbine possible for a given vacuum was procured ; then, the better the quality of the condenser installed, the better the station would be. It would assist the digestion of the information in the paper if the author would differentiate between the figures representing theoretical gains and those which related to "guaranteed gains," or gains which might be attained in practice. It was astonishing to find what differences of opinion existed among turbine-makers as to the effect of vacuum on their particular turbines. He was not a turbine-designer, and could not say whether the differences were due to the idiosyncracy of the turbine or that of the designer or salesman. It might be the factor of safety, as Mr. Trotter called it, which was sometimes the factor of ignorance, because very few of the designers or makers had an opportunity of accurately checking such figures. The matter was not wholly wrapped up with the cost of the turbine or that of the condenser ; it was necessary to have the cost of the plant. When hunting for similar figures, he had found the subject best dealt with in a paper by Mr. Dreyfus, published, he believed, in the *Electrical Journal* of the Westinghouse Company during 1911. Figures were there given for stated conditions of plant ; the effect on the turbine itself ; the effect on the fuel per horse-power, or per kilowatt-hour, &c. Sometimes it would be found that, basing figures upon the best conditions available, it would pay to put in a certain plant with coal at a given figure ; but if, due to circumstances beyond control, the price of coal went up by 50 per cent. to 75 per cent., as it had done in recent years, with very little chance of going down again, he thought that it would pay to put in the very best condenser obtainable, and the most of it.

Captain H. Riall Sankey said that, in regard to the variation in the guarantees given by turbine-makers, there was a simple way of determining these. All experiments he had seen so far showed clearly that the efficiency ratio of the turbine remained practically constant for all loads ; that was to say, the ratio of the heat utilised to the heat available on the Rankine cycle. Having that fact, it was easy at any time, knowing the consumption of the turbine under certain steam conditions, to deduce from that what it would be under other conditions by means of the Mollier chart. He had an example. Taking the case of a saturated-steam engine working at 150 lb. per sq. in., with a vacuum of 28 in. The total heat of the steam was 1195 B.Th.U., and adiabatic expansion down to 29 deg. would give a residual heat content of 875 B.Th.U. Subtracting one from the other left 320 B.Th.U. If, in a turbine tested under those conditions, the consumption was 15 lb. of steam per kilowatt-hour, the efficiency ratio would work out at 70 per cent. Taking the figure 3412 B.Th.U. per minute and dividing it by 15 gave 227, and the ratio of 227 divided by 320 was 70 per cent. Supposing, however, the vacuum to be reduced to 26 in. The previous total was 1195, but adiabatic expansion brought the figure to 910 B.Th.U.; the difference was 285. If that were multiplied by 0.7, the result was 199.5, and dividing 3412 by this latter figure gave 17.1 lb. per kilowatt-hour as the steam consumption with 26 in. of vacuum. In Tables I. and II. the author had given the number of heat units available for 1 in. of vacuum theoretically, while, later in the paper, he had given figures for the heat practically utilised. From the tables, it would be seen that for the same difference of vacuum (26 in. to 27 in.) 15 B.Th.U. were given. The practical figure given was 12 B.Th.U. The ratio between those two was 80 per cent., so that for that portion of the expansion the efficiency ratio was 80 per cent. Returning to the practical figures for 28½ in. to 29 in., and comparing that with the tables, it would be seen that the efficiency ratio was 70 per cent., as would be expected. As the vacuum became better the efficiency ratio became less. Incidentally, he might remark, that was one reason why a turbine could utilise vacuum better than a reciprocating engine, wherein, between 26 in. and 27 in., he felt sure that the ratio of efficiency would not exceed 20 per cent., while between 28 in. and 29 in. it would be negligible. The author had referred to certain gains by utilising the exhaust of auxiliaries, and so forth. He (Captain Sankey) recalled a case of the utilisation of the heat of the circulating water in a Föttinger gear. A paper on the subject had appeared in the *Zeitschrift des Vereines Deutscher Ingenieure*, which showed that in the case of the Konigin Luise (now happily at the bottom of the sea) the gain was 2 per cent. Mr. Stoney had given the value of K as 1500 B.Th.U., and he would ask whether that figure was not very high and practically unobtainable. The conductivity factor might be taken as anything between 300 and 1500 B.Th.U. ; a great deal was left to the imagination, and he would be glad if the author could define the factor a little more closely. The paper also stated that the increase of vacuum did not depend on the quantity of the circulating water ; that was because, as seen in Figs. 4 and 5 of the paper, the temperature t_2 rose, and the curves followed almost proportionately.

Mr. G. Stoney, in reply to the discussion, agreed with Mr. Longridge's suggestion that "B Th.U. convertible into work per pound of steam expanded adiabatically" better expressed what it was intended to convey in Figs. 1 and 2. He had been so accustomed to take the B.Th.U. "available" that it did not occur to him that the matter would not be quite clear. He had taken his figures, without calculation direct, from Peabody's entropy tables, these being the easiest for working out such things. In regard to the weights given, it would be exceedingly difficult to add prices, and he feared it would be impossible to get the consent of those who had given him the weights. Mr. Morison had laid stress on the fact that at low load air extraction was much the most important thing. But there was a point in air extraction, at small loads, where it was possible that the amount of power used in extraction might exceed the gain in the turbine ; the installation as a whole had, in every case, to be considered. Mr. Fothergill had touched upon the same point, particularising the most difficult case of a battle-cruiser, where the cruising power was only about 4 per cent. of the full power. A steam-jet taking, say, ½ per cent. of the steam at full load would at cruising speed take 7½ per cent. Here an important problem presented itself. Was such a large steam-jet worth while, and would the gain in vacuum be equal to it? Of course, it must be remembered that the gain due to vacuum was very large indeed at small loads, and therefore it probably was worth while; but the whole case had to be considered on its merits. It would be interesting if a careful set of tests were made, as nearly as possible under marine conditions, on a land turbine. He thought such a test could be made at small loads on a land installation, taking into account the steam used by auxiliaries and everything, and it would be of great importance in relation to marine work. An advantage of such a test was that it could be made on a fairly large scale without much boiler power. It was a matter which manufacturers of condensing plant and turbines might possibly consider. A good deal might be done by shaping the exhaust and leading it away, so as to reduce the velocity of the steam leaving the blades before it entered the condenser, getting a sort of ejector action. That was largely done in the most perfect of all turbines —the Ljungström—which was a radial-flow turbine. He would refer Mr. Ridsdale to the figures as to gain per inch of vacuum at full load ; the table given embodied data acquired in his own personal experience, and applied to turbines bladed for about 26 in. of vacuum. If bladed for other vacua, different values resulted. Where to measure the vacuum was a most difficult problem. It could not be measured close up to the blades owing to inevitable obstructions in the exhaust, and it was impracticable to measure the temperature and pressure of a moving gas ; nobody had succeeded in doing that. He had always assumed that the vacuum was to be measured at the exhaust flange. That was not correct, but he could not see where else it could be taken. Mr. Ridsdale had stated that in marine practice increase of vacuum always gave increase of speed ; that was to say, when, due to increasing the speed of the circulating and air-pumps on one side of a ship, the vacuum was increased more revolutions were obtained. That was true, but at the same time the steam consumption of the air and circulating-pumps was increased, and if the steam used in these was more than could be condensed by the feed, a reduction in the total efficiency of the whole plant might result from the extra exhaust steam which would go over into the low-pressure turbine or direct into the condenser. As a general rule, the best vacuum was the highest obtainable, although that rule might have to be qualified by the merits of each particular case. Professor Hubert's remark that vacuum was much more important in an exhaust-steam turbine than in a high-pressure turbine was perfectly true ; it was, roughly, of double the value, as would at once be seen by comparing Tables I. and II. With an exhaust-steam turbine the very highest vacuum obtainable was always the best. Mr. Bruce had said that an economy of 15.2 per cent. was got by putting the exhaust into the feed-water, as compared with putting it into the low-pressure turbine. This would be true so long as the auxiliary exhaust was not more than could be condensed by the feed-water ; but in many cases it was much more, and then, of course, it had to be divided between the two. In reply to Mr. Patchell, he would say that Tables I. and II. showed the theoretical gains which might be obtained with suitably designed turbines, while the figures given later represented the actual gains with a turbine designed for 26 in. of vacuum. It was a difficult thing to measure the exact gains of vacuum in a turbine, because the difference measured was always between two big quantities. He himself felt that he knew little about it, and would not undertake to state the gains due to vacuum in a certain turbine. Manufacturers were in a similar predicament, and they usually put down what they thought best. The allowances by different firms all varied. Nobody knew within, say, 1 per cent. what was the effect of vacuum in a given turbine. Captain Sankey had remarked that a conductivity of 1500 in a condenser was very high. That was so, but in highly loaded condensers with an extremely high velocity in the tubes, and with clean tubes, such a value might be obtained. With average condensers the more probable figure would be 600 to 800 at full loads, going down, perhaps, at light loads to 400 or 500, since by reason of air extraction not being perfect, conductivity fell at smaller loads.

The Chairman announced that the date of the Hawksley Lecture, which was to have been delivered by the late Mr. Bryan, had not yet been definitely settled, but the lecture would probably be delivered in a fortnight's time. Mr. Bryan's son had kindly consented to undertake its delivery. The next ordinary meeting was announced to take place on Friday, December 18, when a group of papers on "Audible and Other Cab Signals on British Railways" would be read.

Meeting at Manchester.

Mr. G. Stoney's paper on "The Effect of Vacuum in Steam-Turbines" was further considered at a meeting of the members of the Institution in

Manchester, on Tuesday, the 24th inst. The chair was taken by Mr. Michael Longridge, Vice-President. The proceedings opened with a reference to the death by Mr. E. B. Ellington by the Chairman, who related what had been done in this connection at the London meeting and reported above. Mr. Longridge then announced that he had received a telegram and letter from Mr. Stoney stating that he considered the condition of affairs on the North-East Coast so serious that he did not feel justified in leaving to attend the meeting in Manchester, and therefore with regret had had to abandon his intention of being present. Mr. Longridge then referred to the Association Football scandal and read to the meeting the story of Colonel Burn's appeal of Saturday last to the football crowds at Stamford Bridge. He implored the members present, if any of them were connected with the Association, to write to the officials in no measured terms condemning its present attitude; at the same time he appealed to all who had direct influence with workmen to do all they could to try and get them to do their duty to their country. These remarks of the Chairman met with such hearty approval on the part of the meeting that it was clear that those present had little sympathy in the continuance at this time of the professional football, which, unfortunately, constitutes an all-absorbing attraction to a large portion of our male population. The formal business then having been dealt with, the Secretary, Mr. E. Worthington, read Mr. Stoney's paper on "The Effect of Vacuum in Steam-Turbines."

At the conclusion, the Chairman, Mr. Michael Longridge, remarked that most engineering problems were solved by a compromise. At one end there was the engineer in search of the highest efficiency obtainable; at the other was the money-maker whose prime consideration was low costs. The object of the paper he took to be to give the designer some idea of the measure of the gains brought about by certain possible changes, and some idea of the costs involved. The first point considered was a change in vacuum. In Fig. 1 of the paper there was given a diagonal line showing the B.Th.U. available for conversion into work when expanding adiabatically from 175 lb. pressure and 150 deg. superheat to various temperatures of vacuum. This line ran from about 398 B.Th.U. with a vacuum at 70 deg. Fahr. to 292 B.Th.U., at 140 deg. Fahr. Those were the maximum quantities which could be converted. Unless it was remembered that it was impossible to convert the whole heat, the designer would be led astray. He did not know what proportion was to be expected in turbine work, but if it were possible, say, to convert 70 per cent. of the heat available into work, the line showing actual possible results would run from, say, 278 B.Th.U. to 218 B.Th.U. or thereabouts. It was most important to remember that in this diagram the coefficient reducing the theoretical to the practical value had been omitted. Then, again, with regard to Figs. 3, 4, and 5, which involved the factors K, S, and X, values were given for K varying from 0 to 800. The condenser-designer had to decide upon S and X, and with such a range it was clearly difficult to know what to do. He thought the discussion might advantageously be directed to the coefficient by which theoretical might be reduced to practical figures, and also to the practical values of K.

Mr. Alfred Saxon was the first speaker. He had listened with great pleasure some time ago to Mr. Stoney's lecture on steam-turbines at Owens College. The present paper was masterly. With regard to turbine design, Mr. Stoney advocated practically throughout the high vacuum. The extra gain in the case of the low-pressure turbine should, he thought, stimulate the combination of the exhaust-turbine with the steam-engine. At the high-pressure end of an installation the steam-engine was all right, but at the low-pressure end the turbine was best. He thought it would be interesting, therefore, if the author could give some information as to the reliability and freedom from breakdown of the low-pressure turbine, or section of a turbine, compared with the high-pressure end, which they all knew to be liable to certain failures. It was important to secure a degree of reliability equal to that of the steam-engine if progress with the low-pressure turbine was to be made. He had to thank the author for the straightforward way in which he had dealt with the subjects raised in the paper, and for supplying data which would be valuable to those of them who were not actual builders of turbines. He was himself at the moment putting forward a scheme combining a steam reciprocating engine and an exhaust turbine.

Mr. J. N. Bailey, who followed, said that all would be sorry that the author was not present, as no one was better versed in the subject. The paper was difficult to discuss, because the broad principles enunciated were agreed to by all turbine-designers. With regard to the Chairman's reference to Fig. 1, the values there given varied so much that another paper could well be written on the relationship of theory to practice and the coefficient of reduction. It was impossible to give any hard and fast line. The question of vacuum in connection with turbines was so important that one wondered if the whole subject had not been attacked from the wrong end. The fact was that, had the principles of steam been studied and known to a greater extent, turbine problems would have been approached from the exhaust end. It would, he thought, have developed more quickly if the effect of vacuum had been realised earlier. As Mr. Saxon had said, the steam-engine was satisfactory at the high-pressure end. They were reaching the stage at which they required new materials—something of lighter weight. The shape of the exhaust had a great effect on steam consumption, owing to the formation of eddies. It was essential that the passages should be shaped to give an easy flow from the turbine to the condenser. With regard to the transmission of heat, if the tubes were surrounded by air, the heat transfer would be much reduced. That point had come into prominence in connection with turbine work, and now received a considerable amount of attention.

Mr. S. L. Pearce said the paper was not an easy one to discuss. They agreed with the main principles laid down, but the author, early in his paper, put on one side the consideration of plants working with cooling-towers. The use of cooling-towers complicated matters. In Manchester they were not situated very fortunately with regard to water supply. In connection with the new Manchester scheme he had taken the trouble to get out figures for working with an unlimited water supply, and also with cooling-towers. He found that for 90,000 kw. installed, the difference in working costs per annum would be 14,000*l.* in favour of the towers. Speaking generally, in this country we were not blessed with ample supplies of water. Most electricity-supply undertakings had to work with cooling-towers, and then high vacua could only be obtained at very great cost. The question of air extraction was important, and bound up with the driving of the auxiliaries. In land work they could use electrically-driven auxiliaries. He personally advocated a combination system. It was imperative to divide the auxiliaries into two sets, so as to have ample stand-by plant. It was then possible to have one set driven by steam and the other by electricity. Each condensate-pump and each air-pump should be capable of dealing with normal conditions. The second air-pump could be put on if abnormal leakage developed, as it sometimes did. He did not think it was economical to go in for the various proposals made with the object of eliminating the air-pump owing to the relatively small amount of power it consumed. He had a 7000-horse-power exhaust-turbine coupled to an old reciprocating plant. It had been running for fifteen months without any trouble. He considered that the value of K at his station, with clean condenser-tubes and full loads, worked out to about 800.

Professor Petavel said that the author had spent a lifetime in assimilating his subject, and could put old facts in a new light. The paper showed the enormous advantage of the last inch or two of vacuum. The extra expense of obtaining that last inch had been referred to. He thought an important point was the flow of steam between the last row of blades and the condenser. The study of the flow of high-velocity gases might lead to better conditions at this point. A large amount of work was being done on the flow of air round obstacles, and that might ultimately be of assistance in clearing up difficult points.

Mr. W. H. Roy said the paper dealt wholly with cases in which the supply of cooling water was ample. Cases of restricted supply had not been dealt with, and that point should be remembered if the data given were used. Not one out of four electric stations in this country were operating under conditions similar to those of marine work as regards water supply. The same might be said of collieries, works, &c. The exhaust turbine showed a gain per inch of vacuum of about twice as much as the high-pressure turbine. The exhaust turbine was essentially a land proposition, but, unfortunately, where it was best suited to the conditions to be fulfilled, the water supply was usually unsatisfactory. The paper took up the case of a station with water at 50 deg. Fahr. and a 29-in. vacuum. Mostly they had to put up cooling-towers and work with much less vacuum; 29 in. was quite exceptional as a practical figure. He thought the figure of 1.8 per cent. given as the power taken by the pumps would be exceeded in land work, though it might be correct in marine work.

Mr. W. Ingham said that vacuum had been raised some years ago to a fetish. The word had been dinned into them when young. He had known immense sums spent upon attaining high vacua to be quite unjustified. He thought that often the engineer, by tightening up his joints, &c., could so improve the vacuum as to save his wages. In the turbine one could work well on a good vacuum, but it was possible to pay too dearly for it. The paper showed what vacuum could be got without paying too much for it. Mr. T. Mohn asked what the power taken to drive the auxiliaries amounted to, and was followed by Mr. H. L. Guy, who thought there was a risk that the paper might leave the impression that unless one could get a turbine to take full advantage of a high vacuum, one would be getting something a great deal worse than one ought to get. If a customer insisted on getting a turbine designed to suit his own special idea of conditions, he would have to pay dearly for it. With regard to Fig. 1, the factor for reducing the theoretical to the practical figure depended upon a variety of points. The paper spoke of a 3000-kw. plant at 3000 revolutions per minute, and seemed to suggest that that was the best which could be accomplished at present. That, however, was moderate compared with what was possible and what was even now done. The peripheral speed could be raised above that taken by the author by some 40 per cent. without practical possibilities being exceeded. Taking that increased figure it would be possible to design a 5000-kw. turbine at 3000 revolutions per minute. A reference was made in the paper to throttle and nozzle governing. Actually the difference in effect of the two systems was small, and, if other corrections were introduced, did not need to be taken into account. He thought the rule given stating the exhaust area in terms of pounds of steam per hour a rule-of-thumb, which gave such wide variations as to make it of little service.

At the conclusion of the meeting it was announced that the Thomas Hawksley lecture, after its delivery in London, would probably be repeated in Manchester by Mr. B. Bryan on Tuesday, December 8.

German Iron and Steel Works Production.—The *Revista Minera, Metalúrgica y de Ingeniería* reproduces from *Stahl und Eisen* a note, according to which the total output of the German iron and steel works in Bessemer ingots, basic-steel ingots, ferro alloys, puddled iron, &c., omitting Alsace-Lorraine and Luxemburg, was 518,184 tons during last September, as against 521,427 tons last August, and 1,590,849 tons in September of last year.

Engineers as City Managers.—The American plan of appointing able engineers to the responsible post of city manager seems to work satisfactorily, and to gain increased popularity. The older system, with the lack of stability and continuity, which is characteristic of not a few concerns and institutions in the United States, certainly left much to be desired, and much public business was conducted in an inadequate and inefficient manner. Then the city-manager scheme was adopted, and appears to have solved the problem; in any case some sixteen large American towns now have their city manager. The authority, in the first instance, is vested in a commission, elected by the citizens for a period of four years, some two or three members retiring in turn every year; and this commission, again, as it were, transfers its authority to the city manager, who receives an annual salary of 5000 dols. to 15,000 dols., or even more, according to the size of the town. This official is generally appointed after a public competition, and engineers who have been at the head of railways or large industrial concerns are preferred. The work of the city manager may be divided under five heads: Law; the technical management of the safety section (fire brigade, police, inspection of buildings and factories, &c.); finance and taxation; hygiene (hospitals, parks, play-grounds, &c.). The city manager is not appointed for any fixed number of years, and can only be discharged by the above commission, whilst he engages and discharges all other functionaries in the service of the town.

THE RENNERFELT ELECTRIC FURNACE.

We have, from time to time, dealt at some considerable length with the interesting and instructive experimental electric ore-smelting carried on at the instance and at the expense of the Järnkontoret, Stockholm, and have now pleasure in giving an illustrated description of another Swedish invention in the field of electric smelting or refining, Mr. Ivar Rennerfelt's furnace, which marks a new departure, and in its construction differs from all types which up to the present time are in operation. Its practical merits have demonstrated themselves very quickly, and the Rennerfelt furnace has not only met with much attention and appreciation in Sweden, but also abroad.

The first Rennerfelt electric furnace was constructed at Hallstahammar, in Sweden, in the year 1912, and it worked so satisfactorily that within a year a steel foundry with four electric furnaces was erected at the place, and orders have been received also from the neighbouring countries, the furnaces in question varying in size from 300 kg. to 3 tons. Quite recently orders for three more furnaces have also been received from English works. The manufactures for which the furnaces already in operation are applied comprise steel castings, iron castings, tool steel, electro-steel from pig-iron and ore, refined steel from liquid charges, &c.

In order to put in a few words the special features of this furnace, it may be described as an economical small furnace for crucible works, steel foundries, copper alloys, and chemical processes requiring a high temperature. It is very handy, and can accommodate charges as small as 100 kg. in the same way as it will no doubt lend itself to the refining of steel in large charges. Developments in this direction are taking place, but its evolution has not yet been completed.

The Rennerfelt furnace is preferably built with a horizontal, cylindrical steel shell, with longitudinal axis, and it turns cradle-fashion, or is tilted round a horizontal-diametrical axle. It is lined with silica, carbon, or magnesite brick, according to the uses to which it is to be put. A charging and casting-door, closely fitting, is placed in one side or in each end of the furnace. The outer appearance of the furnace is shown in our illustration, Fig. 1, annexed, a furnace of 1¼ tons capacity, recently erected at Hallstahammar.

The electric current is transmitted by means of three electrodes, one descending vertically through the top of the roof, and two horizontal, one at each side or end. The positions and arrangement of the electrodes will be seen from the illustration, Fig. 2, the side electrodes sliding in fixed holders, but being adjustable axially by hand or motor power. Our next illustration, Fig. 3, shows a section of the same furnace, with the charging and casting-door located in the circular wall.

When the furnace is used for melting light scrap, requiring a fair amount of space below the arcs prior to melting, vertically-adjustable electrodes are to be preferred. This is a special feature of the Rennerfelt furnace, and enables the operator to run the furnace with free-burning arcs, independent of the volume of the charge, or with the arcs in contact with the metal, in case he desires to employ the method of heating as used in the different types of arc furnaces previously constructed.

In ordinary working, the electrodes do not come in contact with the slag or steel, the arcs being free-burning. This ensures unusually smooth working when melting cold scrap, which always has been a difficult operation, especially in cases where the furnace receives the electric energy from a power plant of limited capacity. As to the nature of the energy, three-phase current of any voltage or frequency is passed into a transformer arranged for Scott's method of phase transformation, transforming the received energy into a balanced two-phase current (or two-phase current may be directly generated) delivering single-phase current to each of the horizontal electrodes. A return cable (Fig. 9, page 639) connects the common point of the two phases with the central electrode.

The currents entering through the horizontal electrodes neutralise one another, but the action of the returning current into the central electrode generates a field of force which deflects the arc downwards to the bath, thus forming the arcs into an inverted arrow-head, or *fleur-de-lys*. This form of arc has hitherto been unknown in electric furnaces, and is one of the features responsible for the successful working of the Rennerfelt furnace. The heat generated in the arcs is here, more than in any other furnace, concentrated down upon the bath, though the electrodes do not touch, or even approach, the slag or the metal. The arcs sweep or brush all over the central space underneath the points of the electrodes, ensuring a uniform heating of the charge and rendering the slag very fluid and chemically active. The height of the arcs from the points of the electrodes to the surface of the bath can be adjusted, but it is usually kept at about 6 in. to 12 in. Smaller furnaces are tilted and discharged by hand-lever and ratchet movement, larger furnaces by electric or hydraulic mechanism.

The Rennerfelt furnace may be described as a large, internally-heated crucible, and it can, as stated, be charged with cold or liquid metal. In case of cold metal the latter is charged into the preheated furnace with or without fluxes. The electrodes can be pulled back or raised during charging, so as to prevent their getting injured. When the furnace has been charged, the electrodes are adjusted into proper position, the door is carefully closed, and the current turned on. A cold charge chills the furnace considerably, and it is therefore advisable to use increased power at the outset, gradually reducing it as the brickwork becomes heated, so as not to damage the lining by an excessive temperature. The charge is thus rapidly melted and covered by a thin, but unbroken, sheet of slag, which serves as a protection against any oxygen that may be present in the furnace. As a rule, however, the atmosphere is neutral or strongly reducing, being charged with carbon monoxide. The outside air is not admitted during the melting and refining, the door remaining closed until the charge is ready for testing.

Samples of the steel are then taken as usual, and alloys are added as required. Limey slag, sand or fluorspar, one or all of them is added, fused and skimmed off, practically absorbing all the phosphorus and sulphur of the charge. The number of slag renewals depends upon the quality of the raw material used, and the nature of the finished product desired. When ready the steel is poured into a ladle, and that at a much higher temperature than obtainable in an open-hearth furnace. It is therefore often necessary to keep the steel in the ladle whilst it cools down to a temperature at which it can be safely cast without burning the moulds or spoiling the castings. Perfect deoxidation is thus easily obtained, ensuring unusually good castings or ingots free from blowholes or piping.

After tapping the heat the bottom and slag lining are fettled, if required, with ground dolomite or ganister, the fettling is sintered by turning on the current, and a new heat is charged. One steel-melter and two men or boys per shift can work a furnace of several tons capacity, turning out as much as 20 to 30 tons within the 24 hours. The lining is threefold: first an insulating lining of asbestos board, then silica or first-quality bricks in rings against the former, and this again forms the bedding for the actual inner lining—acid or basic (Figs. 4 and 5). This is made of special bricks, which do not require any cutting, and are set in rings of different diameters, so as to form an egg-shaped interior melting-chamber. The electrodes enter into the furnace through circular openings, formed by special bricks. As to the life of the lining, no definite results have as yet been arrived at, but a furnace, with basic roof and hearth, has run 102 heats without requiring any repairs outside the ordinary fettling; and a furnace, with acid roof and lining, operated continually day and night through two months and a half on acid tool-steel, ran 174 heats. The bottom of the hearth is practically indestructible, and may be used over and over again.

The radiated heat from the free-burning arcs is reflected on to the bath from the entire mirror-like incandescent inner surface of the vault; but the arcs are at such a distance from the roof that the risk of melting it has been minimised. There is no sudden break between the roof, the side walls, and the bottom, all being built together in one continuous curve; the arch, owing to the circular form of the roof, is very strong, and the drawbacks arising from expansion and contraction of the lining have been greatly reduced. To facilitate re-lining, the cylindrical shell is divided into an upper and a lower half, the two being bolted together, when lined, and the cost of renewal of lining is stated to be exceedingly

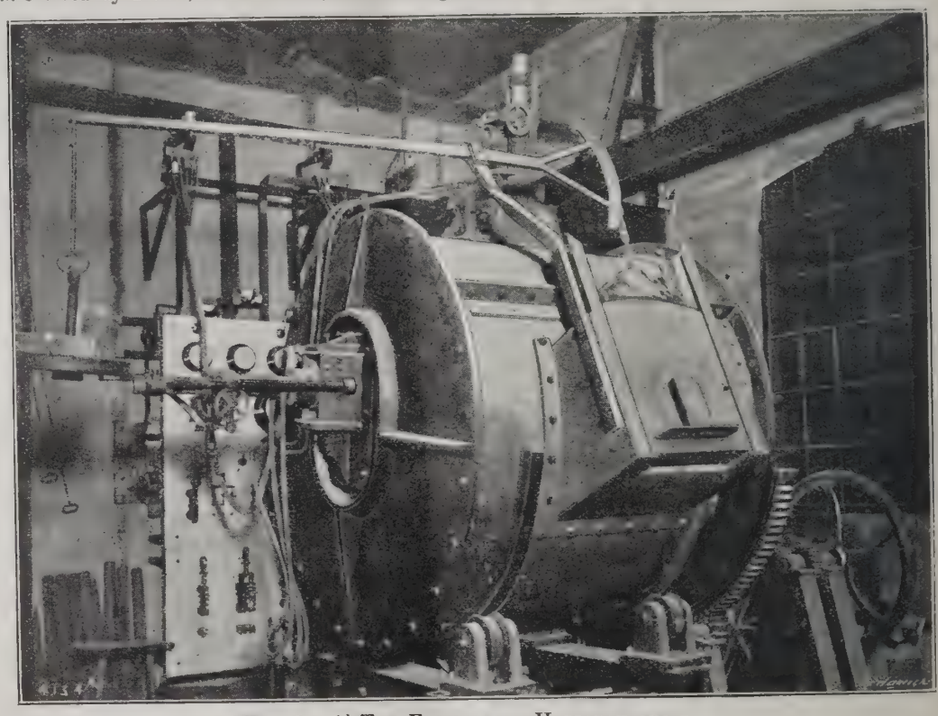


Fig. 1. 1¼-Ton Furnace at Hallstahammar.

Fig.2.

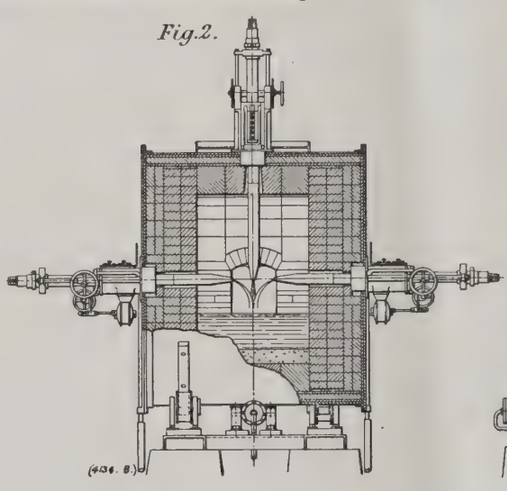
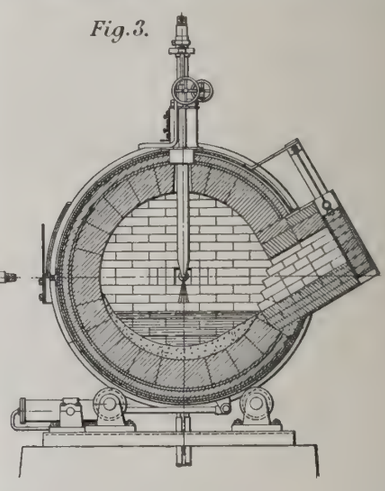


Fig.3.



THE RENNERFELT ELECTRIC FURNACE.

Fig. 4.

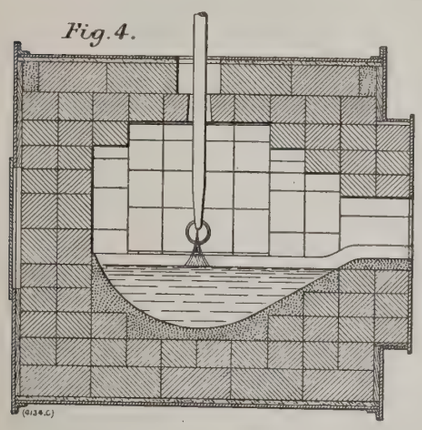


Fig. 5.

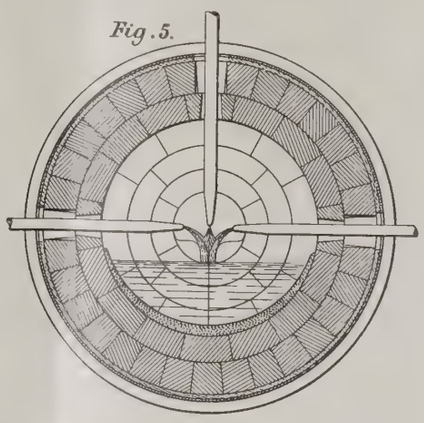


Fig. 6.

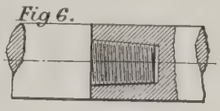


Fig. 7.

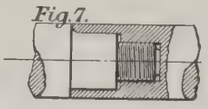


Fig. 8.

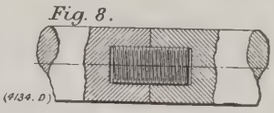


Fig. 9.

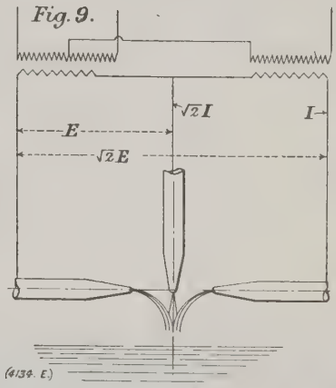
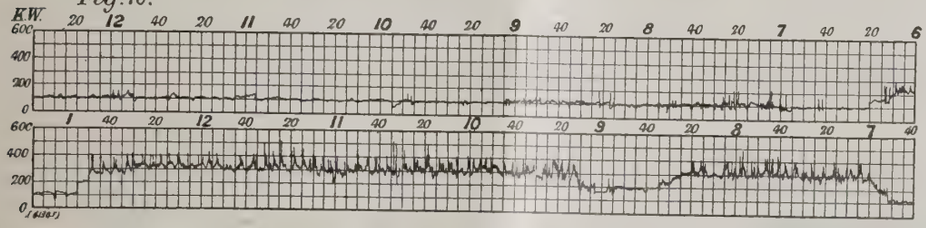


Fig. 10.



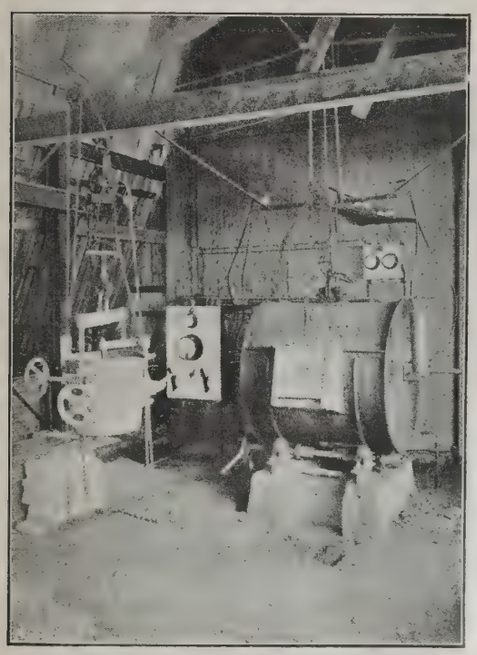


Fig. 11. 600-Kg. Furnace at Ljusne Works.

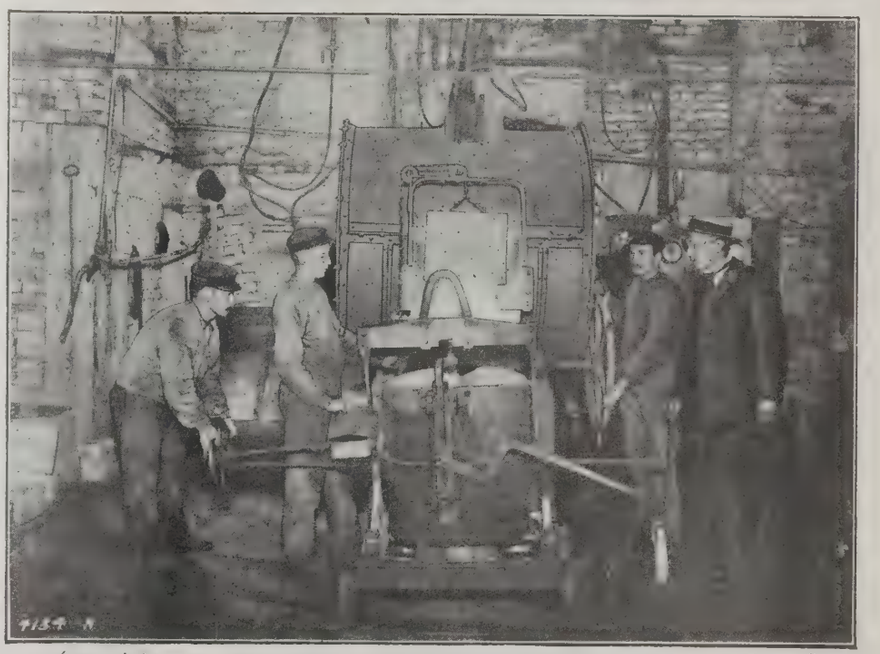


Fig. 12. 600-Kg. Furnace.

Fig. 13.

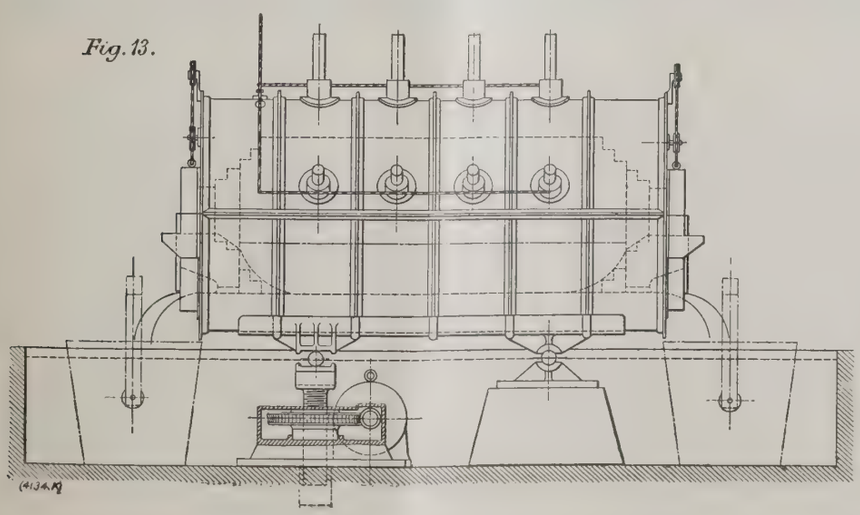
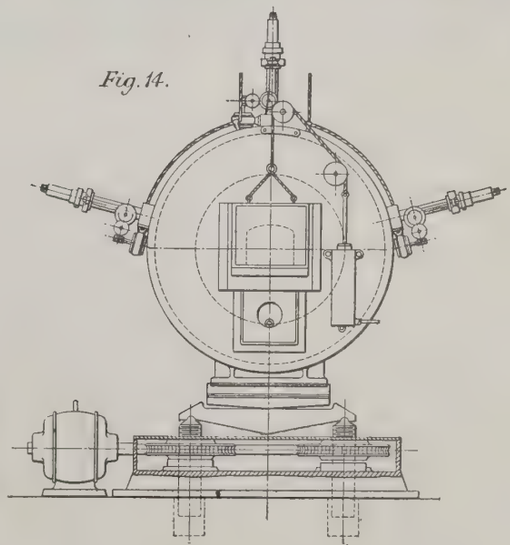


Fig. 14.



THE RENNERFELT ELECTRIC FURNACE.

Fig. 15.

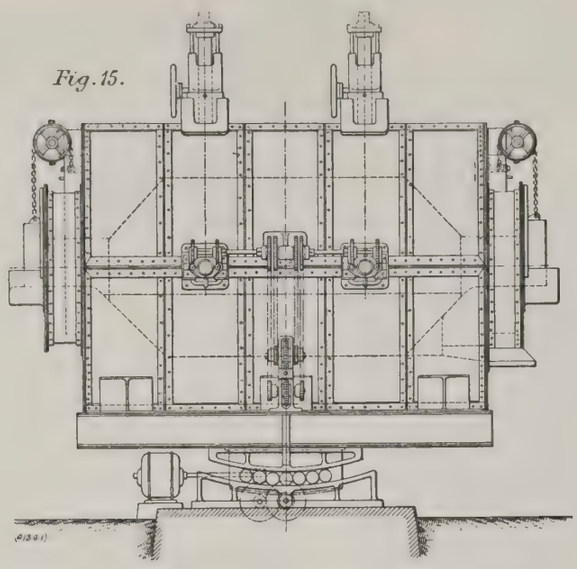
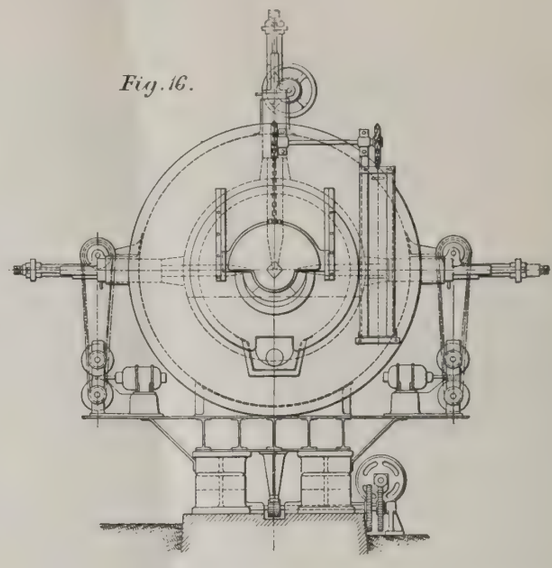


Fig. 16.



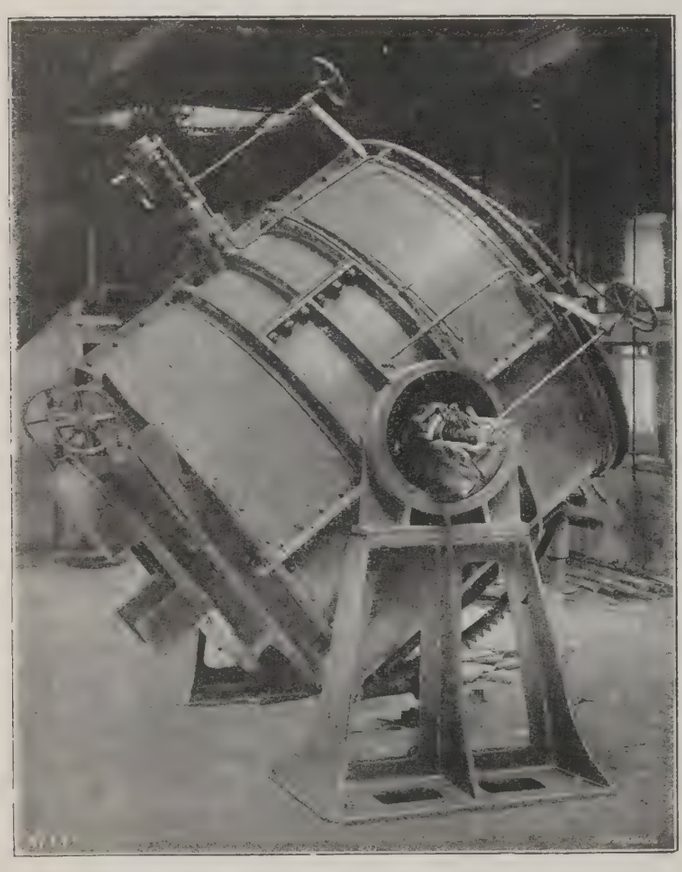


Fig. 17. 2500-Kg. Furnace.

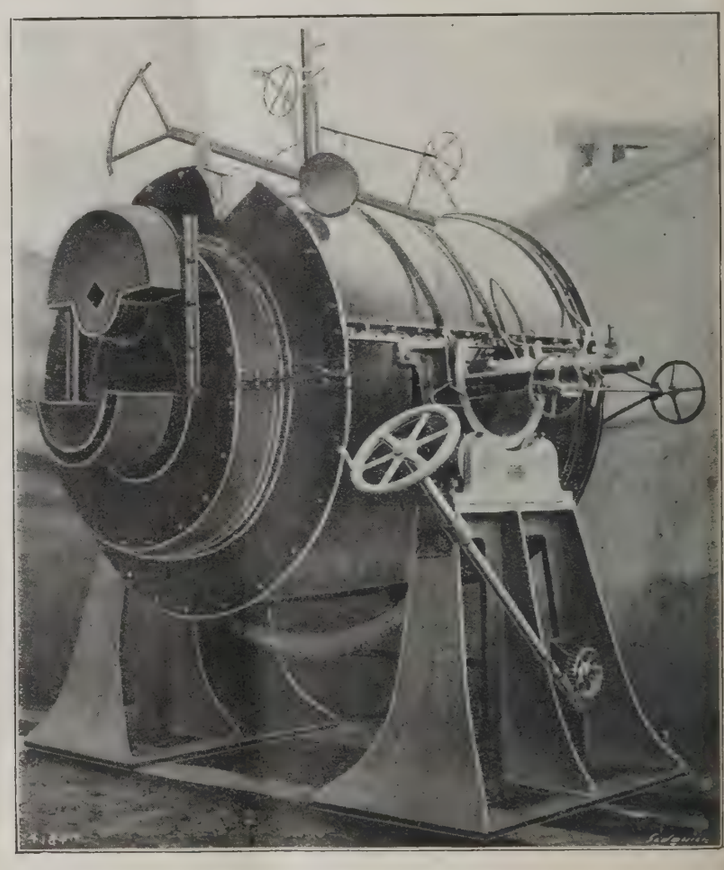


Fig. 18. 1250-Kg. Furnace

small. The cost of repairs is naturally influenced by a number of circumstances, but on the whole it is very moderate; thus the repairs on an output of 87 tons tool steel averaged about 1s. per ton. In a basic-lined furnace of 1¼ tons capacity, the cost of repairs averaged 2s. 6d. per ton on 125 tons of steel. These figures refer to cold scrap, melting it and turning it into tool steel or soft-steel castings. In case the furnace is only used to refine liquid charges, the cost of repairs per ton will only amount to a fraction of the above figures.

The electrodes are held with what may be called a loose but practically gas-tight fit in water-cooled insulated holders of phosphor-bronze or copper, those for the horizontal electrodes preferably being adjustable in the vertical plane. The cables are attached to the electrode-holders, the current being transmitted to the electrodes themselves through sliding contacts or brushes. The electrodes, 2 in. in diameter for a 600-kg. charge, and 3 in. to 4 in. for a 2-ton furnace, are Acheson graphite; they are turned to specified diameters and are made continuous by threaded sockets and dowels. The different ways of jointing the electrodes are shown in Figs. 6, 7, and 8. In the smaller furnaces the electrodes are fed by hand, in the larger automatically. Fig. 9 is a diagram showing a set of electrodes and the connection to a power system by means of a transformer. Assuming the ingoing current at each side electrode to be I amperes, then the current passing the central electrode will equal $I\sqrt{2}$ amperes, provided that the power on the two side electrodes is perfectly balanced, as is generally the case. In the same way, if we assume the voltage across the central electrode and each side electrode to be E volts, then the voltage between the side electrodes will equal $E\sqrt{2}$ volts. The size of the electrodes varies from 1½ in. to 7 in. for the largest furnace, fitted with several sets coupled in parallel. The 1½-in. electrodes (for 100-kg. furnace) have a capacity of some 70 amperes per sq. cm. Those of 2 in. diameter have a continuous capacity of more than 40 amperes per sq. cm., and those still larger can easily carry 30 to 40 amperes per sq. cm. The voltage of the current in the electrodes should vary from 50 to about 125 volts, according to the size of the furnace. The vertical electrode need seldom be touched, and the regulation of the side electrodes is simple enough, by gradually advancing or withdrawing them.

The consumption of electrodes in a 600-kg. furnace, running continuously on charges of cold scrap and pig, has been found to average about 2.8 kg. per ton of steel; this means the gross consumption, there being no stumps left unconsumed. Even when melting pig, and afterwards decarburising it by means of ore, the electrode consumption has not exceeded 3 kg. per ton. The wear of the side electrodes in a small furnace with acid lining, 2-in. electrodes, amounts to about 1 in. of electrode per hour, which comes out at about 6 kg. per 24 hours,

which, with five heats of 600 kg. each, makes about 2 kg. electrodes per ton. The curves given in Fig. 10, page 638, show the smooth operation of a Rennerfelt furnace, the one in question being a 600-kg. furnace, running on tool steel in a Swedish mill at Trollhättan. The furnace is rated normally at 125 kw., but, as the curves will show, only about 100 kw. are utilised; the furnace is running day and night on cold charges only. Some portions of the curves are also affected by the operation of some rolling-mills, which caused very strong fluctuations in the power-curve, in spite of heavy fly-wheels, which were intended to reduce fluctuation. The curve is somewhat peaky, when the rolling-mills are on, but comes down almost to a straight line at night and at noon, when the furnace alone is working.

The 1½-ton furnace (Fig. 1, page 637) is rated at 200 kw., and is being operated without any automatic regulators or similar protective apparatus, receiving the surplus energy from a hydro-electric plant of some 800-horse-power capacity. Only an ordinary oil-switch, with time relays, is needed to ensure sufficient protection for the generators, the circuit-breaker being adjusted so as to operate at 400 kw., or double normal furnace load. The furnace works as a large enclosed arc-lamp, practically without disturbing influence from the charge beneath the arcs. As to small phase displacement, simultaneous readings of kilowatts, volts, and amperes indicate a very satisfactory value of cos ϕ; in one instance a value of cos $\phi = 0.97$ has been ascertained at a furnace operated with a current of 50 periods.

With regard to efficiency, a small furnace of 600 kg. at the Ljusne Iron Works, in Sweden, illustrated in Fig. 11, will melt and refine a full charge of cold scrap with not more than 700-kw. hours per ton. The normal rating of a furnace of this capacity is 125 kw., but 82 kw. to 90 kw. have been shown to be sufficient to complete a 600-kg. heat in five hours, indicating a very satisfactory thermal efficiency even when running with only 75 per cent. of full load. White pig-iron has been melted in the same furnace under similar conditions with an average of 405-kw. hours per ton. With 425-kw. hours per ton, grey pig-iron has been melted and overheated, the melting including 22 kg. basic slag per ton of iron. This consumption of energy indicates a furnace efficiency of about 70 per cent., but the thermal efficiency has been as much as 85 to 90 per cent. Fig. 12, page 638, shows another furnace of the same capacity, but of larger dimensions.

The Rennerfelt furnace has been proved to be well suited for producing high-grade tool steel from pig and ore. A ton of pig, charged cold, can be converted into steel with a consumption of about 850-kw. hours; a liquid charge will entail a saving of 350-kw. hours; 500-kw. hours will thus be sufficient for the decomposition of the ore required and to deoxidise the steel resulting from 1 ton of liquid pig. The electric steel thus made is stated to have been practically tested as against a world-renowned high-grade Swedish crucible steel, and to have proved superior to the latter. No difficulty was experienced from the very violent boiling of the bath, as it could not possibly affect the discharge of heating energy between the points of the electrodes, located well above the turbulent surface of the charge. This position of the electrodes also protects them from wear and tear from the strongly oxidised slag, an advantage compared with other furnaces in which the electrodes dip into or approach the surface of the slag.

The furnace under review is being used for steel-foundry work, and produces exceedingly good castings; the steel is tapped extremely hot, and, as has been already stated, has often to remain some time in the ladle for cooling. High-class pig-iron castings also turn out very satisfactory, accurate control being possible as to reactions in the charge. The furnace has also been tried with good results for melting copper and other metals.

The Rennerfelt principle also lends itself to the construction of a really large electric furnace, capable of receiving the entire charge of steel from the Bessemer converter or open-hearth furnace up to 50 to 75 tons in size. A refining furnace of the latter capacity will require about 7500 kw. To exploit effectively such a large amount of energy it is essential—or rather primarily necessary—to subdivide it into a number of smaller units by employing several sets of electrodes. This arrangement both keeps the electrodes within practical dimensions, and prevents the heat from being centred at a few points with a destructively high temperature. It is claimed for the Rennerfelt multiple-unit arc furnace that it has satisfactorily solved the problems attached to a furnace of this class, and it is shown in the illustrations, Figs. 13 and 14. The furnace takes the shape of an elongated crucible, of preferably cylindrical cross-section, made up of a number of similar sections bolted to one another, and each fitted with one set of electrodes, arranged according to the diagram shown in Fig. 9. The small heat-generating sets of electrodes being equally distributed over the entire surface of the bath, the latter will therefore be uniformly heated all over. The heat rays, radiating from the "inverted arrow" arcs, have only a very short distance to pass from the arcs to the steel, whilst the distance from the arcs to the roofs and walls of the furnace is considerably greater. It is claimed that this arrangement makes it possible to work with the furnace with a very much higher average temperature than could be compassed in such a large furnace with only a few electrodes. The wear and tear on the brickwork is reduced in proportion, and the output largely increased, which means a saving in upkeep and renewals. The better distribution of heat, and the higher mean temperature in the active zones, also produce more rapid and more certain chemical reactions. The cylindrical, elongated form of this furnace ensures a strong casing, not subject to distortions from the heavy strains caused by the heat. The lining consists of rings with bricks of only few and simple patterns, in every respect easy and cheap to handle. These cylindrical furnaces can be enlarged simply by adding cylindrical sections to the shell at a small cost, and the transformer plant can also be increased without discarding any portion of the old plant.

The control of the electric energy in this furnace is extremely simple, the current being distributed between several sets of electrodes connected in parallel, but otherwise independent of each other. The entire plant may be considered as made up of several small furnaces, each kept under separate and easy control. The current in each electrode is conveniently limited, and everything connected with their mounting and handling has in consequence been simplified and reduced in cost. This distribution of the heat also entails other advantages, and irregularities in the consumption of energy are alleviated through the comparative smallness of the arcs. The power curve of a furnace thus heated will approach a straight line with only few and relatively unimportant deviations.

A somewhat smaller furnace, with a different construction of tipping gear, is shown in Figs. 15 and 16, on page 640. In conclusion, we give illustrations of two more furnaces, Figs. 17 and 18 respectively, of 2500 kg. and 1250 kg. capacity; the former has been installed in St. Petersburg, the latter at the works of a Sheffield firm. The Rennerfelt patents are owned by the Elektriska Ungar Company, Stockholm.

INDUSTRIAL NOTES.

THERE are signs, says the *Manchester Guardian*, that the dispute between the shipowners and seamen in the freight trade, which, early last week, led to a strike of seamen in Liverpool and Manchester, will soon be settled. In Manchester two of the largest firms affected have conceded the demand made by their men.

The strike arose out of negotiations between the shipowners and the Seamen's Union, in which a demand was made for an additional 1*l.* a month wages, as compensation for war risks. It was pointed out on behalf of the men that there had been a considerable increase in freight charges, which not only affected the seamen themselves as consumers, but was also a clear sign of the increased risk incurred by the whole merchant service. After considering the claim for ten days, the owners replied that they could not grant the advance asked for. The men were able to hold up a number of vessels both in Liverpool and Manchester. Some of these boats are still unable to sail, but in Manchester two firms—the Manchester Liners, Limited, and the Leyland Line—have decided to pay the extra 1*l.* The Leyland Line is associated with other companies, which are also expected to make the concession, and it seems probable that the new war rate will be generally established.

The Amalgamated Tool-Makers' Monthly for November gives the following figures:—

	Oct., 1914.	Oct., 1913.	
Members ...	14,815	10,905	Inc., 3910
Unemployed ...	112	162	Dec., 50
Reserve funds...	45,000*l.*	38,500*l.*	Inc., 6500*l.*

As a result of the marked increase of the buying of steel material, the Scottish and English Steel-Makers' Associations met in London in conference a few days ago to consider their policy. It was decided to make no change in the quotations of Scotch material, but it is understood that makers in the north-east of England were authorised to advance their prices for ship-plates and angles by 5s. per ton. Buyers are now more anxious to cover requirements ahead than for many weeks past.

The report for the present month of the United Society of Boilermakers and Iron and Steel Shipbuilders showed a balance in hand on October 3 last of 46,566*l.* The total membership was 68,000.

The Huddersfield and Colne Valley Districts of the General Union of Textile Workers held a meeting in Huddersfield, on Sunday, the 22nd inst., when they passed a resolution expressing dissatisfaction with the refusal of the employers to grant 1½d. extra per hour for overtime for weavers, and a district rate of wages in cases in which it is not paid. The resolution instructed the executive again to approach the employers on these matters, and, failing a satisfactory answer, the two districts were recommended to take a ballot as to future action.

The November report of the Steam-Engine Makers' Society states that its membership is now 17,400, with a capital of 137,000*l.* The proportion of unemployed members was only 0.3 per cent. The society was formed in 1824.

It is satisfactory to note that the question of the extent to which Belgian refugees of the working class may be employed during their stay in this country has formed the subject of an exchange of views between the leaders of the Belgian trade unions and the heads of the principal British unions. The following points have been agreed upon:—1. Fully qualified members of Belgian trade unions now resident in this country will only seek employment in districts where they are advised by officials of British unions that there is a shortage of local labour. 2. They will not, under any circumstances, accept employment at lower rates than those recognised by the unions covering the particular industry, nor will they accept employment where there is a dispute between the British employer and his men. 3. Cards of Belgian trade unions will be recognised by the corresponding British unions, and holders of them will be granted all the privileges of British trade unionists without any entrance-fee or payment. So far as possible, Belgian trade unionists in this country will conform to the rules of the British union whose hospitality they enjoy.

As dealing with the same point, we may state that having been asked in Parliament by Mr. Hunt whether Belgian artisans in this country were being employed at skilled labour considerably under trade-union wages, Mr. Runciman replied that he had no information which confirmed the suggestion made.

The Government had the matter under their careful consideration, and a departmental committee, under the chairmanship of Sir Ernest Hatch, had been appointed by the President of the Local Government Board to make recommendations thereon.

In the meantime, any employers desiring Belgian labour should apply to the Labour Exchanges, who, in dealing with such applications, will have full regard to the interests of British labour.

A meeting of the Executive Council of the Yorkshire Federation of Building Trade Employers was held last week at the Town Hall, Wakefield, Mr. T. Ledgard, of Leeds, occupying the chair. The Mayor of Wakefield (Mr. E. Stonehouse), welcoming the federation to the city, said the building trade was closely connected with corporations, and during his 26 years' experience in Wakefield Corporation work he had heard many complaints by builders, who had accused the Corporation of lack of enterprise in building. "But I could show you object-lessons in Wakefield," continued the Mayor, "of the work that had been allowed to be done in years gone by owing to lack of proper supervision and proper by-laws—work which, I think you would agree with me, is neither a credit to the Corporation nor the building trade. Our Corporation has just completed a revision of the by-laws, and I am happy to say that the alterations which have been made have rendered the conditions for builders easier."

The business of the Council was private.

LEAD AND THE WAR.—A lead famine—or, in any case, a very inconvenient shortage of this metal—is reported to be making itself felt in Germany, which, to the extent of one-third of its consumption, depends upon imports from abroad. Germany had some stocks when the war broke out, but they are quite exhausted, and the imports have practically ceased. The latter average some 8000 to 9000 tons per month. There has been a question of fixing maximum prices on several metals in Germany (such regulations may already have been issued), so as to prevent speculators from taking an undue advantage of the exceptional conditions brought about by the war.

THE ELECTRIC VEHICLE COMMITTEE.—The Electric Vehicle Committee of the Incorporated Municipal Electrical Association has issued a specification for a standard sign to be fixed outside garages or stations which have facilities for the charging of battery vehicles. The sign consists of a car-wheel and simple explanatory lettering in white and red, and is to be either of enamelled iron or of an illuminated type. It is to be about 2 ft. 6 in. square. The committee also announces that, in view of representations which have been made, it has been decided to limit the standard charging-plug, which we illustrated in our issue of September 25 last, to one size of cable only for the present, and that it should accordingly be made for conductors of 0.1 sq. in. cross-section.

36-IN. DOUBLE-HEADED SHAPING-MACHINE.

CONSTRUCTED BY MESSRS. LOUDON BROTHERS, LIMITED, ENGINEERS, JOHNSTONE, SCOTLAND.

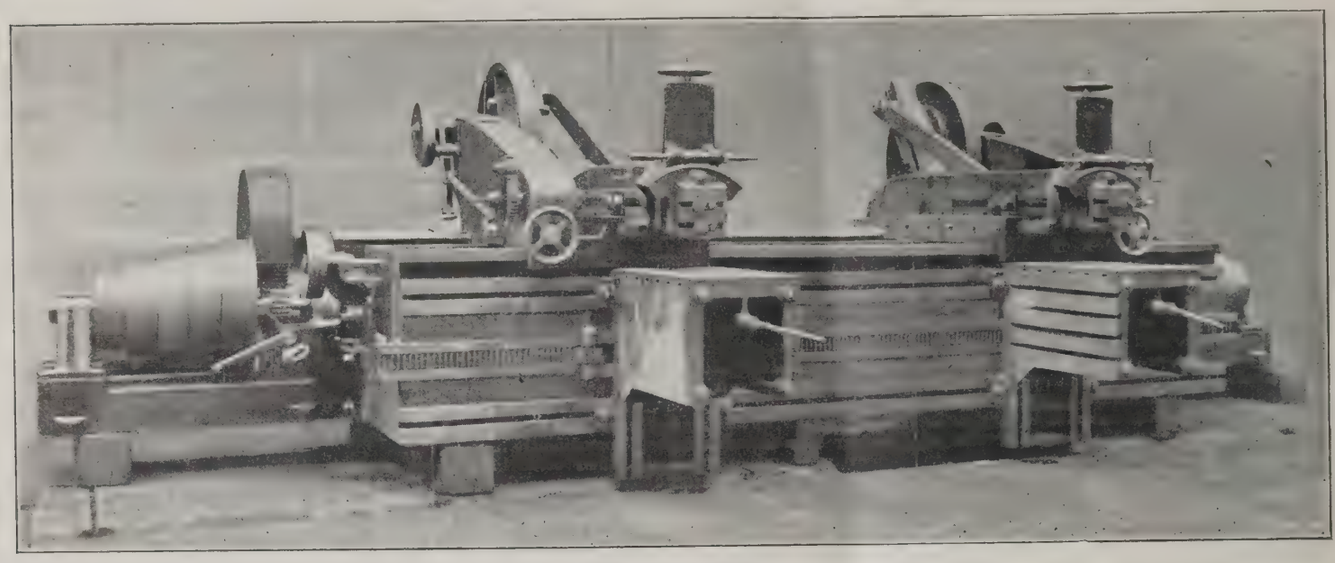


FIG. 1.

WE illustrate above and on the opposite page a heavy high-speed double-headed shaping-machine recently constructed by Messrs. Loudon Brothers, Limited, of Clyde Engineering Works, Johnstone, Scotland. Fig. 1, which is reproduced from a photograph, shows the machine as erected in Messrs. Loudon Brothers' works, while Fig. 2, on page 643, is a side elevation, and Figs. 3 and 4 are elevations from the left-hand and right-hand ends respectively.

The bed, it will be seen, is of strong box section, and is brought down to the ground line for the whole of its length to ensure rigidity; it is 18 ft. long, 3 ft. 6 in. wide, and 3 ft. 3 in. deep. The heads are accurately scraped and fitted to the bed on specially wide bearing surfaces. They have self-acting feed-motions in either direction, and can also be moved along the bed by hand and power through a rack and pinion. The control gear for hand and power traverses, as shown in Fig. 1, is brought to the front of the machine for convenience in working. A large range of variable and reversible feed-motions, controlled by an indexed lever, are provided. The rams, which are of T section, run in efficiently lubricated square slides. They are centrally driven from a geared disc, which gives a variable stroke up to 3 ft. in length, with any cutting speed up to 50 ft. per minute; the stroke-plate is indexed for convenience in adjusting the stroke. A quick return, up to 90 ft. per minute, is obtained by means of the Whitworth motion. The tool-boxes have a vertical slide, and are indexed for dealing with angular work; they are also each provided with a worm and quadrant for cutting internal curves. Each headstock, as shown in Fig. 2, is arranged to be driven independently by a five-speed cone-pulley, capable of taking a 6-in. belt; about 15 horse-power is required for each head. The two tables, which each measure 3 ft. 2 in. long by 2 ft. wide, have T-slots on their upper surfaces and on their inner sides. They can be adjusted vertically by screws and mitre-wheels, and horizontally by means of a rack and pinions.

The weight of the machine is approximately 27 tons. All gearing is machine cut, and is guarded where necessary. Two sets of countershafting, having self-oiling adjustable bearings, are supplied with the machine. If required, self-acting vertical feeds can be fitted to the tool-boxes, and the mandrels may be provided with circular feeds; but the machine illustrated is not so fitted.

TRADE IN METALS AND MACHINERY WITH JAPAN.

THE latest report of the Commercial Attaché to His Majesty's Embassy at Tokyo, Japan, contains a considerable number of interesting and important items, but the ones which are likely to appeal to the greatest number of our readers are those which deal with the import trade in metals and machinery. The Japanese have a saying that business in metals gets very bad every seven years, and the report states that there can be no question that it was very bad in 1913-14. From the customs' returns, it might be inferred that there had been satisfactory activity, as the figures show a slight increase over 1912, which in itself had been 36 per cent. better than the previous record year. But the returns, unfortunately, are not a correct index to the state of affairs, and it is probable that importers, dealers, and brokers alike have had a very trying time. It is clear that it will be some time yet before the market regains its state of healthy activity, and in the meanwhile importers will have to put their goods into godowns, and let storage and insurance charges accumulate until matters improve. The chief cause of the trouble has been that metal dealers had good years in 1911 and 1912, and they imagined that the increase in Japan's consumption of metals was natural, and must continue. Unfortunately, the political crisis at the beginning of 1913 upset all their calculations. The inauguration of a policy of retrenchment and readjustment caused a large falling-off in Government orders, which reacted on the market, and brought about a curtailment and postponement of those industrial schemes in which big quantities of metals are required. To make matters worse, prices began to fall at home, and each successive drop accentuated the difficulties in Japan.

The following are the figures for the quantities and values of iron and steel, pig and ingot, imported in the years 1912 and 1913, and the countries concerned:—

Country.	1912.		1913.	
	tons	£	tons	£
United Kingdom ..	159,293	609 600	103,473	488,400
India	50,789	170,000	81,171	300,000
China	10,590	46,100	59,469	209,000
Sweden	6,353	49,100	16,011	128,000
Germany	10,381	51,200	14,847	80,000
Other countries ..	1,000	33,000	3,846	58,900
Total	238,406	959,000	278,817	1,264,300

It will be seen that although the United Kingdom still heads the list, she has lost ground seriously, and is the only country which has not registered a gain. The advance with regard to China is only natural, in view of the more settled state of affairs in that country, and should the Hanyehping contract be definitely confirmed, it is clear that the importation of iron ore and pig-iron to Wakamatsu for use of the Government foundry must continue to reach very high figures. As we have pointed out on previous occasions, the shipping ports and the railways of Japan have been so arranged that the raw materials of China can be very conveniently imported into Japan, to be converted into manfactured products. As a result of the freight war being waged by the British India Steam Navigation Company and the Nippon Yusen Kaisha, it has been possible to secure very cheap rates of freight for pig-iron from the Tata Iron Works in India, and an import which was non-existent two years ago has now reached the huge amount of 81,171 tons, valued at 300,000*l*. The figures for bars and sections are given in the next column.

Country.	1912.		1913.	
	tons	£	tons	£
United Kingdom ..	48,202	420,600	37,687	377,500
Germany	97,466	630,400	93,423	621,600
Belgium	42,811	270,500	40,409	267,100
United States ..	24,705	176,200	7,807	64,900
Sweden	1,761	24,800	2,486	32,800
Austria-Hungary ..	625	24,400	925	30,200
Other countries ..	2,858	24,300	1,000	18,800
Total	218,428	1,571,200	183,737	1,412,900

Here there has been a small decrease, and it will be noticed that the American contribution, which made a sudden jump in 1912, has fallen back to its former level.

The following are the figures for black plates and sheets:—

Country.	1912.		1913.	
	tons	£	tons	£
United Kingdom ..	45,848	449,800	38,002	402,900
United States ..	38,388	315,400	10,823	142,000
Germany	21,707	165,300	33,242	246,000
Belgium	4,057	31,000	9,983	75,100
Other countries ..	100	1,200	1,037	9,600
Total	110,100	962,700	93,087	875,600

In the importation of tin-plates the United Kingdom has nearly a monopoly, the figures being 25,912 tons, valued at 463,400*l*., out of a total of 26,307 tons, valued at 470,400*l*.; and the same is nearly true of galvanised sheets, the figures being 30,502 tons, valued at 491,200*l*., out of a total of 34,025 tons, valued at 549,300*l*. With regard to iron pipes and tubes the figures are as follow:—

Country.	1912.		1913.	
	tons	£	tons	£
United Kingdom ..	7,902	136,500	7,728	158,000
Germany	7,603	126,300	9,373	160,000
United States ..	19,986	240,100	27,152	372,900
Other countries ..	214	3,600	947	16,900
Total	35,706	506,500	45,200	707,800

With the exception of pig-iron, this is the only item to record a large gain, but it will be seen that although the United Kingdom and Germany both increased their amounts, it was America that enjoyed the lion's share of the advance. Big importations were made on behalf of a syndicate which anticipated large requirements from the oil-wells in consequence of the discovery of the better results obtained by deep boring. The most interesting feature in connection with pipes and tubes is the erection of new works at Kawasaki, half-way between Tokyo and Yokohama, where a large plant on the Mannesmann system has been installed, with foreign experts and foremen to assist in instructing the workmen. Great secrecy is observed, but it is reported that very satisfactory progress has been

36-IN. DOUBLE-HEADED SHAPING-MACHINE.

CONSTRUCTED BY MESSRS. LOUDON BROTHERS, LIMITED, ENGINEERS, JOHNSTONE, SCOTLAND.

(For Description, see opposite Page.)

Fig. 2.

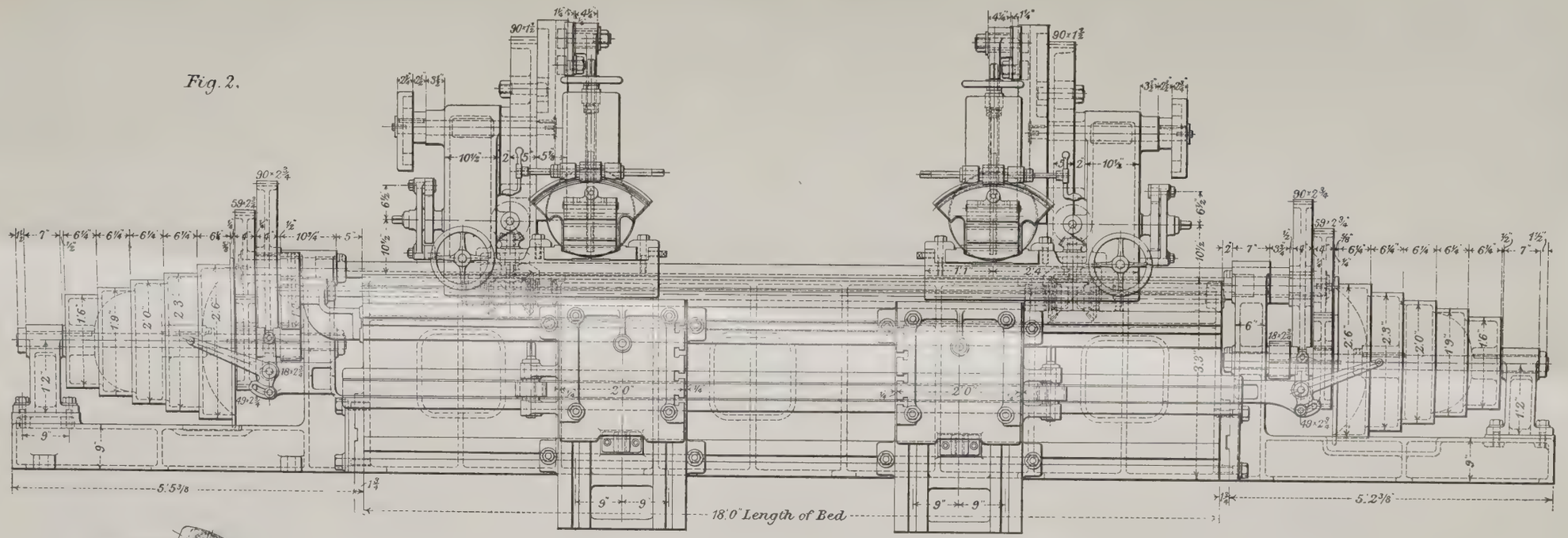


Fig. 3.

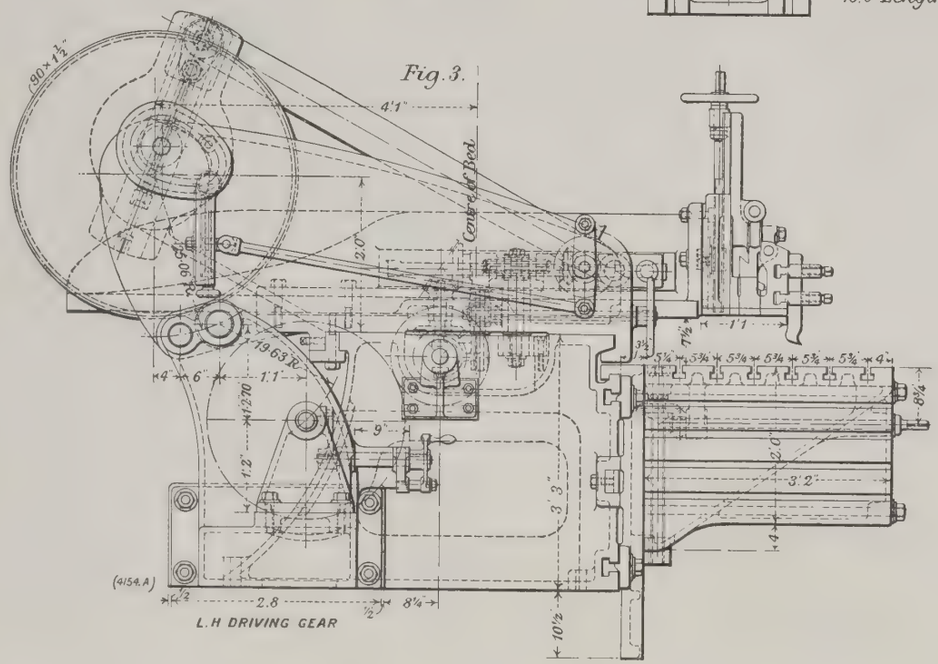
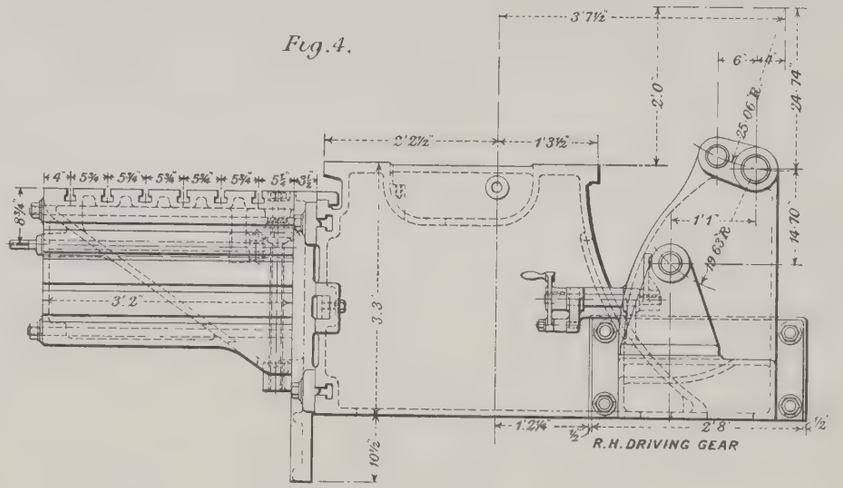


Fig. 4.



made, and the promoters are exceedingly hopeful of gradually driving foreign pipes out of the market.

The Japanese have made great progress in the manufacture of wire nails, the import of which has dropped from over 350,000*l.* to 140,000*l.* This, however, is a line in which the United Kingdom has never been interested, and it is America which is the chief sufferer. In other metal manufactures, a considerable decrease is to be observed in the imports of screws, bolts, nuts, rivets. &c., while a still higher falling-off is to be found in insulated electric wires, which are now manufactured locally. There are several companies engaged in this business, and they seem to have extended their plant rather recklessly, without considering the laws of supply and demand, with the result that the market is largely over-supplied. In rails and in construction materials there was a small advance, and as regards the former the United Kingdom's share was larger than for some time past. The figures were as follow :—

Country.	1912. £	1913. £
United Kingdom	13,900	56,700
Germany	68,500	122,200
United States	252,700	196,200
Belgium	58,800	21,500
Other countries	8,300	20,600
Total	402,200	417,200

The figures for machinery are very high, and easily beat all previous records. The following table gives the amounts for the three years 1911, 1912, and 1913 :

Country.	1911. £	1912. £	1913. £
United Kingdom	1,269,600	1,456,380	1,737,800
United States	644,600	705,600	754,300
Germany	674,300	658,900	873 600
France	18,500	18,500	24,700
Other countries	211,000	148,300	362,300
Total	2,818,000	2,987,600	3,752,700

To a certain extent, however, the increase for 1913 is misleading, because, instead of representing activity during 1913, it should be taken as an indication of the optimistic feeling which prevailed as to the future in 1911, inasmuch as a large part of the machinery arriving last year was ordered more than twelve months before. At present there is a comparative cessation of new works and of development of existing factories, so that the outlook for the next year or two is not very bright.

It will be seen from the above table that the United Kingdom remains well at the head of the list, but her share has not advanced as much as that of Germany, the percentages of increase being 19 and 33 respectively. Although Japan still imports machinery in such large quantities, it is interesting to note that there has been solid development on the part of Japanese machinery makers. In the case of gas plant for lighting and power it has been quite remarkable. They are making suction-producers, gas-engines, retort-furnaces, and are building complete gas works. Practically all the appliances required by gas companies are now made in Japan, including meters, stoves, burners, lamps, glassware, mantles, &c. The above are being produced by a number of factories on a very large scale. They are somewhat inferior, lighter, and cheaper than imported goods, but they suit the market, and freight and duty make it quite impossible for foreign goods to compete.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, November 11.

PRODUCERS of both crude and finished materials continue to face depressing conditions. The output of crude iron declined very considerably in October, and more furnaces will be blown out. Such price reductions as have been made have had no influence on demand. Very little of the projected new work is coming out. Plans are laid, requirements are made known, but orders are not placed except for material absolutely necessary. In this way the entire industry is sagging. Stocks on consumers' hands were, perhaps, never so low, except in actual panic conditions. Mills are anxious to keep going, and statements are sometimes made of remarkably low prices ; in fact, cost prices by mills here and there. Export business is still disappointing, with the possible exception of steel billets. There is an inquiry for 30,000 tons of rails from Norway. Southern billet makers have made several good contracts on export account. Some western mills have also captured fair export orders in billets. The export business in wire continues good, and quite a number of mills are running to capacity. Much wire inquiry has not yet resulted in orders. Foreign inquiry covers rails, steel bars and sheet bars. Mill people are strangely reticent as to what foreign business they are actually doing. Notwithstanding the low output, there exists a strong undertone, and the depleted production with exhaustion of stocks means eventually a strongly compensating demand.

THE ROYAL METEOROLOGICAL SOCIETY.

THE opening meeting of this Society for the session was held on Wednesday evening, the 18th inst., at the Surveyors' Institution, Great George-street, Westminster, Dr. H. N. Dickson, Vice-President, in the chair.

Dr. H. R. Mill and Mr. C. Salter communicated a paper on "*Isomeric Rainfall Maps of the British Isles.*" The average monthly rainfall, expressed as a percentage of the average annual fall of each of about 300 stations, forms the basis of a set of twelve monthly and four seasonal maps. The most striking features are the occurrence of two types of seasonal March—one chiefly characteristic of western or wet districts having a winter maximum and a summer minimum, the other chiefly confined to eastern or dry districts having a winter minimum and a summer or autumn maximum. The equinoctial maps show the transitional stages between these two extremes, the spring months having everywhere a low rainfall and small range, with a central maximum inland and a peripheral minimum on the coast, and the autumn months a large rainfall with a central minimum and a peripheral maximum. The maps show that the relation of heavy rainfall with high-lying land is a relation of cause and effect; the relation of the winter maximum with the heavy rainfall is therefore an indication of the common cause. High land is only associated with heavy rain because it meets rain-bearing winds, and the true connecting circumstances are the position of high land and its relation to the prevailing winds. The occurrence of rain with easterly winds, affecting principally the east coast, makes it impossible to view the British Isles as having a rainfall *régime* solely produced by south-westerly winds. The far greater frequency of southerly and westerly winds than of easterly and northerly, and the fact that the latter occur mainly at certain seasons, go far to explain the features both of the average rainfall maps and of the isomeric maps.

A paper by Mr. J. I. Craig, on "*A See-Saw of Temperature between England and Egypt,*" was also read. In this paper were given diagrams of lines of thermal equi-correlation with Egypt.

WATER-POWER IN NORWAY.—The unusually low water level of a number of Norway's rivers threatens to cause much inconvenience to various Norwegian industries. At one place there is only half a foot of water as against an average of 5 ft. to 6 ft. in the autumn season ; in another place there is 2.95 ft., against 4.80 ft. In some places work has been entirely stopped ; in others it has been reduced to half-power. In many parts no one can remember such a scarcity of water.

LLOYD'S RETURNS OF VESSELS LOST.—Statistics of vessels lost during the quarter ended June 30 last have just been issued by Lloyd's Register of Shipping. Steamships are first dealt with, and we find that 54 vessels, aggregating 86,105 tons in all, have been removed from the Register during the period. Great Britain has, of course, been the greatest sufferer, 20 vessels, totalling 48,373 tons, having been lost. This is, however, only 0.26 per cent. of the total gross tonnage owned in this country. Of the 20 ships, 3 were burnt, 4 lost in collision, 2 foundered, 3 are missing, and 8 were wrecked. The British Colonies lost only 4 vessels, all of which were wrecked. Their total tonnage was 2118, which is 0.13 per cent. of the tonnage owned in the Colonies. In order of magnitude of losses, Germany comes next on the list, this country having lost 3 vessels, with an aggregate tonnage of 8036, which is 0.16 per cent. of the total German tonnage. Norway, the United States, Russia, and Italy come next in order on the list, their respective losses being 5148, 3336, 2340, and 2276 tons; the percentages of their total tonnages lost by these countries are 0.26, 0.16, 0 27, and 0.16 respectively. The only other countries with individual losses exceeding 1000 tons are Sweden, France, and Japan; the figures for these countries are 1472 tons (0.14 per cent.), 1284 tons (0.07 per cent.), and 1260 tons (0.07 per cent.) respectively. Other European countries have, however, lost 8868 tons between them. Coming now to sailing-ships, we should first mention that the figures given for these vessels are the net tonnages in all cases, whereas those previously given for steamers are gross tonnages. In this class of shipping the most severe losses have been sustained by Norway, this country having lost 10 ships, aggregating 9936 tons, which is 1.81 per cent. of the total tonnage of Norwegian sailing vessels. The United States takes second place with 8 ships, making 5103 tons in all, and France comes third, her losses being 9 ships, of 3479 tons in the aggregate. For these two countries the losses are 0.54 and 0.88 per cent. of the total sailing tonnage owned. Next in order on the list are Russia, with 1992 tons (0.99 per cent.), and Central and South America, with 1872 tons; the percentage lost by the latter countries is not stated. Strangely enough, the tonnage of sailing-ships lost by the British Colonies during the period we have been considering exceeds that lost by the Mother Country. The figures for the Colonies are 6 ships, making 1215 tons, which is 0.78 per cent. of the total Colonial tonnage, and for the United Kingdom 7 ships, totalling 1157 tons, and making 0.32 per cent. of the total tonnage of British sailing vessels. Only two German sailing-ships have been lost during the quarter, but the tonnage lost is almost exactly equal to that of the seven British ships lost. The figure for Germany was 1158 tons and the percentage lost was 0.36. The losses of other countries are insignificant, and the total number of sailing-ships lost amounts to forty-nine vessels, of an aggregate tonnage of 26,404. It should be noted that vessels of less than 100 tons are not considered in compiling the above statistics ; vessels trading on the Great Lakes of North America are also excluded.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was quiet, but Cleveland warrants were firm. The turnover was limited to one lot at 50s. 3d. one month, and closing sellers quoted 50s. 1d. cash and 50s. 4d. one month. The afternoon session was dead idle, but sellers increased their prices for Cleveland warrants to 50s. 2½d. cash and 50s. 6d. one month. On Friday morning the tone continued strong, but only one Cleveland warrant was done at 50s. 3d. cash, and at the close sellers named 50s. 4½d. cash, 50s. 7½d. one month, and 51s. 3d. three months. In the afternoon, business was still on a small scale, but Cleveland warrants again made an advance. Dealing was limited to one lot at 50s. 9d. one month, and closing sellers quoted 50s. 7½d. cash and 50s. 10½d. one month. The upward movement made further progress on Monday morning, when 2500 tons of Cleveland warrants were put through at 50s. 10½d. seven days, 51s. 5d. January 28, and at 51s. and 51s. 2d. one month. The market closed with sellers naming 50s. 11½d. cash and 51s. 3d. one month. Strong conditions still ruled in the afternoon, when 1500 tons of Cleveland warrants were dealt in at 50s. 11d. cash and 51s. 5d. one month, with sellers over at 51s. 3d. cash and 51s. 6d. one month, and buyers at 51s. 1d. and 41s. 4d. respectively. On Tuesday morning Cleveland warrants continued to rise, and the turnover was 2000 tons at 51s. 9d. one month, 52s. January 28, and 52s. 3d. three months. Sellers' closing quotations were 51s. 6d. cash, 51s. 9d. one month, and 52s. 4d. three months. In the afternoon the tone was easier, and one Cleveland warrant changed hands at 51s. 4½d. one month, with sellers over at 51s. 3d. cash and 51s. 6d. one month. When the market opened to-day (Wednesday) a recovery took place in Cleveland warrants, which were quoted by sellers at 51s. 5d. cash, 51s. 8d. one month, and 52s. 1½d. three months. No dealings of any kind were reported. In the afternoon the tone was flat, and 500 tons of Cleveland warrants were done at 51s. 4½d. one month, and at the close sellers quoted 51s. 3d. cash and 51s. 6d. one month, with buyers at 51s. 1½d. and 51s. 4½d. respectively.

Sulphate of Ammonia.—During the past week there has been a fair demand for sulphate of ammonia, and the price has varied slightly. The current quotation is round 11*l.* per ton for prompt delivery, Glasgow or Leith.

Scotch Steel Trade.—The recent improvement in shipbuilding on the Clyde is being reflected in the Scotch steel trade, throughout which there is a much better feeling and an increased inquiry. Another factor of no little importance to the industry is the inability of the German mercantile fleet to carry cargoes to the overseas markets, with the result that whenever these markets get busier, the bulk of the business is almost bound to come to Britain. America will also share in the stoppage of supplies from the Continent, but, all the same, our portion will be considerable, and the outlook is indeed favourable. Specifications for heavy material are still somewhat slow in coming in, although improvement is noticeable, but all round there has been more doing as greater confidence prevails. At a joint meeting of the Scotch and English steel-makers, held in London last Friday, several items of interest were discussed, but in the matter of prices it was agreed to make no official change at present. The expansion of trade will probably be a little slow, but that it is coming along all right is the general opinion. Black-sheet makers report practically no change in their position, but the demand for most kinds of light structural material is rather better. There is a decided dulness in the export demand, and only moderate orders are coming through ; but this hand-to-mouth policy cannot continue for any great length of time, and as the financial position abroad improves, better buying will be general. Prices are, as stated, without actual change, and although very firm, the quotation for ship-plates is still 6*l.* 15s. per ton, less 5 per cent. delivered Clyde or equal.

Malleable-Iron Trade.—Some of the malleable-iron makers in the West of Scotland are moving along very satisfactorily, while others are still complaining of the scarcity of business. On the whole, the position has not changed, and prices are unaltered at 7*l.* 12s. 6d. per ton, less 5 per cent., for "crown" bars. The revival in business, which is so freely talked about at present, cannot come along too soon now, and an increased demand will be much appreciated in the malleable-iron industry.

Scotch Pig-Iron Trade.—During the past week there has been a more pronounced desire on the part of buyers to fix up for further supplies of the ordinary qualities of Scotch pig-iron, and consequently orders have been more numerous than for several weeks back. The export trade also shows signs of improving, and the bookings include one or two fairly decent lines. Less is now being stored. Prices are firmer, and the following are the market quotations for makers' (No. 1) iron :—Clyde, 68s.; Calder, Gartsherrie, Summerlee, and Langloan, 68s. 6d. (al shipped at Glasgow); Eglinton, 62s. 6d., and Glengarnock 70s. (both at Ardrossan); Shotts (at Leith), 68s. 6d.; and Carron (at Grangemouth), 69s.

Shipbuilding.—Intimation is made that the shipbuilding yard at Kelliebank, Alloa, which has been shut down for the past nine months, will shortly be reopened under the management of a London firm, who have several good contracts on hand. A twenty-one years' lease of the ground has been secured.

Scotch Imports of Iron and Steel Products.—The undernoted table gives the total registered imports of the

named kinds of iron and steel manufactures, during the month of October, into the ports of Glasgow, Greenock, Grangemouth, Leith, Dundee, and Aberdeen :—

	Ex Continent. Tons.	Value. £	Ex U.S.A. Tons.	Value. £
Iron bars, angles, &c.	23	215	—	—
Steel bars, angles, &c.	4	23	24	160
Iron and steel hoops and strips	55	541	1768	11,471
Iron and steel plates and sheets, not under ⅛ in. thick.. ..	48	336	—	—
Iron and steel plates and sheets, under ⅛ in. thick	—	—	59	1,014
	130	1115	1851	12,645

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—A slight improvement has been experienced in the demand for house coal, but merchants report great difficulty in obtaining supplies. There is a marked shortage of wagons and a good deal of delay on the railways. Pits are working full time, and supplies are adequate if they could only be secured. Contract deliveries of gas fuel are irregular. A decreased consumption is reported by gas and electric supply concerns, as a result of the restrictions placed on street-lighting. The market for steam hards continues weak. Shipments are exceptionally light. Little business is passing *via* the Humber ports, but increased quantities are going to the Mersey, but with an unusually large demand from home consumers, some of whom are taking abnormal quantities where Government work is plentiful, values are steady, and have a stronger tendency. With regard to slacks, the position has somewhat improved. Lancashire trade is decidedly on the upward trend. A considerable tonnage is still available on the open market, but prices are not subjected to the same amount of cutting, and are steadier. Cokes are quiet and unaltered. Quotations :—Best branch hand-picked, 16s. to 16s. 6d.; Barnsley best Silkstone, 12s. to 13s. 6d.; Derbyshire best brights, 12s. 6d. to 13s. 6d.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 11s.; small nuts, 9s. to 10s.; Yorkshire hards, 10s. to 11s.; Derbyshire hards, 9s. 6d. to 10s. 6d.; best slacks, 7s. to 8s.; seconds, 4s. 9d. to 5s. 9d.; smalls, 1s. 9d. to 2s. 9d.

Iron and Steel.—Despite a further reduction of prices in the local iron market, little business is being done in common brands, and forward buying is on a small scale. Lincolnshire No. 3 foundry is quoted at 56s. 8d., Lincolnshire forge at 55s. 8d., Derbyshire No. 3 foundry at 55s. 6d., and Derbyshire forge at 53s. 6d., but only a very small amount of business is transacted at these figures. Derbyshire forge can be bought at 52s. to 52s. 6d., Derbyshire foundry at 54s. to 54s. 6d., Lincolnshire forge at 53s. 6d. to 54s. 6d., and Lincolnshire foundry at about 55s. 6d. Makers express confidence in the future, and are not taking any steps to restrict production. Buying of hematite continues on a heavy scale for armament purposes. Local users are deriving advantage from the slump in export business caused by Government prohibitions in relation to exports to certain foreign countries. As in the case of common irons, West Coast hematites, officially quoted at 80s., can be bought at 2s. less, and East Coast sorts, quoted at 70s., from 2s. to 3s. less. The South Yorkshire Bar-Iron Makers' Association maintains its basis quotation of 8*l.* 10s. for crown bars. Sheets are quoted at 9*l.* 10s. A steady demand prevails for scrap at slightly lower rates. There is still a pronounced shortage of Siemens-Martin steel, but additional furnaces are being erected, and it is hoped that when the output is augmented adequate supplies will be available for all classes of consumers. In the existing circumstances heavy armament-makers are taking big tonnages, and manufacturers of products not intended for war purposes are having to go short. Special steel is a brisk medium. Orders are under execution for Bombay, Chicago, New York, Yokohama, Montreal, and Colombo. Railway steel departments are looking forward to supplying several of those who were Germany's best customers, but at present general business is quiet. Wagon-builders are better employed. Some good orders for tramway material have been received from colonies and home corporations. Firms making shells, guns, and armour, including Messrs. Vickers, Limited, Messrs. Cammell Laird and Co., and Messrs. Hadfield, Limited, are enlarging their already record capacity for output. Tool-makers have more work on hand from the Government for picks, shovels, axes, &c., than they can comfortably handle. Steel billet prices are a little easier, production being cheaper on account of the decline in hematite values.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—A cheerful tone prevailed during the week and a fair amount of business has been transacted. The quotations are consequently steadily maintained, and with the demands of the shipbuilders increasing, coupled with an access of Government orders, the improvement is likely to be maintained. The home demand for pig-iron continues steady, and deliveries can be made by rail to Scottish customers at a charge of 7s. 6d., as against the recent rate of 8s. 10d. per ton. No. 3 g.m.b. Cleveland changed hands at 51s. 3d., f.o.b. delivery, though there were instances during the week of 3d. more being asked ; No. 4 foundry is maintained at 50s. 9d. ; No. 4 forge at 50s. 3d. ; and mottled and white iron at 49s. 9d. to 50s., early delivery. Hematite prices have also shared in the general improvement, Nos. 1, 2, and 3 East Coast brands being very firm at 65s. per ton. Rubio ore is quoted 20s. ex-ship Tees for 50 per cent. quality, freights, Bilbao-Middlesbrough, being 7s. Blastfurnace coke is 17s. 6d. delivered at furnaces.

Stocks and Shipments.—Stocks of Cleveland pig-iron in the public warrant stores now stand at 103,643 tons. Since the beginning of the month the stock has been reduced by 418 tons. Shipments of pig-iron from the Tees to date this month average 2270 tons per working day, the total despatches being returned at 47,680 tons, 43,915 tons of which have gone from Middlesbrough and 3765 tons from Skinningrove. To the same date last month the loadings were given at 38,449 tons, or a daily average of 1830 tons, and for the corresponding part of November a year ago the clearances reached 67,497 tons, or an average of 3214 tons per working day.

Manufactured Iron and Steel. — Very satisfactory accounts are given of all branches of the manufactured iron and steel trades. Works are kept busy, and several producers are being pressed for delivery. Some large orders have been placed for steel angles and plates, the prices of which have been advanced 5s. per ton, making plates 7*l.* 10s. and angles 7*l.* 5s. Constructional steel is in good demand, but rails are quiet. Principal market quotations stand :—Common iron bars, 8*l.* ; best bars, 8*l.* 7s. 6d. ; best best bars, 8*l.* 15s.; packing iron, 6*l.* 5s.; iron ship-plates, 7*l.* 5s. ; iron ship-angles, 8*l.* ; iron ship-rivets, 8*l.* 7s. 6d. ; iron girder-plates, 7*l.* 5s. ; steel bars (basic), 7*l.* 10s. ; steel bars (Siemens), 7*l.* 15s. ; steel ship-plates, 7*l.* 10s. ; steel ship-angles, 7*l.* 5s.; steel boiler-plates, 8*l.* 5s. ; steel strip, 7*l.* 5s.; steel hoops, 8*l.*; steel joists, 7*l.* 2s. 6d.; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s. ; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 7s. 6d.; steel railway sleepers, 7*l.*—railway material net at works, and all other descriptions less 2½ per cent. discount ; galvanised corrugated sheets, 24 gauge, in bundles, 14*l.* f.o.b.—less 4 per cent.

ELECTRICITY AT LEEDS.—In the six months ended September 30, the Leeds electricity undertaking increased its output both for lighting and power, notwithstanding some falling off having been experienced at the beginning of the war through a temporary depression of trade. The units sold for private lighting in the six months under review were 7¾ per cent. more than in the previous corresponding half-year, and there was an increase of 19⅝ per cent. in the units sold for power. A further evidence of the growing popularity of electric lighting and power in Leeds was afforded by the number of consumers, which rose to 10,226, as compared with 9612; the aggregate capacity of the motors installed also growing from 26,842 horse-power to 29,052 horse-power. The number of consumers of current for heating purposes rose from 735 to 804, and the total sales for the half-year were 18,626,358 units, or nearly 45 per cent. more than in the corresponding six months of 1913 ; the prices charged averaged 0.83d. per unit against 1.02d. per unit, and there was, accordingly, an increase of only 17¼ per cent. in the cash income. The income derived from the sale of current for all purposes during the half-year ended with September 30 was 64,262*l.*, as compared with 54,814*l.* A gross profit of 33,553*l.* was shown, as compared with 31,755*l.*

METROPOLITAN RAILWAY DEVELOPMENT.—The laying down by the Metropolitan Railway of a new express line on the route between Baker-street and Harrow entailed the construction of a new railway viaduct at Kilburn. The widening of the railway track commenced with the demolition of two tunnels at Finchley-road. From this point the railway branches from four to eight rails, and the traffic is divided here into local and express trains. Most of the new line has been laid on land belonging to the Metropolitan Railway parallel with the existing lines ; but between West Hampstead and Kilburn stations it was necessary to construct a lofty viaduct, passing over the London and North-Western Railway lines and a number of streets and thoroughfares. The viaduct, without approaches, is over one-third of a mile in length, and forms an engineering work of considerable magnitude. The works were started in June, 1913, and are expected to be completed towards the end of January, next year. They include the construction of four bridges, as follows :—The bridge over the London and North-Western Railway, built on a skew, has two clear spans of 97 ft. and of 80 ft., the girders being 7 ft. 6 in. at the ends and 9 ft. 6 in. in the centre. The bridge is of the hog-back plate type, with pressed trough flooring, the total weight being about 300 tons. The bridge crossing Iverson-road weighs about 300 tons, is of the hog-back lattice type, having a clear span on skew of 99 ft., with plate flooring. Girders are 8 ft. 6 in. deep at the end and 13 ft. at the centre of the bridge. The bridge crossing Loveridge-road has a clear span of 80 ft. between the bearings. It is of the lattice type, with plate flooring, with girders 10 ft. 6 in. deep at the ends and 13 ft. in the centre, and has a weight of about 180 tons. The largest bridge, that at Kilburn High-road, which weighs about 600 tons, has a clear span of 147 ft. centre. This bridge is also of the lattice type, with plate flooring, the girders being 11 ft. 6 in. at the ends, and 15 ft. 6 in. at the centre. This bridge will have a cast-iron ornamental parapet 7 ft. above rail-level. All the railway lines will be carried over the bridges on ballast. The engineer is Mr. W. Willox, M. Inst. C.E., engineer to the Metropolitan Railway. The contractors for the bridges over Kilburn High-road and Loveridge-road are Messrs. E. C. and J. Keay, Darlaston, and for the bridges over Iverson-road and the North-Western Railway, Messrs. Eastwood, Swingler and Co., Derby. The work is under the superintendence of Mr. O. G. C. Drury, resident engineer.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has shown little change. Tonnage arrivals over the week-end were low, and the number of steamers in dock was smaller than usual. Coal stocks being heavy, sellers for immediate shipments have been making concessions to immediate buyers, but they have maintained forward values, as they are looking for a good future demand. Rather higher prices have been obtained for bunker smalls. House coal, patent fuel, and coke have shown scarcely any change. The best Admiralty large steam coal has made 20s. to 22s.; best secondary qualities have brought 18s. to 19s. ; other secondary descriptions, 17s. 3d. to 17s. 9d. ; best bunker smalls, 8s. 9d. to 9s. 3d. ; and cargo smalls, 5s. to 7s. per ton. The best household coal has been quoted at 19s. to 20s. ; good households have made 17s. to 18s. ; No. 2 Rhondda large has been priced at 12s. to 14s. ; and No. 2 smalls have realised 6s. 6d. to 7s. 6d. per ton. Patent fuel has been quoted at 16s. 6d. to 17s. 6d. per ton. Special foundry coke has realised 27s. to 30s. ; good foundry coke, 24s. to 25s. ; and furnace coke, 17s. 6d. to 18s. 6d. per ton. As regards iron ore, Rubio has been making 17s. 6d. to 18s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Bristol and the North Pacific.—The Maple Leaf Line is making elaborate arrangements for accelerating its service between Bristol and San Francisco. The Bristol agents for Messrs. Evans and Sons, of San Francisco, are Messrs. Bethell, Gwyn and Co., and they announce that vessels of the Isthmian Steamship Company will be worked in conjunction with the Hall boats—a group of steamers running from Atlantic ports to the west coast of South America. The Maple Leaf Line has for the last three years maintained a regular service between the Pacific Coast and certain English ports, including Bristol ; and the opening of the Panama Canal has made an accelerated service a matter of urgency ; it is also necessary to increase the fleet. Ten vessels will be placed on the regular service, and if trade increases, more frequent sailings will be arranged. The Maple Leaf Line has hitherto run from New York and Savannah to British Columbian ports *via* ports in South America, through the Straits of Magellan to the Pacific Coast. The return voyage will now be made from San Francisco, touching at Seattle, Tacoma, Portland or San Pedro, and thence through the Panama Canal to ports in the United Kingdom, such as Bristol and Swansea, returning thence to New York, and so completing a round trip. The voyage from San Francisco to Bristol *via* the Panama Canal will occupy about 40 days, considerable saving of time thus being secured.

Wales and Germany.—The prohibition of tin-plate exports to Holland, Denmark, and Sweden has been loyally received at Swansea, makers fully agreeing that it is probable that Welsh plates have been finding their way into Germany in a manner beyond their knowledge and control. The effect of the new order will, however, mean the closing down of about thirty-five mills employing some 1700 men. The effect of the action of the Government will be more severely felt in another week or fortnight, as many more mills must then close down.

Newport.—The steam-coal trade has shown weakness, stocks being regarded as excessive, while tonnage has been scarce. The best Newport slack vein large has made 16s. 6d. to 16s. 9d. ; Western Valleys have brought 15s. 9d. to 16s. 3d. ; and Eastern Valleys 15s. 6d. to 15s. 9d. per ton.

Cardiff Dock-Gates.—The Chepstow Bridge Works have secured a contract for a pair of dock-gates for the Cardiff Railway Company, to replace a pair built by the late Mr. Finch over fifty years ago. The firm intends to complete the gates at its works and launch and tow them to Cardiff, where the existing gates have to be removed and the new ones placed in position in five tides, or less than three days. As each gate weighs nearly 100 tons, the importance of this operation can be inferred.

THE SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.—The twenty-second general meeting of the Society of Naval Architects and Marine Engineers will be held in Assembly Room No. 1, Engineering Societies Building, New York, on Thursday and Friday, December 10 and 11. The final list of papers follows :—"International Conference on Safety at Sea," by Hon. E. T. Chamberlain, Hon. Associate Member ; "Safety of Life at Sea : Application of Subdivision Rules Adopted at International Conference," by Mr. James Donald, Member ; "Safety of Life from Fire at Sea," by Mr. W. O. Teague ; "Launching Data for a Battleship," by Naval Constructor J. G. Tawresey, U.S.N., Member ; "Stability of Vessels as Affected by Damage Due to Collision," by Mr. William Gatewood, Member ; "Expansion or Contraction of Certain Dimensions and the Effect upon Resistance," by Professor H. C. Sadler, Member of Council ; "Some Experiments with Models having Radical Variations of After-Sections," by Naval Constructor D. W. Taylor, U.S.N., Vice-President ; "Recent Developments in Submarine Signalling," by Mr. J. B. Millet ; "The Thermodynamics of the Marine Oil-Engine," by Mr. John F. Wentworth ; "Refueling of Warships at Sea," by Mr. Spencer Miller, Member ; "Our First Frigates : Some Unpublished Facts about their Construction," by Hon. F. D. Roosevelt, Assistant Secretary of the Navy ; "The Behaviour of Riveted Joints under Stresses," by Mr. James E. Howard ; "The Present Status of Marine Diesel Engine Installations," by Mr. W. R. Haynie, Associate ; "The Application of Electric Propulsion to Battleships, together with the Experience Gained in the Jupiter," by Lieutenant S. M. Robinson, U.S.N., Member.

GRANARY AT GLASGOW HARBOUR; GRAIN-CONVEYING MACHINERY.

MR. W. M. ALSTON, M. INST. C.E., ENGINEER TO THE CLYDE NAVIGATION TRUST, GLASGOW; MR. G. H. BAXTER, M.I. MECH. E., MECHANICAL ENGINEER.

(*For Description, see Page* 633.)

FIG. 88. SUBWAY IN QUAY WALL, WITH BANDS AND DUST TRUNKING.

FIG. 89. LONGITUDINAL SUBWAY UNDER GRANARY.

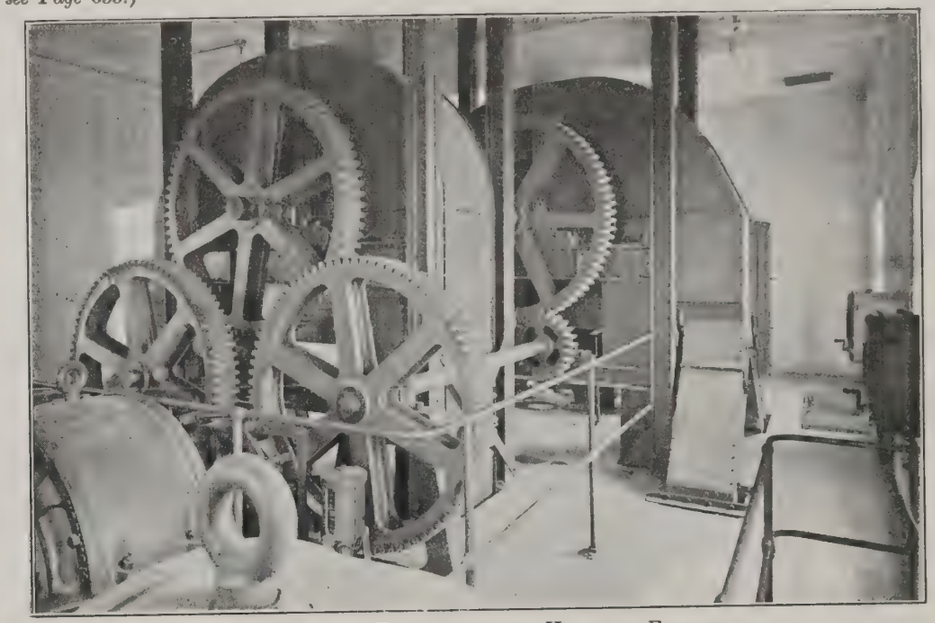


FIG. 90. ELEVATOR-TOWER, SHOWING HEADS OF ELEVATORS.

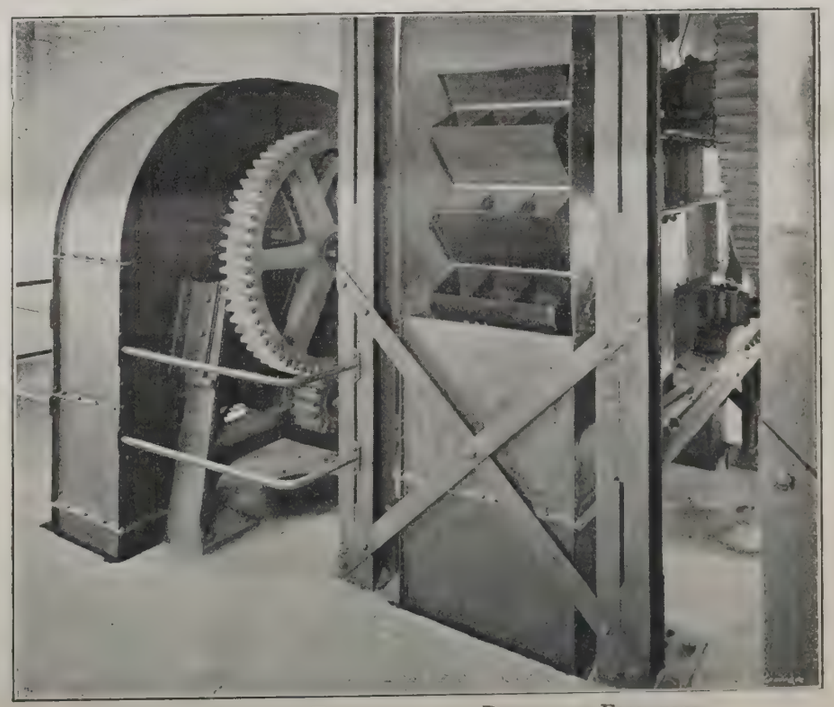


FIG. 91. ELEVATOR-TOWER, SHOWING BUCKETS IN ELEVATORS.

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NOTICES OF MEETINGS.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (INCORPORATED).—Friday, November 27, at 7.30 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-on-Tyne. Discussion on Mr. J. W. Hobson's paper, "Industrial Locomotives" (read October 30); paper by Mr. W. J. B. Wilson, entitled "The Remarkable Failure of a Consignment of Steel Plates."

THE ROYAL SOCIETY OF ARTS.—Monday, November 30, at 8 p.m. Cantor Lecture: "The History and Practice of the Art of Printing," by Mr. R. A. Peddie (Lecture II.). Wednesday, December 2, at 8 p.m. "Britain and Germany in Relation to the Chemical Trades," by Mr. William Reginald Ormandy, D.Sc., F.C.S. The Right Hon. Lord Moulton, M.A., LL.D., F.R.S., will preside.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 1, at 8 p.m. Papers to be read:—"Tests of Reinforced-Concrete Structures on the Great Central Railway," by Mr. James Benjamin Ball, M. Inst. C.E.; "Corrosion of Steel Wharves at Kowloon," by Mr. Somers Howe Ellis, M. Inst. C.E.; "Concreting in Freezing Weather and the Effect of Frost upon Concrete," by Mr. John Hammersley-Heenan, Assoc. M. Inst. C.E.

THE RÖNTGEN SOCIETY.—Tuesday, December 1, at 8.15 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. A discussion on "The Localisation of Foreign Bodies by X Rays" will be opened by the Hon. Secretary. An exhibition of apparatus devoted to the localisation of foreign bodies will be held, and several short lantern demonstrations will be given.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, December 1, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C., when a discussion on "Illuminating Engineering in War Time: Some Lessons to be Learned from the Present Lighting of London," will be opened by Mr. Leon Gaster.

THE INSTITUTION OF ELECTRICAL ENGINEERS: YORKSHIRE LOCAL SECTION.—Wednesday, December 2, at 7 p.m., at the Philosophical Hall, Leeds. A paper will be read on "Power-Plant Testing," by Mr. W. M. Selvey, Member, to be followed by a discussion.

THE SOCIETY OF ENGINEERS.—Monday, December 7, at 7.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. A paper entitled "Mechanical Appliances for the Painless Killing of Animals" will be read by Mr. S. M. Dodington.

ENGINEERING.

FRIDAY, NOVEMBER 27, 1914.

THE STEAM-TURBINE AND ITS CONDENSER.

AN incidental result of the inability of the reciprocating engine to utilise high vacua effectively was a very general neglect by steam engineers of the theory of the condenser. Whether the design of the latter were good or bad affected to but a very minor degree the steam consumption of the average commercial steam-engine. As a consequence the true character of the phenomena occurring within a condenser were, if anything, less known and appreciated by the steam-engine designer of fifteen or twenty years ago than by the pioneers of a previous generation, with whom the introduction of this important accessory to this steam-engine originated. No doubt the intervening period was not free from attempts to improve condenser practice, but the more successful of these owed their vogue mainly to considerations of manufacturing convenience, no real improvement in design being made until the introduction of the steam-turbine.

The problems which had to be solved by Sir Charles Parsons and his associates in making a commercial success of the new prime mover were remarkable both for variety and difficulty. These difficulties were, moreover, enhanced by the fact that the steam-turbine is inherently better adapted to the development of very large powers than to the 50-kw., 100-kw., or even 350-kw. sets, which constituted the maximum sizes of unit for which orders were obtainable during this period of development. The small size of the unit enhanced, indeed, not only the difficulty of the turbine design proper, but also that of its generator, a sufficiently tough problem in any case. The load on the large generators now installed is characterised by a very favourable diversity factor. The current taken by any motor on the mains constitutes, in fact, but a very small fraction of the total output, and if suddenly thrown off does not appreciably affect the regulation. It was far otherwise in the pioneering period, and difficulties due to regulation were added to those inherent in the design of a machine to operate at what was then considered an abnormally high speed of rotation.

To some small degree these obstacles in the path of commercial success were lightened by the turbine's ability to make effective use of the highest practicable vacuum. For long, indeed, inspecting engineers failed to realise the difference in this regard between a steam-turbine and a reciprocating engine. With the latter a 28-in. vacuum, as shown by the gauge, might be taken as an actual 28-in. vacuum without either unduly handicapping the engine if the barometer were high, or favouring it were it low. Moreover, many engineers had a prejudice against the specification of high vacua, since with reciprocating engines the air leakage is likely to be large, unless continuous care is taken to check it. Thus, if a 27½-in. vacuum were specified for a turbine, the builder might well pray that what meteorologists call an area of marked depression might prevail at the time of the tests. A 29-in. barometer with the gauge showing an apparent 27½-in. vacuum would, in fact, correspond actually to a 28½-in. vacuum, with which the steam consumption would be some 5 or 6 per cent. less than with the 27½ in. assumed in the specification. Nowadays, of course, it is difficult to realise that any engineer of standing should have failed to understand that it was the back pressure on the turbine that mattered, and not the nominal vacuum as shown by the gauge; but it is not many years since a leading South African engineer declared publicly that steam-turbines were out of place in the Transvaal, because, owing to the high level of the country, it was impossible to obtain a vacuum of more than 26 in. The general neglect into which the theory of the condenser had fallen is further indicated by the fact that the installation of a central condensation plant was at one time considered the acme of progress in the lay-out of a power-station; and, indeed, with reciprocating engines the drop of an inch or two of pressure between the engine exhaust branch and the condenser was, no doubt, a matter of no very vital importance.

When at length the peculiar characteristics of the steam-turbine were recognised, a complete change had to be made in certain treasured features of surface-condenser design. It was quite common, for example, to fit diaphragms within the condenser, so as to give the steam a more or less tortuous passage over the tubes. A spreader fitted below the inlet branch was also not infrequently fitted, the idea being to distribute the steam more evenly over the tubes. When such devices were used with the high vacua desiderated in steam-turbine practice, their evil effects quickly became obvious. A drop of as much as an inch of vacuum has in some such cases been noted between the top and bottom of a condenser, which was eliminated on removing the guides and plates incorporated by well-meaning but injudicious designers.

With a well-designed condenser there is, in fact, little difference observable in the pressures recorded at the top and bottom of the condenser; but, on the other hand, there is always a difference in the temperatures registered in the two localities. Moreover, it is often the case that neither of these two temperatures corresponds to that which the steam should be, according to the usual steam-tables. The temperature is always highest near the steam inlet, and generally does not deviate from the tabular figure by more than a degree or so (being generally a little too high), and with due care in making measurements a still closer accord can be attained. Such discrepancy as exists here arises from the inherent difficulties attaching to the accurate measurement of the pressure and temperature of a rapidly-moving gas, which offers a problem that, as Mr. Stoney well said on Friday last, when replying to the discussion on a paper on "The Effect of Vacuum on Steam-Turbines," which he had read before the Institution of Mechanical Engineers, has never yet been successfully solved.

At the air-pump inlet, on the other hand, the temperature can be measured with considerable accuracy, as it may in most cases fairly be taken as that of the water discharged. Thus measured, it is, however, invariably below that corresponding to the vacuum shown by the gauge, and often by a very considerable amount. Thus Mr. J. M. Newton has recorded a test in which the hot-well temperature was 65 deg. Fahr., whilst the temperature corresponding to the vacuum should have been 102 deg. Fahr. This defect is, of course, due to the presence of air in the condenser. Ordinary boiler steam contains, at least, 1 part in 4000 by weight of air, and this air content is further augmented by numerous leakages at joints of every kind, so that, by the time the steam enters the condenser, some 4 lb. of air may be expected to be present for each 10,000 lb. of steam, and much more than this if the leakage is great. By Dalton's law, each gas in a cubic foot of a mixture exerts exactly the same pressure as if it had the whole of the space to itself, and the other gases were absent. Near the exhaust inlet the contents of a cubic foot of condenser space contains, say, 10,000 parts of steam to 4 of

air, and to the total pressure, therefore, the air here contributes but $\frac{1}{1000}$ part. As the mixture passes through the condenser the steam progressively disappears, until at the air-pump inlet each cubic foot of condenser space contains rather more air than steam—say 3 parts by weight of the one to 2 parts by weight of the other. If the vacuum be 28 in., corresponding to about 1 lb. back pressure, to this pressure the steam will contribute some 0.52 lb., and steam at this pressure has a temperature of about 80 deg. Fahr., which is therefore the temperature recorded by a thermometer at the air-pump inlet. On the other hand, where the steam enters the condenser, the proportion of air is so small that practically the whole of the pressure recorded is due to the steam, and the temperature here is accordingly about 102 deg. Fahr.

There is, of course, nothing novel in the point above discussed, but in the absence of an explanation of this kind, some of our less-experienced readers may find the extremely valuable paper by Mr. Gerald Stoney, F.R.S., which we reprint on another page of this issue, a little above their heads. Mr. Stoney's career has been identified with the development of steam-turbine engineering, in which condenser problems first became of supreme importance, and has probably forgotten more about condensers than most of us ever knew. It was both natural and proper, therefore, that his paper should be devoted mainly to the many other intricate problems relating to the turbine and the condenser, as to which he has special knowledge, inaccessible to the bulk of us, rather than to such questions of elementary physics as have been discussed above.

The effect of vacuum on a steam-turbine is, indeed, in some respects paradoxical. It is quite possible, for instance, that an increasing vacuum may diminish the efficiency of a turbine, whilst actually increasing the steam economy. This is not always realised by those ill versed in steam-turbine practice, but the fact is well illustrated by the following figures published some time ago by Mr. M. G. L. Swallow, as the results of very careful tests on a large and highly efficient turbine. On increasing the vacuum from 27 in. to 28 in. the actual reduction in the steam taken per kilowatt-hour was 5 per cent., whilst that theoretically due was 6 8 per cent. On still further raising the vacuum to 29 in. the actual gain was 6 per cent., which must be compared with a theoretical figure of 11.4 per cent. Here it will be seen that the efficiency of the turbine has been reduced, since, whilst it returned 73 per cent. of the work theoretically due to an increase of the vacuum from 27 in. to 28 in., it only converted into useful work 41 per cent. of the additional energy rendered "available" by the increase from a 28-in. to a 29-in. vacuum. The same peculiarity is, perhaps, more clearly shown in the correction curves which accompanied Mr. K. Baumann's paper, read before the Institution of Electrical Engineers in 1912. These curves showed that on increasing the vacuum from 28 in. to 29 in., the steam consumption per kilowatt hour is reduced by some 6 per cent., but the efficiency of the turbine is simultaneously reduced by 3 per cent.

It is obvious, therefore, that the rule given by Captain Sankey during the discussion of Mr. Stoney's paper at last Friday's meeting of the Institution of Mechanical Engineers (see page 634 *ante*) is only roughly applicable to estimates of the effect of vacuum on a steam-turbine. Captain Sankey said that at all loads the efficiency ratio of a steam-turbine was nearly constant, and it is, in fact, true that if a series of tests at different powers are made on a steam-turbine, the efficiency ratio varies relatively little under considerable changes of load. Thus in the trials of the famous Elberfeld turbine the gross efficiency ratio at an output of 994.8 kw. was 55 per cent., and at 1190 kw. it was 56.5 per cent. Even greater constancy than this is exhibited in other cases. Thus with one of the early Rateau machines the efficiency ratio was 54.4 per cent. at half load and 54.9 per cent. at full load. This apparent constancy in the efficiency ratio is, however, largely attributable to the fact that at low loads the vacuum is generally better than at full load, and, in short, as a working rule, it may be taken as substantially correct that the "shaft" efficiency of a steam-turbine is the same when the ratio of exhaust to admission pressure is the same; that is to say, a given turbine shows the same consumption per shaft-horse-power hour when supplied with steam at 200 lb. absolute below the governor-valve and exhausting at 28 in. as when supplied with steam at 100 lb. absolute and exhausting at 29 in. The "indicated" output, on the other hand, is exactly proportional to the steam pressure below the governor-valve, being double as much with 200 lb. below the governor-valve and a 28-in. vacuum as with 100 lb. below the governor-valve and a 29-in. vacuum. In applying this rule, "indicated" output may generally be replaced by the actual output measured at the turbine-shaft, since it is only at very low loads that the "constant" portion of the turbine losses becomes large in comparison with the power developed. These "constant" losses consist mainly in journal friction and in the steam supplied to the glands. Other losses, such as dummy leakage, disc or drum friction, and the like, are sensibly proportional to the load.

In one part of his paper Mr. Stoney laid down a very striking relationship between the blade speed of a turbine and the degree of vacuum which can be profitably utilised. If the speed of revolution is fixed, as it generally is, by the periodicity of the current supplied by the generator driven, the area available for flow at the exhaust end of the turbine will vary as the square of the mean blade velocity, and the inevitable losses to exhaust will, in consequence, vary inversely as the fourth power of the blade speed. This rule, of course, does not hold good when the designer is not bound to a specified number of revolutions per minute. If he is quite free in this regard, the loss to the exhaust will be less the lower the blade speed. This follows because the "carry over" of kinetic energy from the last row of blades is proportional to the blade speed, and with high speeds may thus become of material importance. This consideration has its bearing on turbines of the double rotation type, such as devised by Mr. Ljungström. Here the absolute velocity with which the steam leaves the last row of blades is double what it would be in an equivalent single-flow turbine. Considerations of this kind have led to the introduction of diffusers in the exhaust end of a turbine, with a view to converting into pressure some of the kinetic energy of the steam as it leaves the blades.

So far, however, we believe devices of this kind have given very disappointing results, and it remains to be seen whether further experiments will end more favourably. In these days of high blade speeds, it is certainly desirable, as pointed out both by Mr. Stoney and Mr. Morison, that an attempt should be made to diminish the loss resulting from the very considerable kinetic energy "carried over" by the steam exhaust from modern high-speed turbines. On the other hand, the exhaust branch has to be short, or even more serious losses may ensue, and it is accordingly difficult to arrange for a diffuser which will not waste as much in friction as it will gain by the conversion of kinetic energy into pressure head.

We may, perhaps, add an explanatory note to Mr. Stoney's remark that in general the "no-load" pressure of a high-pressure turbine is 15 lb. absolute per sq. in. This is very generally true, but only when the generator losses are included. If the excitation is cut off from the magnets of the generator, the plant will run at full speed with a pressure of only some 8 lb. to 9 lb. absolute per sq. in. below the governor-valve.

Complaint was made at Friday's meeting of the wide range given by Mr. Stoney for the "apparent conductivity" of the condenser. This, he stated, varied from less than 300 B.Th.U. up to nearly 1500 B.Th.U. transmitted per square foot of cooling surface per hour and per degree Fahr. of mean temperature difference. This wide range is, however, a fact perfectly familiar to those who have had experience with modern condensing plants. In this connection there are, we think, some advantages in considering the heat-flow in terms of the resistances opposing it rather than in terms of the conductivities of the different layers traversed by the heat. The resistance is, of course, the reciprocal of the conductivity, and a convenient unit is a resistance such that 1000 B.Th.U. will pass per hour and per square foot of surface for each degree Fahr. of temperature difference between the surfaces through which the heat is transmitted. In other words, with unit resistance, practically 1 lb. of steam will be condensed per square foot for each degree Fahr. of mean temperature difference. Conversely, unit resistance corresponds to a value of K = 1000, as defined by Mr. Stoney. The use of resistances in place of conductivities has, in the first place, the advantage that such temperature-curves as are plotted in Figs. 4 and 5 of Mr. Stoney's paper (see page 655) become straight lines when resistances are taken as abscissæ instead of conductivities. Secondly, the total resistance of a number of layers in series is equal to the sum of the resistances of each, whilst the conductivity of two conductivities in series is not equal to the sum of these conductivities.

In a condenser there are generally at least four resistances to the transmission of heat from the steam to the circulating water. In the first place, a blanket of air tends to form round each tube. The resistance due to this may, under the most favourable conditions, be as little as 0.2 unit, but with large air-leakage and inefficient air-extraction its value may readily rise to as much as 5 or 6 units of resistance. Secondly, there is a fall of temperature between the condensing steam and the film of water which forms on the tubes. The corresponding resistance is small, but the resistance of the water film itself is very considerable, being represented by about 0.3 in the units defined above. Next comes the resistance of the tube-wall; this is small, being of the order of about 0.07 unit. After this comes the resistance of any fur deposited on the tubes by the circulating water; and, finally, there is the resistance to the transmission of heat from the solid surface to the circulating water in contact therewith. This latter resistance is nearly inversely proportional to the velocity of flow, being with $\frac{3}{4}$-in. tubes about 1.3 units, when the velocity is 3 ft. per second, which diminishes to about 0.4 unit if the velocity is raised to 9 ft. a second.

Of the above resistances the station engineer can control the air resistance and that due to the furring of the tubes. Both are of very great importance, and some means of deciding whether a fall in the efficiency of a condenser is due to excessive air leakage or to dirty tubes is of great practical value. A convenient method of discrimination in such cases consists in taking records of the temperature of the steam admitted to the condenser and of the hot-well temperature. If there be but little difference between the two, the defective performance of the condenser is due to deposit in the tubes, which require cleaning, whilst a wide gap between these temperatures is evidence of large air-leakage. The plan above outlined is in constant use at a large London power-station, where the temperatures in question are logged hour by hour. As showing the amelioration possible in condenser efficiency by merely stopping air-leaks, we may instance a further test by Mr. J. M. Newton of the condenser, for which results obtained in an earlier trial have already been quoted above. In that case the temperature difference between the incoming steam and the hot-well was, as stated, 37 deg. Fahr., and the amount of air entering the condenser was about 20 lb. per hour. By very carefully stopping every detectable air-leak, including even minute pin-holes, the amount of air entering the condenser was reduced to about 2.1 lb. per hour.

Corresponding to this improvement, the difference between the temperature of the incoming steam and the hot-well was reduced to 7 deg. Fahr., and the vacuum maintained was raised from its former value of 28 in. to nearly 29 in., and this result was, it may be added, secured with ordinary Edwards air-pumps, and without the aid of a vacuum augmenter. Nevertheless, the maintenance of so high a degree of air-tightness as the foregoing requires constant vigilance on the part of the station engineer, and Mr. Morison is no doubt quite correct in holding that, in practice, the use of some form of augmenter is essential to high condenser efficiency.

We may add that a deposit of fur in the tubes is at least as inhibitive of condenser efficiency as the admission of air. Quite a thin deposit will easily have a resistance of 2 units, and with thicker deposits resistances of as much as 3, or even 4, units are met with. With a clean condenser, nearly air-free, and a good speed of circulating water, total resistances of 1.2 to 1.3 units are frequently recorded, but a very little fur will increase this total to $2\frac{1}{2}$, or even $3\frac{1}{2}$, units. In fact, engineers compelled to utilise dirty condensing water can seldom maintain the resistance of their condensers at less than the lower of these two figures. Considerations of this kind tend to emphasise Mr. Stoney's contention that the provision of ample surface in a condenser constitutes an excellent investment.

THE HARDENING OF METALS.

The winter session of the Faraday Society was opened last Monday by a general discussion on "The Hardening of Metals." The meeting was held in the rooms of the Chemical Society, at Burlington House, Sir Robert Hadfield, F.R.S., President of the Faraday Society, being in the chair. On the agenda paper were an introductory address by the President, and twelve papers or shorter communications, in addition to a demonstration of instruments for testing hardness. Several of the expected speakers were prevented from attending, one of them being Professor Ernst Cohen, of Utrecht, who had intended to come over especially for the meeting; but others took their places. With the actual state of science and the co-ordination of its various branches it is always very difficult to limit the scope of a "general discussion." Very little was said concerning the practice of hardening, but a great deal about amorphous and crystalline phases and allotropic modifications and the theory of hardening; and though the practical metallurgist and engineer was not offered any real explanation of the hardening problem, he will probably acknowledge that the discussion, which attracted a great many experts, was instructive and interesting.

In his introductory address, Sir Robert Hadfield reminded the audience that before the introduction of steel (disregarding the handful produced by the crucible or puddling process) the main object of the metallurgist had been to keep his metal soft, because heat treatment was unknown, and any approach to hardness meant brittleness. Now 55 million tons of steel, or "hardened metal," were used every year, and the Brinell hardness number had gone up from less than 100 for wrought iron to 300 for special steels. It was interesting to mention that he had quite recently received from Mr. Bhandarkar, the Superintendent of Archæology in Western India, a specimen of a metal which contained 0.7 per cent. of carbon, and was really a steel in the modern sense, whilst the many other steels which had been sent to him were iron. The specimen, from the base of the stone pillar of Heliodorus (the name of the Greek who erected it) at Besnagar, dated from 125 B.C.; it was a plate $\frac{1}{2}$ in. thick, weighing $\frac{1}{2}$ lb., which could still be hardened by heating and quenching, showing that it had undergone no change of structure in two thousand years, beyond surface oxidation.

Sir Robert also referred in appropriate terms to the death of Professor A. Martens, Director of the Materialprüfungsamt at Berlin, who died in the last days of July. Martensite was named after him by Osmond; Martens had done much for hardness research and testing in general, and although we were at war with his nation, that did not prevent our appreciating his merits.

Sir Robert then briefly abstracted a paper sent by Professor Henry M. Howe, of New York, on "Hardening without Martensitization." We hope to print this paper in an early issue. Professor Howe discussed the amorphous theory of hardening of Beilby, the γ-iron theory, and the β-iron theory. The first (Beilby) could explain five methods of hardening (by martenising and cold work), but not the non-martenising way—which, he explained, was the holding of manganiferous austenite below the transformation range—when hardening took place in the absence of carbon, whether the cooling were fast or slow. Sir Robert was pleased, of course, that Professor Howe came round to his theory, that the hardening of steel was due to a combination of iron and carbon. Professor Howe also described some new experiments on the influence of the rate of cooling on the hardness of Hadfield's manganese steel after being kept at high temperature.

Dr. G. T. Beilby, F.R.S., first called upon by the President, reviewed the main features of the amorphous-crystalline theory of the hard and soft states. Three years before the theory had been published he had noticed that a vitreous layer was produced on the surface of mechanically-disturbed metals by the breaking down and flow of the crystalline units; movements of slip due to overstrain caused the same flow within the mass. Differences in other mechanical, physical, and chemical properties, some previously known from scattered observations, also pointed to two different states; these differences disappeared by annealing to the modern temperature at which recrystallisation was complete. Other workers had subsequently extended the range of properties which were modified by the change from hard to soft or from soft to hard. In the liquid state rigidity did not exist except at the boundary, where the unbalanced portion of the molecular attraction reduced the freedom of the skin molecules. Cohesion bound the molecules more closely in the surface skin, and should necessarily act more effectively still on the more closely assembled, less highly energised molecules of the solid. Plastic mobility was transient and could not be repeated indefinitely. The crystalline state depended not merely on mobility, but also on the vibrational energy conferred on the molecules by heat; that energy conferred upon the molecules a certain potential mobility. In mechanically-produced flow these potentially mobile molecules were further energised by the deforming stress and slip, and slipped over each other like liquid molecules. It was not at all necessary that the temperature of liquefaction was reached. When actual flow ceased, and the outside supply of rotational and translational energy was cut off, the aggregate returned to the solid state with a suddenness greatly exceeding that of any form of chilling in which heat had to be removed from the mass by conduction. We did not know enough about the orienting powers; but by chilling and undercooling a liquid, a solid aggregate could be obtained having the character of the amorphous aggregate resulting from flow under deforming stress. Molecular constraint was not the cause of rigidity; rigidity was, in a narrow sense, rather the cause of molecular constraint; but the true antecedent cause of both was cohesion.

If the amorphous-crystalline theory of hardening by deformation explained the hardening of pure metals, it should also be applicable to alloys and mixtures of metals with metals or metalloids whenever breaking down had occurred. In alloys and mixtures, moreover, an amorphous state would directly be produced from the liquid by chilling, and temperature changes would lead to a change in the distribution of the hard and soft portions.

Dr. Cecil H. Desch had sent two contributions, which were abstracted by Dr. Lowry. The first was on "The Hardness of Solid Solutions." Dr. Desch pointed out that the hardness of solid solutions of silver and gold, two completely isomorphous metals, was greater than would appear from calculations based on the law of mixture, a mixture in equal proportions being about twice as hard as either constituent. That held also for magnesium and cadmium, except that the curve was not simple, but consisted of two arcs, because there was a definite compound, Mg Cd. The hardness of elements was a periodic function of the atomic weight, and the hardness curve resembled the atomic-volume curve. Benedicks had found the hardness proportional to the "atomic concentration" (the quotient of density by the atomic weight), and the rule had been extended to compounds. A closer agreement between theoretical and experimental values for the hardness, which was difficult to determine, was obtained by applying the equation of Van der Waals to solids:—

$$\left(p + \frac{a}{v^2}\right)(v-b) = \mathrm{R\,T},$$

$\frac{a}{v^2}$ being termed the internal pressure, according to which the elements were grouped. This internal pressure, expressed in mega bars, rose from 8190 for potassium to 5,458,000 for diamond (Traube's table). Hardness was connected with the close packing. Now the atomic volumes of gold and silver were nearly the same, and the two space lattices might interpenetrate freely without appreciable distortion; but an alteration in the closeness of packing would not explain the great hardness of the solid solution. According to the theory of internal strain, the hardness of a solid solution was due to the same cause as that of a cold-worked metal—namely, to a disturbance of the crystalline structure, giving rise to an amorphous, irregular arrangement of the molecules (Beilby). Tammann ascribed the increased hardness of solid solutions to the fact that the attractive force between two similar molecules was greater than the attraction between two similar molecules in the same mixture. That attraction and the hardness should be greatest in solid solutions containing equal molecular proportions of the two components. Direct experimental evidence of the constrained condition of the molecules of solid solutions was, however, difficult to obtain in the case of metals; but the optical study of isomorphous salts was easier. There, however, optical anomaly did not by any means always indicate internal strain, possible anyhow in the case of salts (Retgers). The problem might further be investigated by the determination of the heat of formation of solid solutions. Why the attractive force between gold and silver should be twice as great as between gold and gold was not easy to understand.

The second paper by Dr. Desch was a "Note on Crystal Twinning and the Martensitic Structure." It was a reply to a paper presented by Professors H. C. H. Carpenter and C. A. Edwards to the Iron and Steel Institute last spring, concluding that martensite and austenite were constitutionally identical, and differed only in the repeatedly twinned structure of the former. Dr. Desch questioned that conclusion, and he also opposed the view that hardness was due to twinning. His slides showed Neumann (narrow twinning) lines in bismuth, antimony, and various steels, and tended to prove that a martensitic structure need not be accompanied by increased hardness.

Professor Edwards, in a paper on "The Hardening of Metals by Quenching," dealt, on behalf of Professor Carpenter and himself, with these criticisms, which he considered hasty; Dr. Desch had, he said, misunderstood this theory. Before coming to this, however, Professor Edwards pointed out that the hardness of steel, as would generally be admitted, was connected with the Ar_1 change, which was accompanied by an evolution of heat. According to physical laws that change should occur at lower temperatures (below 760 deg.) when the cooling rate was accelerated, and that was so. But the question was: Were the rates of cooling in quenching sufficiently rapid to suppress the heat evolution? Benedicks had not observed any heat evolution in small specimens when accelerating the rate greatly, and the martensite structure (as distinct from the troostite structure) seemed to correspond to the suppression of the heat evolution. Troostite was the first compound to break up in solid solutions at high temperatures. They (Carpenter and himself) believed that internal stresses were set up in quenching, resolving themselves into internal strains, and also that an amorphous layer was produced in the operation of quenching. This view had been criticised by Rosenhain, who wanted actual internal strains, not stresses only. But a metal like lead might be deformed without taking hardness, and severe internal stresses were not necessary to produce hardness. Hardening by mere compression was different from hardening by deformation. These views were illustrated by many beautiful novel slides, exhibiting remarkable twinning and slip-bands in steel, zinc, and tin. A plate of tin, bent, showed twinning only on the inside (compression), not on the outside (which would be under tension); slip-bands only appeared when the tin was bent in both directions. Sir Thomas Kirke Rose (of the Mint) pointed out afterwards that tin annealed itself within less than twenty-four hours, and Professor Edwards added that the growth of twinning could, indeed, be observed when the tin was scratched with a pin.

In the absence of Mr. Andrew McCance, of Glasgow, a short abstract of his paper on "The Interstrain Theory of Hardness" was read by the Secretary, Mr. F. S. Spiers, B.Sc. We print this paper in another part of this issue. Paying, like all the other speakers, his tribute to Dr. Beilby for the immense service which his theory of the amorphous phase had rendered to metallurgical studies, Mr. McCance asked whether it had experimentally been demonstrated that the amorphous state was actually harder than the crystalline at the same temperature; was the transparent glass, *e.g.*, harder than the devitrified glass? [This same question was afterwards put by Mr. Hatfield, though couched in rather obscure terms.] Mr. Humfrey's views were almost identical with his (McCance's), and they found it difficult to correlate the magnetic properties with the amorphous phase theory. Mr. Humfrey thought, however, that all the atoms were similarly arranged in each molecule, and that the molecules were regularly spaced in the crystalline space lattice, whilst physicists believed that it was the atoms which were so concerned, and that in a binary compound the space lattices of the two components were mutually interplaced, giving rise to a new space lattice. He also differed from Humfrey as to martensite. According to Humfrey structureless martensite was formed after all the austenite had been transformed into amorphous α iron, and the more

prominent structure obtained from a higher quenching temperature was due to the retention of much austenite. But he (McCance) had shown that 0.86 per cent. carbon steel retained the same percentage of γ iron whether quenched from 1000 deg. or from 760 deg. Cent. The martensite structure represented the cleavage planes of the γ iron at the temperature of quenching, and the apparent lack of structure of steels quenched from 760 deg. was due to the small size of those crystals.

The contribution by Mr. J. C. W. Humfrey, M.Sc., M.Eng., of Sheffield, was entitled "The Part Played by the Amorphous Phase in the Hardness of Steels." He started by pointing out that years ago Barus had recognised what Roberts-Austen expressed by the words: "When iron passes through the temperature of recalescence its molecular constitution is for an instant almost chaotic." An allotropic change must be accompanied by a change in the internal structure of the molecules, either a reorganisation of the atoms composing the molecules or a change in their number. During the intermediate period of disorder, the structure, Mr. Humfrey thought, was amorphous; that state corresponded to the liquid phase which would be formed by the fusion of the solid phase stable at the lower temperature. But the conditions could be so adjusted that recrystallisation was prevented; an example in question was the change of monoclinic into rhombic sulphur, which normally took place at 95.6 deg. Cent.; but rhombic crystals could be made to melt at 115 deg., and monoclinic at 120 deg. Cent. In the case of iron, the temperature-tenacity curve indicated a similar phenomenon, the rapid drop in the tenacity both of α and of β iron before Ar_3 suggesting that they were approaching their melting-points; if the recrystallisation into γ were prevented by suitable pressure, a true melting-point could be observed at 900 deg. Cent. These changes were not instantaneous, because they started from nuclei, and a second crystallisation could only take place when the mass was not too viscous; for this reason abnormal conditions, such as rapid cooling, might delay the change to well below the normal change temperature. Pure iron changed and recrystallised at 860 deg.; with increasing percentages of carbon the change temperature was lowered, to 680 deg. at 0.9 per cent.; in iron of less than 0.45 per cent. of carbon a second change occurred at 780 deg. (marked by an evolution of heat and discontinuity in magnetic and elastic properties); above 860 deg.—but not below it—iron was normally capable of holding carbon in solid solution, in the form of carbide (Fe_3C?); the temperature at which amorphous matter formed by overstrain began to recrystallise (the temperature at which crystallisation could occur in an undercooled mass on cooling) was about 500 deg. for mild steel (Goerens); the hard structure produced in carbon steel by quenching was due to the presence of a hard amorphous solution of α iron and iron carbide.

Dr. T. M. Lowry, F.R.S., presenting, on behalf of himself and of Mr. R. G. Parker, a "Note on Metallic Filings," said that it was generally recognised now that the strained metal, though harder, was less dense than the unstrained metal. Dr. Brislee had proved this in the Faraday Society with regard to aluminium, which became lighter when rolled, but not under simple tensile stress. It might be that compression made the elastic molecular spheres yield and approach one another, whilst rolling was accompanied by slipping, leading to a change of state and to expansion. They had been studying metal filings, because successive layers of filings taken from a metal should show the effects of cold-working more strongly than thick plates or wires, and they had made some peculiar observations with regard to the so-called dental alloy, Ag_3Sn. Fresh filings of this alloy, when amalgamated, took up less mercury than old filings (67 against 75 per cent.), but gave up twice as much mercury on squeezing. Now the fresh filings, they had observed, were amorphous, and the old filings crystalline, and that difference seemed to hold also for finely-reduced copper, which, as T. R. Merton had quite recently announced, absorbed gases as well almost as charcoal when fresh, but not when old or when heated above 200 deg. Cent. The dental alloy was remarkable for its low annealing temperature, which was 100 deg. Cent. (boiling water), whilst the changes in density studied by Beilby required temperatures of about 250 deg. They had found that gold and tin did not change in density by continued heating to 100 deg.; but antimony did when kept at 78 deg. for 17 hours, and bismuth, cadmium, and copper were likewise affected by a temperature of 100 deg.

Professor Thomas Turner, D. Met., pointed out that tenacity and hardness should be distinguished. Hardness depended upon the distances between the molecules, and as all metals were practically incompressible, the interstices must be very small. Rolled metals became, indeed, lighter; yet the first effect of rolling was to increase the density, because the pores were closed; afterwards the plate gripped between the rolls was pushed and pulled as well; it was not all compression. As regards solid solutions, he agreed with Desch, but not with regard to compounds like Mg Cd; in the case of copper-zinc the alloys might be harder or softer than the constituents; Cu_2Zn_3 was harder. Mechanical means could at best double the tenacity (by drawing); but in solid solutions the hardness would be more than doubled. In steel, carbides were taken in or taken out of the solution, and that changed the hardness. With regard to annealing temperatures, Professor Turner mentioned an experiment he used to ask his students to make. Some fusible metal would anneal and evolve heat simply when taken in the hand, and the student had to drop the specimen to avoid being burnt.

Mr. W. H. Hatfield, D. Met., of Sheffield, said that cold work certainly seemed to produce the mobile amorphous phase. Pure iron could not be hardened by quenching, but it could by cold work. He agreed with Humfrey that γ iron passed through the amorphous phase in being transformed into α iron; the β phase he considered as dismissed. But there were some peculiar contradictions in these views with respect to troostite and to the holding in solution of carbon, which was supposed to give rise to hardness.

The next speaker, Mr. T. G. Elliott, of Sheffield, offered similar objections. What is martensite, he asked? Dr. Rosenhain seemed to turn round to the carbon theory of hardening in his new book on metallurgy; the matter had not been simplified by the attention physicists had given to it.

Dr. Brislee asked Dr. Beilby whether the tensile strength should necessarily increase when a metal was rendered amorphous by mechanical work. That work sometimes diminished desirable properties, prevented bending at right angles, *e.g.* Was the change from the crystalline to the amorphous phase a transition point coinciding with the annealing point? With regard to Professor Cohen's paper*—with which we intend to deal on another occasion—he remarked that the experiments on metastable lead, which appeared diseased like tin, were very important and might account for many troubles with lead cables.

We must pass over other remarks. At the end of the discussion, which lasted very nearly three hours, Mr. H. L. Heathcote gave a demonstration of his "Instruments for Testing Hardness." We described these instruments in connection with the spring meeting of the Iron and Steel Institute. Dr. Beilby, called upon to reply, had only time to say that the tenacity could, of course, be increased very much by cold work, but wire could be overdrawn.

If we may indulge in a paradox, we will offer the remarks which Dr. J. E. Stead had sent in as his contribution, as a summary of the discussion, though Dr. Stead was not present, and could hardly have seen all the papers when he was drawing up his own communication. The fact is we have not sufficient data to found any definite conclusion as to why steel is hardened by heating to above Ac_{1-2-3}, followed by quenching. That is what Dr. Stead emphasised. One thing was certain, he stated; the carbon was mainly responsible. The different behaviour of hardened and of annealed steel when heated with chemical reagents was a proof of differences in the chemical constitution of the two. It was difficult to determine the real difference, and he hence welcomed the prize which Sir Robert Hadfield had offered.† The allotropic theory of Osmond had never been advanced as other than one of a tentative character; the purely solid-solution theory might be one of several which pointed in the right direction; the internal-stress hypothesis might be more or less correct, but 0.9 per cent. carbon steel, it was well to remember, could never be stressed in the cold into glass-hard steel. He himself had particularly studied iron-phosphorus compounds. Iron saturated with 1.7 per cent. of phosphorus was difficult to drill; yet Cleveland pig, or other grey pig, with more than 2 per cent. of phosphorus even could readily be machined. In the hard condition the phosphorus was in solid solution; in the pig it was in the free state. A Mexican meteorite containing free phosphide crystals was very soft; but, on heating, the crystals diffused into solid solution, and the metal turned hard. There was thus a close analogy between steel and iron containing phosphorus; but it would be premature to hold solid solution alone responsible for the hardness of quenched steel. The meteorite mentioned contained more than 1000 Neumann twin laminæ in each eighth of an inch. Those lines disappeared at 800 deg. Cent., and yet the metal did not become sensibly softer. Twinning was therefore no indication of hardness, and the suggestion that martensite should consist of twin laminæ was open to doubt; 0.9 per Cent. carbon steel was equally hard when quenched from 900 deg. or from 750 deg.; the former was pronounced martensitic, the latter barely so. Dr. Stead also referred to nickel steels.

At the conclusion of the meeting Sir Robert Hadfield mentioned that the Institution of Mechanical Engineers had appointed a Hardness Test Research Committee.

* "The Influence of Allotropy on the Metastability of Metals, and Its Bearing on Chemistry, Physics, and Technics."

† See the Hadfield Research Prize, page 577 *ante*.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. XIII.

By Frederick William Lanchester, M. Inst. C.E.

Air Power as Affecting Combined Tactics.

Some indication has been given in the preceding articles of the influence that the advent of aircraft may be expected to have on the tactical value and employment of the other Arms of the Services; more particularly attention has been called to the changes that will almost inevitably be found necessary in the employment of cavalry. Certain writers, basing their views too exclusively on the experience of the present war, have expressed the opinion that the aeroplane, and, more broadly, aircraft, though of the greatest service and utility as a new means of reconnaissance (and, to some extent, of offence), will not have any material influence on the tactical employment of the older Arms, either Infantry, Cavalry, or Artillery. In the opinion of the present writer this view is fallacious, and the present war, at least as so far developed, cannot be taken as a criterion. It may be thought overbold thus to give preference to purely theoretical deduction in place of actual experience, but a little consideration will show that the experience, such as it is, cannot be regarded as a serious indication of the future. It is an undeniable fact that the aeroplane has, in the present war, been able to give information of the positions and movements of the enemy that would have been otherwise unobtainable, and in a few cases it has enabled points to be attacked that could not have been reached by any other means. To this extent it may be said to have invented or originated new duties that do not overlap those of the older Arms. It is equally true that, so far, it has not seriously encroached by its employment on the duties of the other Arms—it has not replaced cavalry in any measurable degree, neither has aeroplane bombardment been found effective as a substitute for gun-fire. There is, however, one important consideration that should prevent us from drawing too hasty a conclusion from these facts. The number of aeroplanes at present in service is small in relation to the size of the armies in the field, so much so that we can only afford to employ our aeroplanes for work for which they are pre-eminently suited; that is to say, to perform mainly those duties which cannot be done by other means.

The position is perhaps most easily illustrated by means of an analogy. Some years ago, when the milling-machine was first introduced into our general engineering shops, it was not an uncommon thing to see one such machine installed (more or less experimentally) in a large machine-shop alongside some hundred or so lathes and other machine-tools; such a machine usually had allotted to it a number of odd jobs that could not be done conveniently or cheaply on any other machine. Any superficial observer asked to report on the innovation might have been tempted to say, "By means of this new machine work may be under-

taken which could not, commercially speaking, be done previously; it does not, however, show any promise of replacing to any extent the older forms of machine-tool, and can only be regarded as useful for doing the special work for which it has shown itself of unique value." Such a view would, we know, have been utterly wrong. The milling-machine to-day is doing a multitude of jobs formerly looked upon as essentially work for the lathe or planing-machine, but *it had no opportunity of demonstrating its full capacity until installed in sufficient numbers.* The above is merely an illustration chosen from innumerable examples that might be cited.

Without attempting to discuss fully the influence of the development of the Fourth Arm on questions of "grand" or "combined" tactics, mention may be made of one salient fact which has already become manifest: the influence of aircraft as a means of reconnaissance has greatly increased the power of *defence* without, it would appear, conferring a commensurate benefit on the *attack.* It is possible that the fighting power of the aeroplane may in the future be found to redress the balance of advantages; but, so far, there is no definite indication that this will be the case. It may be stated tersely that the equilibrium between forces conducting respectively an attack and defence is normally maintained by a balance between strategic and tactical advantages. Thus the tactical advantage lies with the defender, in so far that he may be presumed to occupy chosen positions carefully prepared and fortified in advance, so that to place the attack on terms of equality the force employed must (locally at least) be numerically stronger; a numerical superiority many times that of the defending force may be required. The strategic advantage is with the attacking force, owing to the fact that the general in command can select any one of a number of possible points at which to deliver his assault. By exerting pressure at other points, by way of feint, he can keep the enemy in ignorance of his intentions whilst he is concentrating at the point chosen for the main attack, and so prevent him (the defender) taking steps to reinforce his lines. Thus an attacking army can always ensure a local numerical superiority at the decisive moment, and the issue will largely depend on whether this advantage is sufficient to outweigh the tactical advantage of the defending force as due to its choice of position and entrenchments and other defensive works. Clearly much, if not everything, depends upon the general in command of the attack being able successfully to conceal his movements until the moment arrives for delivering his blow. But the veil of secrecy has been lifted by the advent of aircraft. It is for this reason that the power of aerial reconnaissance has proved so valuable a weapon to the defending force, and of comparatively little value to the attack. It is quite true that the aircraft of the attacking force may be of considerable use in reporting the nature and strength of the defences, and so may disclose the points of weakness at which the chances of successful assault are the greatest; but this will only in a very small degree compensate for the premature disclosure of the whole plan of attack to the defenders, a disclosure which, if we may judge from experience so far gained, appears to be little short of complete.

The foregoing applies more particularly to warfare in which large bodies of troops are engaged over a great extent of territory; evidently where fighting is on a small scale, and the whole of the movement constituting a concentration and attack can be executed between sunset and sunrise, the whole operations can be considered to be of a purely tactical character. It may be emphasised that it is by destroying the *strategic advantage* hitherto enjoyed by the attack that aeronautical reconnaissance gains its especial value as an aid to the defence. Thus, so far, the advent of aircraft in the field of battle has had the effect of tending to produce a deadlock, or position of stalemate, such as we are able to witness at the present time in the north-west of France and on the Belgian frontier.

It is of interest to note that, previously to the arrival of the aeroplane, most of the improvements of weapons and armament have tended to favour the attack and to render defence more difficult. During the last three or four centuries we have seen the value of permanent defences gradually diminish, as constructional improvements and scientific methods of usage have rendered the Artillery Arm more and more deadly. Of more recent times we have witnessed the result of the increased effectiveness of fire-arms generally in the greater concentration that can be effected on any given point in a field of battle. In other words, the *depth* of the line has been increased by the greater range of small-arms, and it may to-day be increased almost indefinitely by the employment of artillery of heavier and heavier calibre, with correspondingly increased range. Such increase in the depth of the line only becomes of general value when, as in the present war, the number of men per mile of front is great, and more men are available than can be effectively employed in the trenches or infantry supports. Any additional numerical strength must then be assigned to the Artillery Arm, and the greater the supply of men (in other words, the greater the density of the line), the heavier and longer range should be the artillery brought into action, in order to ensure that the weight of numbers shall tell, in some degree at least, in accordance with the n-square law. It would seem that this is a point which has been very fully realised by the German Staff. In our own experience it is certain that the Boer War, owing to the comparative openness of the country and less density of the fighting-line, did not fully demonstrate the importance of artillery from the standpoint of modern European warfare.

The Command of the Air.

It is probable that in the future the employment of aircraft in large numbers, tactically in a combative capacity, may, in effect, still further deepen the fighting-line. Without attempting to predict exactly what *rôle* the aeroplane will take in this regard, it is safe to say that if, during a battle, it is found practicable to conduct air raids and air attacks systematically over a considerable belt of territory in the rear of an enemy's lines, this belt will require to be defended, and (if the air forces employed are of numerical strength comparable to the other Arms) the belt will actually become a measure of the depth of front. The permanent defeat of the enemy's air fleet and, as we may express it, the *capture of his air* will then become the first and most important duty of the Aeronautical Arm. It is difficult to gauge what the total consequence of defeating the enemy in the air will be. It is unlikely that it will entirely prevent his aerial reconnaissance; his scouts will doubtless manage to run the gauntlet and continue to keep him sufficiently informed. On the other hand, he will be deprived of all those uses of the Aeronautical Arm in which some more direct and definite purpose is involved, such as the direction of gun-fire, defence of stores, protection of cavalry, &c. He will require to submit to aeroplane attack without possibility of effective counter; he will be subjected to long-range gun-fire (directed by aeroplane) without means of returning it; his cavalry will be continually harassed by machine-gun fire and explosive grenades, and will cease to be of service; his railways, convoys, and mechanical transport will be nowhere safe; and he will need to expend an undue proportion of his resources in patrolling his lines of communication and guarding points of strategic importance. The command of the air opens up possibilities in the direction of raiding of a kind and with a scope not hitherto known in warfare. To what extent it will be found possible for aircraft to detach themselves from their base, and execute extended raids in territory held by the enemy, only the future can determine. It would certainly appear that if the inhabitants are friendly, and the enemy's aircraft are no more a force to be reckoned with, tactics of this kind may be quite feasible.

Once again the writer would point out that the experience of the present war is no guide; the Aeronautical Arm *quâ* Arm cannot at present be said to exist. The Flying Corps, excellent though it be, is scarcely more than necessary to constitute an armed reconnaissance service.

From the foregoing it would appear to be at least doubtful whether in future warfare an army which has been deprived of its aircraft, or has to admit the air supremacy of an enemy, will find itself in a position to carry on a campaign. It is in any case certain that it will only be able to do so at a very grave disadvantage. It is the writer's opinion that the time will come when the total and irretrievable loss of the command of the air to an enemy will be regarded as a disaster of an altogether irreparable and decisive kind, and although there may be a great deal of fighting still before the end, nothing less than an overwhelming superiority in the other arms will save an army deprived of its air service from ultimate defeat. We are thus led to the consideration of a branch of the subject of extreme importance—namely, *aeroplane tactics.*

In some of the previous articles (Article VII., *et seq.*) the question of aircraft fighting—*i.e.*, aeroplane *versus* aeroplane—has been considered, and matters such as armament have been fully discussed. We shall now deal with the employment of the armed machine in its fighting capacity, not as a single unit, but as part of a force whose function is the destruction of the armed air fleet of the enemy, and the crippling of his reconnaissance service. It is evidently necessary to assume that the enemy in his turn has prepared an armed air fleet, and that the problem to be studied is the handling and bringing to battle of the two air fleets in their struggle for supremacy.

The various factors that enter into the problem, apart from the *personnel*, are those of speed, climbing power, armament, and last, but not least, numerical strength. These, together with that all-important item—the tactical scheme—are the more important of the material factors on which the question of victory or defeat will turn. The relative importance of the different items is not by any means always the same. It may, for example, usually be assumed that one or the other of the combatant forces is seeking, and the other endeavouring to avoid, battle, or at least is only willing to accept battle under conditions deemed favourable; thus it may be that the enemy can be only brought to battle by virtue of superior speed. In other cases it will be possible to force the enemy to give battle by attack upon some vulnerable point connected with his land forces; all this is strictly analogous to the similar problems of naval warfare. Given the main conditions, all that can be accomplished by a tactical scheme is to ensure bringing the enemy to battle in the most favourable manner possible, and, as in the problems studied in Articles V. and VI., bringing the greatest weight of numbers possible to bear on lesser numbers of the enemy, in order to reap the advantage of the n-square law. The object of the practice of tactical exercises will be to enable an air fleet to manœuvre to defeat the enemy in detail, and, if his numbers are superior, to prevent him from bringing his whole concentrated fire to bear by the adroit handling of the weaker numbers, and so to neutralise the advantage of his numerically superior force.

NOTES.

The Spanish Iron and Steel Industry.

In a paper on this subject, reproduced in the Madrid *Revista Minera, Metalúrgica y de Ingenieria*, the various difficulties against which the Spanish iron and steel industry has to labour are passed in review. One of these relates to the lack of fuel and the duty on foreign coal, which duty reacts upon the price of Spanish coal. The paper adds that the present moments are decisive moments for the future of the Spanish iron and steel industry. Whatever be the result of the present war, there is sure to occur a displacement of the hegemony in iron production, and this will largely affect Spain. The triumph of Germany would give that country the French Lorraine iron deposits; these are of so great an importance that in the past year they represented 90 per cent. in the French production of iron. If these deposits were taken over by the German Syndicates, the extra output of the Zollverein would reach such proportions as totally to eclipse the stunted output of the smaller industrial nations. On the other hand, the triumph of France would probably lead to the recovery of the part of Lorraine beyond the present frontier, and with it the minable zone from which Germany now obtains her supply of ore. In this latter case, France would occupy a premier position in iron production, coming second after the United States. Germany's enterprise, her industrial organisation, the encouragements she gives to exporting, and the system of dumping which she practises, would render competition with her products most difficult. On the other hand, the fact that France adjoins Spain, the financial influence which France exerts upon Spain, and the innumerable undertakings controlled by France, as a consequence of her financial support, would also be factors most difficult to compete against when tendering for iron

and steel products. Therefore, says the writer of the paper referred to, the means to be taken by Spain is to strengthen her tariff defences in so far as they apply to iron and steel products, not only by reason of the disadvantages against which the Spanish works now labour for their manufacture and distribution, but also to counteract in part the state of inferiority in which these works will find themselves in regard to their competitors as soon as the present hostilities cease.

Railways in War Time.

We take the following remarks from the Madrid *Revista de Obras Publicas*:—The late General Moltke stated that railways furnish the best means of carrying out the first operations of an army, and with this in mind he organised the German system of railways. When he was a Staff Captain, he published a pamphlet on the military utilisation of railways; this was at a time when they were viewed with such distrust that some experts advocated that they should only run at a distance from fortified positions. At the same period, the Marquis de Sainte-Croix was studying the problem in France. Since that time the great military value of railways has gradually been recognised. The railways served a great purpose in Italy, in 1848, when the Sardinian General Durando prevented the union of the forces of General Count von Thurn with those of Radetzky, by transporting his troops to Vicenza before the penetration of the Austrian troops. They played a great part in the German campaign in Schleswig-Holstein, and also in the war of 1850 between Prussia and Austria, and their aid was most effective in the Franco-German War of 1870-71. When the present war broke out, the French Minister of War divided the nation into two zones: that of the armies and that of the interior, separated from each other by a line of demarcation, the first zone being controlled by the military authorities, the second one remaining under the control of the railway companies. Our contemporary then gives an account of the working of the German railways in 1870, and adds that the experience then gained has borne fruit, as was shown by the concentration of three million men on two fronts in the first week in August, a result due in a large measure to the working of the German railways. He states that the organisation and working of the French and German railways have now many points in common. The Russian General Staff had foreseen the possibility of a conflict with the two Central European empires, and had prepared a defensive scheme, utilising the fortifications of Warsaw, Ivongorod, and Brest-Litowsk, to the rear of which line mobilisation and concentration would take place This plan was, however, abandoned for one of sudden offensive attack, on the recommendation of the French General Staff, who also recommended the improvement of the lines on the west frontier. Russia immediately commenced working in this direction, duplicating her lines. The Russian activity in railway construction, which had barely commenced, decided Germany to anticipate events, since she feared that the increase in the Russian railway system would allow of a rapid concentration on her frontier of large masses of troops, rendering all her own defensive efforts useless. The *Revista* then prints in italics the following statement:—"The proximate development of the Russian railway system was one of the main causes for the present European war." This shows, adds the *Revista*, the enormous importance of railways in war time.

Clarification of Sewage by Fine Screens.

In Continental countries natural waterways are longer and population on the average less dense than here, and it is possible in many cases to adopt less elaborate methods of treating sewage than are rightly enforced in this country. In a paper published in the August issue of the Proceedings of the American Society of Civil Engineers, Mr. Kenneth Allen states that most of the actual nuisance due to sewage is attributable to the relatively coarse suspended matter which is offensive to the eye and gives rise to foul deposits on the bed of a waterway, besides being largely responsible for depriving the water of its natural content of oxygen. By removing this coarse material, although the dissolved organic matter and the accompanying bacteria remain, the greater part of the nuisance is suppressed. Even if the conditions will not allow of the direct discharge of sewage thus clarified, the process is still useful as a preliminary to the more refined processes of purification by biolysis. Thus, in Baltimore, fine screens placed between the tanks and sprinkling-filters have made it possible to reduce the time spent in cleaning the filters from 16 hours to 4. In Germany this clarification is, he states, effected by means of relatively fine screens, which Mr. Allen defines as the openings in which are not more than $\frac{3}{8}$ in. in diameter, and such screens are, he states, capable of removing up to about 30 per cent. of the suspended solids, and of this 30 per cent. two-thirds may be taken as being organic in character, and valuable either for the recovery of grease or for the production of fertilisers. The screens used vary much in construction. In some places a band screen is used, consisting of an endless flexible band of wire netting, or an equivalent, which passes over under and upper rollers, and is rotated so as to bring the area to be cleaned above the water-level. The wing screen is another type. This consists of five independent screens, arranged radially round a horizontal axis. The screen in use dips into the supply channel, of which it touches the bottom, which in this neighbourhood takes the form of a circular arc concentric with the axis on which the screens are mounted. The length of this arc is such that a new screen comes into contact with it before the soiled screen moves out. Another pattern used consists of a drum of perforated plates or wire mesh, rotating on a horizontal axis, whilst a variant of this consists of a perforated disc mounted upon an inclined axis, so that part of the disc comes above the water level, and the remainder forms the active portion of the screen. As the latter rotates, the fouled surface comes above the water-level, and is replaced by a corresponding area of cleaned surface entering the water from the other side. The cleaning is effected automatically by scrapers and rakes. An advantage claimed for these screens is that they are very compact, and in this respect they compare very favourably with settling-tanks, though the latter are generally cheaper to build, and capable of removing a greater proportion of organic matter. In the case of large plants, the screenings may be treated for the recovery of grease or for the production of fertilisers, but in other cases they are best dealt with by incineration.

The "Daily Mail" Year-Book, 1915.—We have received a copy of this year-book for 1915, the fifteenth year of issue. It is edited by Mr. David Williamson, and is published by the Associated Newspapers, Limited, London, E.C., at the price of 6d. net. As is admitted in the opening statements "to the reader," the war covers a large section of the contents of the present edition. Various aspects of the war are dealt with by experts, and their views form interesting reading. Subjects of general interest are also treated, and reference to the book is facilitated by a very complete index.

The City and Guilds of London Institute of Technology.—The annual report of the Department of Technology of the City and Guilds of London Institute just issued draws attention once more to the immense value and importance of the work done in the promotion of technical education. The City Guilds examinations in technology were inaugurated in 1879, when there were seven subjects of examination, twenty-three examination centres, and 202 candidates' papers. Last year the number of subjects on which papers were set was seventy-three, and the number of examination centres numbered 467. The number of classes held under the direction of the department was 5049, which were attended by 55,996 students. Included in the report are comments of the examiners on the character of the work done. The results of the examination show that many teachers are relying too exclusively on text-books, and they are accordingly warned that they are expected to keep their knowledge up to date by studying the Transactions of the leading technical societies and the leading technical journals. The examiners also report that in many subjects a more thorough training of the students in fundamental principles is very desirable. Simple mathematics is still a stumbling-block to many students, and there is evidence that students are being admitted to technical classes without sufficient grounding in mathematics, English, and practical science. The weakness in mathematics shown by candidates, even in the final examination for mechanical engineering, is said to be surprising; whilst in structural engineering the candidates, though better grounded in mathematics, show, on the other hand, a lack of practical knowledge. In electrical engineering, the continuous-current work appears reasonably good, but the theory of the alternating current appears to present much difficulty. In the final examination in electrical engineering, a large proportion of the candidates were far from sufficiently prepared for so severe a test.

THE BRITISH ASSOCIATION IN AUSTRALIA.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE—*concluded*.

(*Continued from page* 611.)

Viscosities of the Halogens.

Dr. A. O. Rankine presented a paper on "The Viscosities of the Halogens (Chlorine, Bromine, Iodine) in the Gaseous State," describing in particular the method used for the absolute measurements of the viscosity of iodine. Two bulbs of glass were connected by a capillary. In the one bulb iodine was heated in a steam-bath; the bulb became filled with saturated iodine vapour; the other bulb was removable, and served as a condenser, and arrangements were made for keeping the air pressure on the condenser side below the saturation pressure. Then iodine vapour flowed through the capillary, and condensed in the second bulb; and from the rate of distillation, and the known pressure, and the known density of the vapour, the viscosity of the vapour could be calculated. The condenser was removed and weighed from time to time; to prevent condensation of iodine in the capillary and in the exposed parts of the connecting tubes, electrically-heated jackets were provided. The following table summarised the results obtained:—

Gas.	Temperature.	Viscosity. C.G.S. Units.
	deg. Cent.	
Chlorine	12.7	0.0001297
,,	99.1	1688
Bromine	12.9	1511
,,	65.8	1705
,,	99.8	1885
,,	139.8	2079
,,	179.8	2273
,,	220.4	2880
Iodine	124.0	0.000184
,,	170.0	204
,,	205.4	220
,,	247.1	240

Solar Observatory in Australia.

The report of the Committee appointed to aid in the Work of Establishing a Solar Observatory in Australia was presented by the Secretary, Professor G. Duffield, D.Sc., of University College, Reading, one of the distinguished members of the over-sea party, who was re-visiting the country of his birth and of his first university training, South Australia. Professor H. H. Turner has succeeded the late Sir David Gill as chairman of this Committee, which was appointed in 1908. Dr. Duffield pointed out that the study of the sun was one of the most important scientific investigations in progress; no one could estimate the possible practical outcome of a more intimate knowledge of the connection between solar and terrestrial phenomena. Scientists of all nations were agreed upon the necessity of constant observation of the sun for the twenty-four hours of the day, and upon the urgent need of such an observatory in Australia to supplement the work which was being done in Europe, America, and India. On behalf of a former Commonwealth Government, Mr. A. Deakin had promised to propose a grant of 1300*l.* for the upkeep of such an observatory in Australia; but until recently the Commonwealth Government had not seen its way clear to bind itself, and they had not accepted the instruments offered. Dr. Duffield was therefore glad to inform the Section that he had, in March last, received a letter from the Commonwealth Government advising that in the scheme for the organisation of the services at the seat of Government at Canberra (the new capital of the Commonwealth) provision had been made for the establishment, amongst general astronomical studies, of a section to be devoted to solar physics in particular. Since then, unfortunately, the war had broken out, but Mr. Thomas Crawthorne had offered a sum of 10,000*l.* or more for establishing a solar observatory in New Zealand. Geographically New Zealand was better situated perhaps than Australia, for it was a question of having observations in different longitudes as well as latitudes; but the climate and the transparency of the Australian atmosphere made Australia preferable, and it was to be hoped that both projects would be carried out.

Professor H. H. Turner remarked that the hope of furthering the solar research work had been a prime factor in inducing him to come to Australia. They had too long been regarding the sun as a per-

manent constant source of light and heat; modern science believed in a variability of solar radiation, which should thoroughly be investigated. There was need for observation in the southern hemisphere further north than New Zealand, and both longitude and latitude were of importance in this respect.

These same considerations were urged upon the Prime Minister of the Commonwealth, Mr. J. Cook, in the afternoon of that day, by a deputation of the British Association, comprising, in addition to the two members mentioned, Professor Abbot, Dr. Dyson, Sir O. Lodge, and Mr. Alfred Deakin. The Prime Minister was able to give a favourable reply, though he reminded the deputation that the proposal involved the consideration of the question whether it was desirable to maintain the three State observatories at Sydney, Melbourne, and Perth after the new observatory had been founded.

Proofs of the Sun's Variability.

Professor C. G. Abbot, Director of the Astrophysical Observatory of the Smithsonian Institute, read a very interesting communication on "Proofs of the Sun's Variability." Measurements of the solar constant had been conducted by the Institute for eight years, he stated, on Mount Wilson, in California, and during the years 1911 and 1912 simultaneously also at Bassour, in Algeria; and these measurements proved that the estimates by the spectrobolometer of the intensity of solar radiation outside the terrestrial atmosphere at the two stations were identical for the same day; the values varied by nearly 10 per cent. during the continuance of the expeditions. The coefficient of correlation, computed by H. H. Turner, was 52 ± 7 per cent., and, rejecting three extreme cases, 60 per cent. Thus very strong evidence had been obtained of the variability of the sun's radiation, which was irregular in period and amplitude apparently. It was highly important, however, that this work should be taken up at other stations. When the monthly means of the solar constants were compared with Wolfer's sun-spot numbers, increased sun-spot numbers were found to correspond with increased radiation values, and *vice versa*, and the correlation coefficient was (according to Turner) again 53 ± 7 per cent. Thus the sun varied from day to day and from year to year.

In September, 1913, another method of observation had been applied on Mount Wilson. A tower telescope formed an image of the sun (by the aid of mirrors without lenses), 9 in. in diameter, on the slit, $\frac{3}{8}$ in. in height only, of a spectrobolometer. The clock of the telescope was stopped, and the image thus drifted centrally across the slit, producing an automatic record, a curve of the distribution of the intensity of solar radiation along a diameter of the sun's disc. This curve had the form of a U; the length of the straight limbs of the U represented the intensity at the edges of the sun's disc, and the height of the U up to the centre of the curve the intensity of the radiation at the centre of the sun's disc. Thus a contrast of the intensity of radiation along the sun's diameter was made manifest. These observations were taken on fifty days for seven different wave lengths of the spectrum between 3700 and 10,000 Angström units, two curves being obtained for each wave-length. Similar observations had been conducted by various methods, by Vogel, Pickering, Langley, Schwarzschild, &c., and by Abbot and Fowle, in 1907, and the comparison, especially of the 1913 values and the 1907 values, pointed to a change in the distribution curve between these epochs; the contrast was greater in 1907 than in 1913, and that was so for all wave-lengths, but particularly so for long waves. By comparing the results of one day with another in the year 1913 it was further found that a change of contrast in brightness was going on all the time, again irregular in period and amplitude. When the daily values of the solar constant were compared with the distribution of brightness along the sun's diameter, a close correspondence of variation was revealed, an increase in the solar constant being accompanied by a diminution in the contrast. That latter result was contrary to the observations of Abbot and Fowle in 1908, and there was apparently a change in the sign of the coefficient of correlation, suggesting a greater complexity of the solar problem than had originally been assumed.

The Mount Stromlo Observatory.

Mr. P. Baracchi, the Federal Astronomer of Melbourne, described the Federal Observatory which the Government of the Commonwealth had erected at Mount Stromlo, about 6 miles from the site of the projected Federal Capital at Canberra; the meridian of this observatory was to serve as the common longitude datum for all State surveys. The site was selected in 1910; a concrete structure with an 18-in. dome was erected, and a 9-in. refractor by Grubb was installed in September, 1911. Astronomical observations (visual, spectroscopic, photographic, but not solar research) carried out there till April, 1913, had justified the selection, and the suitability of the site for a first-class observatory had been established.

Australian Longitudes.

A discussion on "The Present State of the Problem of Australian Longitudes" was opened by Mr. P. Baracchi. He discussed the longitude values assigned to the two Australian meridians of Port Darwin (North Australia) and Southport (Queensland), which are the terminals of two chains of telegraphically-determined longitudes carried eastward from Greenwich *via* India, Singapore, to Port Darwin, and westward *via* Canada and the Pacific Ocean to Southport. The connection between these two meridians, obtained by means of the measured longitudinal arcs, Port Darwin-Melbourne, Melbourne-Sydney, and Sydney-Southport, completed a "whole longitude circuit round the earth," with a closing error of less than 100 ft. This error was suspiciously small, the discrepancies being larger in other links which had been measured more than once. In order to render the whole of this longitude circuit homogeneous and reliable, Mr. Baracchi suggested a remeasurement of the arcs measured, and he desired to enlist the sympathy and practical advice of the British Association in this matter. The sense of the Section was, however, not in favour of making any definite recommendation. Considering that geodetically Australia could not be connected with Asia, and that the perfection of the radiotelegraphic service and of the photographic method developed on the European continent would place more reliable means at the disposal of astronomers, the several speakers, Professors Dyson, H. H. Turner, E. W. Brown, and others, though not altogether of one opinion, agreed that the matter was not pressing.

We pass over a paper by Mr. E. Kidson, "The General Magnetic Survey of Australia," which was taken as read, and over two strictly astronomical papers, by the Astronomer-Royal, Dr. F. W. Dyson, F.R.S., "The Distribution in Space of the Stars near the North Pole," and by Professor A. S. Eddington, F.R.S., of Cambridge, "The Oblate Shape of the Stellar System."

The Motion of the Moon.

Professor E. W. Brown, F.R.S., of Yale College, New Haven, Connecticut, was announced to deliver an address on "Cosmical Physics" to the Astronomical and Meteorological Sub-Section of Section A, at Brisbane. The meeting was, however, practically a plenary meeting; for the sub-section never met this year, and the address was a discourse on the "Motion of the Moon," which Professor Brown has made his study for many years. He pointed out that the history of the motion of the moon had for more than two centuries been a struggle between the theorists and the observer. The subject had lost all practical interest, because navigators no longer took their bearings from the moon's position. Theoretically the problem had a high interest. It was one of the most difficult tasks to settle where the moon really was at any particular moment. The theory of the moon's motion had been outlined by Newton in his "Principia," and had been worked out further, especially by Euler, and in the last century by Delaunay and by Hansen. Dr. Brown's own theory was rather the fulfilment to the utmost of the ideas of others, notably a development of the classic memoir of Hill—who had died since Dr. Brown left America—than a new method of finding the motion. In the past every observation had been compared with the phase indicated in the Nautical Almanac, and the small differences between them had been recorded from day to day. At Greenwich the moon had been observed since 1750, and some 20,000 observations were available for comparison. Some of those, however, involved errors of observation which could not always be allowed for at present, and were connected with defective theories. The tables of the moon's motion constituted an intermediate step between the theory and the positions of the moon according to the Nautical Almanac. These tables involved many terms; Hansen had 300 terms in his co-ordinates, and Dr. Brown's 120 new tables—which were nearly complete now, and had been compiled with the assistance of Mr. H. B. Hedrick and many computers—included more than 1000 terms, eight on the average per table.

The difficulty was to determine the gravitational action of every particle of matter which might have an effect on the moon's motion. The slides exhibited showed that the differences between the theoretical orbit of the moon and the observed positions—derived from meridian observations or occultations—had amounted to more than $\pm$ 4 seconds of arc, in extreme cases, since 1750, and that there was a certain regularity in them. That proved that certain disturbing factors were not yet determined; but the deviations had become much smaller of late. Other curves exhibited concerned the determination of the constants of eccentricity, inclination, position of the perigee and node, which could now be calculated with practical certainty. The result of these studies was that the index which the law of inverse squares involved did not differ from the theoretical value by more than one part in 400 millions. What Dr. Brown himself had done was to find the deviation of the mean latitude for 64 years, a periodic term in latitude from 55 years of observation, and a periodic term in longitude from observations covering 150 years. In part of this work he had been anticipated by Bakhuysen, and in others he agreed with F. Hayn and Franz; and it would appear that the edge of the southern limb of the moon was in general further away from the mass centre of the moon than the northern limb; in other words, the density of the moon's crust was not the same in the two hemispheres, but the higher ground seemed to be on the southern hemisphere, whilst it was in the northern on the earth. It was interesting that a certain value of the earth's ellipticity would make the observed motions of the perigee and node agree with the theory. That value was $1/293.7 \pm 0.3$; but Helmert's value from gravity determinations was 1/298.3, whilst three other methods (parallax and geodetic measures) gave the value 1/294, which might therefore be preferable. The Harvard method of photographic parallax determinations seemed most suitable for settling this question; if possible, two identical instruments should be mounted on different hemispheres, on the same meridian, differing in latitude by 60 deg. or 90 deg., and Australia would be an excellent place for such researches.

The outstanding residuals in the moon's motion consisted mainly of long-period fluctuations in the mean longitude of the moon. These might be due to intra-Mercurial planets (improbable according to St. Blancat), to the shading of gravitation by interposing matter (of which Bottlinger found no evidence). An equatorial ellipticity of the sun would account for certain difficulties. H. H. Turner had suggested a disturbance caused by the swarm of the Leonid meteors, which did not appear probable to Dr. Brown. Finally, there might be changes in the directions of the magnetic fields of the moon and planets, as well as of the sun and the earth. It thus became instructive to examine the orbits of the planets for disturbances like those of the moon's orbit. Materials for this were available in the case of Mercury (Simon Newcomb). When the fluctuations of the moon's motion, of the earth's longitude, and of Mercury's orbit were plotted on the same diagram, there was a certain parallelism between these three curves, whilst Wolf's sun-spot frequency curve (added because of the connection between sun-spots and prevalence of magnetic disturbance) had the opposite trend. It was difficult, however, to understand on the electron theory of magnetic storms how the motion of the moon and planets could be affected by the electrons.

Seismological Investigations.

The nineteenth report of the Committee on Seismological Investigation was read by the Chairman, Professor H. H. Turner, of Oxford, who had drawn it up. For the first time the late John Milne was not its author; we would refer our readers to our comments of last year, when the Birmingham meeting followed the death of John Milne, in July, 1913, within a few weeks.

The report stated that the continuation of the invaluable work done at Shide, Isle of Wight—

under the superintendence of Professor Turner—was by no means financially secured. The volunteer services and the Government grant of 200*l.* might fail. At present the work was carried out by Mr. J. H. Burgess, John Milne's assistant after the death of his Japanese assistant, Shinobu Hirota, who died a year before Milne. Mr. S. W. Pring and his daughter had temporarily assisted. The form of the circulars had been changed, and a card catalogue system had been adopted in the place of the large book in which Milne had entered his records. The familiar earthquake map of Milne had also been changed. The surface of the earth was divided by three great circles, cutting it at right angles, into eight equilateral spherical triangles, and each triangle was projected on a tangent plane at its centre. Thus an octahedron was obtained, surrounding the sphere, and this could be unwrapped into a plane in various ways; this map brought out the seismological and geographical symmetry of the earth. The report then proceeded to a lengthy discussion of the results from different seismographs, undertaken chiefly for the purpose of bringing out the attainments of the Milne instrument in comparison with the more modern and more sensitive instruments. The comparison was based on the weekly bulletins, issued since January, 1912, from Pulkova, giving epicentres determined by Galitzin's method; this computation was made by Mr. A. E. Young, formerly Deputy Surveyor-General of the Malay Survey, at present at the Oxford Observatory. A comparison of the films of 1911 had also been undertaken, films having been forwarded to Shide from the Cape, Toronto, the Seychelles, and a great many more stations in order to ascertain in how far the deviations of Milne instruments from others might be due to faulty readings and to confusion of the different phases of earthquake curves. Mr. G. W. Walker, at Eskdalemuir, Messrs. L. F. Richardson and L. H. G. Dines, of the Meteorological Office, had further compared the Milne instrument and the seismometer of Prince B. Galitzin, of Petrograd, at present considered the most perfect instrument. While the Milne instrument consisted essentially of a simple light boom, suspended by a wire, and pivoted at the other end, and was inexpensive and easy to standardise and to read, the Galitzin instrument was complicated. It was a short, heavy pendulum, suspended by two wires, with or without a pivot; the registration was not optical, as in the Milne instrument, but electrical, the pendulum carrying coils and a damper disc of copper, moving between four powerful horse-shoe magnets; the coils were connected with a moving-coil galvanometer. These instruments were made by Mr. H. Masing, of Petrograd. The Galitzin pendulum was expensive, and required trained assistants and periodical laborious re-standardisation; but it indicated the true movement of the soil, though the interpretation of the records was difficult, whilst the Milne pendulum was rather a seismoscope unless damped. That damping was a difficult matter, but Mr. J. J. Shaw, of West Bromwich, seemed to have overcome this difficulty, and the usefulness of the Milne instrument was therefore by no means at an end. The report was to be supplemented; Milne's idea that the wave velocities east and west differed from those north and south did not appear to be confirmed.

Mr. G. Hogben had sent a communication on "A Map of the Principal Earthquake Origins of the South-Western Pacific," which was taken as read.

The Upper Atmosphere.

In presenting the report of the Committee on "The Investigation of the Upper Atmosphere," Mr. E. Gold, M.A., of the Meteorological Office, London, mentioned that balloons of various diameters (up to about 20 ft. inflated) had been sent up from ships by Dr. Rosenhain, himself, and other members of the Association on their different routes out to Australia, for the purpose of studying the direction of the winds and to look out for the anti-trade wind in the upper layer. The balloons were watched by means of telescopes; the conditions had not been favourable on the whole, clouds and the sun glare having often prevented observations.

Antarctic Meteorology.

Antarctic problems naturally claimed a large share of the interest of the Australian meeting, since Sir Douglas Mawson had only recently returned from his great Australian expedition to the South Pole. The matter came before Section A in the shape of a discussion on "Antarctic Meteorology," which was opened by Dr. G. C. Simpson, of the Meteorological Department of Simla; like all the speakers we shall mention, he had taken part in a British Antarctic expedition. It is well known that meteorologists attach the greatest importance to the exploration of the climate of the vast continent about the South Pole. The old text-book idea of a cyclone round the Pole, Dr. Simpson said, could not be maintained. Dr. W. J. S. Lockyer had suggested that an intense South Pole anti-cyclone fed cold air into a series of large cyclones circulating the Southern Ocean and having their centres near the 60 deg. of latitude, with west winds in the "roaring forties" and easterly winds in higher latitudes. That suggestion was confirmed to a large extent, and supported also by Meinardus, of the Gauss expedition, who questioned the anti-cyclone, however. Dr. Simpson's remarks concerned mainly the Ross Sea area, and he ascribed many peculiar meteorological features to the peculiar configuration of this area. The Ross Sea remained open during winter, apart from frozen pack-ice; to the south of it was the great Barrier Ice, a sheet of frozen snow as big as France, about 100 ft. above sea-level; to the west were the high mountains of Victoria Land, running north from Cape Evans (near Ross Island) to Cape Adare. Meteorological observations had been made at these three points, and also at Framhein, east of Cape Evans, and the horizontal and vertical temperature distribution had been studied. The air above the Barrier Ice was much colder than above the sea, but the air became warmer first at higher levels above the ice. In the gully between Ross Island and the mountains blizzards frequently blew from north or south, at 80 miles an hour; the blizzards could not be explained by the barometric waves which travelled east to west and were often insignificant in blizzard periods. The air seemed to drift north in general, but was strongly deflected by the earth's rotation, except near the mountains. Dr. Simpson discussed these features with the aid of many diagrams, illustrating observations of his own and others, including records from the observatories of Southern Australia.

Captain J. King Davis, who had taken several ships over to the Antarctic Continent, wished, he said, to refer to one point only, the influence of the floating ice on the climate of Australia, only 1500 miles from the Antarctic shores. The frozen pack-ice broke up in summer and drifted north, sometimes far away. Dr. R. N. Rudmose Brown, of Sheffield University, pointed out that the distribution of the winds and the movement of the ice would make the approach to Coats' land, in Weddell Sea (on the other side of the South Pole, reckoned from Ross Sea) very difficult. Mr. Griffiths Taylor dwelt on the great difference between Arctic and Antarctic; the North Pole area was oceanic apparently; the South Pole was a huge plateau, the biggest known, up to 11,000 ft. above sea-level.

We can only mention a paper by Professor H. H. Turner, F.R.S., of Oxford, on "Discontinuity in Meteorology," and must pass on to mathematical papers.

Mathematical Papers.

The Mathematical Department met under the presidency of Professor E. W. Brown, F.R.S., of New Haven, Connecticut, and discussed papers by Professor Carslaw, F.R.S., of Sydney, Mr. T. Chaundy, of Oxford; Professor J. C. Fields, F.R.S., of Toronto; Professor W. H. H. Hudson, of London; and Mr. F. S. Macaulay, of London. The proposal of a further grant for the "Tabulation of Bessel and other Function," found warm support; Professor J. W. Nicholson is secretary of this Committee. We mention here also a paper by Professor A. Gray, F.R.S., of Glasgow, on "The Attractions of Ellipsoidal Shells," which was brought before the main Section.

Three communications from New Zealand, joint papers by Professor T. H. Laby and Messrs. E. O. Herens, W. Stuart, and G. E. Adams, on "An Absolute Determination of the Thermal Conductivity of Air," the "Nature of γ Rays," and the "Length and Electrical Resistance of Steel Tapes," were taken as read in the absence of the authors.

(To be continued.)

The International Electrical Congress. — The International Electrical Congress, which was to have been held in San Francisco in September, 1915, is to be postponed on account of the war.

THE EXCHANGE OF SINGLE-LINE RAILWAY TABLETS.

To the Editor of Engineering.

Sir,—I have read with much interest Mr. Benjamin Hall Blyth's presidential address, which appeared in your issue of the 6th inst. In a paragraph relating to the Great North of Scotland Railway Mr. Blyth rightly states that that company was the first to introduce "the exchange of tablets at high speed," but the date given—"1899"—is not correct; the year was 1889. And I may remind you that the tablet-exchange apparatus designed and introduced by me when locomotive superintendent of the Great North was fully described and illustrated in Engineering of October 11, 1889.

I am, yours faithfully,
James Manson.

Deanhill, Kilmarnock, November 14, 1914.

ECCENTRICALLY-LOADED PILLARS.

To the Editor of Engineering.

Sir,—Section 21 (*c*) of the 1909 London County Council General Powers Act, which regulates steel-frame buildings in London, stipulates that pillars eccentrically loaded shall have the stresses caused by such eccentricity computed and added to those caused by direct loading, &c., to obtain the total permissible stress which is limited by the Act.

The majority of pillars in a steel frame receive eccentric loads upon the two principal axes, and a question arises which can be illustrated by the following simple case:—

A rectangular post, $b'' \times d''$ in scantling, has projecting arms at right angles to b and d, each carrying loads W b and W d. What is the greatest stress in the material of the section? The stress caused by each load along the side nearest to it can be ascertained by the ordinary formula $\frac{W}{b'' d''} + \frac{BM}{z}$, and apparently at the corner of the section where the two faces meet, the stress would be the sum of both. But this presupposes that the post will bend in two directions simultaneously, whereas one would anticipate that, under the action of both loads, it would actually bend in a diagonal direction. If so, the correct method of treating the problem would apparently be to calculate one bending moment as caused by the sum of the loads acting at their centre of gravity, and equate it with the diagonal section modulus in the same diagonal direction.

As the question is one which can materially affect the total tonnage of a steel-frame building, it would be desirable to have it settled.

Yours faithfully,
Enquirer.

November 19, 1914.

MOTOR ROAD VEHICLES.

To the Editor of Engineering.

Sir,—Manufacturers of chassis seem loth to profit by experience in their repair. Having found that the modern quick-revolution four-cylinder engine with three main bearings wears away the central bearing more rapidly than the end ones, even when, as is not usual, it has the greater bearing surface, I would like to suggest, in view of the magnitude of the inertia loads, that this bearing has at least double the bearing area; if it is the same diameter, let it be at least twice as long as the other main bearings. The journal as well as the bearing wears.

Making the centre bearing double the length, unfortunately increases the over-all length of the engine, and consequently the cost of production and weight. The remedy is to provide, as several makers of repute are doing, only two bearings to the crank-shaft, and increasing its thickness, which appears to be good so long as the maximum possible revolutions per minute are limited by restricted ingress rather than by general friction. Now that valves and ways are so large, should engine-builders revert to governors?

Yours truly,
A. E. Parnacott.

Penge-lane, Penge, S.E., November 23, 1914.

Personal.—Mr. Ernest C. Haarer, M.I. Mech. E., has been appointed chief engineer and manager of the London Hydraulic Power Company and the Liverpool Hydraulic Power Company, in succession to the late Mr. E. B. Ellington.

Competition with Germany and Austria-Hungary.—In connection with the campaign undertaken by the Board of Trade, on the advice of their Advisory Committee on Commercial Intelligence, to assist British manufacturers and merchants to secure trade formerly in the hands of German or Austro-Hungarian firms, the Board have received a very large number of inquiries for names of sellers or buyers of articles of which the sources of supply or markets have been interfered with by the war. Special arrangements have been made in the Commercial Intelligence Branch of the Board of Trade for dealing with the inquiries, and lists are being prepared and circulated of articles which inquirers desire (*a*) to purchase, and (*b*) to sell. The fifth list which has been prepared is now ready, and may be obtained by United Kingdom manufacturers and traders, together with copies of the previous lists, on application to the Branch. British firms interested in any of the goods mentioned, either as buyers or sellers, should communicate with the Director of the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C.

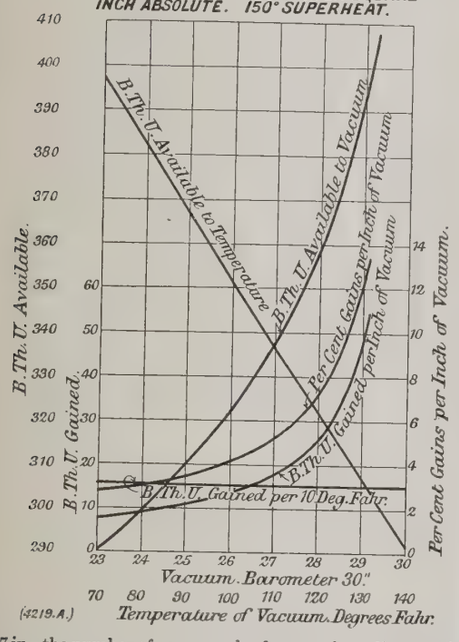
THE EFFECT OF VACUUM IN STEAM-TURBINES.*

By G. Gerald Stoney, F.R.S., Member, of Newcastle-on-Tyne.

In considering the effect of a change of vacuum on a steam-turbine, whether on land or at sea, and also the most efficient vacuum, many things have to be taken into account. It is not sufficient to consider the effect on the turbine alone, but the installation as a whole must be reviewed. This means that not only the turbines, but also the boilers and condensing plant, have to be studied, and that each case must be considered on its merits. As it is impossible in the course of a paper to deal in detail with every item, only the more salient points will be considered.

In this paper the turbine will be taken first, and then the installation as a whole, comprising boilers, turbine, condenser, and their auxiliaries, but confined to the case where there is an ample supply of circulating water, whether from the sea or from a river or other supply. The much more complicated case where there is a restricted supply, or where cooling-towers are used, will not be dealt with at present. The degree of vacuum which gives the same velocity ratio at the exhaust end as throughout any given turbine is the vacuum under which the best results are obtained; consequently, a turbine designed for 29 in. vacuum, barometer 30 in., requires more rows of blades or wheels than one designed for

Fig. 1. DISTRIBUTION OF HEAT DURING ADIABATIC EXPANSION.


INITIAL PRESSURE 175 LBS. PER SQUARE INCH ABSOLUTE. 150° SUPERHEAT.
B.Th.U. Available.
B.Th.U. Gained.
Per Cent. Gains per Inch of Vacuum.
B.Th.U. Available to Temperature
B.Th.U. Available to Vacuum
Per Cent. Gains per Inch of Vacuum
B.Th.U. Gained per Inch of Vacuum
B.Th.U. Gained per 10 Deg. Fahr.
Vacuum. Barometer 30"
Temperature of Vacuum. Degrees Fahr.
(4219.A.)

27 in., the number of rows or wheels on a given diameter in each case being proportionate to the B.Th.U. available in the range between the initial and final pressures and temperatures through which the turbine works. As will be seen later, however, there may be considerable latitude in the velocity ratio at the exhaust end without seriously affecting the available economy. Neglecting the effect of the reheat factor, which is small in modern high-efficiency turbines, and also neglecting terminal losses, with 175 lb. absolute initial pressure and a superheat of 150 deg., the gains per inch of vacuum in the B.Th.U. available during adiabatic expansion are as shown in Fig. 1, and are:

Table I.

Between 23 in. and 24 in., 3 per cent., or an increase of 9 B.Th.U. on about 300 B.Th.U., available at 23 in.						
Between 24 in. and 25 in., 3 per cent. or 10 B.Th.U.						
,,	25	,,	26	,, 4	,,	12 ,,
,,	26	,,	27	,, 5	,,	15 ,,
,,	27	,,	28	,, 6	,,	21 ,,
,,	28	,,	28½	,, 8	,,	29 B.Th.U. per
,,	28½	,,	28¾	,, 9	,,	36 inch
,,	28¾	,,	29	,, 11	,,	42 ,,
,,	29	,,	29¼	,, 13	,,	54 ,,

For saturated steam at 175 lb. absolute, the figures are approximately the same.

In the case of an exhaust turbine working with, say, 15 lb. absolute or atmospheric pressure, the gains per inch of vacuum, as shown in Fig. 2, are:—

Table II.

Between 23 in. and 24 in., 9 per cent., or an increase of 10 B.Th.U. on about 110 B.Th.U., available at 23 in.						
Between 24 in. and 25 in., 10 per cent. or 11 B.Th.U.						
,,	25	,,	26	,, 11	,,	13 ,,
,,	26	,,	27	,, 12	,,	17 ,,
,,	27	,,	28	,, 14	,,	22 ,,
,,	28	,,	28½	,, 17	,,	30 B.Th.U. per
,,	28½	,,	28¾	,, 20	,,	38 inch.
,,	28¾	,,	29	,, 23	,,	45 ,,
,,	29	,,	29¼	,, 27	,,	57 ,,

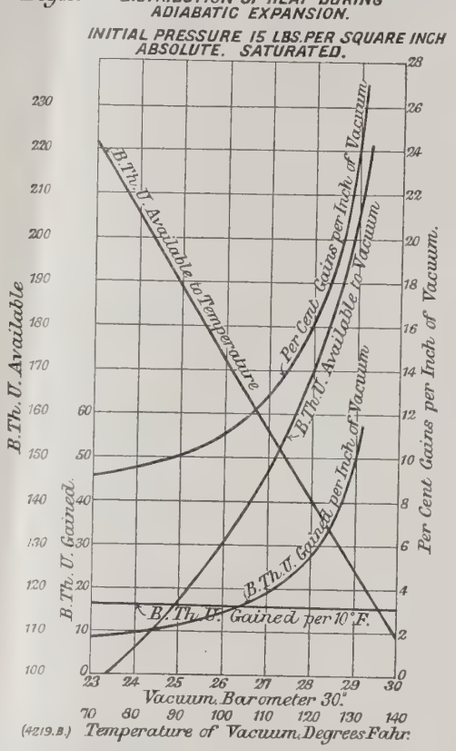
* Paper read before the Institution of Mechanical Engineers, November 20, 1914.

It is thus seen that the percentage gain due to vacuum depends on the steam conditions, being much more with low-pressure than with high-pressure steam, and that the gain in B.Th.U. available is almost independent of the steam conditions. That this is the case is apparent from the Mollier diagram, in which the lines for constant pressure are practically parallel at low pressures for all ordinary ranges of initial pressure and temperature.

Another way to look at it is that for each degree Fahr. that the temperature due to the vacuum is reduced, there are approximately 1.5 more B.Th.U. available, and this is approximately the case through the whole range considered above in Tables I. and II. and Figs. 1 and 2. This method of looking at the question is useful in considering condenser problems. These gains due to vacuum are wholly attainable when the turbine can be suitably designed, but, in the case of high-speed, large-output land turbines, allowance must be made for increased terminal losses.

For example, in a 3000-kw. land turbine at 3000 revolutions per minute, with an initial pressure of 175 lb., 150 deg. Fahr. superheat, and a vacuum of 29 in., the consumption will be about 12 lb. per kilowatt-hour, and the steam per hour will be 36,000 lb., or 10 lb. per second.

Fig. 2. DISTRIBUTION OF HEAT DURING ADIABATIC EXPANSION.


INITIAL PRESSURE 15 LBS. PER SQUARE INCH ABSOLUTE. SATURATED.
B.Th.U. Available.
B.Th.U. Gained.
Per Cent. Gains per Inch of Vacuum.
B.Th.U. Available to Temperature
Per Cent. Gains per Inch of Vacuum
B.Th.U. Available to Vacuum
B.Th.U. Gained per Inch of Vacuum
B.Th.U. Gained per 10° F.
Vacuum. Barometer 30.
Temperature of Vacuum. Degrees Fahr.
(4219.B.)

The volume at exhaust, allowing for condensation, will be about 6000 cub. ft. per second. With present materials available, it is not in general customary to go above about 550 ft. per second for the mean velocity of the blades at the exhaust end, giving a mean diameter of 42 in.; and as the blade height in practice cannot be more than one-fifth of this, or 8.4 in., the area of the annulus is 7.7 sq. ft. The velocity of the steam leaving the blades through the restricted area will then be 780 ft. per second, and involves a loss of 12 B.Th.U., assuming that the velocity ratio and angle of the blades is such that the steam leaves them axially, as it should, to give the minimum loss. Even under these conditions, however, there is still a gain of 6½ per cent. between 28-in. and 29-in. vacuum. For still larger powers, however, these effects become more pronounced, until conditions are eventually reached in this class of turbine having a highly restricted exhaust end when an increase in vacuum causes no gain. It is the constant aim of designers to increase the limiting vacuum by using higher blade speeds and enabling an exhaust end of larger dimensions to be employed. This is undoubtedly a direction in which increased efficiency in large-power, high-speed turbines is to be found. The effect of increased blade speed is very marked, as for a given vacuum the reduction in available gain varies inversely as the fourth power of the blade speed, since, as the blade height cannot well be more than one-fifth of the mean diameter of the blades, the area at the exhaust will vary as the square of the diameter, or as the square of the mean blade velocity. Therefore the longitudinal velocity varies inversely as the square of the mean blade velocity, or the B.Th.U. lost, inversely as the fourth power. Of course, the reduction can be halved by adopting a turbine with double flow at the exhaust, but this often introduces complications, although many highly economical land turbines of large power have been designed on these lines. Something can also be done by shaping the exhaust suitably, so as gradually to reduce the velocity of the steam on leaving the blades.

A high-speed, large-output land turbine running at full load having been dealt with, the case of reduced loads will now be considered. With throttle governing, the initial steam pressure is reduced in accordance with a right-line law, similar to the Willans law, for the steam consumption, and it may be taken that in this case the initial pressure at no load is approximately atmospheric. If at full load the initial pressure is 175 lb. absolute, at half load it will be about 95 lb., and at quarter load 63 lb. At half load, with a vacuum of 28 in. to 28½ in., the percentage gains in consumption per inch of vacuum would be increased by about 1 per cent., and at quarter load by about 2½ per cent. above those given already, owing to the reduced B.Th.U. available by reason of the reduced initial steam pressure. The exact amounts of these gains will depend on the velocity ratio throughout the turbine, which has been assumed to be constant at full load.

At reduced loads with throttle governing, the velocity ratio will be approximately the same as at full load throughout the turbine, except near the exhaust end, where it will be greater at reduced loads. This may either slightly increase or diminish the efficiency at the exhaust end, according as the general velocity ratio is high or low, but in general the effect will be small.

With nozzle governing, the gains due to increased vacuum at reduced loads are somewhat less than with throttle governing, and the exact amount depends on the type of nozzle governing used; but broadly, at full load and at reduced loads the gains in consumption per inch of vacuum are more nearly equal with this type of governing. When a turbine is not bladed so as to give the full velocity ratio right up to the exhaust end at full load, it is obvious that the above gains due to vacuum must be modified.

Direct-coupled marine turbines especially, from considerations of weight and space, are often bladed so as to give uniform velocity ratio at full speed with about 26 in. vacuum, and from various causes many land turbines have been similarly bladed. In turbines so bladed and with ordinary steam pressures, it has been found by experience that the gain per inch of vacuum at full load is:—

Between 26 in. and	27 in.,	4 per cent.,	or	12	B.Th.U.	
,,	27 ,,	28 ,,	5	,,	17	,,
,,	28 ,,	28½ ,,	6	,,	22	,,
,,	28½ ,,	29 ,,	7	,,	27	,,

In the turbines so bladed and at constant speed, as in land work, the velocity ratio at the exhaust end would automatically become, at half load, uniform with the rest of the turbine at about 28 in., and for quarter load at about 28¾ in., so that in general it may be said that the theoretical gains as given already will be completely obtained at reduced loads; but for strict accuracy each case should be considered on its merits. It may be noted here, however, that, although there is a decrease in efficiency at the exhaust end by having a cramped exhaust and low-velocity ratio, there is but little loss when the exhaust end is large and has an unnecessarily high-velocity ratio.

Land turbines running at constant speed having been dealt with, the case of a marine turbine running at reduced speeds, when the load is reduced, may now be considered. Geared turbines can be bladed and should be bladed for high vacuum, and here it may be mentioned that the blading should be for nearly the highest vacuum obtainable in the waters in which the ship trades, as there is but little loss by running a turbine bladed for high vacuum at a lower one. For example, it should be bladed for 28½ in. to 29 in., the vacuum obtainable in home waters and the like, and not for 27½ in. to 28 in., which will be the vacuum obtainable in the tropics with a good condensing plant. In such turbines the full theoretical gain due to vacuum will be attained at full speed. At half speed and one-eighth power, if the consumption at full load is assumed to be 12 lb. per shaft horse-power, and at half speed 16 lb., the steam at half speed will be one-sixth that at full speed, and the velocity ratio three times that at full speed for the same vacuum, so that the exhaust end is amply large enough for the highest vacuum which can be attained, and therefore the gain due to increased vacuum will be somewhat more than that at full speed.

It may be mentioned that, in most cases, blading a geared turbine for high vacuum, as compared with low vacuum, adds very little to the weight, and generally only necessitates the exhaust end being made somewhat larger. It is very important that the exhaust between the turbine-blades and the condenser should be free, and should be unrestricted, so that the loss of vacuum between the last row of blades and the steam space in the condenser should be a minimum. This applies to all classes of turbines.

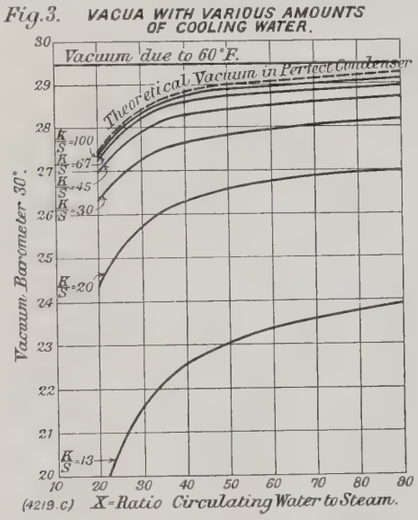
It is equally important that the loss of vacuum between the steam space in the condenser and the air-pump suction should also be a minimum. In other words, given a condenser and an air-pump of the highest efficiency, the difference in vacuum between the air-pump suction and exhaust end of the turbine should be reduced to an absolute minimum. The great importance of this requirement should be carefully noted when analysing data obtained from any particular turbine installation, whether land or marine, as otherwise erroneous conclusions may be formed. For example, if any of the many factors in design which influence the efficiency of any given installation as a whole are not provided for, it is futile to carry a vacuum higher than such provisions warrant; the consequent sacrifice in economy is measured in such cases by what is obtained and what is obtainable. Sometimes a definite velocity is fixed on for the velocity of the steam in the exhaust, but this has the difficulty that it entirely depends on the vacuum for which the condenser is designed. A better way is to make the area of the exhaust have a definite ratio to the area of the annulus of the last row of blades, and in direct-coupled marine turbines this ratio is generally 1.5 to 1.7, but in geared turbines it can be increased to about 2. This means that if the reduction of velocity

can be made to take place gradually, as in a diverging orifice, most of the terminal loss at the blades will be recovered, and a great deal can be done in this direction, in many cases, by careful attention to having gradually diverging stream-lines of steam from the blades to the condenser. A rule sometimes used on land is to have 18 lb. to 20 lb. of steam per hour per square inch of exhaust area, and in many cases this also works well in practice. Much more careful attention is required in the future, as to the shape of the exhaust, than in the past, for even at present many exhausts are so shaped as to cause considerable and unnecessary loss of vacuum.

The case of a direct-coupled marine turbine, only bladed for 26 in. at full speed, is rather different. Here, at full speed, the effect of vacuum will be as given on page 655, but the cases of half speed and one-eighth power have to be specially considered, more particularly on account of such devices as cruising turbines, &c. If we assume the steam per shaft horse-power with Parsons turbines to be 13 lb. at full speed and 21 lb. at half speed, and that the shaft horse-power at half speed is one-eighth that at full speed, the steam per hour will be one-fifth that at full speed. Assuming that throughout the main turbines generally the velocity ratio is 0.5 at full speed, then at half speed the velocity ratio throughout the main turbines will be 0.25, except at the exhaust end, where it will be 1.25. This means that the full effect of vacuum will be obtained up to over 29 in. vacuum, and, on account of the low velocity ratio, the effect, provided the condensing plant will respond, will considerably exceed the theoretical at lower vacua.

Up to the present the turbine alone has been considered, but in a complete installation, whether land or marine, there are many other factors to be taken account of. As increase in vacuum is associated with a correspondingly lower temperature of condensate, it follows

Fig. 3. VACUA WITH VARIOUS AMOUNTS OF COOLING WATER.



that if the vacuum is raised, and the condensate is delivered to the boiler at the same temperature at which it leaves the condenser, either the quantity of steam generated in the boiler per unit of coal is decreased or the quantity of coal per unit of steam generated is increased. If the difference between the temperature due to the vacuum and that of the condensate is taken as constant, a reduction of 10 deg. in the temperature of the feed-water delivered to the boiler is equivalent to an increase of about 1 per cent. in coal consumption per unit of steam generated, or

	Per Cent.
Between 26 in. and 27 in.	= 1
,, 27 ,, 28 ,, ...	= 1½
,, 28 ,, 29 ,, ...	= 2

Such a condition, however, never arises in practice on land or at sea, as the condensate is invariably heated either by the waste gases from the boiler or by the exhaust steam from the auxiliary engines, or by both. Land installations usually include an economiser in the boiler uptake, and the practical requirement in such a case is that, in order to prevent sweating on the tubes, the feed-water should be delivered to the economiser at a temperature of about 120 deg. Fahr. But even at the highest vacua there is usually sufficient exhaust steam from the auxiliaries to raise the condensate to this temperature, so that such a system represents the highest economy attainable with any given plant.

Marine installations present a different problem by reason of the large quantity of exhaust steam available from the auxiliary engines, and it may here be noted that the heat in exhaust steam is used to the greatest advantage possible when it is redelivered to the boiler with the feed-water. It follows that in order to attain maximum economy on shipboard, the entire exhaust from auxiliary engines should be condensed by the feed-water. The quantity of heat that can be absorbed depends, of course, on the temperature of the condensate delivered from the condenser, and on the pressure, and, therefore, the temperature at which the exhaust from the auxiliaries is maintained. A perfect installation from this point of view would be one in which the turbine works under the highest attainable vacuum with efficiency, and in which the exhaust steam is maintained at such pressure as will enable its heat to be wholly transferred to the feed water. In fact, the economic pressure for the auxiliaries to exhaust at is that in which the whole of their exhaust can be condensed by the feed. Obviously there should be no surplus exhaust, and if there is a surplus it should should never be discharged into the main condenser, because of the highly prejudicial effect of oil on the heat-transferring efficiency of the condenser-tubes and on the vacuum. The direction in which progress is to be made on marine turbine installations would therefore appear to be :—

(*a*) High-vacuum turbines.
(*b*) High-efficiency condensing plant.
(*c*) Economical auxiliaries.
(*d*) Efficient exhaust-steam feed-heaters.

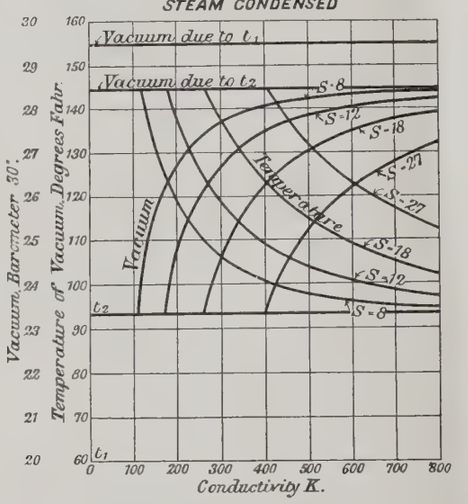
In some cases where there is a surplus of auxiliary steam, it is turned into the low-pressure turbine, and here there is an apparent partial recovery of the loss, but in practice this arrangement has the defect of fouling both the turbines and the condenser with oil and reducing their efficiency, so that the entire power of the turbine may easily be reduced to a far greater extent than it can be increased by the use of such surplus steam. If, however, the steam is used in this way, it should be very carefully filtered.

In order to consider further the effect of vacuum on an installation, it is necessary to consider the question of the condensers and the power necessary to work them. In a surface condenser there are three losses to be considered :—

(*a*) The temperature rise in the circulating water.
(*b*) The resistance of the tube to heat transmission from the steam to the water.

Fig. 4. VACUA AND TEMPERATURES WITH VARYING CONDUCTIVITY.

CIRCULATING WATER (60°F.) 60 TIMES STEAM CONDENSED



(*c*) Air insulation of the condensing tubes.

These may be summed up in the apparent conductivity K of the condenser—that is, the B.Th.U. transmitted per square foot per hour per 1 deg. Fahr. difference of temperature between the steam and the water.

Let

t_1 be temperature in deg. Fahr. of inlet water to condenser.
t_2 be temperature in deg. Fahr. of water leaving the condenser.
T be temperature in deg. Fahr. due to the vacuum.
X the ratio of circulating water to steam condensed.
S the steam condensed per square foot of condenser surface per hour.

(For convenience this is reckoned on the outside of the tubes.)

Then

$$K = 2.3\ S\ X \log \frac{T - t_1}{T - t_2}.$$

As it takes in ordinary practice about 1000 B.Th.U. to condense each pound of steam, we may write :—

$$1000 = X\ (t_2 - t_1),$$

and writing

$$T - t_2 = \delta,$$

the equation becomes :—

$$K = 2.3\ S\ X \log \frac{\delta + \frac{1000}{X}}{\delta}.$$

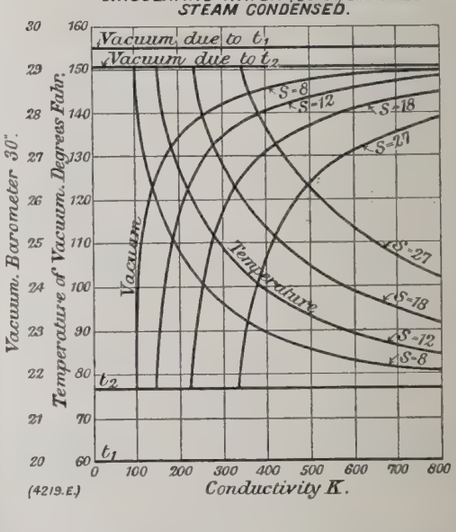
As the maximum vacuum a condenser can produce is that due to the temperature of the exit water, the object of the designer is to have δ as small as possible. With a condenser in average conditions of cleanliness and efficient air withdrawal, the value of the conductivity K is obviously much higher than with inferior air extraction or a dirty condenser. The conductivity is also influenced by the load. For example, in a very heavily-loaded condenser, under the best conditions, a value of K of 1500, or even higher, has been reached, whilst in condensers under low load it may be no higher than 300, so that this method of comparison requires to be used with some discretion.

Fig. 3, above, shows the vacua obtainable with various values of K, S, and X, and Figs. 4 and 5 the effect of conductivity at various rates of condensation for X = 60 and X = 30. All these are for an inlet temperature of 60 deg. Fahr., and similar curves can be plotted for any other temperature, but as they are all similar in character, those for 60 deg. Fahr. are alone given. It will be observed from Figs. 4 and 5 that the effect of reduced conductivity, such as is caused by air, is much more at high rates of condensation than at low, showing that the effect of a faulty air-pump or dirty condenser is much more when the rate of condensation is high. It will also be seen that approximately the loss of vacuum below that theoretically obtainable depends only on the rate of condensation and on the amount of air insulation, and not on the quantity of circulating water—that is, that δ is approximately independent of X, always assuming a condenser free from oil on the outside of the tubes and scale on the inside. From the curves it follows that there is not much use in having more circulating water than about sixty to eighty times the steam condensed at full load in home waters and the tropics respectively.

Figs. 4 and 5 also show the importance of having ample surface, and confirm what has often been found, that money put into a condenser of ample size is money well spent. Ample surface also gives a good margin to allow of the condenser getting dirty or for overloads. With a high rate of condensation, especially if the condenser is dirty, when an overload is required the vacuum will drop so much that not only is there often difficulty in getting the overload out of the turbine, but the boilers are still further overtaxed, due to the increased steam consumption causing the steam pressure to drop just at

Fig. 5. VACUA AND TEMPERATURES WITH VARYING CONDUCTIVITY.

CIRCULATING WATER (60°F.) 30 TIMES STEAM CONDENSED.



the time it is most important to have full pressure. It is usual in modern power-stations to have a vacuum of about 29.1 in., barometer 30 in., with 50 deg. Fahr. cooling water, and circulating water sixty-five times the steam condensed, and 28 in. with 80 deg., seventy times, and it seems as if these conditions cannot be much improved upon, as, if the circulating water were increased in this case from 65 to 100 times the steam, the improvement in vacuum would only be about ⅛ in., and the pumps and circulating pipes would have to be increased 50 per cent. With sixty-five times also and a moderate rate of condensation, such as 6 lb. to 8 lb. per sq. ft. at normal load, there is an ample margin for overload, an overload of 50 per cent. only reducing the vacuum by about ½ in.

In cases where there is not a supply of natural cooling water or only a restricted supply, or where cooling-towers are used, the question of the best vacuum has to be most carefully considered, and so many factors come into the case that each problem must be considered on its merits and alternative schemes worked out to find which is best. Such cases it is not proposed to deal with in this paper.

In the mercantile marine, the only question that has to be considered in practice is the case of full speed at sea, and everything has to be arranged for the highest economy at that speed. In a recent geared-turbine meat-carrying ship the turbine is bladed for about 28½ in. to 28¾ in. vacuum, and the condensers have a surface of 8 lb. per sq. ft. or 1½ sq. ft. per shaft horse-power, or equivalent to, say, 1.35 per indicated horse-power, and circulating water equal to seventy-five times the steam condensed, so as to provide for tropical waters. The vacuum is 29.1 in. with 50 deg. Fahr. sea temperature, 28.8 in. with 60 deg. Fahr., and 28 in. with 80 deg. Fahr. The weight of the Scotch boilers is 62 per cent., of the main turbines 12 per cent., of the condensers 3 per cent., of the circulating and air-pumps with their pipes 5 per cent., and of other auxiliaries, pipes, &c., 18 per cent. of the total weight in engine and boiler-rooms.

If the surface of the condensers were halved, giving 16 lb. per sq. ft., keeping the same circulating water, there would be a loss of vacuum of about ½ in., and a saving on the total weight by smaller condensers of 1½ per cent. This would increase the steam consumption by, say, 5 per cent., and therefore the weight of the boilers, by 5 per cent., and the total weight by 1½ per cent., not to speak of the 5 per cent. extra coal that would

have to be carried. A reduction in the circulating water would also tend the same way. It is much more economical to save at the low temperature or condenser end of the system than at the high temperature or boiler end, and therefore to have as high an efficiency in the condensing plant as possible, and turbines made to suit. The increase of weight in the condensers and turbines is much more than counterbalanced by the saving of weight in the boilers and coal to be carried. High efficiency in the condensing plant means not only sufficient surface and sufficient circulating water, but also most efficient air withdrawal, as, for example, by a steam jet.

The case of warships has also to be considered. In the case of a battleship with direct-coupled turbines the weight of the water-tube boilers is 35 per cent.; turbines, 25 per cent.; condensers, 3 per cent.; circulating and air-pumps, &c., 4 per cent.; and other auxiliaries, &c., 33 per cent. of the total engine and boiler-room weights. The condensers condense at full power 18 lb. per sq. ft., and the circulating water is sixty-five times the steam. This gives, with 60 deg. Fahr. sea temperature, a vacuum of 28¾ in. Direct-coupled warship turbines are bladed for about 26 in. for reasons given before, but with geared turbines bladed for higher vacua it is evident that it would pay to reduce the boilers and increase the condensers. At reduced speeds the condensers are lightly loaded, and here, as explained before, the highest vacua can be taken advantage of by the turbines. With the lightly-loaded condensers the loss of temperature and vacuum due to the conductivity between the water and the steam through the tubes become small, and the important point is efficient air withdrawal.

At half speed or one-eighth power the condensers are only loaded to about 4 lb. per sq. ft., and as the vacuum is generally only about 28½ in., this means a conductivity of only about 150 as against 600 to 800 at full load. But if greater care were taken to instal air-withdrawing apparatus of the highest efficiency and ample capacity, such, for example, as is obtainable with a steam-jet combination, this vacuum could be raised to fully 28¾ in. or 29 in. with sea-water at 60 deg. Fahr., provided the condenser was of suitable design, thereby effecting a gain of at least 3 per cent. on the coal consumption, an amount which would far outweigh the comparatively slight additional cost and weight of the apparatus. This gain is entirely independent of the drop of temperature of the condensate, as at low powers there is always more exhaust steam available than can be condensed by the feed-water. Other types of warships can be similarly considered, but the case of the destroyer is especially difficult, as it is essentially a compromise, and here it has been considered economy to load up the condensers at full speed to about 27 lb. per sq. ft. and reduce the circulating water to about fifty times.

With the advent of geared turbines the case becomes different, since they can be bladed for high vacua with very little increase in the weights and sizes of the turbines, and it is clear that the greatest benefits from the highest vacua will be found. It is to be expected that in such cases there will be a large increase in the surface of the condensers and improvement in air withdrawal, with a consequent reduction in the boilers and fuel carried. The effect of vacuum on turbines is so great that a given weight expended on the condenser end is far more profitable in power production than a similar weight expended at the boiler end.

The aims of an efficient condenser are to have the maximum of heat transferred from the steam to the circulating water—that is, a minimum difference between the temperature due to the vacuum and the temperature of the circulating water leaving the condenser, and also to deliver the condensate to the hot-well as near the temperature due to the vacuum as possible. And here it is important to consider the steam consumption of the auxiliaries and the air-withdrawal arrangements which comprise air-pumps in some form, together with the withdrawal of the condensate from the condenser. It is not proposed to enter into the different types of air-pumps, but as the driving power of these pumps is at most only about 1 per cent. of the power of the turbine at full load, and in general much less, the importance of the steam used per unit of power required for driving an air-pump is negligible compared with its vacuum-producing qualities. The steam required by the circulating-pumps depends on the steam consumption W in pounds per water horse-power-hour of the engine driving the circulating-pumps, the ratio X of the circulating water to the steam condensed, and the total head h in feet on the pumps. We have then:—

$$\text{Percentage of steam used by pump} = \frac{W \times h}{20{,}000}.$$

For example, if we take W = 60, X = 60, and h = 20 ft., we have percentage used = 3 6.

For X = 30 the percentage is 1.8.

The difference in the hot-well temperature, between condensers using these quantities of circulating water, is about 17 deg. Fahr., so that without allowing for condensation it may be said that in this case the temperature of the feed, after it has condensed the steam from the circulating-pump, is largely independent of the quantity of circulating water, and this has to be considered in making up the final balance-sheet, which alone enables the most difficult problem of the best vacuum for any particular installation to be considered.

In the foregoing an attempt has been made—it is felt a very imperfect one—to review the general position as to the effect of vacua in turbine installations, and the author hopes he will be excused for the many imperfections in his paper. An endeavour has been made to point out a few of the leading points that have to be considered, and to show how each case must be considered on its merits.

In conclusion, the author wishes to thank numerous friends for the help and advice they have given in connection with this paper, without which help and advice it would have been impossible for him to write it.

THE INTERSTRAIN THEORY OF HARDNESS.*

By Andrew McCance, A.R.S.M., B.Sc.

1. There are three methods by which a pure metal may be made harder—namely, by mechanical deformation, by the addition of elements which form solid solutions, and by the application of heat treatment (in certain cases), but as yet there is no theory which can be said to demonstrate the underlying connection which must exist between these three means of achieving the same end. For it can be said with certainty that so long as the metal retains its chemical characteristics the same effects must be derived from the same immediate causes.

It is with the hardening effect caused by heat treatment that this short paper will deal, but it can be shown that what is true for iron is also generally true for all alloys where corresponding conditions exist.

2. The great amount of attention which has of late been concentrated on the nature of the allotropic changes in pure iron has made it clear that from ordinary tempera-

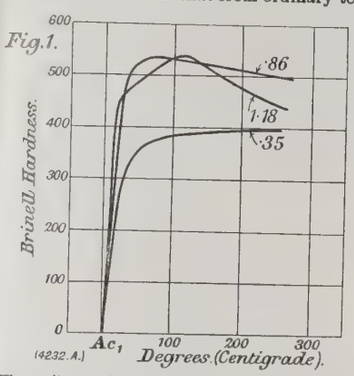


Fig. 1.—The units are degrees Centigrade above the Ac_1 point, and increase in hardness in Brinell numbers above the annealed value.

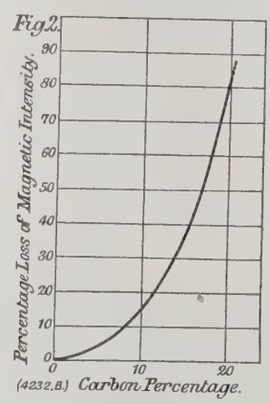


Fig. 2.—From data published by Hadfield and Hopkinson and by the author.

tures up to 1000 deg. Cent. only two real allotropic forms of iron exist—the α and the γ—and that the so-called β iron is in reality α iron which has become non-magnetic from purely thermal causes, the apparent liberation of heat at A_2 being due to the rapid change in the specific heat which accompanies the ferro-magnetic transition.†

Since α iron loses its magnetic properties above a definite temperature, it might be suggested that γ iron, which at high temperatures is non-magnetic, might itself become magnetic at lower temperatures. Non-magnetic manganese steel, however, is not transformed even at the temperature of liquid air,‡ and no treatment can make austenitic steels magnetic which does not increase the specific volume at the same time, and when this takes place it points conclusively to the transformation to α iron, for the thermal magnetic transition makes no appreciable alteration in the specific volume.

The development of enormous crystals in low-carbon steels which have been strained and afterwards reheated to any temperature below Ac_3,§ and in thin sheets of electrolytic iron cooled from above Ac_3,‖ proves that iron possesses the same crystalline form above A_2 as below it, and that the A_2 point is not evidence of allotropy.

3. The great and important distinction between the two forms of iron is their behaviour towards carbon, which is soluble in α iron only to a very small extent, but can dissolve with readiness in γ iron, and on this preferential treatment rests the explanation of the unique position which carbon occupies as a cause of hardening by quenching in iron. There is no doubt that if another element can be found possessing the same property of exclusive solubility in γ iron, that element also will possess to a similar extent the hardening power of carbon.

4. Pure iron, in common with all metals, is hardened after permanent deformation, and it is best described after such treatment as being in a condition of "interstrain." Metals in their normal unstrained condition are crystalline; that is, they are composed of an orderly arrangement of their constituent atoms arranged in a space lattice which conforms with whatever symmetry the crystals possess. Successful attempts have been recently made by the aid of X rays to determine the actual position occupied by the atoms, and copper,* for instance, has been shown to have its atoms built up in a "face centred" cube; that is, a cube having an atom at each corner and one at the centre of each face.

The effect of deformation on such systems must be to alter the position of each atom relatively to its neighbour, and permanent deformation must cause so much alteration that the atoms along the planes of slip can no longer return to their positions of equilibrium. This corresponds to the condition of interstrain, and results in a hardening of the material. That the destruction of the crystalline arrangement goes so far as to render the material in those planes of greatest movement actually amorphous and devoid of crystalline form, as Beilby has proposed, has never been seriously questioned; but the writer thinks that the following facts are strong arguments against this theory of a hard vitreous amorphous phase. In the case of a dimorphous metal like iron, the vitreous phase, to be truly amorphous, must possess the same physical properties, no matter from which crystalline form it has been produced by deformation; and since strained α iron loses none of its magnetic intensity, we must assume that amorphous iron is magnetic; consequently it is to be expected that strained γ iron will also be magnetic, since the same constituent is produced. The important results of Hadfield and Hopkinson† show, however, that the magnetic intensity of austenitic manganese steel after severe straining is only augmented to 0.3 per cent. of the intensity of pure iron, and is still practically non-magnetic, although the hardness has increased from 200 to 490. It would seem that the iron in the interstrained condition has not lost the distinguishing properties which are the result of crystalline form.

Hanriot‡ exposed small cubes of metal to a fluid pressure of 10,000 kg. per sq. cm., and although no measurable deformation could be detected, the hardness had increased in every case as follows:—

Metal.	Hardness (Before).	Hardness (After).
Silver	20.3	32.2
Iron	57.7	62.3
Brass	24.0	36.5
Zinc	33.1	43.0

The microstructure was the same after this treatment as before, while to suggest that the hard vitreous phase had been formed as the result of pressure would, of course, be out of the question, since iron which expands on becoming liquid would have its melting-point raised, and not lowered, by pressure.

Deformation does not necessarily produce an amorphous constituent, but only results in some permanent alteration of the atoms from their positions of equilibrium in their crystalline space lattice; and, conversely, it will be true that any metal whose atoms are prevented from reaching their positions of equilibrium will be in a condition of interstrain, and will be hardened.

5. To harden steel it is necessary to heat it above the Ac_1 point; that is, to heat it to the temperature at which the carbon is all in solution, and then to cool it at a rate which is sufficiently rapid; but the greatest hardness is obtained when the temperature reaches the highest change point; that is, the Ac_3 for hypoeutectoid and Ac cementite for hypereutectoid steels. This is shown in Fig. 1, giving the hardness of three steels with 0.35 per cent., 0.86 per cent., and 1.18 per cent. carbon, and the temperature of quenching in degrees above the Ac_1.

With 0.35 per cent. carbon the structure after quenching from just above the Ac_1 will consist of ferrite and martensite areas (separated by transitional troostite, &c.), and the increase in hardness from this to just above the Ac_3, when the structure is wholly martensitic, corresponds with the gradual replacement of the ferrite by the harder constituent. With 1.18 per cent. carbon the greatest hardness is obtained by quenching from just above the Ac cementite, and the softening which takes place on increasing the temperature corresponds with the appearance of austenite in the micro-section. A very important result is that when the carbon reaches about 0.7 per cent. a maximum hardness is obtained in the quenched state, and this value is not exceeded in any pure carbon steel. If the hardness were the direct consequence of carbon in solution, the hardness would be proportional to the amount of carbon dissolved. That it

* A contribution to a general discussion on "The Hardening of Metals" before the Faraday Society on Monday, November 23, 1914.

† McCance, Journal of the Iron and Steel Institute, 1914, i., page 223; Benedicks, Journal of the Iron and Steel Institute, 1914, i., page 439. Engineering, June 12 and 19, 1914.

‡ Hadfield, Journal of the Iron and Steel Institute, 1905, i., page 179.

§ Stead, Journal of the Iron and Steel Institute, 1898, i., page 145. Engineering, September 23, 1898. Chappell, Journal of the Iron and Steel Institute, 1914, i., page 472.

‖ Stead and Carpenter, Journal of the Iron and Steel Institute, 1913, ii., page 113. Engineering, September 26 and October 3, 1913.

* Bragg, *Philosophical Magazine*, September, 1914.

† Hadfield and Hopkinson, Journal of the Iron and Steel Institute, 1914, i., page 125. Engineering, May 29, 1914.

‡ Hanriot, *Comptes Rendus*, 155, pages 713 and 1502.

is not so shows that the action of carbon is indirect, and that the hardening element is the iron itself.

6. It is a fact well known that steels which at the temperature of quenching are non-magnetic are magnetic in their hardened state, and this change must have taken place during the time occupied by the quenching. Since it has been previously shown that γ iron does not itself become magnetic, it is necessary to conclude that during the time occupied in cooling from the higher temperature to the lower the original γ must have changed to the magnetic α condition. Measurements of the electric resistance show that the carbon has not changed its condition, but has remained in solution, and so we recognise the fact that under the conditions of quenching the transformation of the iron from the γ to the α state can take place independently of the change in the state of the carbon from a state of solution to the undissolved state. These two transformations, which on slow heating and cooling take place simultaneously, can behave as independent reactions, although in a sense which is limited. For though martensite may be considered as an enforced solution of carbon in α iron, it must not be forgotten that there is still some γ iron present with the carbon, which is absolutely necessary to maintain its solubility, and any change in the state of the carbon causes the transformation of this γ iron to α. It might on this account be suggested that the iron is chemically combined with the carbon, but an examination of the curve (Fig. 2) connecting the loss of magnetic saturation intensity with the carbon content shows that the γ iron increases much more rapidly than the amount of carbon, which points to purely physical influences.

7. It has been shown elsewhere* that it is possible to calculate the velocity of quenching in a round bar on certain assumptions which are closely realised in the early stages, at least, of quenching, and if the curve thus obtained is compared with the curve connecting the electric resistance, or the loss of magnetic intensity, of a steel with 0.86 per cent. carbon, it is seen that they are closely similar, so that the amount of carbon in solution and the amount of γ iron retained in the cold state are proportional to the rate of cooling; at least, until the carbon is completely in solution.

With a given rate of cooling, the progress of the transition from the equilibrium position for γ crystals to that of α crystals will be arrested, and will ultimately be stopped by the increase in the internal viscosity at the lower temperature. The crystalline transformation, in other words, will be partially suppressed, and a condition produced which is essentially similar to the condition of interstrain produced by deformation, and the hardness which results is accounted for by this condition.

During the cooling of hypoeutectoid steel from a temperature at which it consists of a homogeneous solution of carbon in γ iron, its complete transformation into α iron and cementite comprises two individual transformations:

(a) A change in the state of the iron from γ to α.

(b) A change in the state of the carbon.

The first of these can take place independently of the second; but when the second takes place, it necessarily involves the first. Three possible conditions can therefore result:—

1. Both transformations are completed; this is the normal pearlitic condition of steel, which is soft.

2. Both transformations are suppressed; this corresponds to the condition of pure austenite, which is also comparatively soft.

3. When (a) takes place but (b) is suppressed—that is, the complete transformation is partially suppressed—then the structure is martensitic and the α iron formed under this condition is interstrained and very hard.

Case (3), then, is the important one from a hardening standpoint, and to be possible it is necessary that a difference should exist in the respective velocities of transformation of (a) and (b), so that with an appropriate rate of cooling the slower transformation can be suppressed while the faster is not greatly affected.

This intimate connection between the rate of cooling and hardening is further illustrated by the behaviour of alloy steels. The addition of manganese, for instance, by lowering the temperature of the transformations greatly decreases the velocities with which they proceed, so that with a certain percentage (which varies with the carbon content) the transformation of the carbon may be almost completely suppressed by air-cooling, and the normal condition after such treatment is martensitic accompanied by hardness and brittleness; in fact, all the characteristics of quenched pure carbon steels. Water quenching, on the other hand, results in the complete suppression of both transformations, and the steel becomes austenitic and soft, while the same result is obtained by air cooling when the percentage of manganese is further increased.

Commercial manganese steels after air-cooling are non-magnetic though fairly hard and brittle, but such steels usually contain about 1.2 per cent. of carbon, and this condition is probably brought about by the deposition from a state of solution of the cementite in excess of the eutectoid composition.

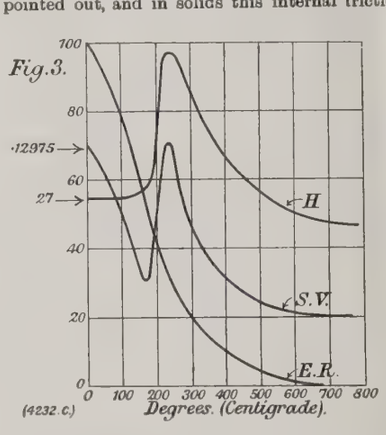
Similar results are obtained by the addition of nickel, and the following facts are also instructive. A nickel steel containing 3.6 per cent. of Ni and 0.19 per cent. carbon had a normal hardness of 188, which, after quenching in water from 1000 deg. Cent., had risen to 444, but a steel containing 0.19 per cent. carbon without the nickel increased, after the same treatment, from 143 to 218; that is, while the plain carbon steel increased in hardness 65 points by quenching, the nickel steel increased by 259. Nickel is known not to form a carbide in this range of composition;† consequently the state of the carbon is similar in both, and the increased hardening power must be due to the influence of the nickel on the iron. It has enabled the iron to retain a greater degree of interstrain by lowering the temperature at which the transformation of the γ to α iron takes place.

8. Tempering allows the metastable conditions which result from quenching to revert to their stable state. In hypoeutectoid steels the carbon is deposited from solution and the specific resistance falls, while at the same time the interstrained condition of the iron is gradually lost with the formation of α ferrite recognisable under the microscope.* As a consequence the magnetic permeability under low fields increases, the remanent magnetism decreases, and the peculiar shape of the curves connecting the magnetic properties with the temperature of tempering is found to be exactly similar for interstrained iron as for quenched steels—a similarity extending also to the rate at which the hardness is lost.†

Turning now to the consideration of the tempering of high-carbon steels which contain a proportion of pure austenite, the curves of specific volume, electric resistance, and hardness of one containing 1.66 per cent. carbon due to Maurer are given in Fig. 3.

The smooth curve for the electric resistance shows that the carbon is deposited continuously, and this causes a decrease in the specific volume; but at 150 deg. to 250 deg. Cent. there is a sudden increase, which is without effect on the electric resistance, and must therefore be due to the transformation of γ to α iron; and since this takes place independently at a low temperature under conditions of high internal viscosity, the α iron formed will be in a condition of interstrain, and an increase in hardness should result. This is strikingly confirmed.

9. The importance of internal friction in retarding transformations and preserving the metastable state has been pointed out, and in solids this internal friction is



H = Hardness curve—each vertical division represents 10 units (Shore).

E.R. = Electric resistance — each vertical division represents 20 per cent. of the total loss.

S.V. = Specific volume—each vertical division represents 0.0004 cub. cm.

very similar to sliding friction between solid surfaces. A fixed amount of super-cooling below the transition range, for instance, is necessary before transformation can take place in solids, and the difference in the temperature of transformation on heating and cooling is a measure of the internal friction. Twenty-five per cent. nickel steel has a transformation-point at 550 deg. Cent. on heating, while on cooling it is transformed in the neighbourhood of −100 deg. Cent., which shows a range of 650 deg.; but manganese steel containing about 14 per cent. Mn has a larger difference in this respect than any other, since on heating the Ac point occurs about 550 deg. Cent., while the Ar_1 does not even take place at the temperature of liquid air, a range of more than 740 deg.

Many of the abnormal properties which manganese steel possesses are due to this great friction. Deformation renders non-magnetic nickel steel magnetic through the transformation of the γ iron to α with a decrease in density, but manganese steel, on the other hand, is practically unaffected magnetically.

Composition	Elect. Res.	Specific Volume.	Hardness.	Magnet. Reman.	Treatment
per cent				cm.	
1.66 C.	1.00	0.12964	28	14.5	Quenched from 1100 deg. C. in iced brine.
1.66 C.	1.04	0.13105	88	28.5	Quenched from 1100 deg. C. immersed in liquid air.
1.94 C.	1.00	0.13233	17	0.8	Quenched from 1200 deg. C. in iced brine.
2.24 Mn.	1.07	0.13439	29	8.2	Quenched from 1200 deg. C. immersed in liquid air.

Tempering at a temperature just below its change-point results in the gradual conversion of the γ iron to α, and the deposition of the carbon from solution, but the α iron is interstrained, and the hardness is increased. It is conceivable that very prolonged tempering would cause this hardness to be lost again with the production of a soft manganese steel which is magnetic.

10. When pure austenite, formed by quenching 2 per cent. manganese steels, or the austenite of high-carbon steels, is immersed in liquid air, the greater supercooling overcomes the internal friction, and the γ to α transformation takes place, although the carbon change is unaffected. The electric resistance is not changed, but the specific volume increases, as well as the hardness, through the production of interstrained α iron. Maurer obtained the following results:—

11. The theory outlined above accounts for the many widely differing conditions which steel can assume as the result of heat treatment in a manner which is simple and consistent.

It is agreed that hardening by deformation results from purely structural causes which affect the crystalline state, and there is much to recommend the term "interstrain" to describe such a condition of hardness, since it is a word which is non-committal regarding any proposed explanation of the effect. The theory of interstrain action is itself an inquiry, but it is secondary to the main issue in the hardening of steel.

* McCance, *loc. cit.*

† Arnold and Read, ENGINEERING, 1914, pp. 463 and 468.

* McCance, Journ. Mech. Eng., 1910, page 1664. ENGINEERING, December 30, 1910.

Maurer, *Revue de Métallurgie*, 1908, page 711.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these can be obtained from the Commercial Intelligence Branch, Board of Trade, 73. Basinghall-street, London, E.C.

Australia: The Sydney Office of H.M. Trade Commissioner for Australia reports that tenders are invited by the Metropolitan Board of Water Supply and Sewerage, Sydney, for the manufacture, supply, and delivery of 20-in. steel pipes and specials (Contract No. 941). The Secretary to the Board, Pitt-street, Sydney, N.S.W., will receive sealed tenders for the above up to December 7. It will be observed that the time for the receipt of tenders is limited, and this intimation will therefore be of use only to firms having agents in the Commonwealth who can be instructed by cable.

Brazil: The *Diario Official* notifies that tenders will be received up to noon on November 30, at the Secretaria, Estrada de Ferro Oeste de Minas, S. João d'El-Rey, for the supply of 300,000 wooden railway sleepers, required during 1915. A deposit of 2000 milreis (about 120*l.*) is required to qualify any tender. Local representation is necessary. The *Diario* also publishes a decree approving the plans for the construction of 17 kilom. (about 10½ miles) of the line between Lages and Macáo, on the Central Railway of Rio Grande do Norte, at an estimated cost of 1,063,807 milreis (about 62,000*l.*). The *Diario* further contains a decree approving the project of the Commissão Federal de Sacramento da Baxada Fluminense for the execution of improvement works on the rivers Sarapuhy and Iguassú, in the State of Rio de Janeiro, at an estimated cost of 860,570 milreis (about 50,000*l.*).

Argentina: The *Boletin Oficial* contains a decree approving the project of the Dirección de las Obras Sanitarias de la Nacion for the construction of a sewerage system in the town of Mar del Plata, at an estimated cost of 373,770 pesos currency (about 32,700*l.*). The *Boletin* also publishes the text of a contract entered into between the Director-General de Obras Hidráulicas, representing the Argentine Government, and the Société des Grands Travaux de Marseille, for the execution of extensive port works at Quequén, at an estimated cost of 2,000,000 pesos gold (about 400,000*l.*). The projected works include dredging and other preliminary works, wharf construction, the erection of metallic sheds and other buildings, and the installation of cranes, electrical plant, &c.

London Electrical Engineers (T. F.).—The Corps of London Electrical Engineers (Territorial Force) is again open to recruiting. Electrical engineers, central station engineers, and engine-drivers are specially required. Forms of particulars can be obtained from the Officer Commanding, at 46, Regency-street, Westminster, S.W.

Catalogue Waste in Central America.—Dealing with the question of how to sell goods in foreign countries, the *Mining and Engineering World*, Chicago, gives publicity to a report by Commercial Agent Gerrard Harris, from which we make the following quotation:—"About the only way in which catalogues may be used effectively is, first, to have the line of goods introduced by a competent, Spanish-speaking traveller, of good address and personality, who can establish the personal relations that count so strongly in business there. A trial order will not create a regular market for goods; it may require several visits to interest the dealer thoroughly and to get the line on a firm basis. Then, after the confidence of the dealer in the goods and the house has been established, catalogues may be used with a considerable degree of effectiveness, provided, of course, they are in Spanish. To send to these countries publications or trade letters in a language not understood by the recipients is a waste of time and money; yet business houses in the United States fill the mails with them, and persist in it. The really unfortunate feature is that, if the expected results are not obtained, firms whose enterprise has not taken the proper channel are discouraged and unlikely to make a second attempt. Not only this, but their experience generally becomes bruited about and deters efforts by others who do not know the real reasons for the failure." The same may be said to apply to this country also.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

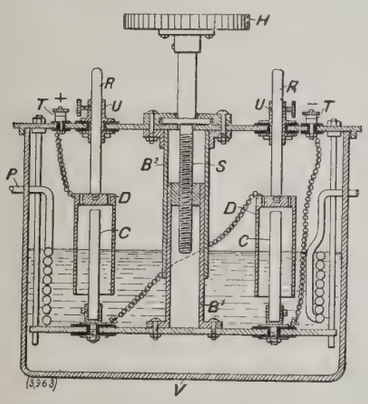
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

3963/14. J. A. Fleming, London. Wireless Telegraphy. [1 *Fig.*] February 16, 1914.—In transmitting apparatus, as used for wireless telephony and also, in some cases, in wireless telegraphy, it is necessary to create in the antenna undamped or continuous high-frequency electrical oscillations. In one well-known form of arc-generator, invented by Mr. V. Poulsen, the electric arc is formed between copper and carbon electrodes, which are enclosed in a chamber kept full of hydrogen, or coal gas, or the vapour of some hydrocarbon. A strong magnetic field is also used, the direction of which is transverse to that of the arc. The carbon rod has also to be kept in rotation and the copper electrode kept cool by water circulating through it. In another form, due to Moretti, both electrodes are of copper, but one is tubular, and water flows through it. This invention has for its object to simplify this arc-generator and to dispense with the necessity for any magnetic field requiring a large and therefore expensive electromagnet to produce it, and also to get rid of the necessity for special cooling arrangements and the use of coal gas or hydrogen in the arc-chamber. According to this invention, an arc-generator consists of a carbon rod and copper enclosing-cylinder placed over it, the latter open at the lower end and nearly closed at the upper end, both being held vertically in a vessel containing high flash-point oil. In a large vessel, which may be conveniently of galvanised iron, a quantity of heavy mineral high flash-point oil is placed. This vessel may be provided with external cooling flanges, like the radiator of a motor-car engine, or it may have a coil of metal pipe placed in it, through which water circulates to keep the oil cool. In the diagram this vessel is represented in section by V and the coil of cooling pipe by P. The vessel is provided with a lid, which may be of metal or of some insulating non-inflammable substance, such as marble, slate, porcelain, or stoneware. If the lid is of metal, then certain insulated bushing-pieces U are provided in it. To



the underneath side of this lid is attached a tube B_2, within which a second tube B_1 slides. This second tube is moved up or down by turning a screw S, having a large head H made of insulating material, such as vulcanised fibre or ebonite. The above-mentioned second tube carries a bottom plate of metal or of some insulating material, to which are attached certain metal sockets, which carry in them rods C, C of arc-lamp carbon. If the plate is of metal, then these sockets must be insulated from it. Over each carbon is placed a copper cylinder D, having its top closed by a thick copper plug. This plug must be riveted in, and have a steel rod R screwed into it on the external side. This plug has one or two small holes in it. Each carbon rod has placed over it concentrically one of these copper cylinders, like an extinguisher over a candle. The copper cylinders are held by the steel rods, which pass through the metal-insulated sockets U, U in the lid of the vessel. These sockets are insulated from the lid by micanite washers and collars, and each one has a set-screw, so that the height of each copper cylinder above its own carbon can be independently adjusted. There may be two, four, six, eight, or more such carbons and copper cylinders in each vessel. Each copper cylinder is joined to the carbon of the next one by a flexible copper-wire connector, having glass beads strung on it to prevent short-circuits. The junctions are so made that when a direct electromotive force from a supply circuit is applied to the terminals T, T a current flows through the series of electrodes from copper to carbon in each case. The cylinders are all first adjusted so that the top of each rests on its own included carbon, and the stems of the copper cylinders are then gripped by the set-screws, then by a turn of the head H all the carbons are lowered together so as to strike an electric arc inside each cylinder between the end of the carbon and the inside of the top of the cylinder. The height of the oil in the vessel V must be so adjusted that it covers the bottom edge of each copper cylinder and rises up to about 18 mm. below the top of the carbon. The arc is thus burning in a nearly closed space with oil as its floor. The oil volatilises and fills this space with vapour and the excess escapes out of the small holes in the plugs of the cylinder. If a condenser and inductance are connected in series with each other to the terminals T, T, and the series of arcs is supplied with a steady or direct current voltage to make them burn properly, powerful undamped electric oscillations are produced in the condenser circuit. (*Accepted September* 9, 1914.)

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

20,882/13. J. Boyle, H. K. Boyle, A. L. Redrup, and C. B. Redrup, Leeds. Internal-Combustion Engines. [2 *Figs.*] September 16, 1913.—This invention relates to valves comprising spring tongues controlling ports in the compression-chamber of internal-combustion engines. According to this invention, the valves are constructed in the form of a spring tongue or tongues, adapted to control an inlet-port or ports located in the side wall of the cylinder in the compression-space of the engine. In carrying this invention into effect in one convenient manner, a port or ports *a* is provided in that part of the side wall of the cylinder which forms the compression-space, the port or ports being connected in any suitable manner to the fuel-supply pipe *b*, and being conveniently, though not necessarily, arranged in a position diametrically opposite to that of the sparking-plug *c*. Within the cylinder *d* a spring tongue or tongues *e* of tungsten steel or other suitable material is arranged, the springs being anchored at one end of the cylinder wall, as for

Fig. 1.

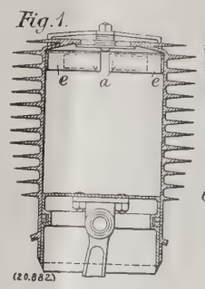
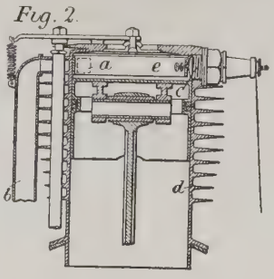


Fig. 2.



example, by means of the screws, while the other end of each tongue is free to spring inwards on the suction stroke of the engine, thereby uncovering the inlet-ports *a* and admit fuel to the engine-cylinder. It will be noted that valves of this form will be kept tightly over the inlet-ports when the pressure within the cylinder is above atmospheric pressure, while the valves may be kept practically to the temperature of the cylinder-wall, seeing that they are in close contact therewith. For the purpose of obtaining the necessary resiliency it is preferred to make the spring-valves of substantial length, and, if desired, to taper them in the manner shown more clearly in Fig. 2 by making the material of the valves thicker at that end at which they are anchored to the cylinder-wall, and gradually tapering off to the free end. (*Accepted August* 19, 1914.)

GUNS AND EXPLOSIVES.

17,708/13. Sir A. T. Dawson and G. T. Buckham, London. Breech-Loading Guns. [5 *Figs.*] August 1, 1913.—This invention relates to lock mechanism of the kind in which the lock-frame is capable of moving laterally in a box-slide on the breech-screw carrier, and in which a repriming device is employed, the said device comprising a priming magazine or hopper and a bolt which is carried by the laterally-movable lock-frame, and by the movements it receives from a cocking hand-lever operates to insert in the chamber of the vent axial a new primer obtained from the magazine or hopper. According to this invention, the primer magazine or hopper occupies a stationary position at one side of the vent axial, as has before been proposed, and the lock-frame has a mouth or opening formed in it above the forward portion of the bolt-sleeve, so that when the lock is moved into its fully open position, the bolt-sleeve will lie beneath the exit opening of the magazine or hopper, from which a primer will fall through the mouth or opening in the lock-frame on to the top of the bolt-sleeve, in which position the primer will remain during the movement of the lock-frame into its closed position. B is a portion of the carrier, C is the box-slide, and D the removable lock-frame provided with the aforesaid mouth or opening D^1. E represents the primer magazine or hopper, F the bolt employed

Fig. 1.

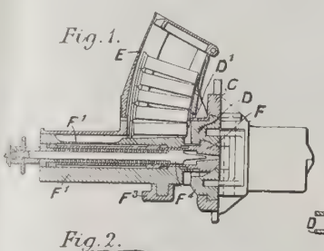


Fig. 3.

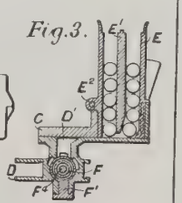
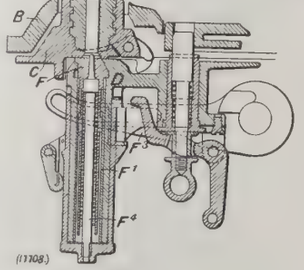


Fig. 2.



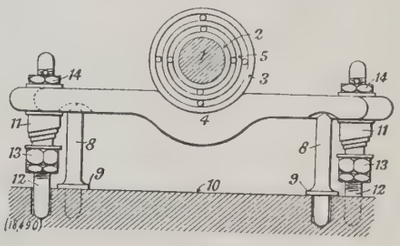
for inserting the primers into the primer-chamber of the vent axial, F^1 the bolt-sleeve, and F^3 an arm operating upon the bolt-sleeve for unlocking and retracting the bolt and moving it to the forward and locked position to insert the primer and leave the striker F^4 cocked. In the example shown, the hopper E is detachably mounted in an opening in the box-slide C, and is provided with a vertical partition E^1, which divides the hopper into two chambers. The hopper is retained in position by a spring-pin E^2. When the parts are in the firing position, as shown in Fig. 3, the mouth or opening D^1 in the lock-frame D is some distance to the left of the exit opening of the hopper E. After the gun has been fired (or in the event of a misfire) the lock-frame is moved laterally to the right, and the opening D^1 then comes beneath the exit opening of the hopper, with the result that the lowermost primer in the left-hand chamber of the hopper falls upon the bolt-sleeve. The return movement of the lock-frame to the closed position causes the primer immediately above that in the opening D^1 of the lock-frame to be forced back into the right-hand chamber of the hopper, the upper surface of the lock-frame then closing the exit opening of the hopper. When the lock-frame reaches its closed position, a cocking hand-lever connected to the arm F^3 is operated to unlock and retract the bolt, thereby allowing the primer that was resting upon the bolt-sleeve to fall into the bolt-way in front of the bolt-head. Displacement of the cocking hand-lever in the reverse direction then moves the bolt forwardly, and locks it to the lock-frame, at the same time inserting the new primer into its chamber, and leaving the striker F^4 in the cocked condition ready to be released to fire the gun when desired. (*Accepted September* 9, 1914.)

29,979/13. W. J. Mellersh-Jackson, London. (*Winchester Repeating Arms Company, New Haven, U.S.A.*) **Impact Illuminating Bullets.** [7 *Figs.*] December 30, 1913.—The invention relates to an improvement in that class of bullets charged with a composition flashing upon the impact of the bullet, and thus illuminating the place where it struck for the information of the user of the gun from which it was fired, the object being to produce a superior bullet of that character. The bullet in accordance with the present invention comprises a metal body having within its nose an open-ended cavity formed with forwardly-converging walls and provided with a charge of unconfined percussion igniting flash-light composition held in its

place by the forwardly-converging walls. In carrying out the invention, as shown, the metal bullet 2 is formed with a capacious pear-shaped concentric composition-cavity 3 located within its forward end or nose, and having its forward end contracted. Into this cavity is introduced a charge 4 of percussion-igniting flash-light composition chemically compounded with particular reference to the character of the momentary or brief illumination which it is desired to secure. The charge 4 is unconfined and introduced directly into the bare cavity 3 without any containing envelope of any sort to retard its free flashing on ignition which is caused by the shock of impact. (*Accepted September* 9, 1914.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

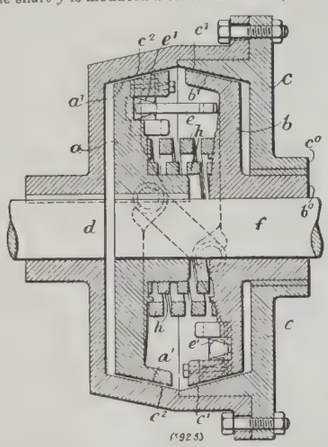
18,490/13. A. J. Hollick and W. Kneen, London. Anti-Frictional Mounting of Shafts. [5 *Figs.*] August 14, 1913.—This invention has relation to the anti frictional mounting of shafts, and has for object to provide improvements in anti-frictional mountings of such character and nature that the weight of, and the load, if any, on the shaft is carried in a more advantageous manner than is now the case. The invention further has for object to render it possible to employ ball or roller bearings, and to enable such ball or roller bearings to carry a greater load than is now possible in view of the limitations as to load governing or pertaining to bearings of the kind mentioned. In carrying a shaft and its load, if any, in accordance with this invention, a plurality of spring, pneumatic, hydraulic, or other bearing-supporting arrangements of the type which are limited as to motion in one direction, and are subjected to a stress or load of such magnitude that, under normal conditions, the bearing-supporting arrangements are always in their limiting positions, are employed, the arrangement being such that each bearing-supporting arrangement is free to give or move separately and independently of the other bearing-supporting arrangement or arrangements, and in one direction only when the shaft and its bearings are or become subjected to abnormal influences. 1 is the shaft; this shaft is carried by a plurality of ball-bearings. The bearings are spaced apart, and are distributed along the length of the shaft as found necessary, and as circumstances will permit. When employing ball-bearings of the simple type, the one member or race 2 of each bearing is mounted on, and is attached to, the shaft 1, and the other member or race 3 of each bearing is supported by, and, it may be, is attached to, a bearer 4, which is, preferably and as shown, disposed transversely of the shaft 1. In the arrangement illustrated, the ball-bearing is not of the simple type comprising two ball-races and an interposed row of balls, but is of what may be described as a compound type, and comprises an inner race 2 mounted on and attached to the shaft 1, an outer



race 3 supported by, and, it may be, attached to the bearer 4, and an intermediate or double race 5, which is free, and rows of balls interposed between the races 2, 5 and 5, 3 respectively. There may be more than one free and double race 5, and for each additional double race 5 employed an additional row of balls becomes necessary. The bearer 4 is, or may be, supported at one or both ends by spring, pneumatic, hydraulic, or other arrangements. In the arrangement shown, the bearer 4 is so supported at one end and at its other end is carried by a fixed member 8 in suchwise that it can pivot or turn in relation to such fixed member. There may be a separate member 8 for each bearer 4, or a member 8 may be such as to extend the length of the shaft, and the several bearers 4 will then be mounted thereon at one end. 9 is the base or bed-plate of the member 8, and this plate 9 is bolted, or otherwise secured or fastened, down to the floor or other foundation 10. In the drawing, members 8 are shown as arranged on both sides of the shaft 1, and the bearers 4 disposed with the one end supported by the members 8 alternately at the right and left-hand sides of the shaft 1. The other end of each bearer 4 is supported by an arrangement of parts, as will now be described. 11 is a spring of the coiled or helical type, surrounding a pin or support 12, either formed integral with or mounted on the base or bed-plate 9, or mounted directly in or on the foundation 10. The pin or support 12 is screw-threaded for a portion of its length, and on the screw-threaded portion or portions are mounted nuts 13, 14. The lower end of the spring 11 rests upon the nut 13, or upon an interposed washer, and the upper end of the spring bears against the underside of the bearer 4, which is formed with a hole so that the one end thereof may be passed on to the pin or support 12. The nut 14 is disposed on the pin or support 12 above the bearer 4 and can be screwed down against the bearer and locked in position. In use, the shaft 1 is mounted by means of the ball-bearings on the bearers 4 and the weight of the shaft is distributed amongst the several ball-bearings. Before the shaft 1 is applied to the bearers 4 the nuts 13, 14 are so adjusted that each spring 11 is subjected to an initial stress of a magnitude greater to a small

extent than the load it will have to carry under normal conditions. The spring will therefore exert a greater upward force than the downward force due to the weight of the shaft, ball-bearings and bearers, and the difference between the two forces will, under normal conditions, cause the bearer to be always in contact with the nut 14, which nut therefore acts as a limiting device. When the shaft, or a bearing or bearings is or are subjected to an abnormal influence or influences acting in a downward direction a bearer or bearers 4 is or are caused to move in opposition to a spring 11 or springs 11. The spring or springs 11 tends or tend to return the shaft, or a bearing or bearings to its or their normal position as the abnormal influence is lessened or reduced. If an abnormal influence acts on the shaft or a bearing or bearings in an upward direction, a bearer 4 or bearers 4 tends or tend to follow the upward movement of the shaft, bearing or bearings, but such movement is prevented and resisted by the nut 14. The action of the springs 11 is thus limited to abnormal forces acting in one direction only. (*Sealed October* 29, 1914.)

5925/13. C. H. de Rusett, London. Clutch and Brake Mechanism. [1 *Fig.*] September 10, 1913.—This invention relates to clutch or brake mechanism of the type in which the clutching action is automatically increased after the clutches have been sufficiently engaged, and especially in clutches in which two clutch members relatively rotatable on an axis form together one of the clutch parts, and are adapted to engage another member forming the other clutch part, said clutch being operated by links disposed obliquely to said axis in such a manner that the rotary motion of one member acts through the links to produce a combined rotary and axial movement of the other member. A clutch or brake mechanism made in accordance with this invention comprises the combination of a rotatable casing having two clutch faces, two clutching members, each provided with a clutch face adapted to engage a corresponding face in the casing, torque rod or rods, and a spring or springs between the clutching members, and means for moving one of the clutching members axially; and is characterised in that the torque rod or rods are in compression. *d* is the power-shaft, and *f* is the shaft to be driven by the clutch, *c* is a rotatable casing having two clutch faces c^1 and c^2. The casing *c* is slidably mounted on the shaft *d*, and is adapted to be given a longitudinal movement. Upon the shaft *f* is mounted a clutch member *a* which is fixed to



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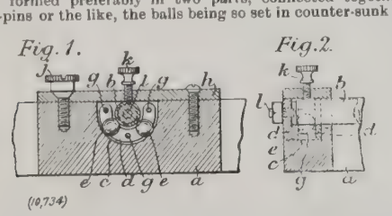
the shaft *f*, and has no longitudinal motion, *b* is a clutch member slidably mounted on the shaft *f*, and having a clutch face b^1. The member *b* is connected to the member *a* by compression or torque-rods *e*, *e*. *h*, *h* are springs disposed between the members *a* and *b*. e^1, e^1 are balls which take the thrust of the rods *e*, *e*. In operation, assuming the clutch to be in the position shown, in which the shaft *d* is free from the shaft *f*, to put the clutch into operation, the pressure restraining the axial movement of the clutch member *b* is removed from the face b^0, so that the springs *h*, *h* force the member *b* into engagement with the member *c* which causes the torque members *e* to pivot on their ends, and thereby supplement the pressure of the springs *h*, *h*, and act to slide the member *c* together with *b* axially along the shaft *f*, and to engage the face c^2 with the face a^1, the pressure between the contacting surfaces then increases according to the torsional effort set up by *b* in relation to *a*, whereby the shaft *f* is driven by the shaft *d*. When it is desired to return the clutch to the position shown, whereby the clutch faces are free, pressure is applied to the face b^0 until the face b^0 is flush with the face c^0, as shown in the drawing, then the pressure is applied to both the faces b^0 and c^0, so as to slide them axially together, so to disengage the faces a^1 and c^2. As soon as the friction between the faces b^1 and c^1 is destroyed, the supplementary action of the torque rods *e* is destroyed. When the invention is adapted to be applied as a brake, one of the shafts *d* or *f*, for example, is held permanently against rotation. (*Accepted August* 19, 1914.)

SHIPS AND NAUTICAL APPLIANCES.

10,734/14. W. D. Whyte, Glasgow. Compass-Bowls. [5 *Figs.*] May 1, 1914.—This invention relates to anti-friction bearings for the journals of compass-bowls and also of gymbal-rings. The object of the invention is to obviate the use of rollers which have heretofore been employed, and to employ balls, the balls being specially carried and arranged. The improved bearing comprises two or more balls held in position in a semi-circular cage, formed preferably in two parts, connected together by cross-pins or the like, the balls being so set in counter-sunk holes



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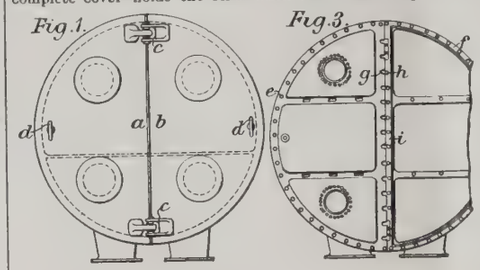
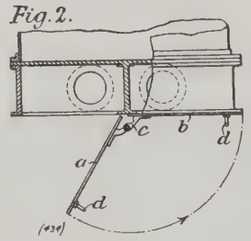
in the parts as to be free to revolve. The balls are of a diameter greater than the width of the cage. *a* represents the gymbal-ring, *b* one of the journals of the compass-bowl, and *c* the recess in the gymbal-ring. As will be seen, the cage consists of two parts *d*, *d* of semi-circular shape, and which are held in parallel position and at a suitable distance apart by means of the cross-pieces or pins *g*, of which there may be three. Located between the parts *d*, *d* are two balls *e*, *e*, and these balls are held in place by means of counter-sinks formed in the parts *d*, *d*, these counter-sinks being sufficiently large and deep to permit the balls to turn freely. The cage is placed in the semi-circular recess *c* and lies snugly therein, the balls projecting beyond the outer periphery of the cage and bearing against the wall of said recess so that the cage can freely move on said balls. The balls also project beyond the inner periphery of the cage, and the journal, as will be clearly seen at Fig. 1, rests upon, and between, the balls *e*, *e*. A horizontal adjusting-screw *l* is, or may be, provided, and also a vertical adjusting-screw *k*, this latter screw being passed through the cover and serving to prevent the journal jumping upwards in the bearing. The recess has over it a cover *h*, which is pivotally secured by means of a screw at one end, and is provided at the other end with a slot h^1 capable of engaging a screw *j*, which can be thereafter tightened so as to lock the cover in position. The cage is made somewhat smaller than the recess, and is therefore free to rock slightly therein, moving on the anti-friction balls, whilst the journal itself is also free to turn upon the balls. (*Accepted September* 9, 1914.)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

434/14. Aktiengesellschaft Brown, Boveri et Cie., Baden, Switzerland, Condensers. [3 *Figs.*] January 20, 1913.—This invention relates to condensers, and has for its object to provide an improvement in, or modification of, the condensers indicated in the Letters Patent No. 12,349, of 1911, more particularly with reference to the means for mounting the doors. The form described in that specification had the doors mounted on the outer shell of the condenser, so that this shell had to support the weight of the opened door. The present invention consists in so hinging the doors that half of the complete cover holds the other when the latter is opened for





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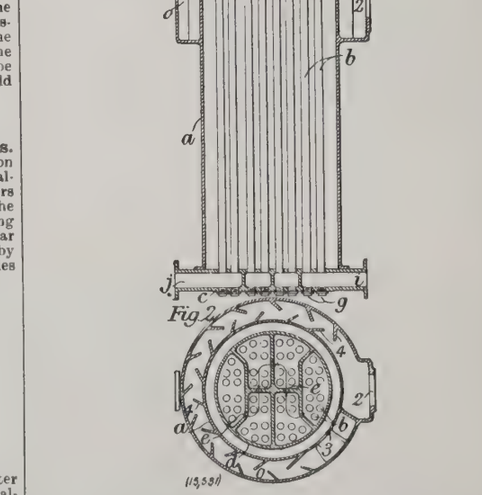
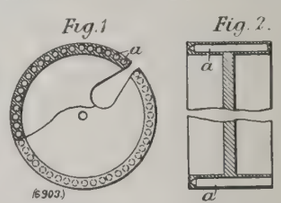
cleaning. The two doors *a* and *b* are interconnected by hinges *c*, and are provided with handles *d*. It will be seen that whichever half is open the other supports it by way of the hinges, and one-half may be swung right back on the other so far as the handles permit. One manner of securing the doors to the outer shell is shown in Fig. 3, in which the doors are provided near the outer periphery with holes *e* for enabling securing to the flange *f* to be effected by bolts or screws. In addition, slots *g* are cut on the inner edge of the door so that the same can be secured by stud-bolts *h* carried by the central partition of flange *i*. (*Accepted September* 9, 1914.)

15,531/13. D. B. Morison, Hartlepool. Feed-Water Heaters. [6 *Figs.*] July 5, 1913.—This invention relates to surface feed-water heaters of the kind comprising water receivers containing one or more compartments and connected together by heating-tubes within a containing vessel, and has for object to provide constructional details whereby provision is afforded for the collection and discharge of air from the heated water, combined it may be with a steam-cleansing device, forming part of or jointed to the containing vessel. According to this invention, a small port or passage places a compartment or compartments in the receiver or receivers in communication with another compartment or compartments of lower pressure and through which air given off from the water may pass and be finally collected in an air-chamber from which it can be discharged, together, it may be, with a small quantity of water, to a feed-tank or elsewhere. The heater consists of a containing vessel *a*, fitted with heating tubes *b*, arranged between two water receivers *c* and *d*, which contain holes provided with removable plugs *g*, through which the tubes may be examined, cleaned or withdrawn. Each water receiver is divided into compartments that are placed in communication with each other by the heating tubes *b*, so that the water entering the branch *i* flows through the compartments in series and passes out through the branch *j*, all in a known manner. Now, according to this invention, the compartments in the receiver *d* are provided with small ports or passages *e* through which the liberated air collected in each compartment in the upper receiver *d* passes from one compartment to another compartment of lower pressure and finally reaches the air-collecting chamber *k* from which it is discharged, it may be with a small quantity of water, through the cock *l* that is flexibly connected to the air-collecting chamber *k* by a pipe. Owing to the frictional resistance of the water in its passage through the tubes, the pressures in the compartments will be successively less, and therefore, although the differences in the pressures are small, it has been found that, provided the means of communication are suitable, they are sufficient to promote the flow of air through the successive compartments into the final air-collecting chamber from which it is discharged from the apparatus. The compartment in which the air first collect may be connected direct to the air-collecting chamber *k* or direct to the cock *l* by a pipe, so that the quantity of air carried into the heater with the feed water, or a large quantity of it, may be directly discharged. The heater is provided with a steam-cleansing chamber *o* having a steam inlet 2, a steam outlet 3 into the heater, oil and water-separating devices 4, and a receptacle into which the separated oil and water can flow. (*Sealed September* 17 1914.)



MISCELLANEOUS.

6903/14. Societe L'Aster, Paris, France. Meters for Liquids. [4 *Figs.*] March 21, 1913.—This invention relates to meters for liquids in which part of the apparatus is supported in the liquid, wholly or partly by air-chambers. According to this invention, a rotary piston is provided with an annular series of air-chambers in its periphery or with a peripheral chamber or chambers. It has been proposed to provide an annular air-chamber in the rotating part of a meter for liquids,



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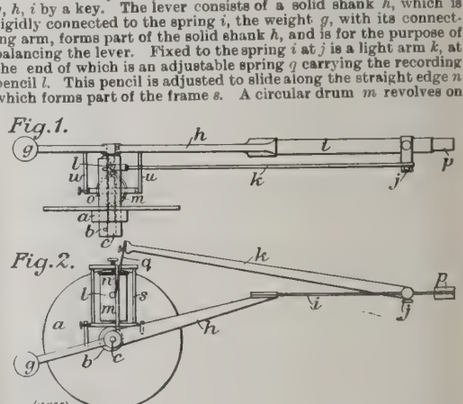
but such a chamber has not been located in the periphery. The piston is preferably made of light material such as ebonite, but any other material may be adopted. The piston is recessed by providing its annular wall with a suitable number of holes not drilled through, but left each with a bottom. The other end of each hole is closed by a close-fitting plug, or even left open, each hole thus constituting an air-bell into which the liquid cannot penetrate. The piston can be rendered the same weight as or lighter than the liquid it displaces. (*Accepted September* 16, 1914.)

12,898/14. W. E. Lilly, Dublin. Torsion-Testing Machine. [2 *Figs.*] May 26, 1914.—This machine is for the purpose of carrying out torsion tests on materials of construction under alternating torsional stresses and automatically graphs to rectangular co-ordinates the alternating stress-strain diagrams obtained from such tests. It differs in this respect from torsion-testing machines at present in use from which stress-strain diagrams under direct torsional stresses can only be obtained. The invention consists in the application to a torsion testing-machine of the mechanism for automatically graphing the alternating stress-strain diagrams to rectangular co-ordinates. A circular table *a* is fixed to any convenient bench or stool; through its centre is a hollow cylinder *b*. In the central part of the cylinder, the specimen *c* to be tested is placed, one end being secured to it by a key and the other end secured to the lever *g*, *h*, *i* by a key. The lever consists of a solid shank *h*, which is rigidly connected to the spring *i*, the weight *g*, with its connecting arm, forms part of the solid shank *h*, and is for the purpose of balancing the lever. Fixed to the spring *i* at *j* is a light arm *k*, at the end of which is an adjustable spring *q* carrying the recording pencil *l*. This pencil is adjusted to slide along the straight edge *n* which forms part of the frame *s*. A circular drum *m* revolves on



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its outer edge *o* on the table *a*, and is connected by adjustable pivot-bearings to the frame *s*, which is connected by adjustable pivot-bearings to the arms *a* of the solid shank *h*. The manner of carrying out a torsion test with the machine is as follows:—The specimen *c* to be tested is placed in position in the cylinder *b*, and secured to it by driving up the key at *d*, the lever *g*, *h*, *i* is now placed in position on the top end of the specimen *c* and secured to it. A sheet of squared paper is now placed on the drum *m*, it is then placed in position on the table *a* and the pivot bearings adjusted, the pencil *l* is now placed in the central position on the drum and in contact with the straight edge *n* by adjusting the arm *k* and the spring *q*. The torsion test on the specimen is now carried out by applying a pull or push to the handle *p*, the pencil *l* then automatically graphs the alternating stress-strain diagrams on the squared paper of the drum. The movement of the pencil *l* along the straight edge *n* is proportional to the pull or push on the handle *p*, and gives to scale the magnitude of the torsional or twisting movement, and the roll of the drum *m* under the pencil is proportional to the twist or torsional strain of the specimen. The pencil *l* graphs the combination of the two movements at right angles to one another, the resulting stress-strain diagrams are thus obtained to rectangular co-ordinates. (*Accepted September* 9, 1914.)

LITERATURE.

Design of Plate-Girders. By LEWIS E. MOORE, B.S., C.E., Associate Member of the American Society of Engineers, Member of the Western Society of Engineers, Associate Professor of Structural Engineering, Massachusetts Institute of Technology. New York and London: McGraw-Hill Book Company, Inc. [Price 12s. 6d.]

THAT another book specially devoted to the treatment of this subject should appear, dealing as it does with the design of the earliest form of built-up metallic construction, may be suggestive of the need that is felt amongst engineers for a somewhat more satisfying method of design than that hitherto available. Whether or no the author meets this demand will be considered in due course.

Much that appears in this book is common knowledge, and may be found in any work dealing with the design of steel-work, having no more particular relation to plate-girder design than to other forms of metallic construction. It is not with this that the reader in search of something new will be interested, for which reason little need be said of about one half of the book, except that it is good matter, relating chiefly to methods of calculating moments, shears, and deflections. With respect to the last-named item, the author gives a method, due to Professor Lawrence, by which all that it is commonly necessary to know may be readily calculated. The treatment is ingenious, and sufficient for most purposes. It may be noted that, in dealing with riveted joints, the author states the essential principles of design with clearness, though omitting any reference to the effect of untacked fillers in reducing the efficiency of rivets. It is to be observed also that the author is content, in the case of joints having staggered rivets, to make the length of solid plate, measured diagonally between holes, equal to the solid measurement straight across. This, though at variance with the deductions of Moberly, from his very extensive inquiry into the question, is yet more nearly consonant with later experiments carried out upon modern steels less liable to erratic fractures, from which little, if any, diagonal excess appears to be necessary for holes spaced as is commonly the case in structural work. A useful chapter of general utility is included upon Shop Hints to Draughtsmen, furnished by John C. Moses, giving much information of value to those whose acquaintance with shop-work is limited, as works cost is much affected by attention to matters very commonly overlooked by those who do not follow their designs to final execution.

The essential problem of plate-girder design is, of course, the treatment of web stresses, of stiffener proportioning and spacing, these questions being inextricably involved with the effects of stiffness of the top boom. Much attention has been given to the study of these matters, which have been in some measure investigated by Fairbairn, Hodgkinson, Brunel, Baker, and Turner experimentally, mathematically by Clark, Airy, Rankine and Unwin, and applying both methods of inquiry by Turneaure, Marburg, Lilly, Guy, and Herbert Moore. There has indeed been no neglect of the subject, but that no entirely satisfactory method of design has yet been reached is sufficient indication of the difficulties surrounding the problem. The author gives the usual explanation of the nature of web stresses, but does not attempt any strict inquiry. He presents, instead, a number of formulæ by which web thicknesses are determined in practical design, with such justification as there may be for some of these. The question of stiffener spacing is dealt with on the dicta of the various authorities quoted. This method of designing work might, in default of a better, as representing practice, be regarded with toleration if undeniably based upon long and satisfactory experience; but as a comparison of these methods yields such diverse results, it is apparent, even to those easily satisfied, that there is still something lacking. Diagrams furnished by the author to facilitate the application of four of the formulæ for web thickness reveal the most amazing differences for the more slender thickness ratios, and make it clear that there is much yet to be learned about webs. The value of this book thus consists, not in throwing any new light upon the question of web design, but in presenting such methods as there are in a form convenient for reference.

Detailed consideration of value is offered with respect to many points. Thus, there is a useful comparison of approximate methods of determining flange areas with methods more exact, and of the more exact processes amongst themselves.

The author gives, for instance, methods of determining the moments of inertia of riveted girders, prefacing this by illuminating remarks upon the position of the neutral axis. He does not, however, exhaust the subject, having omitted to mention a method which, though not in common use, is simpler and probably more exact than any one of those he presents. This consists in computing the moment of inertia for the gross section, which moment is then used to define the extreme fibre stresses, with, in the case of the tension flange, a correction for the relation of net to gross width of flange-plates. The position of the neutral axis is determined, as the author points out, by the gross section rather than by the section where pierced by rivet-holes, and it is the stress resulting from a consideration of this gross section which determines the stress occurring in the tension-flange where rivet-holes exist. To the majority of cases this simplified process will apply satisfactorily.

Detailed calculations are given for bridges of the through-plate girder and deck-plate-girder types, with illlustrative plates. A specification of thirty pages is included, and many tables of sectional areas, moments of inertia, &c., likely to be of service, are given.

The book is no doubt a good book, and represents, it may be supposed, American practice in the design of plate-girders; but it must be confessed, though useful as summarising such practice, it makes no real addition to our knowledge of the subject, nor, indeed, does it pretend to do so. The typography of the book is excellent, the diagrams good, and the folding-plate details to a scale not too small for utility.

BOOKS RECEIVED.

"Daily Mail" Year-Book for 1915. (Fifteenth Year.) Edited by DAVID WILLIAMSON. London: The Associated Newspapers, Limited. [Price 6d. net.]

The British Battle Fleet: Its Inception and Growth throughout the Centuries. By FRED T. JANE. With twenty-five illustrations in colour from the original water-colour drawings by W. L. WYLLIE, R.A. London: S. W. Partridge and Co., Limited. [Price 10s. 6d. net.]

Naval Recognition Book; How to Identify Ships at Sea. British Ships. By FRED T. JANE. London: Sampson Low, Marston and Co., Limited. [Price 1s. net.]

Catalogue of the Mechanical Engineering Collection in the Science Museum, South Kensington. With Descriptive and Historical Notes. Part I. *Steam-Engines and Other Motors. Locomotives and Railways. Mechanical Measuring Appliances. Pumps and Lifting Machinery. Power Transmission.* Fifth Edition, revised, with a supplement containing illustrations. London: Eyre and Spottiswoode, Limited. [Price 1s. 6d.]

Key to the London Telephone Directory. Vol. I., No. 1, July, 1914. London: Stone and Colquhoun, 92, Victoria-street, S.W. [Price 2s.]

Modern Tunnelling, with Special Reference to Mine and Water-Supply Tunnels. By DAVID W. BRUNTON and JOHN A. DAVIS. New York: John Wiley and Sons; London: Chapman and Hall, Limited. [Price 15s. net.]

Ye Sundial Booke. By GEOFFREY W. HENSLOW, M.A. London: Edward Arnold. [Price 10s. 6d. net.]

Discoveries and Inventions of the Twentieth Century. By EDWARD CRESSY. London: George Routledge and Sons, Limited. [Price 7s. 6d. net.]

Transactions and Notes of the Concrete Institute. Vol. V., Part II. London: The Concrete Institute, 296, Vauxhall-road.

The Fourteenth Financial and Economic Annual of Japan, 1914. *The Department of Finance.* Tokyo: Government Printing Office.

The Mine-Wagon and its Lubrication. By CALEB PAMELEY. London: Crosby Lockwood and Son. [Price 7s. 6d. net.]

United States Geological Survey. Professional Papers, No. 90 C: *The Dike Rocks of the Apishapa Quadrangle, Colorado.* By WHITMAN CROSS. No. 90 D. *The Composition of Crinoid Skeletons.* By F. W. CLARKE and W. C. WHEELER. Washington: Government Printing Office.

United States Geological Survey. Water-Supply Papers, No. 323: *Surface-Water Supply of the United States,* 1912, Part III. *Ohio River Basin.* By A. H. HORTON, W. E. HALL, and H. J. JACKSON. No. 340 B: *Stream-Gauging Stations and Publications Relating to Water Resources.* Part II. *South Atlantic Coast and Eastern Gulf of Mexico Drainage Basins.* Compiled by B. D. WOOD. Washington: Government Printing Office.

United States Geological Survey. Bulletins. No. 556. *Results of Spirit Levelling in Oregon,* 1896 *to* 1913, *inclusive.* R. B. MARSHALL, Chief Geographer. No. 557. *Results of Spirit Levelling in the State of Washington,* 1896 *to* 1913, *inclusive.* R. B. MARSHALL, Chief Geographer. No. 571. *Results of Spirit Levelling in Kansas,* 1896 *to* 1913, *inclusive.* R. B. MARSHALL, Chief Geographer. No. 585. *Useful Minerals of the United States.* Compiled by SAMUEL SANFORD and RALPH W. STONE. Washington: Government Printing Office.

FOUNDRY CRANES AND POWER AGENCIES.—No. II.

By JOSEPH HORNER.

ALTHOUGH the chief interest which surrounds this subject centres in the overhead travelling-cranes, they perform, as we have seen, only one branch of foundry service. In the present article the endeavour will be made to define their sphere and to discuss the utilities of the principal types in which they are built. The jib-cranes occur in various designs, but the travellers are subject to much greater variations, though the power agencies employed are more limited. Only two methods of operation can be regarded as available now for overhead cranes—hand and electricity. Formerly the steam-power traveller, carrying its own boiler and engine, or driven by cotton ropes from an engine elsewhere, was employed, but such methods of driving are now very rarely resorted to for workshop use. Both the hand-operated and electrically-driven types, however, occur in numerous variations, adaptable to all conceivable conditions of foundry service. It would be difficult to indicate a type of crane which occurs in wider modifications than this does. For besides the radical differences which result in consequence of the methods of operation employed, there are those which are due to power of lift, and ranges in dimensions and capacity. The heaviest travellers are not required for ordinary iron-foundry service, but, within the moderate powers employed for this, the variations in design are nevertheless very extensive.

One of the obvious differences between light and heavy travellers occurs in the construction of the main girders. Only in the lighter cranes are solid-rolled sections desirable, though they are sometimes used in the cheaper cranes for moderately heavy designs. The parallel form is not the most economical for resisting the stresses imposed, while even when a parallel outline is retained it is better if the girders are lattice-braced, because they can thus be built lighter for equal strength, with lessening of the dead load to be travelled, and with reduction also of the inertia stresses, which become severe when a crane that is fully loaded and travels at high speeds is starting and stopping its travel. But rolled-steel joists are regularly employed for moderate spans and the lighter loads. The very large range in which these sections are obtainable, their comparatively low cost, and the readiness with which the framing of the traveller can be built up with them, induces crane-builders to employ these sections more extensively than they did in the period when iron joists alone were obtainable. At that period, as also often now for the larger cranes, single web girders were and are used, but such girders are liable to buckle laterally if travelled at high speeds. For heavy cranes box-girders with diaphragms were much employed in the past; but they are heavy, and liable to deteriorate from the rusting of the interior, unless large openings are left for inspection and painting. Warren girders are preferably employed instead of these solid-plated designs. In the heavier cranes the Warren or lattice girders are doubled in box-girder fashion. Or sometimes a solid plated and a lattice-braced girder are combined, being connected by lattice bracing. The platform, in many cases, is made stiff enough to provide for, or to increase, the lateral stability of a girder.

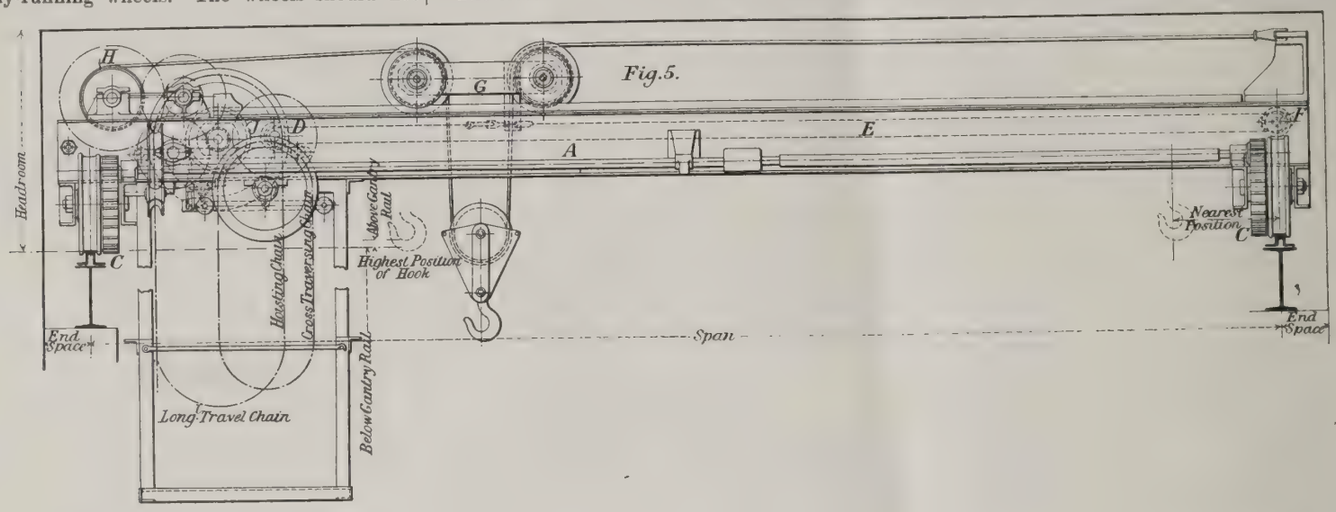
The end cradles or girders are most suitably attached to the main ones with a shouldering down of the latter, so that these partly abut against, and partly rest upon, the end girders. A wholly abutting joint is, however, usual, stiffened with suitable spreading gusset-plates. When headroom is ample the main girders may lie directly on the top of the end girders. In any case, however united, the jointing must be done solidly, because the strains transmitted are very severe. They comprise those which are due to the vertical load, to the travelling motion, and to the cross-traversing. The wheel-base also must be sufficiently long to prevent cross-working, or, say, in the proportion of about 1 to 5 of the span. Whether the rails for the crab shall run on the top or the bottom flanges of the main girders is generally settled by head-room available, as also is the location of the end-cradles, whether set below, or above, or in line with the main girders.

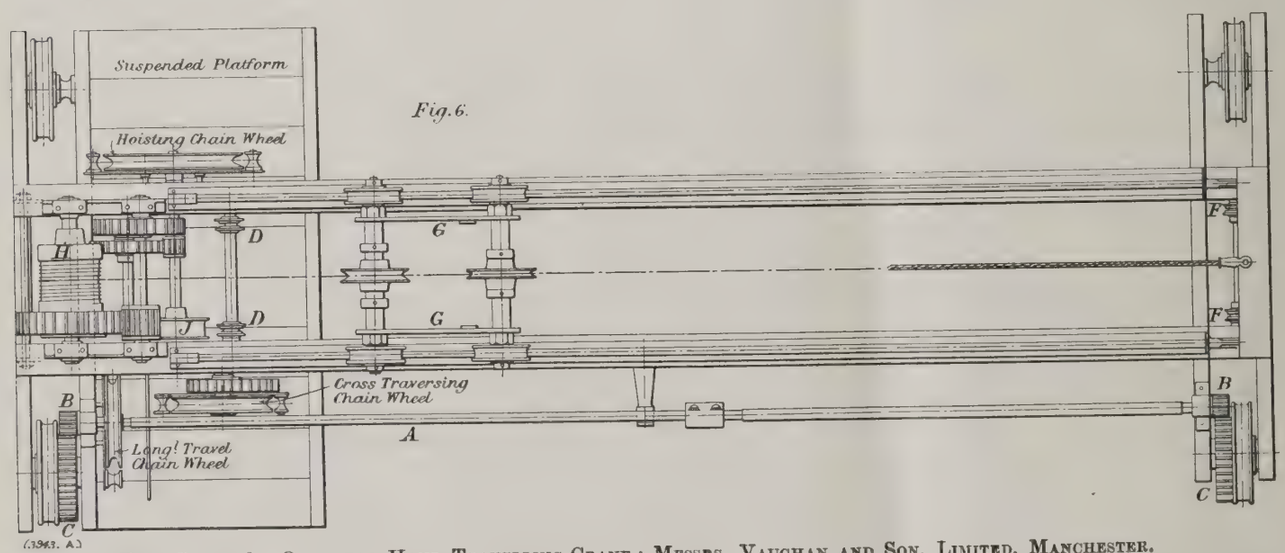
The trolley-wheels must be turned to exactly the same diameters on the treads if the running is to

be steady; they must be double-flanged, and the rails be laid truly. The wear on the wheels of heavy travellers is so severe that cast iron is useless. Even on the lighter travellers, wheels of cast iron soon show grooves. Nothing less tough than cast steel must be used. In the best cranes, centres of cast iron, or preferably of cast steel, are fitted with rolled-steel tyres, registered and shrunk on. The spur-wheels adjacent to the running-wheels, and by which the latter are driven, are not usually keyed on the axles; but, in the more powerful cranes at least, are registered and bolted to the faces of the running wheels, and good fitting here is also essential. Common bearings are not suitable in the heavy cranes for equal distribution of the load on the wheels; but an axle-box of self-oiling design, or some modification of it, should be adopted. A few firms employ fixed axles and loosely-running wheels. The wheels should not only the work that is demanded of the traveller. Or this may be due to the fact that the traveller is mainly installed as a stand-by for occasional heavy duty, where most of the lifting done is of medium weight. Or it may serve only one department of a foundry, as that of the loam-moulders, or the heavy-core makers. In such cases the hand-traveller is the design to instal. Ten tons should generally mark the maximum for hand operation, though higher powers are made. For heavy loads such a crane is operated by a man or men working on the crab-platform, but for light loads a jenny is usually worked by two dependent chains, one for hoisting, the other for cross-traverse. The longitudinal travel of light cranes is commonly effected by simply pulling at the hook or load. Two speeds of lift are often included, an automatic brake controlling the lowering by gravity.

The electric cranes are modified in several ways gears are nearly always spurs; bevels are rarely used now in new cranes.

The question of auxiliary hoisting always arises in the heavier power cranes. Two applications of it are made, and two reasons exist for this addition. One is that of a hand-lift with a winch-handle or handles to a shaft disconnected for the time being from its power drive. This is fitted to some overhead travellers in order to combine the advantages of a slow, minutely-regulated hand-lift for delivery of patterns and closing of moulds, with the rapid power lift and lowering suitable for ordinary service. The other application is that of the auxiliary hoist of low power fitted for service on a crane of high power. The reason for this addition is either and chiefly the handling quickly of light loads, or of occasionally rendering assistance to the heavy lift, as when a ladle of metal held in the latter is tilted by the light hoist. This application





Figs. 5 and 6. Overhead Hand Travelling-Crane; Messrs. Vaughan and Son, Limited, Manchester.

overhang, but run between double bearings, to afford them proper support.

The mechanism for hoisting and cross traverse is provided either in the form of a crab or of a jenny. In general, the first is used for heavy cranes, the second for the lighter ones. Either can be operated from above or below, the first being suitable for regular and continuous service, the second for that which is intermittent. The place of the attendant is seldom now on a platform on the crab (except in the hand-crabs), as it was in most of the old steam-driven cranes, but he is instead located in a cage at one end, below or to one side of the girders. When in this position the switches and various operating levers are brought to the cage, and the work which is going on below can be observed readily.

The proper sphere of the hand-operated traveller is in foundries of no great length, in which the service is irregular and occasional. This may happen so because the foundry is so well supplied with a service of jib-cranes that the transportation of moulding-boxes, metal and castings, is chiefly or to suit purse as well as service. Even a single motor drive is retained in some few cases, whence lifting, travelling, and traversing motions are actuated, with their reversals, through friction clutches and gears. But the individual motor drive is general, one motor for each motion, and in the highest powers two hoisting motors. Two methods of changing speeds in the higher-powered cranes are common. In one, separate motors rated for different loads actuate separate hoisting-drums. In the other the speed changes are effected through gears and clutches to a single drum. If the difference between maximum and minimum loads is large, the additional light auxiliary hoist is often fitted, having its own individual motor and drum. The heavier loads may then be lifted with a single motor actuating two speeds through gears to one drum, or in heavy cranes separate motors may actuate separate drums. Here, too, the selection should be determined by the frequency or otherwise of loads variable in amount. The cost of additional motors and drums is justified when large ranges in lifts are frequent. Transmission occurs in the big travellers for steel works. The auxiliary fitting had its prototype in some of the old hand-cranes that were provided with a light, quick set of gears apart from the slower, heavier gears. But it has only become a prominent development in the electric cranes, for which the individual motor system is so eminently adapted. The auxiliary hoist has its own motor, controller, and wiring. Occasionally, in order to reduce expense, the auxiliary hoist is driven by gears from the main hoisting motor. But this cannot be adopted when the main and auxiliary hoists have to be used simultaneously.

In some cranes a safety provision is included, as an over-winding gear fitted to the hoisting mechanism, by means of which current is cut off automatically from the hoisting-motor, and the magnetic brake is put into action. Another is a governor which prevents excessive speed of lowering. All the best cranes also have a mechanical brake to supplement the magnetic one. The latter is on the motor-spindle or on a second shaft, and is released when the current passes to the motor. The mecha-

nical brake controls the lowering, and will hold up the load if the magnetic one fails.

The motor for the longitudinal travel of the crane is placed at the centre of one of the main girders, and on one side, driving the longitudinal travelling shaft through spur-gears. This shaft drives the travelling-wheels at each end through spur-gears. In high-speed cranes it is sometimes provided with a mechanical brake.

Continuous-current motors, series wound, are the best for crane-work. These run at moderate speeds at full load, and accelerate under light loads. Continuous current at 220 volts is regarded as the standard most suitable for cranes, though double that pressure may be employed. Series-wound motors are preferred to the shunt-wound type, because a large variation in the speed with variable loads is obtainable with those. But cranes operated with three-phase current cannot have their speed accelerated automatically under light loads. Adopting a series motor and continuous current, the question of the selection of a

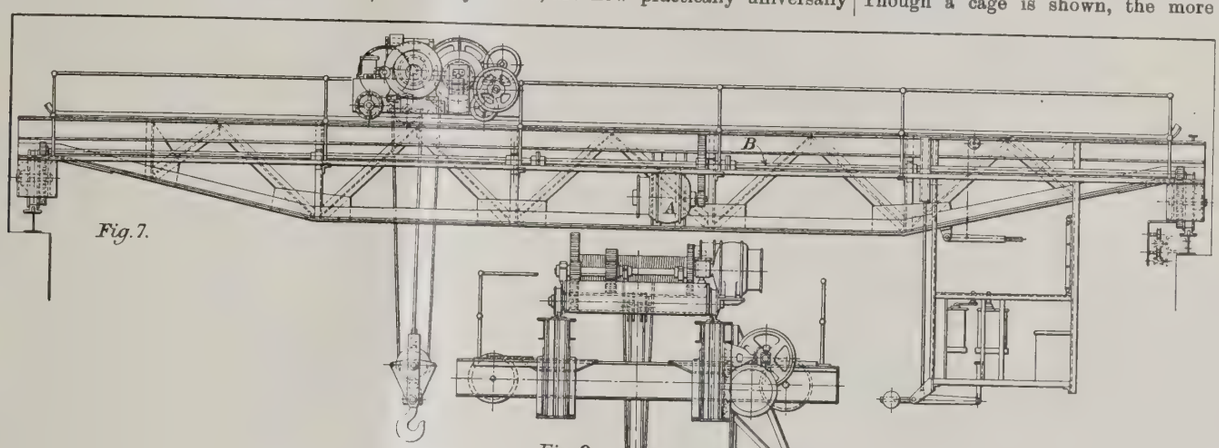


Fig. 7.

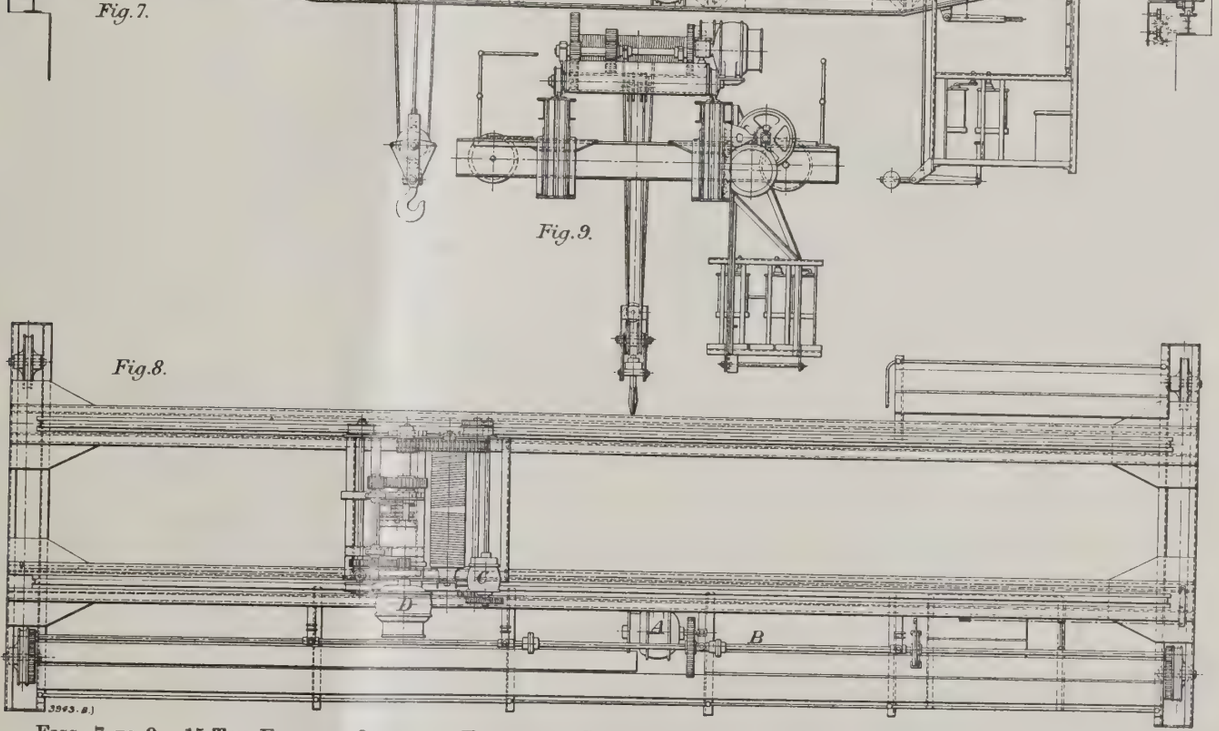


Fig. 8.

Fig. 9.

FIGS. 7 TO 9. 15-TON ELECTRIC OVERHEAD TRAVELLING-CRANE; MESSRS. BABCOCK AND WILCOX, LIMITED, GLASGOW.

high or low speed-rating arises. Practice favours the employment of moderate speeds only at full loads in order to avoid excessive speeding up under light ones. If a motor is highly rated, the speeding up becomes too great at light loads, entailing the putting in of resistance, with waste of current. Special types of crane-motors have therefore been evolved. The usual rating is that which will keep the heat losses low. The motors run at from 450 to 500 revolutions per minute, and it is commonly specified that the rise of temperature shall not exceed 75 deg. Fahr. in half-an-hour of working.

The high efficiency of the best electric cranes is attributable to two causes, first to the judicious design of the electrical equipment, and second to the excellence of the details of the mechanical construction. Looking back to the pre-electric days, the cranes of that period were, in regard to their mechanical construction, vastly inferior to those of the present. The cranes now built excel their prototypes, not in one item of detail only, but in almost every individual section. The girders, the wheels and axles and bearings, the gears, the wire ropes and their drums, and the correct elaboration of designs to resist stresses, afford remarkable illustrations of the great improvements which have been effected. These results have been fostered by the exact measurements which are available of input and of work done in terms of electrical current and pressure. Power absorbed, and work given out, the work done in raising the load, divided by the power consumed by the motor, afford deductions of percentage efficiency which are now known exactly, and which are in marked contrast with the crude estimates of the past. The tractive effort for travelling and for cross-traverse in pounds per ton are also ascertained for the different loads carried. One fact also, which was demonstrated at an early stage of electric driving, was the marked difference in the power required for hoisting and that for cross-traversing, whence followed the economy of performing each motion with a separate motor rated for its one and only duty. At an early period, also, came the abandonment of all bevel-gear drives in favour of spur-gears, which, as already stated, are now practically universally employed. These gears also were rarely cut for the old cranes. They are seldom, if ever, left as cast now in high-class cranes for any of the transmission gears, the drum-wheel and its pinion alone excepted, and these are also sometimes cut.

The constructional portions of cranes have also been improved. The solid-plated main girders are used less, and the Warren girders more. Lateral stresses, formerly ignored, are now provided against in the high-speed long-distance travelling-cranes by means of light lateral girders, which also sustain the platforms. Provisions are made in better fitting and in additional splayed gusset-plates to prevent cross working. Running wheels and shafts are prepared and fitted more carefully. Some heavy cranes employ compensating girders for the end-cradles to ensure equal distribution of the load on the wheels. These and other provisions, characterised by almost innumerable variations in details by the various manufacturing firms, occur in immense numbers of foundry-travellers, throughout the extensive range from the light hand-crane of 1 ton capacity to the 100 or 150-ton cranes employed in some steel works. Cranes for iron foundries rarely exceed 25 tons capacity, but those for steel foundries and steel works may often range to 100 or 150 tons.

Some approximation to standardisation is attempted in electric cranes; but as varying shop conditions have to be provided for, nothing beyond approximation is possible. Usually there is some rather close relation between load and speed of lift; but rates of longitudinal and cross-traverse need not vary in cranes of different powers. In the higher-powered cranes two rates, or three rates, of lift are available with variations in load, as, say, 20 tons at 8 ft. per minute, and 10 tons at 16 ft., or 25 tons at 7 ft., 12½ tons at 14 ft., and 30 tons at 6 ft. Longitudinal travel without the load lies between 200 ft. and 300 ft., and that of cross-traverse at from 80 ft. to 100 ft. per minute.

Illustrative of a type of hand travelling-crane, operated from a cage or from the floor, there are given in Figs. 5 and 6, page 662, views of one built by Messrs. Vaughan and Son, Limited, of Manchester, in a range of from 1 to 7½ tons. Though a cage is shown, the more usual practice is to work these light hand-cranes from the floor, the gang who require its services taking charge of it for the time being. The cross-girders and those for the end cradles are, as is usual in light cranes, made of plain rolled-steel joists. The runway girders are also joists. Three dependent chains and chain-wheels, each lettered, provide for longitudinal travel, cross-traverse, and hoisting. That for longitudinal travel is keyed on a shaft A which runs alongside one of the main girders. This has three bearings, and carries a spur-pinion B at each end, which drives a gear C rigidly connected to the double-flanged running-wheels. The cross-traverse chain-wheel drives through spur-gears, seen outlined in the two views, to a cross-shaft which carries two chain-wheels D, D. From each of these an endless chain E, Fig. 5, passes round similar wheels F, F at the opposite end of the main girders. The chains are anchored to pins on the sides of the block carriage G, and so traverse it across in either direction, corresponding with that in which the chain-wheel is pulled. The hoisting-chain wheel actuates the hoisting-drum through double gears. The wire rope, winding round the drum H at one end, is anchored to a cast-iron bracket at the

FOUNDRY CRANES.

Fig. 10.

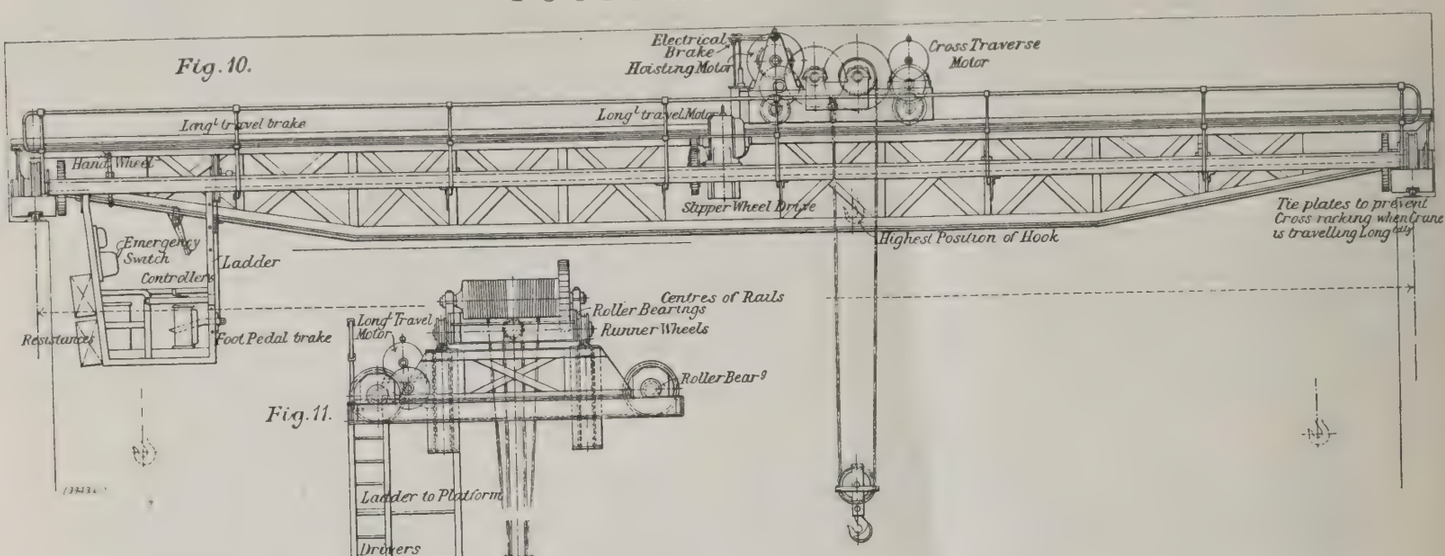


Fig. 11.

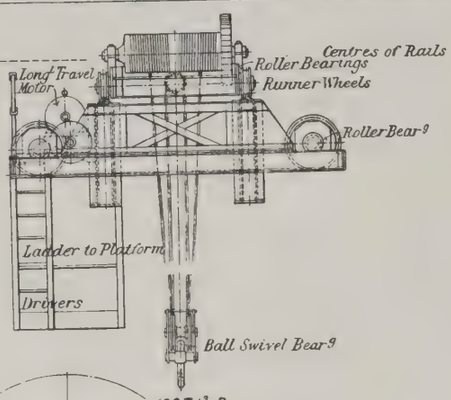


Fig. 12.

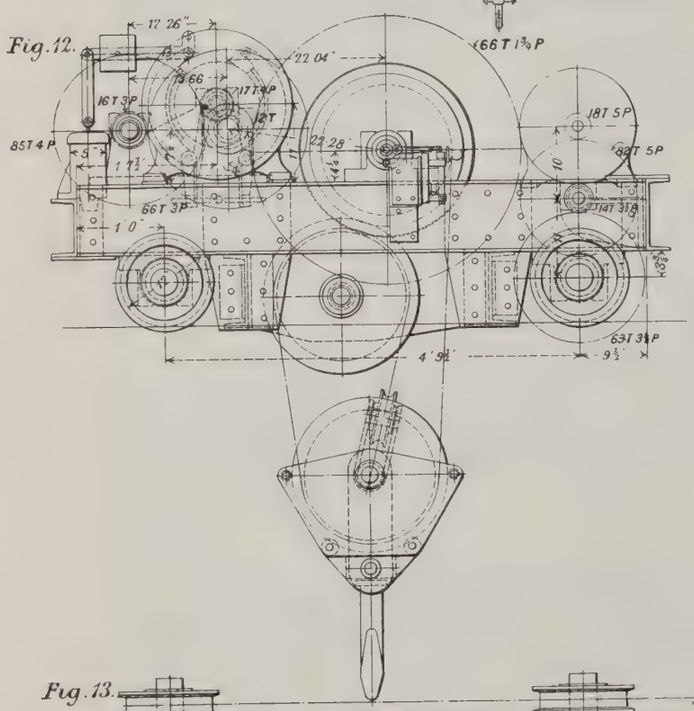


Fig. 14.

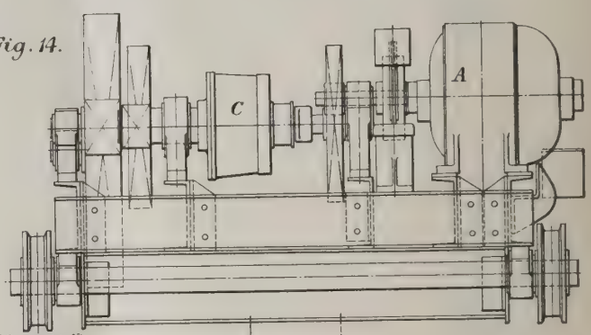


Fig. 15.

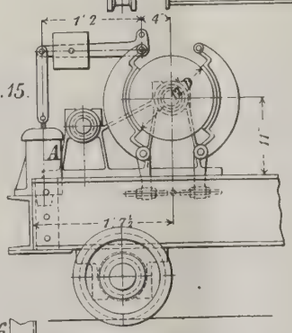


Fig. 17.

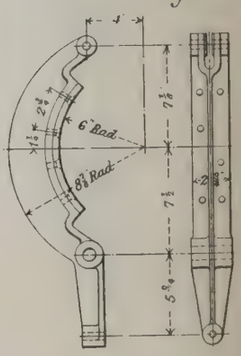


Fig. 16.

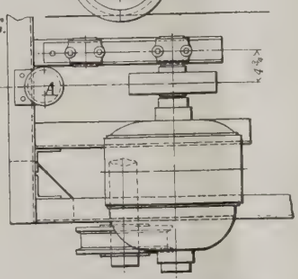


Fig. 13.

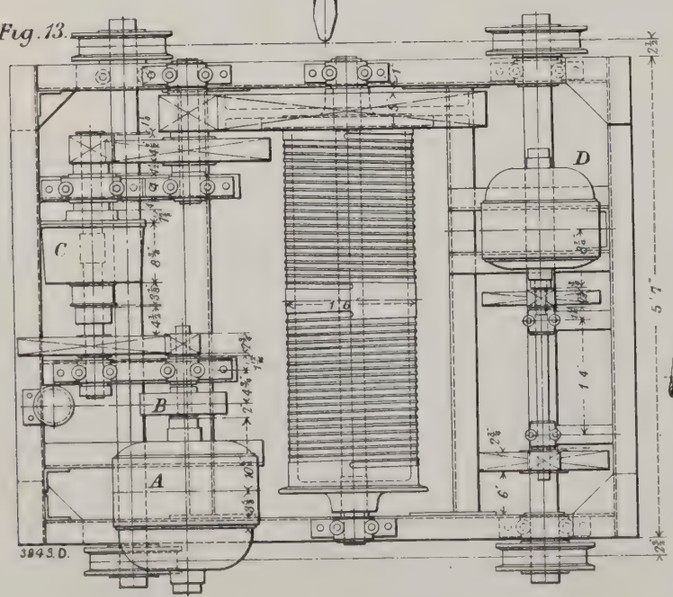


Fig. 18.

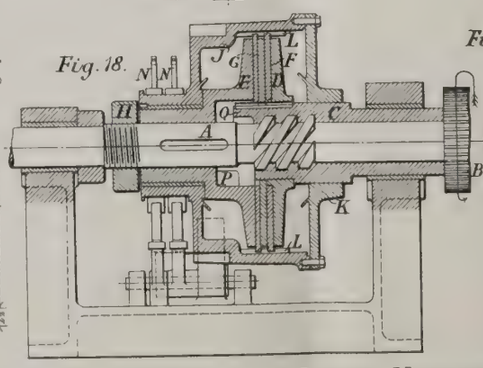
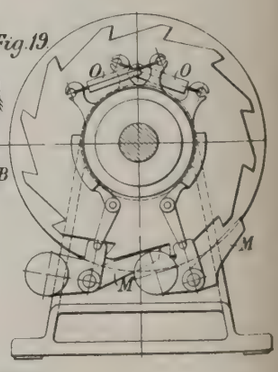


Fig. 19.



Figs. 10 and 11. Electric Overhead Travelling-Crane; Messrs. Royce, Limited, Manchester.

Figs. 12 to 19. Electric Crab and Details; Messrs. S. H. Heywood and Co., Limited, Reddish, Stockport.

other, and passes over the guide-pulleys in the block-carriage G round the snatch-block pulley below. A brake-drum J is provided on the shaft which carries the hoisting-chain wheel at the outer end. The brake-strap is anchored to the lever below, which is counter-weighted, but is not shown in plan.

Figs. 7 to 9, on page 663, illustrate a 15-ton electric overhead travelling crane by Messrs. Babcock and Wilcox, Limited. Though drawn to a rather small scale, the general scheme will be obvious. The longitudinal girders are of Warren design. Instead of imparting a curved camber to the lower boom it is made parallel for about one-half its length, and thence reduced in depth to the ends with a straight taper. Many girders are built thus, which is a rather simpler method of construction for the platers than the regular camber is. The end girders are built of pairs of rolled channels, maintained apart with end-plates and by the longitudinals, which are fitted directly on top of those with broad stiffening splayed gusset-plates to prevent chance of cross-working. A platform runs all the way along one side, and another for a portion of the way along the other, Fig. 8, the latter being to permit getting outside the crab for oiling, or for repairs to the crab on that side. The crane is travelled by the motor A, situated outside midway of the length of the main girders. It drives through one gear reduction to the longitudinal shaft B, which has a spur-pinion at each end, driving spur-gears attached to the travelling-wheels. The shaft is made in lengths with flanged couplings, and runs in self-aligning bearings at positions intermediate from the ends. The cross-traverse motor C on the crab drives through reduction-gear to an intermediate shaft below. Two pinions on this drive the spur-gears attached to the running wheels on opposite sides of the crab. The hoisting-motor D on one side of the crab drives through two sets of reduction-gears to the pinion which gears with the barrel-wheel. The drum, as is usual, winds and unwinds from each end towards the centre, to maintain the load centrally. The wire ropes lead over the two equalising guide-pulleys on the crab to the snatch-block pulleys.

The operator's cage is seen in Figs. 7 and 9, with the controllers, switchboard, &c. The drawing is too sketchy to show all the details of the brake and cable connections, but the following observations relate to cranes of this type :—

The tool-box in the cage serves as a seat for the driver. The switchboard is fitted either to suit two-wire continuous current, or three-wire three-phase alternating. In the first case the switchboard fittings comprise a double-pole fuse, a main double-pole switch, and three single-pole fuses for the motor circuits in a cast-iron case. For the second, three main single-pole fuses are fitted, a triple-pole switch, and two or three single-pole fuses for each motor circuit. Three controllers of tramway type control the hoisting, the traversing, and the travelling motors. The handles are so arranged that the direction of movement of the handles corresponds with that of the load.

The current is picked up from the bare wires that are stretched parallel with the gantry down the shop, seen in Fig. 7. Two wires are shown here for continuous current, three being required, as stated, for three-phase alternating. The intermediate supports are indicated in dotted outlines. The collector-wheels, on a bracket attached to one of the end-cradles, pick up the current from the bare wires as the crane travels, and lift the wires off the intermediate supports as they pass them. The weight of the wires on the wheels is sufficient to ensure electrical contact. The wheels are of gun-metal, grooved to receive the wires. They run at one end of an insulated spindle of gun-metal. The other end of the spindle is formed as a socket, into which one of the cables is soldered to convey the current to the switchboard.

The wiring of the cross-girders is not indicated. Five bare wires are provided for the hoisting-motor for continuous current, six for three-phase alternating. Four are required for the traversing motor for continuous current, six for three-phase alternating. On an extension of the hoisting-motor shaft an automatic magnetic brake is fixed. Two blocks are pressed against the face of the pulley by means of a counterweight when the crane is standing idle. When the current is switched on, the weight is lifted by the action of the solenoid, and is automatically reapplied immediately the current is shut off. A mechanical brake is fitted on the intermediate shaft, operated from the driver's cage by a foot-pedal connected to a lever pivoted at one end of the cross-girder. This lever is attached to a flexible wire that stretches from end to end of the cross-girder, and over and under pulleys attached to the crab-cheek. The brake-strap is kept normally clear of the brake-wheel by a counterweight, and is only tightened by depressing the pedal. Provision is made for lowering the load with precision. In the case of continuous current the hoisting controller is fitted with special rheostatic brake-stops for this purpose. With alternating current, in which this type is not possible, a hand-gear is fitted for mechanically operating the magnetic brake and lowering with precision.

In the Babcock and Wilcox cranes an over-winding gear is fitted at one end of the drum-shaft. It comprises a screwed spindle, which carries a nut that travels, but which is prevented from rotating by a weight. Here the nut travels along the screw by the rotation of the drum until the load has reached its highest position, when the nut comes in contact with a lever. This is connected to an emergency cut-out switch adjacent on the crab-frame, which is in series with the hoisting controller and motor. The opening of the switch cuts off the current to the hoisting motor, the automatic magnetic brake is applied, and the hoisting is arrested.

Figs. 10 and 11, on page 664, illustrate the general scheme of the three-motor cranes built by Messrs. Royce, Limited, of Manchester. The main girders are double-lattice braced. In the lighter crabs they are parallel rolled joists, and rest on end girders arranged in pairs, with the running wheels between them. A pinion on the longitudinal travelling motor-shaft, located at the centre, drives a spur-gear, which is also a slipper-wheel, on the longitudinal travelling shaft. Pinions at the ends of the shaft mesh with the gears on the ends of the wheel axles. A brake is fitted to the shaft just over the driver's cage. The hoisting-motor on the crab drives through two sets of speed-reducing gears, outlined in Fig. 10, to the spiral drum. The cross-transverse motor, carried on the opposite end of the crab, also drives through two sets of reducing-gears to the traversing axle. The position of the electrical brake is indicated. There is also an over-winding safety device. The driver's cage contains the three controllers, an emergency switch, the foot-lever for the brake for the longitudinal travel, and the hand-lever which releases the mechanical brake for lowering loads. The platform is carried between one of the main longitudinal girders and a light girder which flanks it.

Figs. 12 to 14, on page 664, illustrate one of the standard 20-ton crabs by Messrs. S. H. Heywood and Co., Limited, of Reddish. The frame is constructed of rolled channels, to which the cast-iron bearing-brackets or plummer blocks are bolted. The hoisting motor A drives the drum through three sets of reduction gears, but without speed changes. When these are fitted, the changes are made by means of a sliding double-ended clutch. On the first-motion shaft an electric brake B is fitted, and on the second-motion shaft a mechanical brake C. The cross-traverse motor D drives through two reductions to the spur-gear on the shaft below.

An electrical brake by Messrs. S. H. Heywood and Co., Limited, is shown by Figs. 15 and 16 in its relation to the crab framing. A drum bored to fit on the motor spindle receives two brake levers or arms, Fig. 17, lined with "ferodo" blocks. The levers are anchored at the lower end with adjusting-screws, and connected at the other through adjusting-pieces and pins to a bell-crank lever, the horizontal arm of which is weighted and connected to a solenoid at A. The weight maintains contact, and holds the load when current is off; the solenoid lifts and throws the straps off when current is switched on.

A mechanical brake of the Weston type, as fitted to these cranes, is illustrated in Figs. 18 and 19. It will hold up the load without the help of the magnetic brake. Its parts and method of action are as follows :—A is the brake-shaft, B the gear-wheel or pinion, which forms part of and turns with the brake-nut C. The load is always tending to turn the gear in the direction indicated by the arrow on B. The Weston clutch comprises the front-thrust washer D, the back-thrust washer E, faced with phosphor-bronze friction washers F, F flanking a central friction washer G of steel. D is keyed on the outside of the brake-nut C. E slides on the shaft A, to which it is feather-keyed, and along which it is adjusted for setting and for taking up the wear of the washers by means of the nut H. The illustration shows the normal position of the washers close to one another. They are contained in a casing J, with a cover K, into which half a pint or three-quarters of a pint of oil is poured through a plug-hole. The casing rotates with the gear and nut through the keys L, which project within the casing. A ratchet is formed on the outside of the casing at one end, with which two pawls M, M engage, controlled by the slippers N, N, which are themselves under the control of the slipper-springs O, O. The tension of these springs must be so regulated that the pawls M, M are kept clear of the ratchet-teeth on the casing when hoisting, and to bring them in contact when lowering. Stops P on the back-thrust washer, and Q on the brake-nut provide for turning the brake-shaft A through a sixteenth of a revolution in the direction of lowering before the brake-nut C is compelled to turn. These adjustments are made by the nut H.

THE BRITISH ASSOCIATION IN AUSTRALIA.

(*Continued from page* 654.)

SECTION B.—CHEMISTRY.

The Chemical Section had twenty-two discussions and papers on the programme, which it dealt with in six days, subdividing into an Organic and an Inorganic Department on one morning at Sydney. The joint discussion with Section A, on "The Structure of Atoms and Molecules," has already been abstracted in our columns; there was also a joint discussion with Section M (Agriculture). The papers were of a varied character, the attendances good. The officers of the Section were :—President, Professor W. J. Pope, F.R.S., of Cambridge; Vice-Presidents, Professors F. Clowes, D.Sc., of London; H. B. Dixon, F.R.S., of Manchester; Orme Masson, F.R.S., E. H. Rennie, D.Sc., and B. D. Steele, D.Sc., of Melbourne; Secretaries, Messrs. A. Holt, D.Sc., of Liverpool (Recorder); N. V. Sidgwick, D.Sc., of Oxford; D. Avery, of Melbourne; and C. Fawsitt, D.Sc., of Sydney.

Crystal Structure and Chemical Constitution.

Professor W. J. Pope had not given any title to his presidential address; but since he said himself, in his concluding remarks, that no critic would doubt that wide development would follow in chemical science from the cultivation of the relation between crystal structure and chemical constitution, we may adopt this heading. In his introduction he had remarked that, whilst it had not been difficult to form a fairly accurate survey of the position to which chemistry had attained a generation ago, perhaps even a few years ago, probably no intellect at present existing could pronounce judgment upon the present position of chemical science in terms which would commend themselves to the historian of the twenty-first century. The two sciences of chemistry and physics, at one time included as parts of the larger subject entitled Natural Philosophy, had drawn apart in the early part of the nineteenth century. Under the stimulus of Dalton's atomic theory, chemistry had developed into a study of the interior of the molecule and, as a result of the complication of observed phenomena, progressed from stage to stage on a closely-reasoned mass of observed facts and logical conclusions. Physics, less entangled in its infancy with numbers of experimental data which apparently did not admit of quantitative correlation, was developed largely as a branch of applied mathematics. The two sciences, which were so sharply distinguished twenty years ago as to lead to mutual misunderstandings, were now converging; many purely chemical questions had received such full quantitative study that the results were susceptible to attack by the methods of the mathematical physicists.

The atomic theory enunciated by Dalton in 1803, Professor Pope proceeded, was a great impetus to chemical investigation, but proved insufficient to embrace all the known facts. It was supplemented in 1813 by Avogadro's theorem, that equal volumes of gases contained, at the same temperature and pressure, the same number of molecules. The idea of molecular composition thus received a definite

SURFACE-GRINDING MACHINE.

CONSTRUCTED BY MR. ROBERT H. LASH, ENGINEER, LONDON.

(For Description, see opposite Page.)

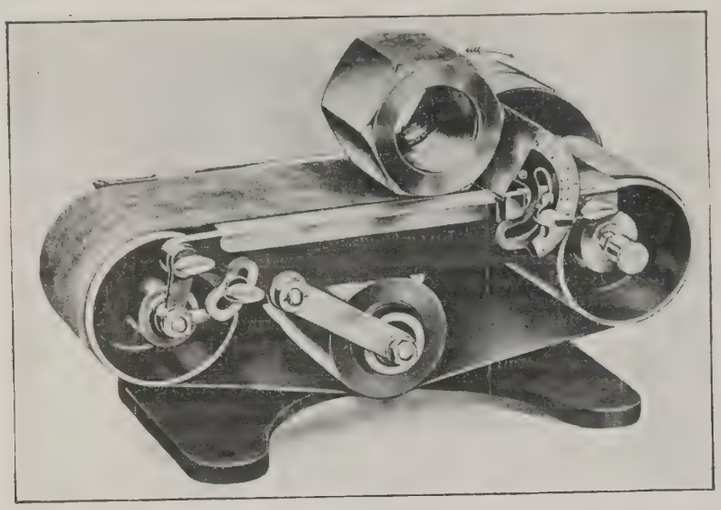


Fig. 1.

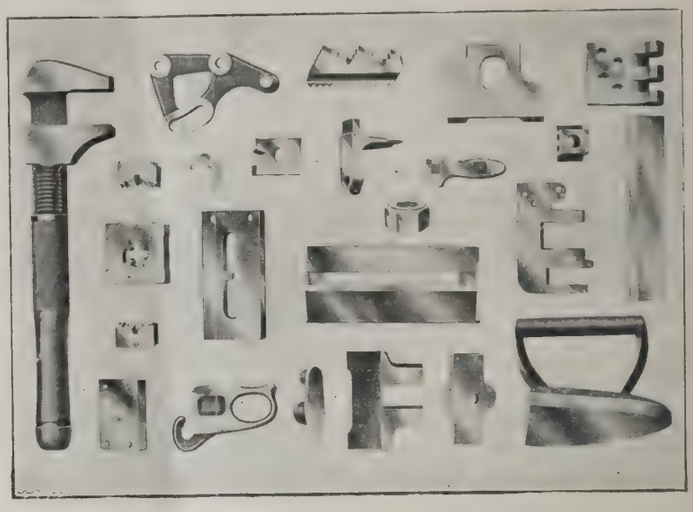


Fig. 2.

physical meaning. Then Frankland and Kekulé introduced in 1852 the idea of valency, and the conception of molecular constitution arose as a refinement of the Daltonian notion. On the other hand, Ostwald and others had made an attempt to treat chemical science without the aid of the molecular theory. The last ten years or so had seen a change in this attitude. The development of organic chemistry had revealed a complete correspondence between the indications of the conception of molecular constitution and configuration and the observed facts, and the recent work on the existence of the molecule, largely in connection with colloids, radioactivity and crystal structure, was so free from ambiguity that persistence of doubt seemed unreasonable.

As regards molecular configuration, Biot observed in 1815 that certain organic substances deflected the plane of polarisation, to the right or to the left; half a century later Pasteur and Paternò pointed to the obvious conclusion that the right or left-handed deviation must be due to a corresponding right or left-handedness in the configuration of the chemical molecule. A scheme representing such right or left-handedness (enantiomorphism) was first enunciated by Van't Hoff and Le Bel on the basis of the doctrine of chemical constitution; they suggested that the methane-molecule CH_4 was not to be regarded as extended in a plane (as represented by the constitutional formula), but as built up symmetrically in three-dimensional space, the carbon atom occupying the centre of a regular tetrahedron, the apices of which were occupied by the four hydrogen atoms. If the four hydrogen atoms were replaced by different atoms, X Y Z W, then two enantiomorphous configurations should exist. They showed, indeed, that every then-known substance exhibiting optical activity in the liquid state could be regarded as a derivative of methane, and the tetrahedral configuration was further worked out by Baeyer, Emil Fischer, and Wislicenus. Twenty years ago it was still believed that carbon stood alone in this respect. Then Le Bel found that an asymmetrical quinquivalent nitrogen atom would give rise to optical activity; later similar optically-active compounds of sulphur, selenium, tin, phosphorus, and silicon were prepared. It should, however, be insisted upon at present that the asymmetry of a particular atom was not the cause of the optical activity, but merely a convenient geometrical sign of molecular enantiomorphism; that fact was recognised by Van't Hoff in 1874, and quite recently Werner had prepared optically-active complex compounds of chromium, cobalt, iron, and rhodium. Yet, in spite of varied researches, a theory of optical activity comparable to the electromagnetic theory of light had not yet been developed.

Passing to the relation between chemical constitution and crystalline form, Professor Pope pointed out that the view that each substance affected some particular crystalline form had given way to the view that the properties of crystalline substances were in harmony with the assumption of a homogeneous arrangement, in which similar units were uniformly repeated throughout the structure. On that assumption 230 geometrically homogeneous modes of distributing units, 230 point-systems, were possible, and they fell into 32 types of symmetry. The purely geometrical solution of these problems had been commenced by Frankenheim in 1830, and completed by Barlow in 1894. The much larger stereo-chemical problems, of determining the units, necessitated the assumption that each atom acted as a centre of operation of two opposing forces: a repellent force attributable to the kinetic energy of the atom, and an attractive force. That assumption was essential for the kinetic theory of gases and of liquids according to Clerk Maxwell and Van der Waals, and it had been extended to crystalline substances by Barlow and Pope himself in 1906. A set of identically similar centres of attracting and opposing forces would, for molecules consisting of one atom only, all similar, be in equilibrium when, with a given density of packing of the centres, the distance separating nearest centres was a maximum.

That condition was fulfilled by the symmetry of the cubic and the hexagonal crystalline systems. The original assumption said nothing as to the magnitude of the atom; but it was convenient to regard the whole of the available space as filled with atoms, without interstices, imagining the spheres to swell until they came into contact, and tangent planes to be drawn at each contact dividing the space into polyhedra. In the cubic system the axial ratio would be $a : b : c = 1 : 1 : 1$, in the hexagonal the ratio of the diameter of the prism to the height might be $a : c =$ either $1 : 1.633$, or $1 : 1.4142$. Now of the crystallised elements, 50 were cubical and 32 hexagonal, and the ratios were very nearly as stated; 15 per cent. of the elementary substances did not fit into this rule, however. But the elements had so far in this deduction been assumed to be monatomic, and many were certainly polyatomic. It was characteristic that carbon (diamond) and phosphorus were cubic, whilst the coloured modifications of these elements (graphite and red phosphorus) were not, colour being apparently connected with some particular molecular aggregation. The examination, by Laue and Bragg, of crystals by X rays indicated that the crystal structure acted on the X-ray beam like a diffraction grating.

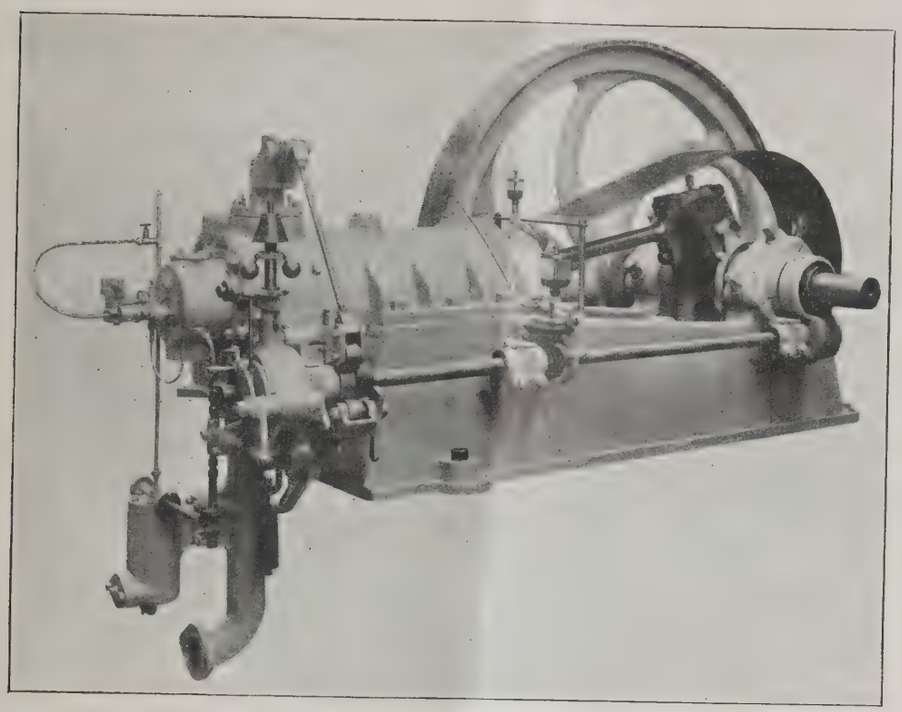
Binary compounds also tended to crystallise in the cubic or hexagonal systems, but the degree of symmetry was not so high as with elementary substances, and Bragg's examination brought out discrepancies; each atom operated separately, as it should, according to the assumptions made. The close packing involved a volume problem, however, and the valency-volume law of Pope stated that in a crystalline structure the component atoms occupied domains approximately proportional in volume to the numbers representing the fundamental valencies of the elements concerned. This law, Professor Pope admitted, would hardly be accepted by the student of molecular volumes; yet many lines of crystallographic argument converged to some such law. If in potassium sulphate, K_2SO_4, the atomic volume of potassium were taken as unity, then, according to that law and to the conception that valency was a volume property, the atomic volumes of sulphur and oxygen each should have the value 2; the sum of the valencies was 12, and in the ammonium sulphate twice that, 24; now these two substances were so closely related as to crystallise together in solid solutions. Similarly the alums, $K_2OS_4 + Al_3(SO_4)_2 + 24\,H_2O$, represented the valencies $12 + 36 + 96$, where 96 was $2(12 + 36)$. Again, in the nitrates of rubidium and of sodium the atomic volumes of metal, nitrogen and oxygen, should be $1 : 3 : 2$; they crystallised in different systems, but it could be shown that the two crystals seemed to be built up of layers or blocks of the same relative dimensions in two different ways, the molecules of $Na\,NO_3$ and $Rb\,NO_3$ possessing the same relative dimensions. This was in disaccord with the classic conception of atomic volumes, of course, but it agreed with the valency-volume law. Such relations were profitably discussed with the aid of so-called equivalence parameters; these were the edge-lengths $x\,y\,z$ of a parallelopipedon, the volume of which was W, also representing the sum of the valencies in the molecule, while the linear and angular dimensions of the parallelopipedon expressed the crystallographic axial ratios. Professor Pope illustrated this further by referring to the three minerals chondrite, humite, and clinohumite, silicates which differed from one another by the increment Mg_2SO_4, which was the mineral forsterite, and the equivalent parameters showed that these minerals could be built up the one from the other by adding a rectangular block representing the molecule of forsterite. We would refer our readers to our account of the discourse which Professor Pope delivered before the Royal Institution in April, 1910.*

Having further explained how the constitution of several isomeric bodies, like the paraffin hydrocarbons of the formula $C_n\,H_{2n+2}$ (or $H(CH_2)_n.H$), could be represented on these lines, Professor Pope returned to the structure of sodium chloride (rock salt), in which, according to Bragg, each sodium atom was identically related to six chlorine atoms; a choice of one chlorine atom as mate need not be made before the crystal was disintegrated by being

* See Engineering, vol. lxxxix., page 517.

HIGH-COMPRESSION CRUDE-OIL ENGINE.

CONSTRUCTED BY THE CAMPBELL GAS ENGINE COMPANY, LIMITED, HALIFAX.



dissolved in water, and even then the sodium chloride molecule seemed to spend the greater part of its time in dissociation—namely, in the act of changing its partner. The solid crystal could be partitioned into unit cells, each composed of one molecule of the substance, and the alternative modes of partitioning led—in rock salt, but not in more complex bodies—to the production of molecular units of identical configuration. There was thus in the theory of crystal structure something bearing a superficial relationship to electrolytic dissociation. Concluding, Professor Pope regretted that crystallography, as dissociated from mineralogy, had only been studied in one English school, founded by H. E. Armstrong and H. A. Miers in 1886; that school was no longer open, and at present no European university applied the principle which Lazarus Fletcher had laid down in 1888—that a knowledge of crystallography, including the mechanics of crystal measurements, ought to be made a *sine quâ non* for a degree in chemistry at every university. Professor Pope's regret was shared by Professors Orme Masson and A. H. Dixon, who moved a vote of thanks to the President. The address was delivered in Melbourne; in Sydney Professor Pope afterwards gave a "Demonstration of Chemical Crystallography."

Residual Affinity and Co-Ordination.

Professor Gilbert Morgan and Mr. H. Webster Moss, of Dublin, submitted an interesting memoir on "Residual Affinity and Co-Ordination," concerning the important question of valency, as to certain aspects of which Professor Morgan differs from Professor Pope. According to the old notion, chemical affinity is manifested by valencies which are exact multiples of the unit valency of a univalent atom or group. But modern views, coupled chiefly now with the name of A. Werner, of Zürich, do not regard the valencies as exactly whole numbers, and suggest that when the integral portions of the valencies have been satisfied, there may remain fractional residual portions of valency which become operative under certain conditions. The recognition of co-ordination in organic compounds, Professor Morgan explained, had necessitated a review of the older notion. The forces to which co-ordination compounds owed their existence could not be regarded as emanating entirely from the central atom; the residual affinity of this element only served as a determining factor. The stability of the arrangement was dependent upon the mutual attractions which the co-ordinating radicles exerted on one another. The general tendency to form hydrated and ammoniated metallic salts was to be attributed chiefly to the capacity for association exhibited by the molecules of water and of ammonia. The presence of carbonyl, nitrate, &c., groups in many stable complexes was similarly to be correlated with the unsaturated nature of those radicles as contrasted with the saturated carbonates, nitrates, &c.

If chemical affinity were regarded as an attractive force proceeding in all directions from the centre of the sphere occupied by the atom, then the smaller the volume the greater should be the concentration of chemical affinity on the surface and the greater the effectiveness of the atom in producing co-ordination. If chemical affinity, moreover, fell off with the square or some higher power of the distance, a slight alteration in atomic volume should have a marked effect on the stability of the compound, because the influence was more concentrated in a small volume, the groups would approach the centre more closely, and the segregating units, remaining outside the proper co-ordination sphere, would fill the space more completely. Now the metallic elements of the eighth periodic family formed the most stable complexes, and these elements had the lowest atomic volumes, whilst the alkali metals, distinguished by the largest atomic volumes, gave very few and unstable co-ordination compounds.

The most stable arrangements should be that of perfect symmetry, and that was only obtainable in the five regular solids, the tetrahedron, octahedron, cube, icosahedron and pentagonal dodecahedron, having respectively 4, 6, 8, 12, and 24 vertices. These integers would be the co-ordination numbers corresponding to the most stable systems. By co-ordination number he understood the greatest number of atoms or radicles which an element could bind; the co-ordination number was not always known, since there was often doubt whether the molecule was $MoCl_3$ or Mo_2Cl_6, *e.g.* Professor Morgan discussed many cases. In the case of methane, CH_4, the four valencies of carbon were satisfied; the co-ordination number was also 4, and there was no tendency hence for the segregation of associating units outside the immediate sphere of influence. In the case of ammonium chloride, $NH_4.Cl$, the maximum valency of nitrogen was 5, but the co-ordination number was 4, and the chlorine atom remained outside the sphere of influence and was ionisable.

As regards the forces of the principal and the residual valency, both forces might be of the same nature, or the former force might be electrical and the residual affinity gravitational. Werner inclined to the former view, principally because polarisation did not, in a certain complex cobalt salt, reveal any difference between principal and auxiliary linking. Professor Morgan, who has himself contributed much to these researches, contended that this optical test might merely reveal the steric arrangement, not the nature of the forces holding the atoms or groups in their positions.

A joint paper by Professor Morgan and Mr. Joseph Reilly on "Non-Aromatic Diazonium Salts," of importance for the dye industry (diazotisability) of wool, was theoretically interesting for similar considerations.

(To be continued.)

SURFACE-GRINDING MACHINE.

The illustration, Fig. 1, on page 666, shows a new type of grinding-machine for finishing the surfaces of small tools and other metal objects such as are illustrated in Fig. 2. The machine, which is designed and constructed by Mr. Robert H. Lash, of 31, Carburton-street, London, W., consists of a cast-iron frame provided with a flat machine-ground table, and carrying two wide pulleys, over which runs an emery-cloth or other abrasive band. The right-hand pulley, which drives the band, is itself driven by a fast and loose pulley in a clockwise direction, so that the upper surface of the band travels from left to right. The left-hand pulley can be adjusted by means of a pair of links and quadrants to allow for the stretch of the band, and a uniform tension is maintained in working by the roller, which can be seen under the table in Fig. 1. This roller and the driven band pulley run on ball-bearings, whereas the driving pulley is mounted on a shaft and lubricated by a grease-cup screwed into the end of the shaft. This grease-cup also serves to lubricate the loose pulley, which runs on a machined boss on the frame.

In using the machine the work is held on the abrasive band, which is supported and kept perfectly flat by the table. Means are provided for adjusting the band laterally while the machine is running, so that the band can be run in the centre of the table or at its extreme edge. The latter position is very convenient for grinding and polishing inside angles, or for working close up to a shoulder. The adjustable angle-rest shown in Fig. 1 is provided to facilitate the grinding of angular work, such as the large nut illustrated in the figure. The rest enables an unskilled operator to turn out perfectly accurate work.

The machine, which is known as the "Linisher," can be used for grinding and polishing all kinds of metals and other materials, such as vulcanite, bone, celluloid, horn, wood, and *papier mâché*, and among several other advantages, it is pointed out by the maker that the straight-line finish imparted to the work is better in appearance than the curved-line finish produced by disc-grinders. Another important point is that the bands, which are woven in continuous lengths without joints, can be changed almost instantaneously, and the troublesome process of glueing and clamping the abrasive discs, which must be gone through with disc-grinders, is avoided. In the machine we have been describing the table is 10 in. long by $5\frac{9}{16}$ in. wide, the band-pulleys are 4 in. in diameter and $4\frac{1}{4}$ in. wide, and the band itself is $3\frac{7}{8}$ in. wide. A larger machine is, however, also made, and in this machine the top of the driving pulley is arranged to come below the level of the table, so that, with a belt driving upwards from the floor, there is no limit to the size of the work that can be dealt with.

TESTS OF A CAMPBELL HIGH-COMPRESSION CRUDE-OIL ENGINE ON MEXICAN FUEL OIL.

The tests here described, and lasting for fourteen days, were recently carried out in the works of the Campbell Gas-Engine Company, Limited, at Halifax, Yorkshire, for the purpose of demonstrating that their high-compression crude-oil engine could work satisfactorily and economically on Mexican fuel oil. This firm has already supplied a number of their high-compression oil-engines, which are running satisfactorily in Mexico on the Mexican residual fuel oil, and running tests had been made in the Halifax works on several samples of that oil sent over for the purpose. It had been found, however, that the fuel to be used in this instance, which is produced by the Anglo-Mexican Petroleum Products Company, Limited, containing, as it does, a large percentage of asphalt, had not given good results in engines of other makes; and even in Diesel engines, the frequent cleaning required, together with the cost of repairs, had been found a serious disadvantage. It was therefore arranged to make the tests as severe and conclusive as possible. This Mexican fuel-oil is the residuum left from the crude oil after the distillation of benzine and paraffin. It is almost black in colour, and in this country is of the

consistency of treacle. The following are particulars of this oil as used on these tests :—

Analysis—	Per Cent.
Carbon	83.52
Hydrogen	11.68
Sulphur	3.27
Ash	0.16
Undetermined (presumably oxygen and nitrogen)	1.37
	100.00
Specific gravity at 60 deg. Fahr.	0.964
Flash-point (close test)	244 deg. F.
Viscosity at 100 deg. Fahr. (Redwood No. 1)	1500 seconds
Calorific value per pound, gross...	18 948 B.Th.U.
Calorific value per pound, net ...	17,899 ,,

The engine used was a standard one, built for stock, and being on the test-plate at the time, was utilised as it stood without special preparation or adjustment of condition, without any appreciable amount of deposit on the valves, in the cylinder, or in the ignition-bulb. It was started up without any adjustment or cleaning for the second run of seven days, which was made without a stop. At the end of the seven days' non-stop run the engine was opened out and carefully inspected. It was found to be in perfect order, there was no deposit of any moment in the cylinder or bulb or on the valves, and the run might apparently have been continued for a considerably longer period. The table attached gives a summary of the readings taken throughout the trials. It will be noticed that during the last four days four hours per day were devoted to running on variable loads, the load being changed about every half hour ; for instance, from full load to no load, then to half load, &c. At the end of the last day the engine was run "light" for one hour, then two hours at full load, and finally for the last hour at maximum load.

The test was made purely as a practical running test to note the behaviour of the engine and to ascertain the fuel consumption, though the latter was a matter of secondary importance. It was not desired to obtain a complete heat account, and indicator diagrams were only taken at intervals to check valve-setting, &c.

Summarised Particulars of Tests on 35-B.H.P. High-Compression Oil-Engine on Mexican Fuel-Oil.

Date.	Duration of Test.	Condition of Load.	Average B.H.P. Developed.	Revolutions per Minute.	Net Load on Brake Wheel 49½ In. Dia.	Total Fuel Used.	Fuel per B.H.P. per Hour.	Circulating Water. Average Weight per Minute.	Inlet Temperature.	Outlet Temperature.
	hrs.				lb.	lb.	lb.	lb.	deg. F.	deg. F.
Oct. 7 ..	12	Full load	31.53	223	360.0	204.5	0.54	14.0	54.0	149.0
,, 8 ..	11¾	Do.	31.5	224	358.0	179.0	0.484	14.0	51.0	143.0
,, 9-10 ..	24	Do.	31.8	226	358.5	380.0	0.498	14.0	52.0	154.0
,, 12-13 ..	30	Do.	31.8	226	358.5	494.0	0.514	14.0	52.5	150.0
,, 14-15 ..	24	Do.	32.3	226	364.0	376.5	0.485	—	—	—
,, 15-16 ..	24	Do.	32 0	226	361.0	377.0	0.49	14.0	59.0	153.0
,, 16-17 ..	24	Do.	32 4	227	363.0	377.0	0.485	13.9	51.5	153.5
,, 17-18 ..	20	¾ load	24.6	230	272.0	237.0	0.482	10.0	59.0	159.0
,, 17-18* ..	4	Variable	—	—	—	—	—	—	—	—
,, 18-19 ..	20	½ load	16.75	233	183.5	170.0	0.51	7.0	59.5	150.0
,, 18-19* ..	4	Variable	—	—	—	—	—	—	—	—
,, 19-20 ..	20	¼ load	8.5	240	90.0	111.5	0.656	4.0	58.0	152.0
,, 19-20* ..	4	Variable	—	—	—	—	—	—	—	—
,, 20-21 ..	20	Full load	31.0	224	352.0	317.0	0.51	13.7	58.0	151.0
,, 20-21 ..	1	No load	—	240	—	3.91	—	—	—	—
,, 20-21 ..	2	Full load	31.7	224	360.0	32.25	0.51	14.0	58.0	151.0
,, 20 21 ..	1	Maximum load	35.0	220	405.0	19.5	0.56	14.0	58.0	152.0

* Half-hour intervals at various loads, ranging from full to zero, and *vice versâ*.

The results are considered highly satisfactory : first, in proving conclusively that the engine will run with entire success on fuel-oil, which it had been thought only a Diesel engine could tackle ; and, secondly, in showing a remarkably low consumption, considering the small power of the engine.

Engines of this type are built in a range of standard sizes by the Campbell Gas-Engine Company, Limited, from 7 to 100 brake horse-power in the single-cylinder design, and with two or four cylinders up to 400 brake horse-power.

any kind. A short detailed description of the engine in its leading features may be of interest. It is a single-cylinder horizontal four-cycle engine, similar to that shown in the illustration on page 667, and of the type known as "high-compression cold-starting." The engine is set in motion by compressed air in the usual way, starting from the cold state. No electric igniter, heating lamp, or other external ignition apparatus is used. The ignition is automatic, the discharge being fired by the heat of compression. The engine will start up from cold in this way with crude oil and many residual fuel-oils.

It should be noted that water-injection is not employed in the cylinders of these engines. It is not required under any conditions, and no provision for its use is made.

The fuel-oil on its way to the pump passes through a heater, through the outer jacket of which a portion of the exhaust gases are diverted. This heater is part of the standard equipment of the engine. The fuel-oil is thus warmed, and rendered sufficiently fluid to flow through the pipes to the pump.

The fuel-pump is operated by a quick-acting cam. It is fitted with suction and delivery-valves of the ball type. The stroke of the pump is adjustable to suit different classes of oil and working conditions. The fuel is injected to the ignition bulb through a mechanical atomiser, which is one of the special features of the Campbell engines. During the charging stroke only pure air is drawn into the cylinder, and is compressed on the return stroke of the piston. The charge of fuel oil is then injected about the end of the compression stroke, and immediately ignites. On this system there is therefore no possibility of a premature ignition. The speed is governed by varying the stroke of the fuel-pump, and an ignition occurs in every cycle at all loads.

The governor is a powerful one, of the centrifugal type. Lubrication of the piston, cylinder, and exhaust-valve is by a pump-lubricator, with separate sight-feed to each point. The cam-shaft and crank-shaft bearings are ring-oiled, and automatic sight-feed lubricators are fitted for the large and small end connecting-rod bearings.

The engine used for this test has a cylinder 11-in. bore by 22-in. stroke, and is listed to develop 35 brake horse-power as a maximum load for short periods, and 31 brake horse-power as a continuous load at 220 revolutions per minute. It was fitted with a water-cooled brake-wheel 49½ in. in diameter on rope centres.

The test was watched throughout by independent engineers, and during the intervals between the runs of the first seven days all the working parts were sealed. The engine was started up from "all cold" each morning in the same state as it had been left the night before. At the end of the first seven days the engine was examined and found to be in excellent

INDUSTRIAL NOTES.

The wages agreement in the engineering trades entered into in 1911 expired in April last ; early in July representatives of the Engineering Employers' Association and of the principal trade unions met in conference to discuss an application for an advance of 5s. per week. The matter was adjourned to a further conference to be held during the second week in August, but this was deferred owing to the war. The adjourned conference was subsequently held on November 13, when it was jointly agreed to recommend :—

"That the employers should grant, and the workpeople should accept, a general advance of 2s. per week on time rates and 5 per cent. on piece prices, to take effect in the first full pay in December, 1914, the increased rates to remain undisturbed for a period of two years from that date."

This recommendation has been submitted to the full membership on both sides, and has been accepted. The advance, which covers practically all grades in the engineering trade, will therefore come into operation the first week in December, and by agreement between the parties concerned will include the Redditch district.

Councillor George Ryder, the Midland representative of the Amalgamated Society of Engineers, has sent an official intimation of the agreement to all firms in the trade, and it is anticipated the alteration will take place uniformly and without friction. When the negotiations were commenced, the men were strongly in favour of pressing their claim for the higher amount; and in view of the abnormal demand for mechanics the acceptance of the modified terms was influenced considerably by the desire to avoid friction in the present circumstances.

The Liverpool shipping dispute has now been settled. It arose out of the refusal of a number of sailors, firemen, cooks, and stewards to sign on unless they were paid increased wages demanded on account of war risks. The dispute lasted about a week. The Board of Trade intervened, and the men agreed to terms which include consideration by the Government of any special risks which may be run by shipping employees.

As a result of a conference of representatives from the three-shift collieries in Northumberland, the following memorial has been drawn up, and is to be submitted to the directors of the colliery companies:—

"The response made by the miners of Northumberland to Lord Kitchener's appeal for recruits has proved that, on the part of the trade unionists, there is no lack of patriotism, but a firm desire to unite for the maintenance of the material and moral well-being of our race and nation. There is no doubt whatever that any further sacrifice which may be called for will be forthcoming from the mining population. We think it therefore an opportune time to point out to you that, while we and our class are doing all in our power, either by military service, keeping the mines going, and subscribing to the utmost of our power to the relief of distress, to serve our country, those of us who are affected by the three-shift system are prejudiced in our organisation for political, social, moral, or religious improvement. Our opportunities for taking an interest in the affairs of our neighbourhood, in sport, or in education, are almost entirely destroyed, while in some cases our home life is seriously impaired, to the detriment of our wives and children.

"Now it is with a sincere and ungrudging spirit that we are doing all we can for our country at this time. We ask you, in return, to make the country, as far as you can, worth fighting for. To us it is inconceivable that any conditions worse than those created by the introduction of the third shift could be tolerable to free men. Many of the best men of the county have already preferred exile, and those who remain are becoming steadily more degraded and apathetic.

"We desire respectfully to point out to you that the recruiting has greatly reduced the number of men available for employment in the collieries. It would seem then an admirable time to reduce the number of shifts, and we are convinced that such a reduction, made at a time when national emergency calls for a sacrifice from all, would be met by the hearty determination of the men to maintain the output. It is unnecessary to point out to you that output depends chiefly upon the goodwill of the hewers, and if goodwill towards the management is impaired in the three-shift collieries, the remedy for that lies in the hands of the management.

"We wish again to point out that in debate provoked on our behalf in the House of Lords on May 25 last, Lord Joicey, who represented the masters, did not attempt to show that our claims were unfounded —namely, that the system was destructive of our health, and degrading to our morality ; he confined himself to a discussion of profits. We submit that as England is fighting against Germany, not for trade, but for the maintenance of the standards of our race, so we are asking you to put our interests down as one of the most important items on your balance-sheets.

"We are well aware that all business must be carried on at a profit, or it must be wound up. But we cannot admit that any business involving the evils necessarily connected with the three-shift system is being carried on at a profit to the nation. On the contrary, the dividends are being paid by a reckless and ruthless consumption of the virility of the miners and of the lives of the miners' wives.

"In conclusion, we ask you to make another effort to find a method of running the collieries on two shifts a day."

The memorial is signed by Mr. J. Dougherty, Newburgh Colliery, on behalf of the conference.

The *Sheffield Daily Telegraph* states that in the automobile building industry, as in many other trades, the labour shortage is becoming a very serious matter indeed. This was emphasised a day or two ago, when a large firm of shipbuilders actually advertised locally for all sorts of skilled and unskilled men, who were wanted "by the hundred." As a matter of fact, Sheffield cannot afford to part with one. Indeed, the need of men is so great, that if many more are drawn from this district to serve with the colours, the problem of executing the orders pouring into the town will be a very grave one. Last week it was mentioned that Belgians had been requisitioned in some trades, and it is now learnt that Belgian refugees, not of a fighting age of course, have been employed at a local automobile works. These men are skilled in the business—for Belgium has turned out first-class vehicles of this kind—and are proving of considerable service in the dilemma in which firms have been temporarily placed.

An example of the far-reaching effects of the present war is afforded by the fact that, as recorded in the *Newcastle Daily Chronicle*, tanners, and consequently

manufacturers of boots and all leather goods, are faced by a serious situation owing to the difficulties in obtaining tanning extracts. Last year the value of tanning extracts of all kinds imported into the United Kingdom reached 922,600*l.* Supplies from Italy have now been wholly, and from France partially, stopped, owing to the increased demand for military purposes in those countries. Quebracho wood extract, a well-known tanning material, is arriving in fair quantities from South America; but with the higher freight and insurance, and the increased demand, the price is bound to rise materially. The supply of valonia, one of the most favourite tanning materials, extracted from the acorn cups of the Turkish oak, is cut off by the entry of Turkey into the war field, and a substitute is urgently needed.

Fortunately, the British Colonies should be able to fill the gap, both South Africa and, in a lesser degree, the Commonwealth of Australia having for some years done a considerable export trade in wattle-bark, while East Africa is also now in a position to begin sending shipments. The value of wattle-bark for tanning has been sufficiently demonstrated by a series of experiments conducted at the Imperial Institute, where samples of the bark from British Colonies and of leathers tanned with it may be inspected. Wattle-bark has been used, moreover, and highly appreciated for some time in Germany, where, curiously, the bulk of the supply forwarded to Europe from the British Colonies has hitherto been ultimately sent. As a large and constant supply is available at a price which is very cheap as compared with that of valonia (which wattle-bark should be able to replace), it is to be hoped that wattle-bark will now be regularly used by British tanners. A difficulty in the way hitherto has been the absence of factories for preparing the bark extract in the country of origin, but this defect is, in the case of South Africa at all events, apparently about to be removed. It is to be hoped that British tanning extract makers will also give their attention to this side of the question.

To this note we may add that the saying, "there is nothing like leather," a saying attributed to a tanner of a past generation, will soon prove a most fallacious one, for leather is becoming every day less durable. It is to be hoped also, therefore, that steps will be taken at the same time to improve matters in this direction, so that the above saying may continue to be applicable.

A meeting of the Improvements and Buildings Committee of the Manchester Corporation was held on the 25th ult., when Mr. Alderman Royle, the deputy chairman, stated that in the last few weeks there had been submitted to the committee an unusually large number of plans for alterations and extensions of workshops. This, Mr. Royle said, the committee took as an indication that some industries of the city were benefiting from the war. The stimulus to trade, he added, came in two forms: first, the attempt on the part of local manufacturers to supply goods which formerly were imported from Germany, notably, rubber goods and dyestuffs; and in the second place, in the more direct form of War Office contracts for clothing, beds and bedding, and small goods.

Mr. W. L. Hichens, chairman of Messrs. Cammell Laird and Co., Limited, presiding over the annual meeting of the Sports Club at Sheffield on Saturday night, November 28, paid a glowing tribute to the service of the men who are working at high pressure on Government work. In alluding to the fact that something like 150 members of the Sports Club had joined the colours, Mr. Hichens observed that he supposed in any other town in the United Kingdom one might have deplored that the proportion of members who had left them was so small, but Sheffield in many things was an exception. As Lord Kitchener and Mr. Winston Churchill had said, those engaged in the manufacture of war material were helping their country more effectually by remaining behind than by going to the front. They were called upon to work long hours, and often on Sundays too. He felt particularly the importance of the work done in the shell department, although there were many other departments doing very valuable work. But it stood to reason, in a crisis like this, that unless they could produce shells as and when they were wanted, the country might suffer severely. Therefore it was a great tribute to the self-sacrifice of all of them that they were prepared to come forward and help the country in this emergency. They honoured the men who had gone on active service, and hoped to welcome them back again in good health and spirits.

The quarterly report for July, August, and September, issued by the Ship-Constructors' and Shipwrights' Association, states the following:—

"The quarter of July, August, and September, 1914, will be a memorable one in the history of the Nation and the Empire. For two months of the quarter the all-absorbing thought has been the world-wide war which has been raging with a violence, and a destruction of life and property that has never been equalled in the known history of the world. Whatever may have been said as to the causes of this terrible war at the outset, it cannot now be disputed that Germany has been making for years steady preparations for war, not only in her own territory, but secretly in others. We could not, as a State, have stood aside, and retained our respect and honour as a nation of free men and women. One thing the present war has shown is that the so-called "International Solidarity of the Workers" rests on a very slender foundation. It is evident that the Social Democrats of Germany, with their millions of votes, have had no power to prevent the catastrophe; indeed, as events have proved, and as many of us feared, the International movement would be found to be a broken reed in time of need. The Labour movement of the whole industrial classes cannot afford to stand idly by in this crisis; we have no sympathy and hardly patience with a section who, during the last few years, have persistently preached the doctrine that our country is always wrong, and who praise every nation but their own. Our country is not always right, but we are not always wrong—and on this occasion the evidence is overwhelming to show that we are right. As a nation, whether rich or poor, every citizen must make up his mind whether the Empire is worth having, and if so, it must be defended at all costs. Once and for all the spirit which has dominated German militarism must be destroyed, and rendered powerless. To this task every Britisher and member of the Empire must bend his will and energy. The war has not been of our seeking, and it will be no light or easy task successfully to overcome our powerful enemies, equipped, armed, and prepared as they have been. There is no room for the indifferent or the laggard. In some form or other everyone can help to prosecute the war to a successful issue. We cannot all be soldiers and win renown on the battlefield, but we can all help to assist those dependants who have been left behind. As an association our members have cheerfully shouldered their part of the burden, and are assisting, as far as possible, the dependants of those of our members who have joined the Colours, and, as far as can be ascertained, over a thousand from our membership are on Active Service."

CONTRACTS.—We are informed that Messrs. Simon-Carves, Limited, Manchester, the well-known coke-oven and coal-washing engineering firm, have started a new mining department to deal principally with the sinking of pits by the freezing and cementation processes. This department is under the management of a Belgian mining engineer who has had a long experience in this class of work. Messrs. Simon-Carves, Limited, have recently obtained their first contract for the sinking of two shafts. —The Electrical Engineering and Equipment Company, Limited, Bank Buildings, 109-111, New Oxford-street, W.C., state that they are executing contracts for several thousand miles of telephone cable for the French Government.

THE JUNIOR INSTITUTION OF ENGINEERS.—Mr. C. E. Ford, last Friday, read a very interesting paper to the members of the Junior Institution of Engineers on the subject of "A Model Drawing-Office System." The manufacture of small and complicated apparatus, he said, such as is met with in electric-instrument making, lent itself, by the very intricacy of the apparatus, admirably to systematical sub-division; a sub-division which is required in order to avoid waste of time and material. Since successful manufacture depended entirely upon the proper sub-division and distribution of labour, and since practice showed that the proper way to obtain accurate detailing and records was by means of systematised drawings and the complementary specifications, it necessarily followed that the drawings were one of the most important details of the system, and the starting-point from which the whole process of manufacture sprang.

PERSONAL.—Messrs. C. W. Burton, Griffiths and Co., Ludgate-square, Ludgate-hill, London, E.C., have been appointed the sole selling agents for the British Isles for the "National-Acme" multiple-spindle automatic screw machine as manufactured by the National-Acme Manufacturing Company, of Cleveland, Ohio, U.S.A., and Montreal, Canada, and will have one of these machines shortly in operation in their show-rooms.—The Electric and Ordnance Accessories Company, Limited, Chesterton-road, Aston, Birmingham, state that they have made arrangements with Messrs. T. J. Grainger and Co., Edinburgh Life Building, 21, Mosley-street, Newcastle-on-Tyne, to act as their sole agents for their electrical apparatus covering "Vickers" switch-gear, direct-current motors, lever switches, motor-control panels, controllers, mining switch-gear and motors, crane panels, fans, starters, electric-lighting accessories, porcelains, heating and cooking apparatus, &c. The area covered is Newcastle and district, including Cumberland, Northumberland, and Durham (excepting the Tees).—Mr. J. W. Restler, hitherto deputy chief engineer to the Metropolitan Water Board, has been selected to succeed the late Mr. W. B. Bryan as chief engineer at a salary of 5747*l.* per annum, inclusive of the compensation allowance of 3247*l.* to which he is entitled under the Metropolis Water Act of 1902.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, November 18.

A SPIRIT of buoyancy prevails throughout the industries, largely based on anticipations of better trade and manufacturing conditions. The source of this wave of confidence lies in the establishment of a financial and banking system which went into effect on Monday, and which releases for business purposes over 400 million dollars, and increases the borrowing and lending capacity of the banks of the country upwards of 1000 million dollars. Enterprise has been checked by various influences—inelastic currency, low tariffs, war, and general resulting despondency. The money question has now been righted, the war has resulted in a swelling volume of business, and the exhaustion of all manner of stocks of material has created a vacuum for a general demand now in sight. The steel industry has been patiently waiting for the inrush of orders that must come. The average productive capacity is about 40 per cent. Export demand for steel products is disappointingly light. Railroads cling to their over-cautious purchasing policy. Building operations calling for steel are dropping off, the active season being over. No disposition is manifest anywhere to buy or order against future probable requirements. One French order for 18,500 tons of bars has been placed at Pittsburg. Much export business is pending, but it closes slowly. The steel situation is far from what had been anticipated three months ago. Tin-plate mills continue to do a good business. Prices fluctuate slightly when a large order is in sight. General business must improve before steel can feel any benefit. Coal continues active for general purposes, but mill and furnace demand is light. Coke is fairly active. Work on the Panama Exposition Buildings is practically completed, and exhibits are rushing in.

THE GERMAN NAVY.

WE read in the September issue of the *Rivista Marittima* that it has been decided to hasten the execution of the German naval programme under the Act of 1912, which included twelve flotillas of twelve destroyers each, six flotillas of six submarines each, besides mine-laying and other ships. It has been further decided to commence immediately the construction of the ships provided for 1915—*i.e.*, three large battleships and two vedette ships. Arrangements have been made with a view to reducing the active life of ships to fifteen years. The Navy Board have been given the right of building any type they may deem necessary in the place of large units. The power of production of the German yards is such as to enable them to give a marked impulse to such new construction. The time required for the construction of a Dreadnought is longer than the probable length of the war, but the smaller units can be built more rapidly; hence, no doubt, the initiative granted the Navy Board above referred to. For example, a considerable number of submarines can be built in a short period, when the work resolves itself in the reproduction of a type actually in the service. Twelve destroyers, Nos. 37 to 48, provided for in the 1914 programme, have been ordered, half from the Germania yard, Kiel, and half from the Vulcan yard, Stettin.

The submarines provided for in the present budget are six in number. It is stated that the U 21 was the first of a new type, of which seven units are already in the service—*i.e.*, U 21 to 27. Their dimensions are said to be: length, 65 m. (213 ft.); breadth, 6.10 m. (20 ft.); whilst the boats of the preceding type have a length of only 39 m. (128 ft.). There are 27 submarines in the service. The six new boats are said to have a displacement on the surface of 900 tons, and a speed on the surface of 20 knots; the radius of action is said to be 2000 miles. They are to be armed with two types of guns, one of 88 mm. (3.5 in.) on a disappearing mounting, and one of 37 mm. (1.4 in.) on a fixed pedestal. A description of this type of gun was given in ENGINEERING, vol. xcv., page 333. It is stated that the German Navy, which now uses 500-mm. (19.685-in.) torpedoes, has designed a new type of 550 mm. (21.653 in.), having a maximum speed of 38 knots and a range of 7000 metres (3.77 miles) at an average speed of 29 knots. The speed of this new type is probably somewhat below that of the recent types of torpedoes of other navies; its charge is said to weigh from 130 kg. to 135 kg. (292 lb.).

Whilst recognising the marked advantages of liquid fuel over coal, in that it takes up 40 per cent. less space, whilst having 25 per cent. more efficiency for an equal weight consumed and reducing the number of stokers, the *Suddeutsche Zeitung*, says the *Revista*, records that Germany has decided to maintain the use of coal for firing her ships' boilers in ordinary circumstances, having recourse to liquid fuel as an adjunct when high speeds are required. The use of liquid fuel on a larger scale would render Germany dependent upon the United States or Roumania. A number of shipping and shipbuilding firms intend building at Hamburg a large Froude tank. The dimensions contemplated are as follows:—Length, 330 m. (1082 ft.), in two compartments, one 8 m. (26 ft.) wide and 6 50 m. (21 ft. 4 in.) deep, and one 16 m. (52 ft. 6 in.) wide and 7.50 m. (24 ft. 7 in.) deep. The models would be about 11 m. (36 ft.) in length, and could be propelled up to a speed of 40 km. per hour (21.6 knots). The tank is to be of reinforced concrete, and will contain 28,000 tons (6,160,000 gallons) of water.

THE LATE ADMIRAL MAHAN.

A CABLEGRAM from Washington brings notification of the death of Admiral Mahan, one of the best known of writers on naval subjects, and one who, probably more than any other, awakened the English people to a realisation of the importance of sea-power and of command of the seas. He was the son of a well-known engineer, his father—Mr. Dennis Hart Mahan—having been for over forty years a professor of engineering, civil as well as military, at West Point. Although of pure Irish blood, Mr. D. H. Mahan was born in America in 1802. His son, the distinguished naval historian and critic, was born on September 27, 1840, at West Point, on the Hudson River, and after a careful education, culminating in matriculation at Columbia College, New York, there was a struggle between father and son as to the profession to be adopted; the father desiring the son to become an engineer, but wisely leaving the final decision in the hands of his son.

Mr. Alfred Thayer Mahan therefore entered the United States Navy as an acting midshipman on September 30, 1856. He took part in the naval operations in connection with the Civil War. The work for which his name is bound to find mention in the history of naval evolution commenced in a somewhat inconsequential way. It was while at Callao, the seaport of Lima, in the early 'eighties, that he was induced to while away weary hours by accepting the hospitality of the English club, and there began in earnest his study of naval history. He has himself told the story in one of his principal works:—"I gave myself to reading, especially the Hannibalic episode. It suddenly struck me, whether by some chance phrase of the author I do not know, how different things might have been if Hannibal could have invaded Italy by sea, as the Romans had Africa, instead of by the long land route; or could he, after arrival, have been in free communication with Carthage by water." The spirit of the historical analyst must undoubtedly have been present—it was probably acquired hereditarily—and only needed this awakening to fire with enthusiasm the determination to search for full knowledge. Mahan began to write in May, 1886, and the first of his productions were delivered as lectures to the Naval War College in 1887. These were embodied in "The Influence of Sea-Power on War," the first volume of which appeared in 1890 and the second in 1892. From this time forward there flowed from his pen a series of works all having the same powerful attraction for naval and even lay readers. The "Life of Nelson: the Embodiment of the Sea-Power of Great Britain," was published in 1897, by which time Mahan had established a place of high renown amongst even English readers.

He visited England in 1894, having been appointed to the command of the Chicago in 1893, the flagship of a squadron sent to European waters, and on that occasion he was given a banquet in this country by his friends and admirers, and, moreover, was officially entertained at the Admiralty. He retired from active service in 1896, being shortly afterwards promoted to the rank of Rear-Admiral, Retired. During the war between the United States and Spain he was a member of the Board of Naval Strategy advising the United States Government, and in 1899 he served as a delegate to the Second Peace Conference at the Hague. Although he had reached the age of seventy-four years, students will naturally regret his death, as no one could have better analysed the naval incidents of the present war.

HEAVY-DUTY VERTICAL DRILLING-MACHINE.

THE illustrations on this and the opposite page show a heavy-duty vertical drilling-machine, designed by Messrs. D. and J. Tullis, Limited, Kilbowie Iron Works, Clydebank. The base-plate (Fig. 1) is a strong, well-ribbed casting, planed on both faces to allow careful setting on foundation, and having a recess to catch lubricant. The column is a heavy box casting of ample strength to withstand all strains and absorb vibration, rigidly bolted to base-plate. The tables are fixed to the base-plate, and have T slotted faces 4 ft. by 2 ft., with recess around to catch lubricant. The tables can be traversed by screw, 18 in. longitudinally and 3 ft. 6 in. transversely.

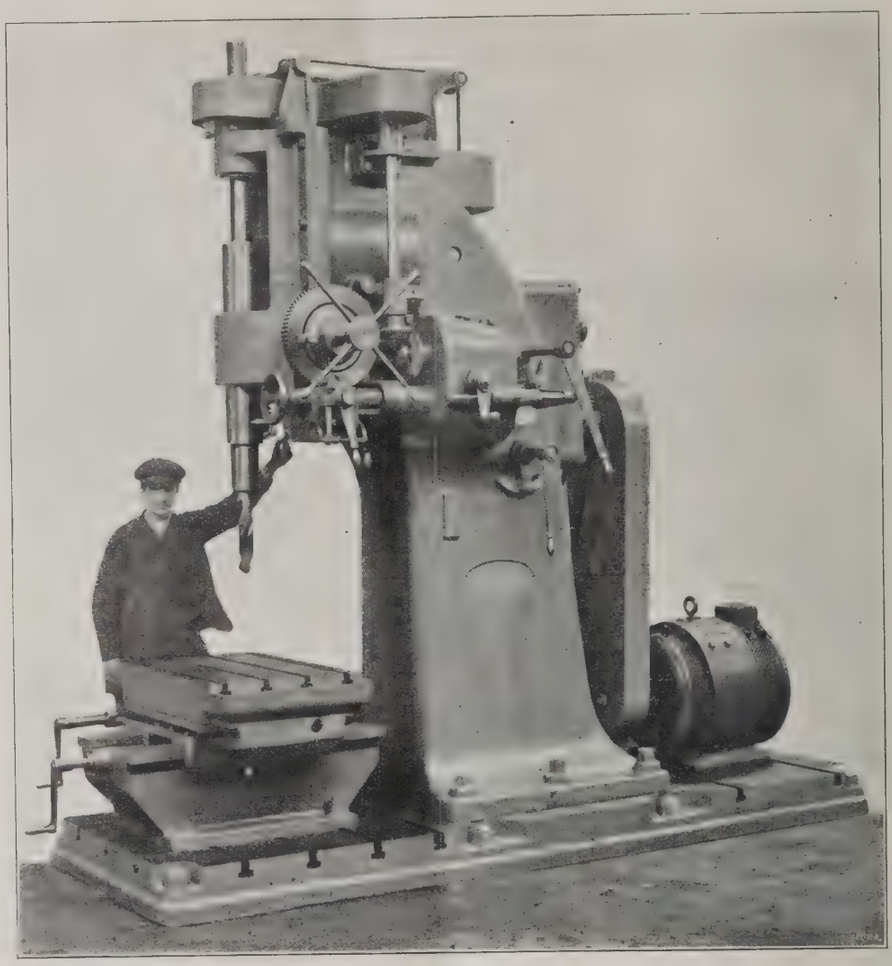
The spindle (Figs. 2 and 3) is of special crucible steel, 3¼ in. in diameter in the driving part, running in adjustable phosphor-bronze bearings, with a steel driving-wheel between the bearings, and ball-thrust washers to take the drill pressure. It has 18 in. of vertical traverse at six rates of feed, 18 to 125 cuts per inch, through a steel rack and pinion. It is carefully balanced for easy and quick adjustment by a star-wheel, and all the feed gear throughout is of steel.

The drive may be either direct from a 15-horse-power motor (Fig. 1), or from a pulley 20 in. in diameter and 6½ in. wide, running at 400 revolutions per minute (Fig. 3). The change-speed gears (Figs. 4 and 5) are of steel, case-hardened, running in an oil-box, and they provide nine speeds, whilst a double gear behind the saddle gives the complete range of 18 speeds from 16 to 400 revolutions per minute.

The machine is fitted with a pump, tank, and lubricant, with fittings for directing an ample supply to the point of the drill. All the bearings are of ample diameter and length; they are bushed with phosphor bronze, and where possible are ring-oiled. The weight is about 8¼ tons.

HEAVY-DUTY DRILLING-MACHINE.

CONSTRUCTED BY MESSRS. D. AND J. TULLIS, LIMITED, CLYDEBANK.



ECCENTRICALLY-LOADED PILLARS.

To the Editor of Engineering.

SIR,—"Enquirer's" interpretation of the stress in a pillar loaded by projecting arms at right angles (or, generally, at any angle) is correct; and is in accordance with the Act, if the word "added" is read, as it should be, in the correct mathematical sense of "taken into consideration in addition to," and as indicating the algebraic sum.

It will upon consideration be apparent that any other or more limited interpretation of the word would impute to the Legislature the manifest absurdity of requiring that the arithemetical sum of the numerical values of simultaneous stresses, which may be opposite in sense and different in direction, should be taken as their combined value. Such an absurdity is not to be lightly attributed to the Legislature; and if the algebraical sum of the stresses due to eccentric loading for any combination of projecting arms, with due regard for the sense and direction of these stresses, be taken for any point in the pillar, the result will be as obtained by "Enquirer" by taking the resultant moment of the loads acting at their centre of gravity, and applying this to the section modulus of the pillar on the line passing through the centre of gravity of the loads and the centre of inertia of the pillar.

In the case of equal loads on arms at 180 deg., or opposite to one another, the effect of the algebraic addition of equal and opposite moments is obviously nil. The obvious truth of this affords a ready illustration of the absurdity of any other interpretation of the word "added."

The ambiguity which arises from the loose drafting of the sub-section is a good illustration of the need for an expert examination of all Acts of Parliament in which the attempt is made to deal with subjects involving description in technical or scientific language. It may be to the advantage of lawyers to have the ambiguities resulting from the absence of such examination left to the settlement of the courts, but it would be greatly to the advantage of the public that they should, as far as possible, be eliminated before the passing of the Acts by an examination corresponding to that made by Speaker's Counsel in the case of unopposed Private Bills, but entrusted to practical men conversant with the subjects dealt with, and limited to reporting whether the terms used express without doubt the intention of the Act.

In this particular case the defect appears to have become apparent to the advisers of the London County Council, for in the revised Bye-Laws for Reinforced Concrete (1913), Sections 38 and 39, the term "algebraic sum" is used in relation to the like provision for eccentric loading on concrete pillars.

I have the honour to be, Sir,

Your obedient servant,

A. H. SHIELD, M. Inst. C.E.

10, Richmond-road, Ealing, W., November 27, 1914.

THE INSTITUTION OF MUNICIPAL ENGINEERS.—Mr. W. H. Matthews Jones, City Engineer and Surveyor, Chester, has been appointed President of this Institution for 1914-15.

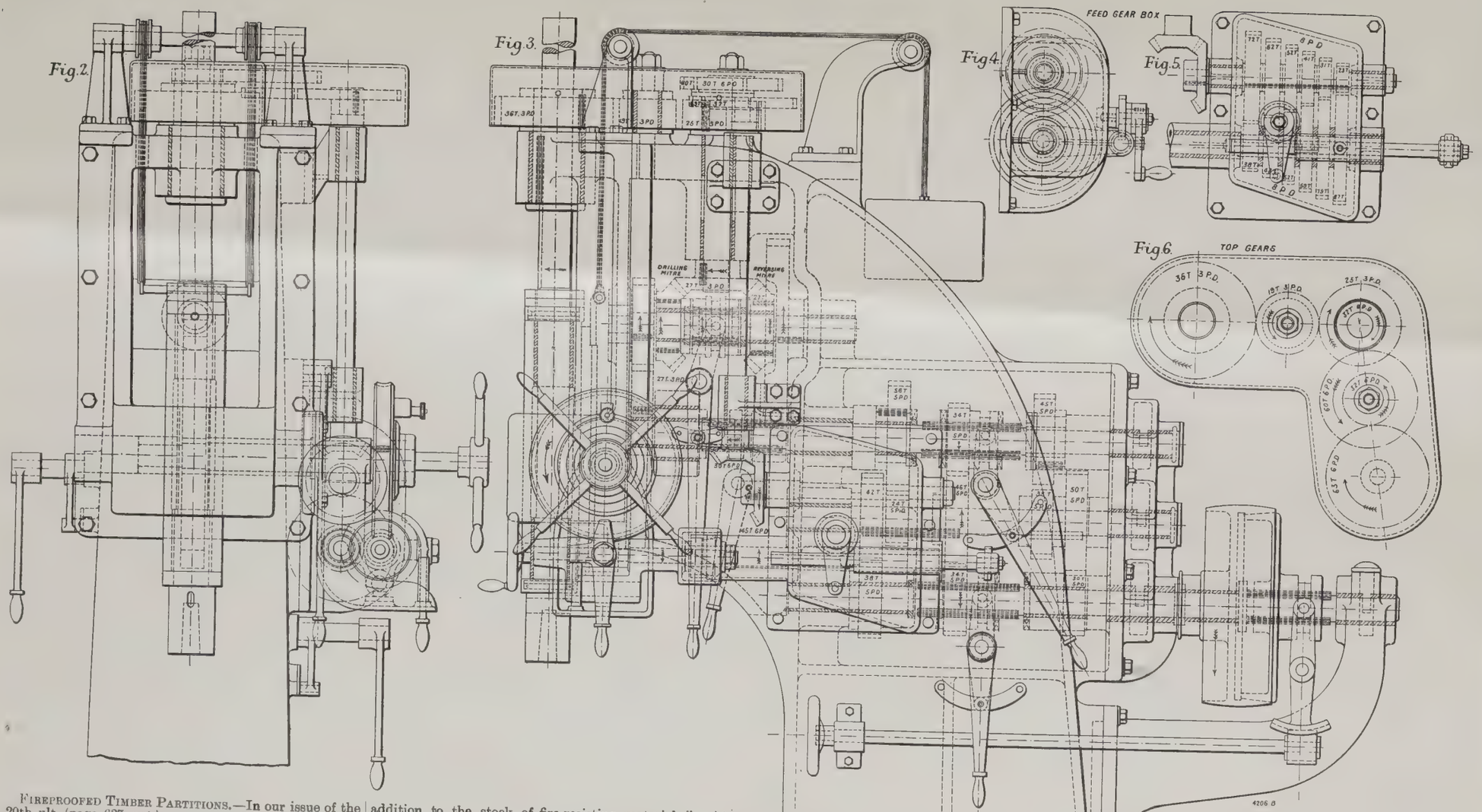
THE INSTITUTION OF MECHANICAL ENGINEERS: ERRATUM.—In our report in our last issue of the remarks of Mr. Wingfield, during the discussion on Mr. Stoney's paper, on page 635, third column, line 24, for "height" read "length."

GERMAN WAR MATERIAL.—German concerns which are engaged in the manufacture of war material proper, and other military requirements, are in many cases working day and night, as, for instance, manufacturers of enamelled cooking utensils, &c. As might be expected, the motor-car industry is exceedingly busy, and it reckons confidently upon being so after the war has come to an end. Of all the motor-cars employed in the war, but few are likely to be fit afterwards for private use, if they ever come back at all, and the immense number of horses which have been killed in the war will further enhance the demand for cars. With the German tendency to systematise everything, efforts are now being made to adopt a more uniform system within the automobile industry, with fewer and more distinct types, both as regards the cars themselves and their more important parts—wheels, for instance. The demand is expected to centre itself upon light cars, and endeavours, therefore, will no doubt be made to produce some serviceable and cheap types in this branch of the industry.

HEAVY-DUTY DRILLING-MACHINE.

CONSTRUCTED BY MESSRS. D. AND J. TULLIS, LIMITED, CLYDEBANK.

(*For Description, see opposite Page.*)



FIREPROOFED TIMBER PARTITIONS.—In our issue of the 20th ult. (page 627 *ante*) we gave a description of some tests conducted by the British Fire-Prevention Committee on a match-boarded deal partition treated with the object of making it fire-resisting. The process in question was that known as the "Oxylene" process of the Timber Fireproofing Company, Limited, Townmead-road, Fulham, S.W. This process was described in detail in ENGINEERING (vol. xcvii., page 760), and is one which is being largely adopted by British railway companies, the Admiralty, &c. Although the Committee publishes no official conclusions, the test showed that the fire resistance was considerable for wood-work, while a note by the secretary states that the process has a retardent effect on combustion and "should be a valuable addition to the stock of fire-resisting materials." At the conclusion of the severe test of 45 minutes' exposure to fire, the outer lining was still intact and remained in position. The observations showed that on the inside the wood charred after some time, but did not flame, and it is for this reason that it is claimed that it would be impossible for a conflagration to take place with material thus prepared.

NEWCASTLE CORPORATION TRAMWAYS.—The number of passengers carried over the Newcastle Corporation tramways in the six months ended September 30 was 31,043,032, showing an increase of 3,044,133 as compared with the corresponding period of 1913. The gross receipts from traffic were 136,858*l.*, showing an increase of 13,852*l.* In addition to the revenue of 136,858*l.* derived from tramway traffic properly so-called, the Town Council tramway undertaking also received during the half-year from lighting streets and buildings, 2700*l.*; from rents, 308*l.*; and from miscellaneous sources, 2200*l.*; making a total revenue for the half-year of 142,066*l.*, or 14,132*l.* more than the amount collected in the corresponding six months of 1913. The working expenses of the past half-year were 80,179*l.*, showing an increase of 6912*l.* The principal items for the past half-year were:—General expenditure, 13,576*l.*; repairs and maintenance, 15,893*l.*; power, 7434*l.*; maintenance and repair of power-station, 2174*l.*; electricity purchased for Newburn, 450*l.*; and public street-lighting, 2397*l.* The surplus for the past half-year was, accordingly, 61,887*l.*, increased to 63,540*l.* by sundry interest. Interest on sinking fund on capital account absorbed 38,870*l.* Of the profit realised on working for the past six months, 9000*l.* was applied in relief of local rates.

EXTENSIONS AT THE HACKNEY GENERATING STATION.

The electricity supply system of the Hackney Borough Council, which was first put into operation in October, 1901, has recently been the subject of important extensions. The scheme, like many others, was initially laid out for direct-current generation and distribution. The original plant had a capacity of 1800 kw., and this was extended in 1905 and 1909 by the addition of two 1500-kw. units. All these early sets were driven by reciprocating engines. In 1911 it became evident that further extension was necessary, and as the prospects of a greatly increased demand were promising, it was decided to remodel the system on more modern lines. A 6600-volt 3-phase scheme with converter sub-stations was accordingly got out by Mr. L. L. Robinson, M. Inst. C.E., the borough electrical engineer. This scheme was approved by Messrs. Preece, Cardew and Snell, and was adopted by the Council. The first part of it has been completed, and the plant is now in operation.

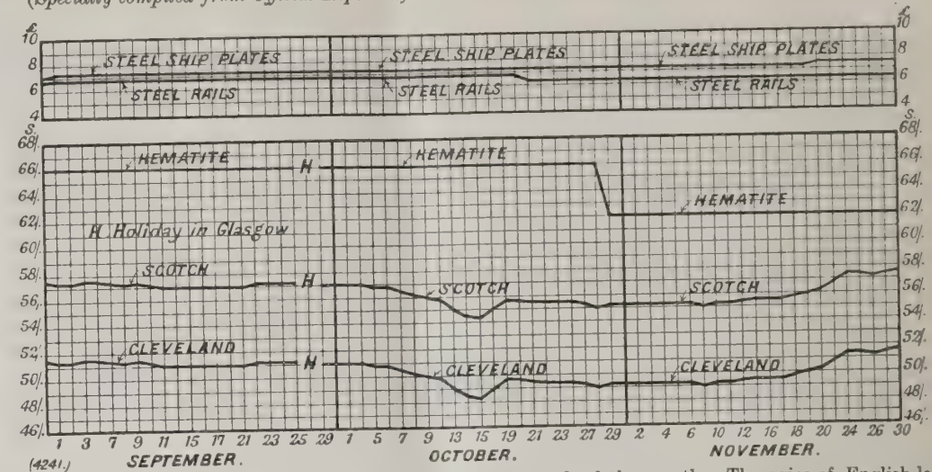
A new station has been built, which at present contains a 3000-kw. turbine unit, and a 5000-kw. set is on order. The station is capable of considerable extension, and forms the nucleus of another large generating centre for London. From the point of view of Hackney, the station is no doubt in every way justified, and will lead to lower costs, and a more rapidly growing load; but it is permissible to point out that this new high-tension scheme still further complicates the question of London's electricity supply, with which the London County Council is attempting to grapple. The proposals of this body certainly contemplate no high-tension station at Hackney, while it is difficult to see that the new 6600-volt mains, which have been laid, can play any part in the proposed standardised high-tension distribution system for the whole of Greater London. All this, of course, is no concern of the Hackney Borough Council, whose duty is to Hackney. The details of its scheme were probably settled long before outsiders knew anything of the London County Council's intentions. The matter, however, is a further illustration of the desirability of carrying through a unification scheme for London as soon as possible, if one is ever to be adopted.

It is not necessary for us to say very much of the new station. It may be described as of standard modern lay-out and construction. It is built alongside the old station on the bank of the Hackney Cut of the River Lea. This gives a good supply of condensing water, and allows of the coal being barged to the site. A coal-handling plant of the telpher type, and of a capacity of 40 tons an hour, has been installed. This lifts coal from the barges and dumps it into overhead bunkers carried above the boiler-house. The same plant also carries the ashes away. The bunkers have hopper bottoms, and feed to a travelling chute fitted with a weighing-machine. The chute can be moved along an overhead track to supply any boiler stoker. This plant was supplied by Messrs. W. J. Jenkins and Co. There are two boilers of the Babcock and Wilcox land type, each having an evaporative capacity of 33,000 lb. of water an hour, and supplying steam at 200 lb. pressure superheated to 600 deg. Fahr. They are fitted with induced-draught plant, also by Messrs. Babcock and Wilcox. The feed-pumps are by Messrs. J. P. Hall. The turbine unit is by Messrs. Willans and Robinson and the General Electric Company. It has an output of 3000 kw. at 0.85 power factor and 50 periods. The main switch-gear is by Messrs. Ferranti. In the generating-station there is also a 1500-kw. La Cour converter, forming a link between the alternating and direct-current machinery. It was supplied by Messrs. Bruce Peebles and Co.

There are three new sub-stations, each containing 1000 kw. of plant. The original station will ultimately form a fourth sub-station. The new stations are fitted with 500-kw. La Cour converters, by Messrs. Bruce Peebles. The switch-gear was supplied by Messrs. Johnson and Phillips. Between the main and sub-stations an extra high-tension ring main has been laid. It consists of British Insulated and Helsby Cable Company's cables in Key Fibre Company's conduit. The total length of conduit line is about 10,000 yards, six conduits being laid round the north half of the ring, and nine round the south. It is pointed out that when these conduits are filled, the capacity of the system can be immediately doubled by laying a set of conduits diametrically across the area. The new low-tension feeder-mains have been supplied by the British Insulated and Helsby Cables, Limited. Few new low-tension feeders will be required for many years, as the old feeders, which used to carry current from the generating station right across the area, are being cut near the sub-stations and looped in. Each old long feeder becoming three short feeders, it will be possible to work at a much higher current density, and the energy-carrying capacity of the old copper will be increased nearly sixfold. This well illustrates the value of high-tension generation and sub-station distribution.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



Note.—The London Metal Exchange reopened for normal trading on the 16th ult., so that official prices are now being quoted. We shall resume the publication of our monthly diagram of metal prices in its complete form next month, when more figures will be available.

The price of tin on the 2nd ult. was 134*l.* per ton for Straits metal and 133*l.* to 135*l.* for English ingots, the former rising to 143*l.* on the 6th ult., and falling to 138*l.* 15s.-139*l.* 5s. on the 12th. The official closing quotations for fine foreign tin, which stood at 139*l.* 15s.-140*l.* 5s. on the 16th ult., fell to 136*l.* 5s.-136*l.* 15s. on the 19th, and gradually rose again to 142*l.* 10s.-143*l.* on the 30th. Standard copper was quoted at 50*l.* per ton early in the month, and rose on the 13th to 51*l.* 12s. 6d.-51*l.* 17s. 6d. On the 16th ult. the official closing quotation was 52*l.* 15s. to 53*l.* for cash., while by the 24th the figure reached was 55*l.* 12s. 6d.-55*l.* 17s. 6d.; the price then gradually fell to 54*l.* 5s.-54*l.* 10s., which was the quotation for the 30th ult. Antimony is scarce, and during the month the price of English metal has varied between 50*l.* and 56*l.* ton. Only American spelter is on the market, and its price has risen steadily from 23*l.* 15s.-24*l.* per ton on the 2nd ult., to 25*l.* 15s.-25*l.* 17s. 6d. at the end of the month. The price of English lead rose from 18*l.* 10s. to 18*l.* 15s. per ton on the 6th ult., and stood at the latter figure until the 23rd, when a further rise to 19*l.* 10s. took place. On the 25th the price was still further increased to 19*l.* 15s., this figure being maintained until the 30th ult. Quicksilver is also very dear, its price having risen from 10*l.* 5s.-10*l.* 10s. per bottle early in the month to 11*l.* 5s. on the 10th ult., this figure remaining unaltered to the 30th. Tin plates have, however, rather declined in price during the last few days of the month. On the 2nd ult. their price was 12s. 7½d. per box of I. C. cokes, and on the 9th the price was raised to 12s. 9d. This figure, which was maintained until the 24th ult., fell to 12s. 7½d.-12s. 9d. on the 25th, and to 12s. 6d.-12s. 7½d. on the 27th.

The above diagram shows the prices of steel shipplates and heavy steel rails, which are plotted to Middlesbrough quotations, and also gives the Glasgow settlement prices for warrant iron; in both cases the prices are per ton. Each vertical line in the diagram represents a market day, and each horizontal line represents 1*l.* in the case of ship-plates and rails, and 1s. in the case of hematite, Scotch and Cleveland iron.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with a quiet tone, and 2000 tons of Cleveland warrants were done at 51s. 3½d. one month and 51s. 9d. three months. Closing sellers quoted 51s. 2d. cash, 51s. 5d. one month, and 51s. 10½d. three months. In the afternoon there was nothing doing, but Cleveland warrants were firm, with sellers quoting 51s. 4d. cash and 51s. 7d. one month. On Friday morning a strong tone again prevailed, and Cleveland warrants, amounting to 3000 tons, were put through at 51s. 6d. cash and five days, and at 51s. 8d. December 23. The close was firm, with sellers quoting 51s. 6½d. cash, 51s. 10d. one month, and 52s. 4½d. three months. The afternoon session was easier, and only one lot of Cleveland warrants changed hands at 51s. 5d. cash, with sellers over at 51s. 5½d. cash, 51s. 8½d. one month, and 52s. 3d. three months. On Monday morning the market developed strength, and Cleveland warrants advanced from 2d. to 3d. per ton. The turnover was 2000 tons at 51s. 7d. and 51s. 7½d. cash, and 52s. 3d. February 23, with closing sellers quoting 51s. 8d. cash, 51s. 11½d. one month, and 52s. 5d. three months. In the afternoon the tone continued firm, and 1500 tons of Cleveland warrants were dealt in at 51s. 11d. one month, and 52s. 4½d. three months, and sellers' closing prices were 51s. 9d. cash, 52s. one month, and 52s. 5d. three months. On Tuesday morning another rise took place in the price of Cleveland warrants, when 2500 tons changed hands at 52s. nineteen and twenty-four days, 52s. 1d. and 52s. 2d. one month, and 52s. 4½d. January 29. The session closed with sellers at 52s. cash, and 52s. 2½d. one month. The upward move made further progress in the afternoon, when 500 tons of Cleveland warrants were done at 52s. 5d. one month, with sellers over at that figure and at 52s. 1½d. cash. When the market opened to-day (Wednesday) the tone was a trifle easier and only a small business was put through, the turnover being 1000 tons of Cleveland warrants at 52s. five and nine days. The closing prices were 52s. cash, 52s. 3d. one month, and 52s. 7d. three months sellers. The afternoon session was stronger, and 2000 tons of Cleveland warrants were dealt in at 52s. cash and 52s. 8½d. three months, and closing sellers quoted 52s. 1½d. cash, 52s. 4½d. one month, and 52s. 10½d. three months.

Sulphate of Ammonia.—On the whole there has been a better demand for sulphate of ammonia during the past week, and a satisfactory inquiry is also reported. The current price for prompt delivery is about 10*l.* 17s. 6d. to 11*l.* per ton, Glasgow or Leith, and for forward parcels 11*l.* 5s. per ton is mentioned.

Scotch Steel Trade.—Considerable strength has been given to the Scotch steel trade position by the recent placing of shipbuilding orders on the Clyde, and better conditions are general. The demand for ship and boiler-plates has improved, and a fair quantity of new work has been booked, while inquiries in circulation amount to a good tonnage. One of the little troubles having to be faced at the moment is the scarcity of skilled labour, as so many of the shipyard and steel workers were army reservists, and so many others among their mates have responded to the call for King and Country, and enlisted in the Army. These men's places are difficult to fill, but quite a number of East Coast fishermen have lately found their way to some of the local steel works, and the gaps in the labourers' ranks are now getting filled up. Works with Government contracts are running night and day, and a big quantity of material is being turned out. Makers of black sheets are a bit better, but could do with more prompt orders for the heavier qualities, whereas, on the other hand, there is an excellent outlet for the lighter material. Specifications all round for immediate lots are not too numerous yet, but an early improvement is certain. The export trade is expanding very slowly, and the false war news "made in Germany," which has been circulated in many distant parts, about the early fall of Britain, has no doubt retarded business. As the truth is becoming known the overseas trade is improving, and the orders of the past week show an increase. Prices are very firm, and an early advance is not unexpected, as raw material, fuel, and on-cost charges have all increased. Ship-plates are presently called 6*l.* 15s. per ton, less 5 per cent. for local delivery and 2½ per cent. for export delivery; boiler-plates are 7*l.* per ton, less 5 per cent., and angles are round 6*l.* 12s. 6d., both for local delivery.

Malleable-Iron Trade.—The conditions in the malleable-iron trade of the West of Scotland are getting brighter, and the orders and inquiries of the past week show that there is more disposition to secure supplies while the price continues at 7*l.* 12s. 6d. per ton for "crown" bars, less the usual 5 per cent. Works are better employed, both on Government and other home orders, but the export branch is still quiet.

Scotch Pig-Iron Trade.—A much better demand for Scotch pig-iron has prevailed during the past week, showing the improvement in business, and buyers have been endeavouring to cover their requirements ahead. This has only been possible at the advanced prices now demanded, which are likely to increase still further, on account of the rise in freights. Hematite iron is also in better request by steel-makers, and the current price

is round 70s. per ton. The following are the market quotations for makers' (No. 1) iron:—Clyde, 68s ; Calder, Gartsherrie, Summerlee, and Langloan, 69s. (all shipped at Glasgow) ; Eglinton, 63s., and Glengarnock, 70s. (both at Ardrossan) ; Shotts (at Leith), 69s. ; and Carron (at Grangemouth), 70s. 6d.

Scotch Shipbuilding.—The brightest and most interesting point in connection with the shipbuilding trade at present is the good number of orders booked during the month of November. It is some time now since any one month brought in contracts for close upon thirty vessels with an aggregate of from 150,000 to 200,000 tons, and that is approximately the new business reported for the past month. It is, no doubt, the increased freights, in some cases fully 100 per cent. up, which have induced shipowners to place new orders, as well as to buy up vessels at present under construction, and as the number of contracts on hand were getting well worked off, this new business has just come along at the right time. The output from the various Scotch yards during the month of November totalled eighteen vessels, of 39,645 tons, which was less than the monthly average for the year. The figures were fifteen vessels, of 38,895 tons, for the Clyde ; one vessel, of 400 tons, for the Tay ; and two vessels, of 350 tons, for the Dee. The Clyde total brings up the output for the year, to date, to 206 vessels, of 440,764 tons, which falls a long way short of last year's magnificent total of 628,816 tons for the same period, and it may also be noted that on eight occasions since 1900 the eleven months' output has been higher than that for this year. We feel, however, that we are on the eve of a good run in trade, and shipowners realise that fact, and therefore they are preparing for the improvement in business which will follow the driving of the German army back to the Rhine.

Increased Wages in the Iron Trade.—The following intimation has been made to Messrs. James C. Bishop and James Gavin, joint secretaries of the Scottish Manufactured-Iron Trade Conciliation and Arbitration Board, by Mr. John M. MacLeod, C.A., Glasgow :—"In terms of the remit, I have examined the employers' books for September and October, 1914, and I certify the average net selling price brought out is 6*l.* 15s. 6.32d. per ton. This means an increase of 2½ per cent. in the wages of the workmen."

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The shortage of wagons previously noted is becoming more pronounced, and, as a result, producers have thought it advisable to lessen their output. The number of wagons in commission is sufficient to cover all deliveries, but delays on the railways are general. The house-coal trade continues good. Consumers in all parts of the country are taking full supplies. London has been an exception, but is now asking for average quantities. The position with regard to hard steam coal shows practically no change. Collieries manage to maintain a working week of from three to four days, and the bulk of the output is readily disposed of to home manufacturers and railway concerns. Very little is going to the ports. Prices are steady, with a stronger tendency. Another decided improvement is shown in slacks, there being quite a revival in buying from the Lancashire cotton districts. Coke shows no improvement. There is a small inquiry for blast-furnace coke at 10s. per ton on rail at the ovens. Quotations :—Best branch hand-picked, 16s. to 16s. 6d. ; Barnsley best Silkstone, 12s. to 13s. 6d. ; Derbyshire best brights, 12s. 6d. to 13s. 6d. ; Derbyshire house, 10s. 6d. to 11s. 6d. ; best large nuts, 11s. ; small nuts, 9s. to 10s. ; Yorkshire hards, 10s. to 11s. ; Derbyshire hards, 9s. 6d. to 10s. 6d. ; best slacks, 7s. to 8s. ; seconds, 4s. 9d. to 5s. 9d. ; smalls, 1s. 9d. to 2s. 9d.

Iron and Steel.—Producers of common irons have this week had less cause to complain of the flatness of the market, for both inquiries and transactions have been more numerous. Coming after a quiet period, this little spurt of business has infused fresh strength into values. Derbyshire foundry is offered at 54s., Derbyshire forge at 52s. 6d., Lincolnshire foundry at 55s. 8d., and Lincolnshire forge at 54s. In each case these figures are below the official quotations of district associations, which are still regarded as nominal. Now that the deflation of values has apparently spent itself, consumers are also coming forward more freely with contract business. The effect of outside influences on local hematite quotations has been only transitory. West-Coast sorts are stronger at 79s., and East Coast mixed numbers at 69s.—a rise in average selling prices of 6d. to 1s. Finished-iron makers maintain their basis price of 8*l.* 5s. for bars, an expansion in general business having improved the outlook. The benefit derived by them from the diversion of German trade has not reached expectations, on account of the facilities for cheaper production in competing districts, but the large amount of Government work in the district is helping to improve the appearance of order-books, especially as regards the requirements of horse-shoe makers. The steel trades are making satisfactory headway, and while "boom" conditions are confined to departments dealing with Army and Navy work, marked expansion is shown in general business with both home and overseas customers. If the expansion is sustained, and as many men continue to be engaged on armament work, the labour shortage is likely to become a very serious problem. One of the most striking features of local trade is the resolute manner in which manufacturers are endeavouring to eliminate suggestions of their past reliance upon Germany. This week the Sheffield Chamber of Commerce has decided to communicate with the Associations of Saw-Makers and Tool-Makers, urging upon them the advisability of taking this opportunity of discarding the use of the word "German" in relation to steel tools. At the moment steel tools are in enormous demand, not only by the British Government and home engineers, but by the Governments of Allied nations, and particularly by Russia. The activity of shipbuilding yards is providing plenty of work in heavy forgings and castings. Respecting trade in steel billets, the pressure on acid sorts is unrelieved, but basic sorts are easier. Hard basic billets are quoted at 6*l.* 10s., and soft at 6*l.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—A good deal of business has been done in pig-iron, and values of Cleveland kinds are realising higher prices than have been obtainable since the latter part of August. That there is confidence in the future is indicated by the fact that traders show disposition to enter into contracts on forward account at above current quotations. Speculative operations in Middlesbrough warrants have assisted materially to advance prices, but the rise is also due to genuine improved demand. Many home consumers of pig-iron have been running on low stocks, and they are now negotiating to arrange supplies over periods next year. No. 3 g.m.b. Cleveland pig is 52s. 3d. f.o.b., whilst No. 1 has become 54s. 6d. ; No. 4 foundry, 51s. 9d. ; No. 4 forge, 51s. 3d. ; and mottled and white iron, each 50s. 9d.—all for early delivery, 6d. above these rates being named on forward account. Buyers of East Coast hematite pig have been in evidence, and they now offer freely 65s. for this year's delivery of Nos. 1, 2, and 3. Substantial business has occurred at that price, and possibly second-hand, and some makers would still accept it, but most producers have sold as much as they care to at the foregoing quotation, and will not now name under 66s., whilst some firms put the price at 67s. 6d. Values of foreign ore are most difficult to fix. The state of the freight market has altogether upset business. Steamers can hardly be fixed at any price, and up to 8s. 6d. is asked for Bilbao-Middlesbrough. Nominally market quotations for imported ore are on a minimum basis of 20s. ex-ship Tees for Rubio of 50 per cent. quality, but many sellers absolutely refuse to quote, pointing out that the f.o.b. price at Bilbao is 12s. 6d., and consequently they cannot do business at anything like 20s. here. Coke is steady and firm, and in fairly good request for local consumption. Buyers are less reluctant to pay the prices asked. Durham beehive blast-furnace coke of average quality, delivered at Tees-side works, is 17s. 6d. There is still a good deal of comparatively cheap Yorkshire coke on the market.

Stocks and Shipments.—Stocks of Cleveland pig-iron in the public warrant stores now stand at 105,291 tons. During the month of November 1433 tons of iron were sent into the stores. There are warrants in circulation for 92,700 tons of No. 3 Cleveland pig. Shipments of iron and steel from the Tees during the month of November showed a slight improvement on those of the previous month, but they fell considerably below those of November a year ago. They averaged 2640 tons per working day, the total loadings being returned at 66,013 tons, 60,098 tons of which went from Middlesbrough, and 5915 tons from Skinningrove. In the previous month the clearances amounted to 56,406 tons, or a daily average of 2256 tons, and for the month of November a year ago the despatches were given at 93,413 tons, or an average of 3736 tons per working day. All the iron cleared at Skinningrove went to Scotland. Of the pig-iron loaded at Middlesbrough, 42,087 tons went abroad, and 18,011 tons coastwise. Italy was the largest buyer with 14,575 tons, and Sweden second with 11,277 tons. Scotland, for some months past the largest customer, received only 9595 tons, whilst Japan took 6348 tons ; Wales, 5290 tons ; Denmark, 2825 tons ; and Holland, 2610 tons. Tees loadings of manufactured iron during the month of November were given at 15,935 tons, 9706 tons of which went foreign and 6229 tons coastwise, and those of steel reached 39,974 tons, of which 34,004 tons went abroad, and 5970 tons to home customers. The Argentine was the largest buyer of manufactured iron, importing 5732 tons, whilst India received 3322 tons. Of steel, India took 9658 tons ; South Australia, 8996 tons ; New South Wales, 3495 tons ; and Victoria, 3323 tons.

Manufactured Iron and Steel. — Very satisfactory accounts are given of all branches of the manufactured iron and steel trades. Works are kept busy, and some producers are being pressed for delivery. Prices all round are firm. Principal market quotations stand :—Common iron bars, 8*l.* ; best bars, 8*l.* 7s. 6d. ; best best bars, 8*l.* 15s. ; packing iron, 6*l.* 5s. ; iron ship-plates, 7*l.* 5s. ; iron ship-angles, 8*l.* ; iron ship-rivets, 8*l.* 7s. 6d. ; iron girder-plates, 7*l.* 5s. ; steel bars (basic), 7*l.* 10s. ; steel bars (Siemens), 7*l.* 15s. ; steel ship-plates, 7*l.* 10s. ; steel ship-angles, 7*l.* 5s. ; steel boiler-plates, 8*l.* 5s. ; steel strip, 7*l.* 5s. ; steel hoops, 8*l.* ; steel joists, 7*l.* 2s. 6d. ; cast-iron columns, 7*l.* 7s. 6d. ; cast-iron railway chairs, 4*l.* 5s. ; light iron rails, 7*l.* 15s. ; heavy steel rails, 6*l.* 7s. 6d. ; steel railway sleepers, 7*l.*—railway material net at works, and all other descriptions less 2½ per cent. discount ; galvanised corrugated sheets, 24 gauge, in bundles, 14*l.* f.o.b.—less 4 per cent.

Finished Iron-Trade Wages.—The accountants to the Board of Conciliation and Arbitration for the manufactured iron and steel trade of the North of England, in their report for the two months ending October 31 last, announce that, in accordance with the sliding-scale arrangement, there will be an advance of 3d. per ton on puddling and 2½ per cent. on all other forge and mill wages, to take effect from the 1st inst. The average net selling price of manufactured iron for the past two months was certified at 6*l.* 19s. 0.56d. per ton, against 6*l.* 14s. 2.15d. in the previous two months.

Northern Shipbuilding Orders.—Several orders for cargo-steamers have recently been placed in the North. Messrs. Hall Brothers, of Newcastle, have contracted with the Sunderland Shipbuilding Company for a large tramp, and Messrs. Wood, Stanner and Co., Bill Quay, have received an order for two large colliers from Messrs. Burnett and Co., of Newcastle. A Sunderland firm has secured the order from Messrs. Wilhelmsen and Co., of Tonsberg, for two large steamers. Orders for three cargo-boats for Cardiff owners have also been placed at Sunderland yards.

NOTES FROM THE SOUTH-WEST.

Cardiff.—Large steams have continued easy for prompt loading, but smalls, being scarce, have shown firmness. Colliery owners are looking for improved tonnage arrivals during the next few days, with heavier shipments and more regular working at pits. In addition to numerous steamers which have been chartered lately, vessels which have been delayed by stormy weather are now due. The firmness of smalls is due to reduced production, especially as regards bunker descriptions. The best Admiralty large has made 20s. to 22s. ; best secondary qualities, 18s. to 19s. ; other secondary descriptions, 17s. to 17s. 6d. ; best bunker smalls, 10s. to 10s. 6d. ; and cargo smalls, 5s. 6d. to 7s. 6d. per ton. Best household coal has made 19s. to 20s. ; good households have realised 17s. to 18s. ; No. 2 Rhondda large has been priced at 12s. 6d. to 14s. ; and No. 2 smalls have brought 6s. 6d. to 7s. 6d. per ton. Patent fuel has been quoted at 16s. 6d. to 17s. 6d. per ton. Special foundry coke has made 27s. to 30s. ; good foundry coke, 20s. to 24s. ; and furnace coke, 17s. 6d. to 18s. 6d. per ton. As regards iron ore, Rubio has realised 19s. to 20s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Rhymney Iron Company. — The directors of the Rhymney Iron Company, Limited, report that the output of coal from the company's pits for the half-year ending September 30 was 561,137 tons, as compared with 661,214 tons in the corresponding six months of 1913. Coke was produced to the extent of 22,422 tons, as compared with 24,695 tons. The considerable decrease in the output of coal was due principally to an inadequate supply of labour. The shortage of men was materially increased from the commencement of August, when Reservists and Territorials were called up for military duty, and the difficulty has since become more acute in consequence of a large number of men having joined the Army. The result of the declarations of hostilities was completely to disorganise business for the time being, and to cause the working of the company's collieries during the latter part of the half-year to be unremunerative. No interim dividend is proposed.

Tin-Plate Shipments.—The tin-plate interest considers that it is possible that certain licences may be granted for shipments to recently-prohibited countries—Sweden, Holland, and Denmark. Applications for permits for special consignments are being made, not only by manufacturers, but by individual merchants. Before any permits are issued, official inquiries are to be made as to destinations and consignees, and the applications will then be considered by a committee of the Treasury.

Newport.—Large descriptions of coal have been easy for prompt shipment, and smalls have shown firmness. Best Newport Black Vein large has made 16s. to 16s. 9d. per ton. Western Valleys have been quoted at 15s. 9d. to 16s. 3d. ; and Eastern Valleys at 15s. 6d. to 15s. 9d. per ton.

Welsh Collieries.—The shareholders in the United National Collieries, Limited, and Burnyeat, Brown and Co., Limited, have received proposals for the amalgamation of the two undertakings. Both companies have collieries in Monmouthshire and the Rhondda Valley. Last year the United National Collieries paid a dividend of 17½ per cent., and Burnyeat, Brown and Co. divided at the rate of 25 per cent., plus a bonus of 50 per cent. In August this year the United National Collieries acquired the Standard Collieries in the Rhondda, and the combined output of the three amalgamated concerns would be one of the most important in Wales.

ENGINEERING GOODS FOR AUSTRALIA.—Mr. G. T. Milne, H.M. Trade Commissioner, at 81, Pitt-street, Sydney, desires us to state that for the purposes of reference he would be glad to receive catalogues of engineering firms. Duplicates should be sent to the Trade Commissioner at Melbourne.

THE AUSTRO-HUNGARIAN NAVY.—We read in the *Revista Marittima* that the time provided for the construction by the Stabilimento Technico Triestino of the new 24,500-ton battleships is only thirty months. According to a table given in another part of the same review these battleships are two in number, marked "VIII." and "IX." ; one was commenced in August last, and the other last October. They are each to be armed with ten 350-mm. (13.8-in.) guns, fourteen 150-mm. (5.9-in.) guns, twenty 90-mm. (3.5-in.) guns, and four or six torpedo tubes. The 1914 naval programme provides for two further 24,500-ton battleships, marked "X." and "XI.," to be commenced in 1915, and completed in 1917. A contract has been given to the Skoda Works, Pilsen, for the construction of forty 350-mm. guns, sixty 150-mm., and a number of small-calibre guns. The 18,000 tons of armour required will be supplied by the Witkowitz Works.

DETAILS OF 2-8-8-8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD.

CONSTRUCTED BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA., U.S.A.

(*For Description, see Page* 682.)

Fig. 81. Front Articulated Section.

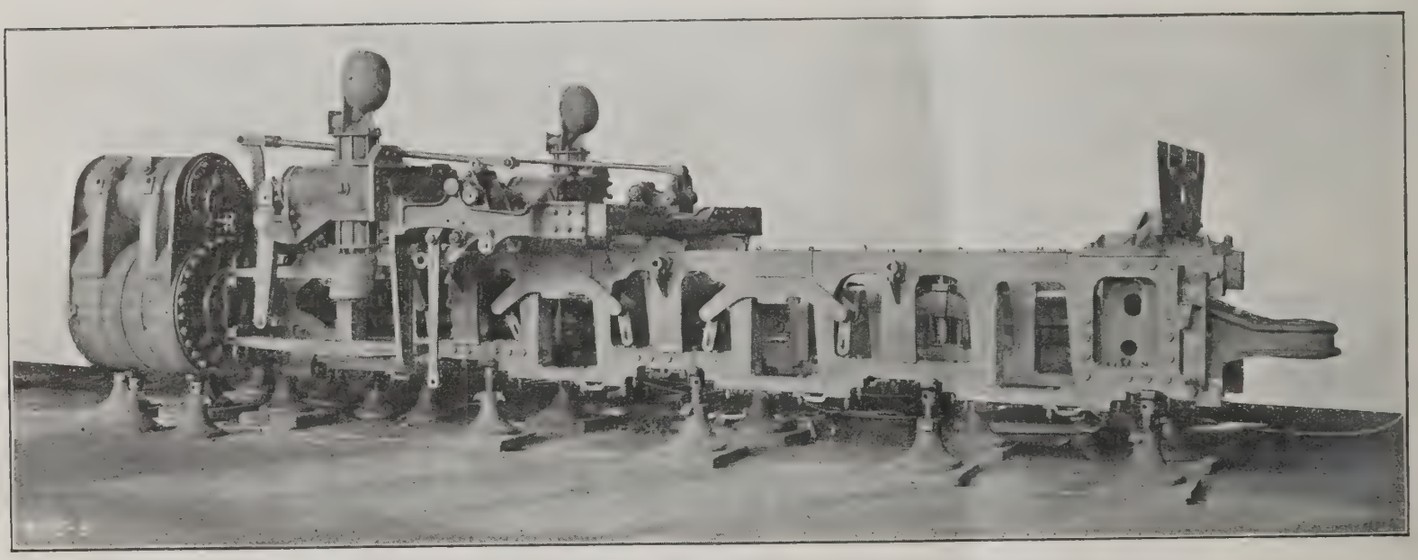


Fig. 82 Central Section showing Rear Articulation.

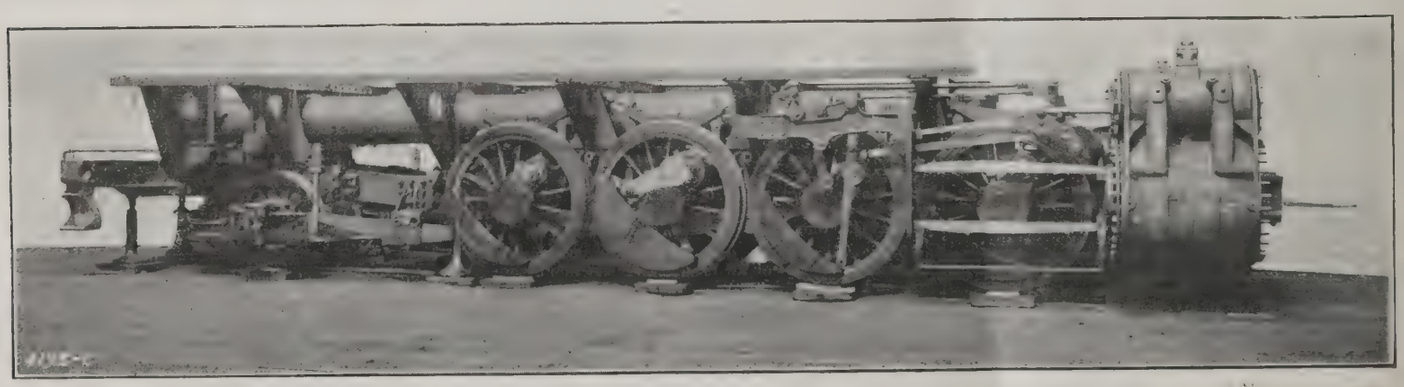


Fig. 83. Rear or Tender Section.

Electric Supply in Copenhagen. — The city of Copenhagen is about to erect a large new electric central station near the Kallebodstrand waterway. The final plan has somewhat reduced the costs, which are now put at about 275,000*l.*

Royal Technical College, Glasgow.—We have recently received from this College a copy of the annual report for the 1913-14 session, which was the 118th session of the College. The numbers of day and evening students enrolled were 660 and 4342 respectively, both of which numbers are greater than the corresponding figures for the previous session. An even more satisfactory feature is, however, the great expansion in "student hours," which for the day classes have increased by over 15 per cent. The governors had intended to increase the staff in all the main departments in order to provide further facilities for higher studies and research work, but the outbreak of the war has led to the postponement of their plans. A considerable section of both staff and students were connected with the Officers' Training Corps and Territorials, and a large number, many of whom received commissions, have been called up for service. In spite of the vacancies thus caused, it is intended to carry on the work of all departments of the College as usual. The department of mining and geology has been sub-divided, and Mr. E. J. Edwards, M.Sc., F.R.G.S., has been appointed to an independent lectureship in Economic Geology. Numerous changes of a temporary nature have been made in other departments. A new 5-in. centrifugal pump has been presented to the engineering department, and a central exhaust cylinder, interchangeable with the existing high-pressure cylinder, has been added to the large horizontal engine. The large plant for the treatment of sugar-juice is now in working order. The report refers to the works and papers published by past and present members of the College, and also includes a financial statement. Lists of distinctions gained by students during the session, and other particulars of the students and their work, are given in a number of appendices to the report.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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Thick "	£1	16	0 ($8.75)
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Thin paper copies	£1	16	0
Thick "	£2	0	6

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Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

READING-CASES.—Reading-cases which will hold twenty-six numbers of "ENGINEERING" may be had of the Publisher or of any newsagent. Price 6s. each.

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With a Two-Page Plate of DETAILS OF ARTICULATED 2-8-8-8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—The "Thomas Hawksley" Lecture. Mr. B. W. Bryan, Member, Chief Engineer of the South Essex Water Works, will deliver the above lecture (prepared by his father, the late Mr. William B. Bryan), on "Pumping and other Machinery for Water Works and Drainage," as follows:—London, at the Institution, on Friday, December 4, at 8 p.m.; Manchester, in the Portico Library, Mosley-street, on Tuesday, December 8, at 8 p.m.; Birmingham, in the Medical Lecture Theatre of the University, Edmund-street, on Thursday, December 10, at 7.45 p.m.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, December 4, at 39, Victoria-street, Westminster, S.W., at 8 p.m. Mr. S. E. Hutson, on "A Reversible Turbine."

THE BRITISH FOUNDRYMEN'S ASSOCIATION: LANCASHIRE BRANCH.—Saturday, December 5, at 4 p.m., in the Municipal School of Technology, Manchester. A paper will be given by Mr. F. J. Cook, of Birmingham, entitled "Carbon in Cast Iron."

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Monday, December 7. General meeting of the members at 5 o'clock.

THE ROYAL SOCIETY OF ARTS.—Monday, December 7, at 8 p.m. Cantor Lecture: "The History and Practice of the Art of Printing," by Mr. R. A. Peddie (Lecture III.). Wednesday, December 9, at 8 p.m. "Domestic Metal Work of the Eighteenth Century," by Mr. William A. Young. William Gowland, F.R.S., F.I.C., F.S.A., Professor of Metallurgy at the Imperial College of Science and Technology, will preside.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH LOCAL SECTION.—Tuesday, December 8, at the Rooms, 207, Bath-street, Glasgow, at 8 p.m. Paper on "The Magnetisation of Iron at High Flux Density with Alternating Currents," by Mr. J. S. Nicholson, B.Sc., Associate Member.

THE ROYAL SANITARY INSTITUTE.—Tuesday, December 8, at 7.30 p.m. Discussion on "Preventive Inoculation," to be opened by Professor G. Sims Woodhead, M.D., F.R.C.P., F.R.S. Edin. The chair will be taken by Sir Shirley F. Murphy, F.R.C.S.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, December 9, at 8 p.m., at St. Bride's Institute, Bride-lane, Fleet-street, E.C. A paper will be read by Mr. Frank Broadbent, M.I.E.E., on "Electricity in the Printing Office." Mr. R. W. Weekes, A.M. Inst. C.E., M.I.E.E., in the chair.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, December 9, at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W., at 8 p.m. A paper will be read, entitled "Benzol, Alcohol, and Mixtures of these Liquids with Petrol as Fuels for Internal-Combustion Engines," by Professor W. Watson, D.Sc., F.R.S., assisted by Messrs. C. W. Frost, W. C. Lloyd, F. W. Richards, W. J. Stern, and H. Shaw.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 10, at 8 p.m. A paper on "Automatic Protective Switch-Gear for Alternating-Current Systems" will be read by Mr. E. B. Wedmore, Member.

THE INSTITUTION OF WATER ENGINEERS.—Friday and (if necessary) Saturday, December 11 and 12, at the Apartments of the Geological Society, Burlington House, W. Proceedings will commence at 2 p.m. on Friday and 11 a.m. on Saturday. The following papers will be read and discussed:—(1) "Notes on Scraping a 15-in. Trunk Main at Batley," by Mr. J. C. Barrowclough, Water-Works Engineer; (2) "The Whitton Pumping-Station of the Ipswich Corporation Water Works," by Mr. C. W. S. Oldham, Corporation Water Engineer.

ENGINEERING.

FRIDAY, DECEMBER 4, 1914.

THE INFLUENCE OF BANKS ON INDUSTRY.

DURING the last three months all financial methods have been subject to startling changes, and old-established precedents have been swept away one after the other until the entire financial world wears quite a new aspect. The outbreak of war caused a total collapse of the whole financial system, with the result that a complete paralysis of the trade of the country immediately followed, and despite all the efforts which have been made and the remedies applied, the recovery of trade is still only progressing very slowly, save, of course, in those industries which are closely connected with the war.

Under these circumstances, it is a matter of great importance to ascertain what financial facilities will be afforded to traders in order that they may continue to carry on their business as nearly as possible to the same extent as at the beginning of the war, and in this respect the influence that banks will have upon industry is undoubtedly a most material factor. It will be admitted that the Government has shown great discernment and enterprise both in the measures it adopted in the crisis and the manner in which it obtained the advice on which it acted; but it is obvious that all these measures with few exceptions can only be temporary expedients, and it is hoped that the necessity for their continuance may speedily vanish, and trade again resume its normal course.

Now that the crisis is passing away, it can be seen that conditions are very favourable for the resumption of the trade of this country. The magnificent response to the war loan has shown the enormous strength of the capital reserves, the credit of the country is still unimpeachable, our resources embrace the products of all the countries of the world, and we are still able to import and export and also to manufacture almost as if no state of war existed. Further, the international money market is still domiciled in London in spite of all difficulties, while internally we have a highly-developed banking system, and a cheap and elastic currency, thanks to the extensive use of cheques and the successful introduction of notes of small denomination.

It is well known, however, that for years past, owing to the supineness of the nation, we have allowed other countries to enter into competition with us, which grew stronger and stronger, until eventually they captured large markets from us, and their commercial rivalry was beginning to be very severely felt. Although now our largest competitor has been for the time eliminated, it is certainly imperative for us immediately to take steps to seize the opportunity offered, and by all means in our power endeavour to recapture the trade that has been taken from us. One of the principal ways by which our competitors have been enabled to undersell and drive out English goods has been by taking full advantage of the great financial facilities afforded to traders by the great foreign banks, who have certainly elevated trade finance to a science, and constant complaints have been made that the English banking system was much out of date, and far behind that adopted by foreign countries, who were able to stimulate and encourage the commerce of their countries to the highest degree by their methods. It is true that these methods largely fostered over-production, but the effect of this evil was infinitesimal compared with the benefits derived by the country as a whole.

Until a comparatively recent period similar conditions prevailed here, although, perhaps, not so highly developed, and the tremendous expansion of English trade was greatly helped by the fact that the local and provincial banks were able to assist and encourage traders and manufacturers by reason of their intimate knowledge of their customers and their resources. But the passing of the Joint Stock Acts, together with several disastrous bank failures, decided the fate of private banks. Impersonal transactions were substituted for personal relations, and these transactions were magnified into figures far too large to be undertaken by the banks with their moderate capital.

With the growth of joint-stock banking, it was, and still is, held by traders very strongly that the English banks are much too conservative in their administration, that they have become hidebound in their methods and do not move sufficiently with the times. Many of the exigencies of modern trade do not come within their purview at all, and the facilitating of trade is completely subordinated to the question of the safety of the banks, all of which facts are undoubtedly a great hindrance and discouragement to the trade of this country, and already have had the effect of seriously endangering our supremacy.

One of the most frequent complaints made by traders against the banks of this country was that too large a proportion of their deposits was used in support of the money market to bolster up the Stock Exchange and in financing foreign-bill transactions, and there is much truth in this complaint. It has been established on the highest authority that bankers' loans to the Stock Exchange reach the enormous total of 80,000,000*l.*, a large portion of which amount, it must be remembered, will practically be locked up until the end of the war under the arrangements recently made. Again, owing to the tremendous activity in new issues that had recently taken place, large amounts had been sunk in these stocks owing to the general public not being able to absorb them, and consequently the banks, as underwriters, had had to take them up, thus rendering another large amount unavailable for the benefit of trade.

The complete breakdown of the foreign exchanges immediately war broke out was very significant of the fact that, instead of being founded on genuine trade relations, as they should have been, there had been tremendous speculation in foreign exchange, and large sums that could have been used in trade to much greater advantage to the country had been employed in these speculations.

Another serious drawback to traders is the rigid rule among English banks that all applications for advances must be accompanied by the deposit of sufficient "approved" security to provide a substantial margin over and above the amount of the advance. The interpretation of the word "approved" is most rigid, and the security which is passed as approved may always be considered as gilt-edged. Now this rule, of course, presses very hardly upon the trader who has sunk all his capital

and personality into his business, and who would benefit largely if he could obtain reasonable advances to enable him to provide for his seasonal trade.

Finally comes the most constant and growing complaint that English banks have no elasticity, and that their administration is simply a huge machine. This defect has been admitted by the banks themselves, and tentative efforts have been made to obviate this difficulty; but the aggregations of capital and power have attained to such enormous dimensions that the play of personality has been entirely prevented, and individuality crushed.

These great faults, which indisputably exist, have handicapped the English traders in a large degree, but now that trade is slowly recovering and re-establishing itself, and the financial system is being recast, it is certainly the opportunity to so amend matters that facilities may be obtained which will stimulate and encourage trade and possess sufficient elasticity to allow the smallest trader to obtain as fully as possible the benefits desired, and also to enable the largest transaction to be successfully and completely carried out.

The main lines which such amendments should take can certainly be indicated without much difficulty, and these would naturally be extended or curtailed as experience showed or caution dictated. But the first essential is that an institution be established whose whole resources should be devoted to the financing and assistance of trade. The methods of making advances should be so widened that assistance could be given to traders on the security of their business, by which is meant the whole of the assets of the business, including goodwill, book debts, and plant. The discounting of long-dated bills of exchange should also be undertaken, for by reason of a bill being based upon actual value, and the support of its endorsements in addition, it certainly constitutes a very good security. Arrangements should also be provided whereby advances could be made against orders in hand, and every facility for assisting traders should be within the scope of the proposed institution, including power to refer proposals to establish business to technical committees appointed by the bank, and upon their favourable report, after consideration of all the circumstances, to make advances to establish the business, to subscribe capital, and appoint a representative of the bank upon the board of the company created under these conditions.

A great recommendation for this innovation is that the bank, and therefore the financial world, would be brought into more harmonious relations with traders, and would, by reason of the knowledge thereby obtained as to the conditions governing trade, be able to give much more effective assistance when required. There is no doubt that a new class of bank founded on the lines set out above would assist commerce in a wonderful degree, and thus enable the country to replace in some measure the enormous waste of capital now necessary, and in this way materially assist in bringing the war to a successful termination; but the great difficulty is to discover the best method of establishment. It was felt that the present banks would be most suitable agents for the economical establishment of such an institution, as their machinery would be invaluable; but they were not prepared for such a development, and, when asked, refused to provide the facilities requested. Of course, industrial banks could be founded with the ordinary joint-stock company procedure, and if sufficient reserve capital were provided for, they would undoubtedly flourish. But a better scheme, in view of the urgency of the case, would be to follow the precedent recently set by the Government for the encouragement of the dyeing industry, and that is, to establish an industrial bank under the Joint-Stock Acts with a large proportion of the capital subscribed by the traders of the country, and then for the Government to subscribe for the remainder of the capital and guarantee a moderate interest on the share capital for a term of years. Under these conditions there is no doubt that capital would be easily obtained, for it must be remembered that there is a large reservoir of capital that has been slowly accumulating ever since the war began, owing to the fact that its investment has been stopped by reason of the closing of the Stock Exchange and the difficulties and dangers of investing money abroad.

As it is computed that the amount of English capital invested abroad reaches the tremendous total of about 10,000,000*l.* weekly, it will be seen that from this source alone there is an ample supply of capital available, and it would certainly be readily invested in a company formed under the ægis of the British Government.

Admitting, therefore, that a case has been made out for the provision of fuller facilities for the financing of trade, it is felt that if the suggestions mentioned above can be carried out without delay, the difficulties of the present time will be greatly minimised, and the trade of this country will eventually increase to even greater figures than it has ever touched before, for it was by such means that the trade of foreign countries was so greatly fostered.

POWER-PLANT TESTING.

The bonus and penalty clauses which are so often found in specifications for prime movers, particularly in those relating to electrical generating units, are in every way just in intention. A machine using 0.5 lb., or whatever it may be, less steam than was contracted for may well be worth its bonus. Contrariwise, a machine falling below the specified consumption may well deserve its penalty. These things are well known, and the bonuses and penalties are usually substantial enough to make their operation worth the serious attention of contractors. As a rule, the bonus for an improvement in consumption of, say, 0.5 lb. of steam will not, by a long way, equal the capitalised value of the resulting saving; but if the sum at issue is large enough to make the contractor supply the best machine he is capable of building for the money he is likely to get, the object of the buyer will be achieved.

The value of improved consumption in power-stations having a high load factor is so great that it might fairly be suggested that considerably higher bonuses and penalties than are now usual might be employed, with the idea of inducing builders to attempt to put forward still better machines. If, however, one is going to do this, or even if one is merely going to retain present practice, it is clear that, in fairness to both buyer and seller, the tests by which the consumptions are determined should be carried out with great care. This statement will be generally assented to, but it is doubtful if the logical consequences of that assent are altogether generally realised. Bonuses and penalties are often given and imposed in terms of consumption of one-tenth of a pound of steam per kilowatt-hour, which, in a turbine using 13.5 lb. of steam, is 0.74 per cent. of the consumption. Clearly, therefore, in fairness to both sides, the tests on which the money payments depend should aim at an accuracy also within 0.74 per cent. It is probably impossible to obtain such an accuracy in practice, but that is no reason for being satisfied with one of 4 or 5 per cent., which it is to be feared is often the sort of thing met with. When one finds an engineer, with special experience in this matter, stating that he has known of a case in which it was proposed to reject a turbine plant on results obtained by using the mean reading of three electricity meters which differed 7 per cent. among themselves, it is clear that in some quarters, to put it mildly, the importance of accuracy in these tests is not properly appreciated.

This 7 per cent. story was told by Mr. W. M. Selvey, in a paper read before the Institution of Electrical Engineers on the 26th ult. Mr. Selvey's subject was that of this article, and his general case was the one we have attempted to make above. To point his moral, he took a numerical example. Dealing only in round and approximate figures, he considered a turbo-alternator having a maximum continuous load of 10,000 kw., and a most economical load of 7500 kw., used on a system where, on the average, it was loaded to 7500 kw. for 8000 hours a year. It would thus generate 60,000,000 kilowatt-hours per annum, and a variation of 1 per cent. on this output, taking coal at 0.15d. a unit, would be equivalent to 375*l.* a year. Mr. Selvey assumed eight years' life in which the machine should be written off, and capitalising the 375*l.*, obtained 3000*l.* He then considered two competing machines, one with a steam consumption of 12.5 lb. per kilowatt-hour, and the other with a consumption of 11.5 lb.—that is, 8 per cent. better than the first. Then if the 12.5-lb. machine was offered at 25,000*l.*, the other would be worth 24,000*l.* more, although it would cost only some 2000*l.* or 3000*l.* more to manufacture. Some of the detail figures of this calculation may be questioned, such as the coal cost of 0.15d. per unit, which is low for common practice; but the general lesson of the example is clear enough. It shows the monetary value of small differences in consumption and the necessity, with a good load factor, of aiming at the best. It also shows how much may depend on the last half pound of steam and makes it clear how important is the greatest possible accuracy in the tests.

As Mr. Selvey pointed out, if the last few tenths of a pound off the consumption are worth so much, it is clearly to the buyer's interest to spend, if necessary, considerable sums on the tests to make sure that he is really getting those last few tenths. In many cases, of course, the testing is very carefully carried out, but it is permissible to doubt if Mr. Selvey's ideal of an accuracy within 1 per cent. is often attained. He did not suggest that this 1 per cent. was possible, but thought it should always be aimed at. To get this 1 per cent. he considered each individual measurement should aim at an accuracy of 0.1 per cent. Put in this way, it is pretty evident that the people who are carrying out the test should know what they are doing. To get anywhere near 0.1 per cent. in all their measurements they must be experts, and much is to be said for Mr. Selvey's idea that, if possible, the work should be carried out by people who make it peculiarly their business. This is already done to some extent, but frequently the work is carried out by the consulting engineer's staff, or even by the contractor's men. The former method may be satisfactory, but hardly the latter. The contractor's engineers may be competent enough, but to set them to test their own plant on the customer's behalf is to put them in a false position. It is in no way necessary to suggest that they will fake the results—cook the superheat reading, use an incorrect vacuum gauge, and afterwards "correct" the results in favour of the plant, or play other tricks which it is difficult for the buyer's engineer to detect. But clearly it cannot be fair to either side that one party to a bargain should act as both client and judge. On the whole, Mr. Selvey's idea of an independent testing firm is the best. It can accumulate more experience, and better watch for subtle errors, than any one else to whom testing work of this class is only incidental among other occupations.

The major part of Mr. Selvey's paper consisted of a series of notes on methods of testing the various machines which go to make up a complete modern electric generating-station. We cannot deal with them *seriatim* in this article, but to illustrate the careful methods proposed in order to approximate to the ideal accuracy of 0.1 per cent. for every measurement, we may mention that Mr. Selvey considered all alternating-current meters, together with their transformers and leads, should be sent to a testing institution and checked before a test. The leads should be made of a length to suit the particular test, so that the meters could be mounted in a position away from heat and vibration. After checking, all terminals and leads should be labelled and brought back to the site by hand, not being trusted to ordinary forwarding arrangements. There is little doubt that measures of this sort are necessary if the accuracy aimed at is to be obtained, but we fear such measures are not common practice.

In connection with the actual carrying out of tests, Mr. Selvey remarked that the idea that anyone was good enough to take readings must be abandoned. None the less, his experience was that practical men, such as first-class engine-drivers, made better assistants than many of our college graduates. For testing assistance, what was mainly wanted was sincerity, and the man who knew a little and used that knowledge was greatly to be preferred to the man who knew a lot and did not use it. In making a test, it was advisable to have full instructions typed out and handed to everyone engaged, and then to make sure that they were read. Sound signals he had almost abandoned in favour of lights, although a powerful hooter was a welcome assistant in a big station. It was his practice to take all readings in triplicate, and in important trials to have one power-station man and one contractor's man to check each set of readings in conjunction, so that any disagreement might be dealt with at the time and on the spot.

THE CHEMICAL TRADE SITUATION.

The much-discussed subject of the control by Germany of a large portion of the chemical industries came before the Society of Arts on the two last Wednesdays in connection with two papers

read respectively by Sir William Tilden and by Mr. W. R. Ormandy, D.Sc. Neither speaker took what we may briefly designate as the commercial point of view, nor did either enter into details of technical problems; Sir William Tilden gave a few statistics, Dr. Ormandy none at all. Both accentuated the general development of industry on methodical scientific lines, and as Dr. Ormandy adopted the more general and broader standpoint, we will begin with his lecture of last Wednesday.

Lord Moulton, the Chairman, opened the proceedings by a few words, which made a deep impression. Speaking under visible emotion, and in terms which would have commanded the respectful assent of men of any nationality, he said that he had had to investigate the question of the supply of certain chemicals formerly obtained from Germany, and the facts were a cause for sadness and national humiliation. The chemical industry, except those branches which required least knowledge, thought, and least study, had, for reasons, perhaps, of our manufacturers being too well off, or of sluggish intellect, been allowed to fall into other hands. It was not that England was incapable or unfitted for the industry. They had to look for some fault in their national character or in their national behaviour, and they had to learn from the enemy. The most glorious moment in Prussia's history had not been their military success, but the period of deepest distress following 1806, when men like Fichte had not spared them, but had told them that only self-discipline and recognition of their national faults could help them to regain their self-consciousness and honourable position. Our position was not that of Prussia after Jena, but it was grave enough. Something more than contemplation of immediate profit was required; we had to rouse ourselves to save ourselves from German industrial domination, as well as from her military domination.

In commencing his remarks, Dr. Ormandy pointed out that when the introduction of the steam-engine as a means of power and transport had rendered industrial development on a large scale possible, Europe outside the United Kingdom was in an unsettled condition, and this country could thus become the workshop of the world. British manufacturers paid low wages for long hours, and made enormous profits. Orders for steel and tools were given without much inquiry about prices, provided quick delivery could be guaranteed. The subsequent rapid development of foreign countries demanded capital for railways, shipping, mining, &c., and the best returns could be obtained from such ventures. English spinners and weavers were supplying the world with their products, while loom and mule machinery makers worked night and day to supply the infant foreign industries with the machinery necessary to compete with England in markets in which this country had held a monopoly. The commercial life of Germany might be said to have commenced little more than a generation ago. An inland country, with little seaboard, few raw materials, no iron ores comparable to Cumberland hematites, and rather poor coal in distorted seams, Germany had seemed at a huge disadvantage. It was early recognised, however, that progress could not be left to individualistic effort. Too much credit could not be given to the far-sighted way in which problems of agriculture and industry were in Germany regarded from a national standpoint, whilst in this country individualism was running rampant. The very people whose fathers had sold land to the railway companies at absurdly inflated prices now complained that, owing to the high freights, they could not make adequate profits from the investment of the money obtained from the same railway companies by an earlier extortion. In Germany afforestation was compulsory; enormous areas, fit for little more than potato cultivation, enabled Germany to produce glucose, starch, and alcohol for all Europe. The iron exports, twenty years ago insignificant, now exceeded the British exports by nearly 100 per cent. Realising that all industrial progress was becoming more and more scientific, and that the adequate utilisation of the by-products might settle the survival of the industry itself, by-product recovery coke-ovens, which also supplied the raw material for dyes previously obtained from England, were installed in the immediate neighbourhood of the blast-furnaces, and the surplus gas from both was utilised for power generation. Favoured by Nature to an extraordinary degree as to pottery, English workmen had acquired a wonderful skill for the production of objects of art; but when the demand arose for complex porcelain castings of high-insulating capacity, Germany was able to secure that market.

The lecturer then passed to other features. Some one said that a nation got the newspapers it deserved. Judging by what had recently appeared in some portions of the daily Press upon German trade, it was devoutly to be hoped that the common-sense of the British nation would not be judged thereby. During the past ten years more than sixty millions of Germans had been fully occupied in industrial operations; our own population had equally fully been occupied, and yet people wrote as though there were a possibility that a large proportion of the activities of the larger nations could profitably be undertaken in a smaller country whose own workpeople had for the most part been quite busy.

Passing to the German willingness and ability to work in co-operation and to the great help afforded by banks to industry, Dr. Ormandy said that the heads of German banks were men of high technical knowledge, and not stockbrokers or retired colonels. These men were accessible to the inventor and ready to avail themselves of technical experts of the highest class to investigate new processes.

The other lecture upon "The Supply of Chemicals to Britain and Her Dependencies," which Sir William Tilden, D.Sc., F.R.S., delivered at the Society of Arts on Wednesday, the 25th ult., was more a plea for scientific research than a commercial review or a statistical compilation. "There is only one road to permanent industrial success, and that is the way pointed by science," was Sir William's advice to the chemical manufacturer. It was the old story in a new garb: chemical industry—some branches of it, at least—had migrated from this country, its original home, to Germany, and the country was now, the speaker said, in want of products which it ought to produce itself.

In his introduction, Sir William Tilden pointed out that Germany had contributed little to laying the foundations of theoretical chemistry a century ago. There had been no German chemist of the first rank, and only one fundamental German discovery, the discovery of isomorphism by Mitscherlich in 1819. Liebig, born in 1803, was the first of the great German chemists. If Professor Tilden had gone three years further back, to the beginning of the century in 1800, he would not have overlooked the birth of Friedrich Wöhler, a man whom chemists are justified in revering as one of the first men of his century and as the father of synthetic organic chemistry, in which, Sir William afterwards remarked, "the most remarkable successes have been won, though not wholly, as sometimes represented, by the German chemist."

Turning to the position of industrial chemistry, Professor Tilden quoted the report on chemical processes and pharmaceutical products and processes at the second International Exhibition of 1862, by August Wilhelm Hofmann, then Professor of Chemistry at the Royal College of Chemistry and Mines: "The contributions of the United Kingdom have not only maintained their pre-eminence, but outdone their own admitted superiority on the corresponding occasion of 1851." Of 762 exhibitors in the class, 200 belonged to the United Kingdom, 136 to the Zollverein, and 115 to France. The statistics of Allhusen and of Gossage showed that the production of heavy chemicals (alkalis, acids, manures, &c.) had nearly doubled between 1852 and 1862. Recent Board of Trade statistics proved that in these respects British manufacturers had no need to fear German competition in the home market. But it was different in coal-tar dyes, drugs, antiseptics, essential oils, aromatic substances, materials for photography, pure chemical reagents, and the many other indispensable products of modern chemistry. The sources of supply of all these materials in the United Kingdom was seriously inadequate. In alizarin, anthracene, aniline, &c., dyes this country imported from Germany, in 1913, goods totalling 1,653,600*l.* in value, and, further, 76,681*l.* worth of synthetic indigo. Drugs, including medicinal preparations, were imported in the same year to the amount of 1,302,860*l.*, and more than one-fourth of these came from Germany, to which only 24,690*l.* worth of coal-tar products were exported. No figures were available as to fine chemicals for analysis, but he might safely say that there was no appreciable production of these things in Great Britain. If that statement were to be met by protests from manufacturers, it was only necessary to refer to the experience of analysts and directors of research laboratories, who had habitually to resort to German makers for their supply of trustworthy reagents.

A chemical manufacturer, discussing the neglect of fine chemicals in this country, had recently remarked, "What does it matter if we are making money?" "I venture to say that that view expresses neither patriotism nor common-sense," was Sir William's comment. German chemists were, indeed, attacking the market for heavy chemicals already. They, Sir William continued, exported three times as much sulphuric acid in 1912 as the United Kingdom did in 1913, and they arrogated the whole field of scientific and industrial chemistry to themselves. In support of this statement, Sir William mentioned that Emil Fischer, in delivering the inauguration address of the Kaiser Wilhelm Gesellschaft zur Förderung der Wissenschaften, had suppressed every foreign name except that of Perkin. That is not quite correct; Sir William was rather severe, and he might, we venture to suggest, have clothed his allusion to that institution in such words as to further his own object—the promotion of scientific research. The facts are that large sums of money had been collected for the advancement of science; German chemical industry, though prosperous, wanted her institution for chemical investigation; the scheme became more and more ambitious, as money poured in, and to make further propaganda Emil Fischer traced in his address the relationship between science and chemical industry in Germany. It was a *pro domo* speech, not rich in names; there was no particular reason for introducing foreign names; yet, we grant, Fischer should not have confined himself to Kelvin, Perkin, Dewar, Berthelot and Baekeland.

In recalling the circumstances which had led to the gradual transference of the colour industry from England to Germany, and to the failure to establish here any appreciable production of synthetic drugs and chemicals, Sir William Tilden regretted that A. W. Hofmann was allowed to return to Germany, where a Chemical Society was only founded in 1867, whilst the Chemical Society of London dates from 1841, and he blamed the anti-scientific spirit and the neglect (up to 1885, at any rate, when Sir William Perkin commented upon it) of research by the old universities of this country. That had quite been altered since then; yet it was necessary to insist that no man should be appointed a professor of natural science who had not shown his ability by original research, and the professor should have a sufficient staff of properly-trained assistants to enable him to pursue a promising line of investigation. Forty years ago British chemical works had no qualified scientific chemists; in the palmy days of colour-making hardly any British manufacturers probably had ever heard of Kekulé's benzene-ring theory, to which German chemists primarily ascribed their prosperity. German indigo had almost driven the Indian planter from the field; the value of natural indigo from India imported into this country had fallen from 124,112*l.* in 1909 to 48,208*l.* in 1913, whilst 76,861*l.* worth of synthetic indigo had been imported from Germany in 1913, as mentioned above. "The strength of our competitors is in their laboratories, and not, as here, on the Exchanges," Professor Meldola had said. The maxim which we quoted in our first lines was indirectly suggested to Sir William by a lecture, delivered by H. Brunck, on "The History of the Development of Indigo," at the Hofmann House in Berlin in 1900, which lecture, Sir William said, "might be regarded as a sermon preached to British manufacturers."

In order to render the Empire independent of supplies from foreign sources, Sir William stated the industry wanted many first-rate chemists, a few engineers, plenty of capital, and some good men of business. It was right to learn from the enemy. British universities could supply the chemists if manufacturers would treat them more reasonably and liberally. The German large works took young university men on the recommendation of the professors, placed them under the chief chemist of the department in the research laboratory, and paid them a salary sufficient to live modestly; their future depended upon their ability. The engineer was, of course, indispensable. As regards buildings, structures, supplies of water, fuel, power, and electricity, the engineer had the field to himself; but the chemist

ought to be supreme as to chemical operations, and in the dye manufacture, *e.g.*, the chemist at present required little assistance from the engineer. We should submit, however, that in the practical adaptation of a process success will much depend upon the engineer. It has been acknowledged that Knietsch finally was able to make the contact sulphuric acid process a success because he was a first-class engineer as well as a chemist.

Sir William, in concluding, said that the establishment of what would practically be a new industry (after the war) would require State aid, and that aid had been promised to the dye industry; it would have to be extended to those chemical products on which the dye manufacturer depended.

In inviting discussion of the paper, Sir William Ramsay, the Chairman, in strange contrast to Lord Moulton, said that the Germans organised a chemical trade campaign as they organised a war. Expert committees looked out for new markets and raw materials, created a demand for them, had agencies all over the world, advised as to loop-holes in patents, and framed the patent laws so as to exclude the foreigner, all this with State aid bounties, export duties, &c. Some British works were, of course, quite as splendidly equipped as German works; but the small manufacturers had to be protected by organisation, lest they cut one another's throats.

Professor James J. Dobbie, of the Government Laboratory, agreed with the lecturer, and referred to one point, the unreadiness of the British chemical manufacturer. Professor A. G. Green, of Leeds, said that the question was simply one of knowledge; the Germans considered it worth while to pay for it, over here we did not. He would give a characteristic case. A firm wishing to take up a new explosive advertised, not for a chemist, but for a workman acquainted with the process; they got one formerly with a rival firm; he wanted fuming sulphuric acid, and the firm again advertised for a workman. Dr. Chapman pointed out that in the science of brewing England was certainly in the forefront, to which the lecturer readily assented; he had deliberately omitted reference to brewing. Mr. Walter Reid complained that the British inventor had to go abroad to get his invention worked. He had made the first smokeless powder, and offered it to the Government, but his offer had been declined because they would have had to change their rifles. The British manufacturers were an untrained mob against an organised army. He had his doubt about Government factories; the Board of Trade should really do something for trade, and be an advisory body; the success of the National Physical Laboratory was largely due to the guidance it received from the general board, on which practical men had seats. Mr. C. E. Cassal, of London, stated that if chemists were advertised for at 65*l.* annually, and Honours men were offered a final maximum of 150*l.* or 200*l.* as chief chemists, nobody could expect able men to select the chemical profession. Sir William Tilden, in his final brief reply, repeated that the German works did not offer their staff more. Those men came direct from the universities, and had to learn their business first; no college could teach industrial chemistry.

ENGINEERING SCHEMES IN PARLIAMENT.

In view of the present conditions it is in no way surprising that the limited list of schemes *d'utilité publique*, announced during recent years in the November *Gazettes*, is on this occasion still further curtailed. Moreover, hardly a single project amongst the lot is of more than of very limited and local interest. The railway companies have long since ceased to fight *inter se*, and in place of one company trying to monopolise the railway development of a new area, which generally led to a rival scheme being simultaneously promoted by a competitor, old-time rivals now in similar circumstances promote a Bill for the joint construction and control of the new lines. In certain quarters this cessation of aggressive competition is deplored, but so far the main sufferers have been the members of the Parliamentary bar. Indeed, of recent years, the companies have had enough to do with fighting the class of politician which threw out a Great Eastern Bill, greatly to the public disadvantage, because a trade unionist was dismissed from a post to which, in view of his antecedents, he should admittedly never have been appointed. Of course, in the long run, the public suffer more than the companies from such tactics, just as it was the citizens of East London, and not the East London Water Company, which suffered most from the successful Parliamentary opposition to the timely construction of the additional storage reservoirs needed. During the next session, however, the class of politician concerned will have little opportunity for the display of his peculiar obstructive proclivities, although he may find his chance in connection with the Metropolitan Electric Power Bill promoted by the London County Council.

Railways.

The Great Eastern is alone amongst the principal English railway companies in seeking power to execute work of a heavy character. The company asks permission to construct a number of widenings on the Colchester main line, some portions of which will be very expensive. In the Mile End Old Town this line is to be widened near Devonshire-street Station. A new line, including a bridge over the River Lea, is to be constructed in Poplar. A further widening of the Colchester main line, including a bridge over the Copper Mill River, will be made in Poplar and West Ham. At Romford the line will be widened between Romford Junction signal-box and Romford Factory signal-box: and further widenings are proposed at Ilford and Billericay. In Chelmsford it is proposed to construct a new branch between the company's River Chelmer goods yard and the Colchester main line; whilst at Ipswich there is to be a widening of the main line.

The Bill promoted by the Metropolitan District Railway gives notice of a projected widening of that company's line near Hammersmith Station.

The South Yorkshire Joint Lines Committee ask leave to construct a light railway from Tickhill, in the West Riding, to Carlton, in Nottinghamshire. In the same neighbourhood, a new company is seeking powers to construct a railway, about 12 miles long, from the Great Central metals at Shireoaks to a junction with the Great Northern main line at Bawtry. At intermediate points, there will be junctions with the Midland at Woodend, the Great Northern authorised Harworth branch at Blyth, and with the North Eastern authorised line at Styrrup.

The leading English companies are not even promoting omnibus Bills.

In Scotland, the only important proposals are those advanced by the Highland Railway, to widen their line in Inverness betweeen Clachnaharry and Clunes, and of the Great North of Scotland Railway to widen their Formartine and Buchan line from Dyce to Ellon, a distance of about 11 miles. The principal interest in the Bill promoted by the Caledonian Railway Company consists in the number of proposals to stop up and abolish existing level crossings.

In Ireland there is a proposal to construct a new line, about 23 miles long, from the Midland and Great Western metals at Mullingar to Kells, where there will be a junction with the Great Northern (Ireland) Railway. The route followed will pass through Castletown-Delvin.

Tramways, Motor-Buses, and Railless Traction Proposals.

The vogue of the trackless trolley appears to be waning, as little reference is made to it in the various schemes to be dealt with in the next session of Parliament. On the other hand, many tramway authorities are taking powers to run motor-buses, and certain local authorities are claiming the right to tax and toll all privately-owned omnibuses passing over their streets.

The Sheffield Corporation are seeking powers to extend their lines to a junction in Tinsley with the tracks of the Rotherham Corporation, and to acquire from the latter such portions of their lines as lie within the Sheffield boundaries. On the other hand, the Rotherham Corporation seek powers to prohibit the passage over roads occupied by their tracks of omnibuses owned by the Sheffield Corporation. They also propose to construct a new branch line to Maltby. Other clauses in their Bill sanction the exercise of running powers over some of the Sheffield Corporation tracks, the latter being given a similar concession over parts of the Rotherham undertaking. Protection is demanded against possible claims by the West Riding County Council for damage due to extraordinary traffic by the Corporation's omnibuses and trackless-trolley vehicles. It is also sought to modify the provisions of the Corporation's Act of 1911, prescribing the payments to be made to local authorities for road damage done by the Corporation's vehicles.

The London County Council propose to lay a few chains of new line in Farringdon-road, from the Charles-street to Charterhouse-street junctions. Another new line is projected from Aldgate to Mark-lane, whilst on the northern section a new line is proposed from Crouch-hill to Seven Sisters-road, and from Mare-street to Terrace-road and Church-crescent. In East London there is to be a new line from Shoreditch High-street to Cambridge-road. Another clause sanctions a line from Tower Bridge-road to Lower-road, Rotherhithe. The projects, it will be seen, are far from ambitious, and in this the Council shows great wisdom, since although the commandeering of a very large number of motor-buses for war service has necessarily had a favourable effect on the tramway receipts, this relief will be but temporary, and the competition will soon be keener than ever, since the continuous improvements in its design will steadily reduce the working costs of the motor-bus. It is not to be expected that Parliament will consent permanently to bind down the community with a highly obstructive transport system by prohibiting omnibus services in streets traversed by the tramways. Incidentally, it may be pointed out that the refusal of Parliament to entertain in the past tentative suggestions of this kind has proved of enormous benefit to the country, as it made practicable the construction of the enormous fleet which is now engaged in military transport service. Between three and four miles of new line are to be laid by the Edinburgh Corporation in Colintown and Corstorphine, being branches in extension of existing tracks. The Dunfermline and District Tramways Company seek powers to extend their existing lines in Dunfermline and Inverkeithing.

The Stalybridge, Hyde, Mossley, and Dukinfield Tramways and Electricity Board propose to construct a number of new lines in Saddleworth, Matley, Glossop, and Mottram. The Board also seek to establish motor-bus services.

Many new lines are proposed by the Halifax Corporation, much of the work proposed having reference to the doubling of existing lines within the town and its vicinity. Powers are also sought to carry minerals and goods over all lines, and to run trailers. Powers are also taken to lay a third rail on certain routes. The area covered in the projects of the Corporation extends out to Hipperholme and Shelf on the east, to Staniland on the south, and to Sowerby on the west of the borough. The Corporation of Bury have a proposal for laying within the borough two new lines, aggregating about a mile in all. The construction of some new lines in Sculcoates is proposed by the Corporation of Hull, and at South Shields the Corporation ask powers for about half a mile of new line. In Wales, the Aberdare Urban District Council seek powers to lay a new line along the Cardiff road, abandoning at the same time powers now held for a trackless trolley service along certain routes, but proposing to adopt this system for operating other routes. Powers are also sought for the running of motor-buses. The Rhondda Urban District Council propose extensions in their district, involving the construction of about 1½ miles of new track.

The Lincoln Corporation seek to establish railless traction and motor-bus services, both within and without the borough, to Greetwell. A clause gives powers for using these vehicles for the carriage of goods and parcels. Other Corporations anxious to establish motor-bus services are those of Plymouth, Dewsbury, South Shields, and Smethwick. The Bill promoted by the latter authority also takes powers to tax or toll motor-buses run by competitors, in compensation for consequent wear of roads.

Electric Light and Power Projects.

Speaking generally, the electrical projects set forth in the *Gazettes* are of a very commonplace character. The time has not yet come for such vast schemes as those suggested some little time ago by Mr. Ferranti, in his presidential address to the Institution of Electrical Engineers. The public will have much both to learn and to unlearn before it will be possible to persuade Parliament to permit our engineers to effect the immense improvement in the amenities of life which would follow from such a cheap and cleanly supply of energy as was foreshadowed by Mr. Ferranti.

The prejudice hitherto entertained in Parliament against efficient power-distribution schemes is well exemplified by the fact that the Yorkshire Electric Power Company are precluded from supplying current for lighting in many parishes traversed by their mains. They are now promoting a Bill to remove this disability, which has been equally disadvantageous to the public and to themselves. It is the rural districts in particular which are most affected by the existing restrictions. Local independent supplies can in such cases only be provided for at prohibitive rates. Another Bill which recalls the opposition of certain municipal authorities to any effective scheme for cheapening the supply of power is that now being promoted by the County Council. The proposals here embodied form a compromise between the views of those who are convinced that in the future, as in the past, the public management of trading concerns is necessarily inefficient, and of those who are in favour of municipalising such services, whatever the consequent cost to the consumer or ratepayer. A striking instance of the, in practice, unavoidable waste attaching to this policy came to light during the recent municipal strike at Leeds, where it turned out that the city services were overmanned by no less than five hundred men, involving a loss in wages of 36,000*l.* per annum. The new County Council proposals have already been discussed at length in our columns, and it will be sufficient therefore to recall that they provide for the works being financed by the Council and operated by a private company. The area included in the scheme covers the whole of Middlesex, and extends into Essex as far as Grays Thurrock, Romford, and Waltham; into Hertford as far as Barnet and Watford; into Kent as far east as Gravesend, and as far south as Sevenoaks. In Surrey the boroughs of Croydon, Kingston, Richmond, and Wimbledon are included within the limits, which extend also to the borders of Reigate on the south, and to Walton-on-Thames on the west. The Bill includes a clause restricting the extension or improvement of existing generating stations within the area scheduled. The new generating stations are to be at Barking and at Erith. At both places there will be an ample supply of condensing water, and in all probability it will prove possible, by installing very large units and adopting high superheats, to generate current for a steam consumption in the neighbourhood of 10½ lb. per kilowatt-hour when working at full load and unity power factor.

In another Bill, in which the name of the promoters does not appear, powers are taken to form an operating company to take over the working of the County Council scheme. The same promoters apparently have another Bill incorporating a company to take over practically the whole of the electricity supply powers now exercised within the Metropolitan area. Further powers are sought to extend the limits of supply as far as Tilbury on the east and to Windsor on the west. Clauses restrict the extension or improvement of existing power-stations. The County of London Electric Supply Company, Limited, seek powers to supply Buckhurst Hill, Chingford, Loughton, Wanstead, Woodford, Chigwell, and Epping. Other private undertakers seek Provisional Orders for Teignmouth, Selby and District, Stanley and District, Andover, Henley and Wokingham, Combe Martin, Boston and District, Glastonbury, Wells and District, Chipstead and District, Aughton.

Applications for Provisional Orders are made by the local authorities at Knaresborough, Clifden, Connah's Quay, Litherland, East Grinstead, Tenby, Normanton, Irlam, Skipton, and for the whole of the Dearne Valley by the local Councils of Wath-on-Dearne, Bolton-on-Dearne, and Thurscoe.

Purchase Bills are promoted by the local authorities at Ystradgynlas and at Glossop, by the Staleybridge, Hyde, Mossley, and Dukinfield Tramways and Electricity Board. On the other hand, the Ryde Corporation propose to hand over their present powers to the Isle of Wight Electric Light and Power Company.

At Warrington the Corporation seek to include within their limits of supply the rural districts of Runcorn and Warrington. The Keighley Corporation have a Bill permitting supply to Oxenhope, Haworth, and Oakworth. Hull wishes to include Hessle and Southampton Bitterne within its authorised limits of supply. The Harrogate Corporation seek powers to supply Knaresborough and District, Wetherby and District, and the Pateley Bridge and Wharfedale District. Apparently this scheme is not acceptable to Knaresborough, which, as already mentioned, is asking for a Provisional Order of its own. The Corporation of Tunbridge Wells are promoting a Bill authorising supply within their 3-mile radius.

Gas.

No important proposals are advanced in respect to gas distribution. Extensions of existing limits of supply are sought in the following localities:—Ormskirk, Warwick, Brighton and Hove, Melton Mowbray, Oakham, Lincoln, Staveley, Dewsbury, Liverpool, and Guildford. Purchase Bills are provided by the local authorities at Port Glasgow (where it is sought to take over the works of the Langbank Gas Company), at Lurgan, Chelmsford, and Skegness. The tendency to substitute a calorific instead of a candle-power test continues to be marked, and a large proportion of the Bills submitted embody a clause authorising the change.

Water Supply.

The most important of the water proposals is that set forth in a Bill submitted by the Glasgow Corporation, which seeks powers to impound further supplies by constructing a dam 282 yards long across the Turk at Callender. The water thus captured is to be led by an aqueduct to Loch Katrine. An addition of 15 million gallons per day to the existing supplies of the city will thus be effected. The new reservoir, to be formed as stated, will submerge existing roads, and the Bill accordingly makes provision for the diversion of these.

The Irvine and District Water Board are promoting a Bill for the construction of new intakes on the Stock Burn and on the Caaf Water at Dalny, and to construct a dam at the same place over the Drum Burn. The County Council of Clackmannan are bringing forward a scheme to supply Alloa and Tillicoutry by raising the level of their existing reservoir on the Craigencash Burn at Logue. The Bill promoted by the Lanarkshire County Council has reference mainly to the construction of two lines of railway from Crawford, on the Caledonian Railway, to the site of the reservoir now in progress of construction over Campswater. It includes, however, provision for building a new service reservoir at Cambernauld and appropriate pipe-lines.

The Metropolitan Water Board have a Bill authorising the construction of a new reservoir adjoining the existing Bourne Hill Reservoir at Southgate. The principal proposals have, however, reference to the improvement of the supplies on the southern side of the Thames, where it is intended to provide a new reservoir at Eltham adjoining that at present in use, two new reservoirs at Bromley, another at Farnham and at Shoreham (near Sevenoaks). The water required to fill these will be taken from the Thames at Walton, where filter-beds will be laid down. A very powerful pumping plant will also need to be installed which will deliver into a new 42-in. main, 19½ miles long, extending from Walton to Honor Oak. The cost of this main is estimated at 309,000*l.*, but the engineers report that, in view of the many obstructions now to be met with in the highways, it is impossible to give a really close estimate.

The Sheffield Corporation are promoting a Bill for a reapportionment of the expenditure of the Derwent Valley Water Board. A new pumping-station is to be constructed by the Wolverhampton Corporation at Ivelsey, with a service reservoir near Boscobel House, Brewood. In the same area the South Staffordshire Water-Works Company ask for an extension of their present limits of supply so as to include the Cannock district, and seek also powers for two new wells and pumping-stations at Brewood. The Weardale and Consett Water Company propose the construction of a new impounding reservoir at Stanhope by a dam across the Burnhope Burn. New intakes and weirs, together with a pumping-station, are to be provided at White Kirkley, the water being drawn from the Bollihope Burn and from the Thornhope Beck. Another new pumping-station is to be erected at Healeyfield.

The Sutton District Water Company are promoting a Bill authorising a new well-pumping station and reservoir at Cheam, and the Frimley and Farnborough District Water Company seek powers to abstract more water from their existing well at Cheam. A large number of new pumping-stations to be situated, respectively, at Hullbridge, Hockley, South Fambridge, Canewdon, Paglesham, Holehaven, and Leigh Beck are to be established by the Southend Water Works Company. The Ashington Urban District Council ask leave to construct further pipe-lines and a service reservoir, whilst the Barnoldswick Urban District Council wish to construct a new impounding reservoir at Elslack, by damming the Elslack Beck, and a new service reservoir at Barnoldswick. An extension of time for the construction of the new Hull Reservoir and the Scout Moor Reservoir, works authorised in 1903 and 1908, is sought by the Bury and District Water Board.

Harbours, Piers, and Waterways.

There does not appear to be a single application this session for powers to construct pleasure piers, the whole of the work foreshadowed being of a strictly commercial character. The Blyth Harbour Commissioners ask in their Bill for powers to construct about 36½ chains of new breakwater, in addition to two jetties, each about 6 chains long. The work proposed will be in extension of the existing south breakwater. Another Bill proposes to transfer to a Board of Trustees the existing harbour at Portmadoc, and will confer powers for the construction of three new training-walls there. A Bill is promoted by the Corporation of Nottingham to acquire part of the undertaking of the Trent Navigation Company, though a clause reserves powers to contract with that company for the working and maintenance of the section taken over. This stretches from Trent Bridge, in Nottingham, to Averham Weir, just outside Newark. The arrangement will facilitate the provision of the money needed for the locks at Stoke Bardolph, Gunthorpe, Hazleford, and Holme Pierrepoint, authorised in 1906.

Drainage and Sewerage.

Powers are sought by the Lanarkshire County Council, the West Kent Drainage Board, and the Corporation of Dewsbury to restrict the admission to the sewers of trade refuse, petrol, or other deleterious matters. The Eastern Valleys (Monmouthshire) Joint Sewerage Board propose the construction of an intercepting sewer at Blaenavon and to lay down and maintain there purification works. A clause in the Bill restricts the admission of trade refuse and the like. In Carmarthenshire the Ammanford Urban District Council propose to construct a long range of new sewers in Bettws, the sewage to be finally delivered to, and disposed of by, the Amman Valley Joint Board.

In Lincolnshire a Board of Drainage Trustees seek to improve the waterways of the River Glen and the Deeping Fen in the neighbourhood of Spalding.

NOTES.

Production of High Vacua.

The production of high vacua by means of charcoal, cooled by the aid of liquid air, is now in so general use, and air-pumps themselves have been so much perfected, that little attention is paid to other means of removing or absorbing gases. Yet there are ways which do not require the use of either expedient, and liquid air and high-class pumps are not always available. Soddy observed, in 1907, that calcium vapour, produced by heating calcium metal, absorbs gases, with the exception of the monatomic gases of the helium group, so that these gases can be purified by this method from diatomic gases. Gehlhoff found that potassium vapour will answer for the same purpose, when the discharge of an induction coil is sent through the vapour, and Pfund observed subsequently that the electric discharge will render charcoal highly absorbent, even at ordinary temperature. According to a communication sent to the Chemical Society this spring by T. R. Merton, of London, finely-divided copper can likewise be utilised in a very simple manner. This copper is a brown-black powder, which is prepared by reducing copper salts (by means of hydrogen?) and sold commercially as "precipitated copper." The product is not pure, and contains water in addition to occluded gases; the impurities are removed by heating the copper, which is then kept sealed. When wanted, a few grammes of the substance are placed in a glass bulb, which is joined to the vessel to be evacuated; in most cases an air-pump is first worked, during which period the copper is heated to 250 deg. Cent. The cooling copper afterwards absorbs gases readily, and gives

them off again when more strongly heated. Care must, however, be taken not to heat it too highly, lest the copper lose its effectiveness as an absorbing agent; the glass of the bulb should not be allowed to impart a yellow glow to the gas flame. Contact with mercury vapour must also be avoided, because mercury is a poison to the copper in this respect. The copper becomes fatigued after prolonged use. When the absorption of gases is watched with the aid of a spectroscope, the carbon bands disappear first, afterwards the nitrogen and hydrogen lines; helium is not absorbed, as it is not in the other cases. As the gases are so easily expelled again, chemical compounds do not appear to be formed. When the expulsion is performed for the first time, the gas is given off with such energy that copper particles may be carried over into the pump. For this reason the glass bulb into which the copper is charged should not be filled to more than one-third of its height. The communication in the Journal of the Chemical Society reads like a preliminary notice, and does not give further particulars.

Rebuilding the Maribyrnong River Bridge, Victoria.

An interesting example of the replacement of an old bridge by a modern one without interfering with heavy railroad traffic is recorded in a recent issue of the *Commonwealth Engineer*. The bridge in question was one over the Maribyrnong River, between South Kensington and Footscray, Melbourne, over which 320 trains pass every week day and 100 on Sundays. The old bridge was erected in 1857, and consisted of three main box girders, 14 ft. 6 in. in height, the centre one being 4 ft. 7 in. wide, and the outer two 3 ft. 6 in. Cross-girders were riveted between the main girders, just above the bottom flanges. The bridge weighed about 460 tons, and accommodated two lines of road. It has been replaced by a lattice bridge of two main girders. The new structure weighs 345 tons, and will carry, with the same factor of safety, loads twice as great as the old one. About nine years ago it was necessary to assist the bridge by placing under it timber trestles, one larger opening being left for the passage of boats. In 1911 it was decided to replace the old bridge, but, on account of certain delays, the work was only recently completed. In the act of replacing care was first taken to make sure that the trestles all took a reasonable load, and special supports were added. Sighting-boards were arranged on each trestle, so that any subsidence could be immediately checked. The next step was to build a gantry for overhead travellers. This was erected on the two outside girders, high enough to provide a platform clear of the final loading-gauge limits and capable of supporting two 5-ton travellers. The latter ran on rails on the top of the gantry, and projected outwards on either side of the bridge 10 ft. This was to enable material to be picked up off pontoons. By means of these cranes a number of rolled-steel joists were then inserted above the trestles and under the original cross-girders, so as to support the tracks, and the central box-girder was then cut out by the oxy-acetylene process, to a line just above the cross-girders. This left a clear platform on which the two tracks were raised on timbering. The new height of the rail level was 5 ft. 3 in. above the old, and the tracks were brought closer together. The raising was done in three lifts, between 1.0 A.M. and 8.30 A.M. on Sundays. Gaps had to be left in the timbering for the new cross-girders, which were 5 ft. deep. After these were placed in position the centre bay was completed with top and bottom flanges, verticals, diagonals, &c. Work was then carried on from the centre towards the ends. The lattice girders had a depth at centre of 37 ft, and they were built inside the two old outside girders. The old outer box-girders, the old decking, &c., were then removed, leaving the new bridge in position. Mr. F. K. Esling, of the Victorian Government Railways, was in charge of the reconstruction, assisted by Mr. G. S. Luttrell. The bridge was designed by Mr. A. G. Goudy, under the supervision of Mr. J. H. Fraser, Chief Engineer of Way and Works, Victorian Railways. The steel-work and riveting up were executed by contract. The erection and bolting up was done by the railway department. The new bridge was badly needed, and its erection without interference with the very heavy traffic on the line is highly creditable to the engineering staff of the railway.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. XIV.

By Frederick William Lanchester, M. Inst. C.E.

Need for an Independent Combatant Air Fleet.

The subject of aeroplane tactics, or air tactics, is one which lies wholly with the future. Hitherto the aeroplane has acted in its combative capacity as an individual unit; there has been no systematic co-operation between a number of machines for the organised destruction of the enemy aircraft, such as could be described as tactics in the military sense.

Before we can usefully discuss the present branch of the subject we must look forward to the time when air fleets or squadrons will be organised for the purpose of operating together according to some well-understood, or prearranged, scheme as combatant units. We have already defined the duties of attack and defence by air against the air forces of the enemy as constituting the secondary function of the Aeronautical Arm. Taking this as the mainspring from which the tactics of the air must derive its motive, we require to take for our foundation the material provided by our previous consideration of the primary function of the Arm. The initial condition of the problem, then, is that both combatant armies are provided with reconnaissance machines of two types, namely, the long-distance or strategic scout—an unarmed machine built for speed and endurance, and the tactical scout, probably mounting a machine-gun, and protected by light armour from attack from below. Beyond this there is possibly a type, which must be taken into account, more essentially designed for taking a hand in support of ordinary military operations on the lines already foreshadowed, protected beneath by heavier armour or by point-blank-proof shields, and mounting a multiple machine-gun, or a mitrailleuse having three or four barrels, and capable of firing 2000 to 3000 rounds per minute. Further than this, there will doubtlessly be machines expressly constructed for bomb-dropping, in addition to specialised naval types. These latter, however, do not require particular consideration, since, in view of the weight they have otherwise to carry, their power of offence against hostile aircraft (as measured by their gun-power) will of necessity be feeble.

In the absence of any organised air fleet intended for the destruction of the types as above defined, there will doubtless take place, indeed as is already the case, a certain amount of desultory fighting of a local character; at one point the aircraft of one belligerent will secure the advantage, and at some other point the reverse may be the case. So long as neither air force possesses any marked superiority in the matter of speed, and so long as neither army has at its disposal more machines than are reasonably necessary for the reconnaissance and other services mentioned, we cannot anticipate that the results of such aerial combat will be decisive in any sense. We may assume that numbers may combine in order to overweight the enemy locally, and drive him out of action; the advantage obtained, however, would only be temporary. In such desultory air warfare there will be a continual wastage of men and machines, but these losses can be made good by new units and new formations. In order to effect anything decisive, an organisation of an entirely new character is required: an air fleet absolutely free from any routine or other set duties, whose one and only object is to seek out the enemy's aircraft wherever reported, and effect their destruction with the utmost swiftness and despatch; in brief, an independent air fleet, whose unchallenged existence alone stands for the command of the air.

The Independent Air Fleet. Air Tactics.

It may be laid down that the independent air fleet, in order that it shall be capable of fulfilling the duties assigned to it, must be strong by virtue of numbers. In order to destroy—*i.e.*, not merely to drive away—the active aircraft of the enemy, it must be of decisively higher speed, so that the enemy, whether reconnaissance or fighting machines, will be compelled to surrender or give battle. An exception may be made in the case of the strategic scout, which, being designed purely for speed and being burdened with neither armour or armament, may be taken as, within reason, faster than anything that can be brought against it. This need for superiority in the matter of speed means evidently that the air-fleet type must suffer in some degree in the matter of armament; alternatively it must be a heavier type machine for machine. Closely allied to the question of speed is that of climbing power. Other things being equal, whether for increased speed or for increased climbing power, a greater horse-power per unit weight is necessary. If we assume some given value for the horse-power per unit weight, then a machine may be designed either to develop the highest flight speed possible or to obtain the greatest rate of altitude increase —*i.e.*, vertical velocity. Any actual design is of the nature of a compromise; maximum flight speed is kept as high as possible consistently with obtaining a sufficient rapidity of ascent. The independent air fleet must be, without question, the master of the service machines whose destruction it is required to encompass, both in the matter of speed and climbing capacity. Thus it will require to possess a considerable superiority in the essential matter of horse-power; it must be made impossible for its prey to escape either by horizontal flight or by putting on altitude.

This question of altitude is one of really vital consequence in connection with the tactics of the air. The service machine designed to fulfill the primary function of the Arm must evidently carry its protective plating or armour distributed in such manner as best to resist gun-fire from below. Also the armament is necessarily directed mainly to the downward projection of missiles, by gun-fire or otherwise. Hence to obtain the "upper berth" in an air-fleet action is at the outset to secure a great tactical advantage. It might be supposed that these considerations will lead to an increase in the protection accorded—that is to say, that the service fighting-machine will be fitted with a complete panoply of steel plate, above as well as below. This, however, is improbable, since any such measure would, by reason of the additional weight, so reduce the general mobility of the machine as to constitute too serious a handicap. It would appear to be only possible to ameliorate the conditions under which a machine will have to fight when resisting an attack from above by arranging the gun armament with as great a capacity for upward fire as possible. A further advantage in the possession of the upper berth or "gage" lies in the fact that the potential energy, represented by the difference of altitude, may, at any time, be used to augment the velocity of flight above normal, a power which cannot fail to be of potential tactical value.

It is a fact which cannot be too strongly stated that the independent air fleet must be homogeneous. It must be composed of units of approximately the same capacity of speed and climbing power; the range of its weapons also should be the same. As a counsel of perfection, the fleet should be of *one design*, mounting one standard type of gun, using one kind of ammunition. Owing to the need for aeronautical ascendancy, we have seen that the armament cannot be of the heaviest; it may more often than not be individually less powerful than that of its opponent. The independent air fleet must therefore base its strength on its numerical superiority. It is precisely here that the need for homogeneity becomes manifest. Properly to assert the power of numbers, the whole fleet must come into action as nearly as possible as a single unit; in brief, it must concentrate the whole power of its combined fire on the numerically inferior enemy, and so take full advantage of the n-square law. No fleet can accomplish this unless its components are able to move and act in concert; thus the slowest vessel in a fleet must regulate its speed, and that which has the weakest armament the battle range.* In the case of the air fleet also we have the slowest climber determining the rate of ascent.

Air Tactics. Formation Flying.

In order that the air fleet shall be brought into action as a single unit, it is not only necessary that it should be in its constitution homogeneous, as already pointed out, but it must also be handled in some definite formation. Where the numbers are moderate, as, for example, in the handling of a single squadron, the formation adopted may evidently be fairly elastic, and there will be no difficulty in bringing the tail of the formation promptly into action. When, however, as we may suppose will

* The range of the armament is mainly a question of muzzle velocity, not calibre.

some day be the case, the numbers become great the whole question cannot fail to become one of the first magnitude. The actual importance will again be greatly increased when air fleet meets air fleet, for in view of this eventuality, numbers will be augmented to an extent that we have as yet no means of gauging, perhaps beyond anything that we can at present imagine.

It would not serve any useful purpose in the present state of knowledge and development to attempt to discuss too closely the types of formation that may or may not be found suitable. We have the same, or an analogous, tactical problem in each of the older arms of the military organisation, and in the Navy, and in every case, in spite of the store of practical experience available, there is still a deal of controversy, different ideas being represented by different "schools" of thought; even in the case of the infantry there is no unanimity of opinion. This being so, it would clearly be futile to attempt to lay down any scheme for an arm that cannot yet be said to exist. However, in spite of all this, there are certain outstanding facts that cannot fail to have some bearing, and will assuredly act as controlling influences.

When the numbers become great a point will inevitably be reached when the accuracy and closeness of the formation will be a matter of first importance to the tactical scheme, since the only way in which the whole force can be brought to bear at once will be by a studied plan, in which each machine will have its allotted place. In other words, the number of machines from the point of view of the *n-square law* will no longer be the number brought into the field by the strategic plan, but rather such portion of it as can be brought to bear simultaneously on the enemy; it will become a battle of airmanship. One of the difficulties that exists to-day, and probably will always be a matter of anxiety, is that of signalling; and to whatever extent this remains a difficulty, the flexibility of the formation will be impaired. The air fleet with the most perfect system of signalling will be the best able to take advantage of any opportunity that may arise in the course of an engagement by adapting its tactical scheme to the needs of the moment. In order to render it possible to control large numbers, it would appear to be evident that the unit command will be a small group, or what is at present termed a "flight" (some four or five strong), and that the individual machines will act on the plan of follow-my-leader; in other words, they will have instructions to keep station. It may be found desirable to extend the same system to larger units, as tending to avoid possible confusion.

There is a point in connection with the pattern or character of these unit formations that may turn out to be of importance. It has for long been observed that certain birds, flying numbers strong (as in migration), are in the habit of assuming definite formation, and that this formation is of the shape of a letter V travelling point first; each bird, besides being some distance behind its leader, is also somewhat on one or the other flank. The reason for this is almost certainly one of aerodynamics; the air immediately in the wake of a bird in flight has residuary downward motion, and so is "bad" air from the point of view of the bird following. On the other hand, the air to the right and left of the leader has residuary upward motion owing to the vortical character of the wake disturbance, and so is "good" air; consequently the V formation arises naturally from each bird seeking the air which gives the best support, a matter in which most birds show consummate skill. There is very little doubt but that by this manner of flight, formation flying in fact, a flight of birds is able to cover the ground with a material saving of work done. If the point in question is as important as it appears, it will certainly have to be taken into consideration in connection with aeroplane tactics, and more particularly formation flying. The follow-my-leader formation will evidently be on a V or diagonal plan rather than in line ahead.

Whatever formation plan be adopted, it is evident that provision must be made for machines that are disabled or shot down being able to leave the lines without creating confusion; evidently the closer the formation the more danger there will be of a real mix up and *débacle* in case of any confusion arising. Similarly, it is important that the enemy shall not be able, by ramming tactics or otherwise, to throw the formation out of gear; once more the "upper berth" clearly has every advantage.

Conditions in Aerial and Naval Tactics Contrasted.

The conditions, both as to armament and otherwise, which obtain in the Navy and in the Air Fleet offer many striking contrasts, and are such as should prevent too much reliance being placed on analogies between the Services, except where the issues under consideration are of the broadest description.

The range of the gun-fire of an aeroplane (or other aircraft) is less a matter of the ultimate range of the gun employed than it is of the angular magnitude of the objective and of those other factors, such as speed and light, which contribute to render accurate shooting more or less difficult. In this the conditions differ remarkably from those which obtain in the Navy, where the useful range is, roughly speaking, the ultimate effective range of the weapon employed. Thus in air warfare the craft carrying the heavier guns will in nowise possess the advantage that accrues in the corresponding case in the Navy. To a certain degree the larger aeroplane (or airship) will be penalised by the fact that it offers a target of greater area, and hence it will be more vulnerable. It may therefore be anticipated that the trend of design in the fighting-machine will not be in the direction of very heavy units analogous to the battleship, but rather in the construction of machines of moderate size and weight, with the maximum possible rate of fire. As pointed out in one of the earlier articles, this *rate of fire* will be measured by the *number* of projectiles per second, rather than by their weight or striking energy. Whilst pointing out that the large aeroplane does not possess the striking advantage over smaller aircraft that has led in the Navy to the development of the Dreadnought and the super-Dreadnought, the writer does not wish it to be inferred that his opinion is against the reasonable development and growth in the weight and dimensions of the fighting-machine. It may, indeed, be found when the size of air fleets becomes great, that, owing to the numbers becoming unwieldy, the only way in which the fighting strength can be increased will be by increasing the power of the individual units—that is to say, by employing larger machines, mounting more guns.

Again, the larger machine, owing to its less relative body resistance and other well-understood causes, has a lower coefficient of traction, and so, where the speed is important (as we may always assume to be more or less the case), the advantage is with the larger machine. Alternatively, the larger machine, speed for speed, will, with equally good design, be the better climber; these points have already been discussed to some extent. It is only necessary here to draw attention to their influence. It would thus appear that there is nothing to be gained at the present time by attempting anything heroic in the direction of aeroplane design; the large machine will come (if it does come) by a natural process of evolution.

In contrast to the large machine the present writer has frequently expressed the opinion that the single-man machine for many purposes would be able to effect all that is required of it (chiefly reconnaissance), and in this he has found himself absolutely opposed by the official views and specifications of the Departments concerned. However, the experience of the present war seems to indicate that there is something in this view, and it is more than probable that in the future the single-man machine will be a recognised type for military purposes. The advantage of the single-man type is that the machine can be altogether smaller and more compact, it can be designed to possess, speed for speed, a higher degree of inherent stability, and so will *fly itself*, leaving the pilot quite free to make observations and notes. Beyond this it is more difficult to hit and may more easily escape observation; it is also better to manage when it comes to alighting in a difficult situation. Needless to say, the single-man type is not a fighting type, although for bomb-dropping and such like duties it seems clear that the weight of a second man in extra bombs would be of far more value than the man himself.

Aeronautical tactics will present many fascinating problems and opportunities to the air-fleet commander of the future, entirely without parallel in the pre-existing Arms of the Service, and there will be ample scope for originality and resource. Take, for example, the operations of aircraft in a mountainous country such as the Alpine regions of Europe; the selection of aeroplane stations or bases at high altitude, and their employment to determine an ascendancy over an enemy less fortunately situated; the utilisation to their full extent of air-currents, &c. It must be remembered that an advantage in altitude can be always turned to account to give a temporary advantage in speed, as in the swoop of a bird of prey. We may look confidently to the wide employment of such swooping tactics in the future of aerial warfare. The advantage possessed by an air fleet having its base at high altitude, sometimes even some 6000 ft. or 8000 ft. above sea-level, will be very great; it will have the initial advantage of the *upper berth*, and under some circumstances may result in the enemy fleet, or sections of it, being kept flying for long periods together at high altitude in order to avoid the possibility of being engaged in action at a disadvantage. Such a process might conceivably result in the wearing away of a hostile air fleet to such a degree as to determine its ultimate defeat.

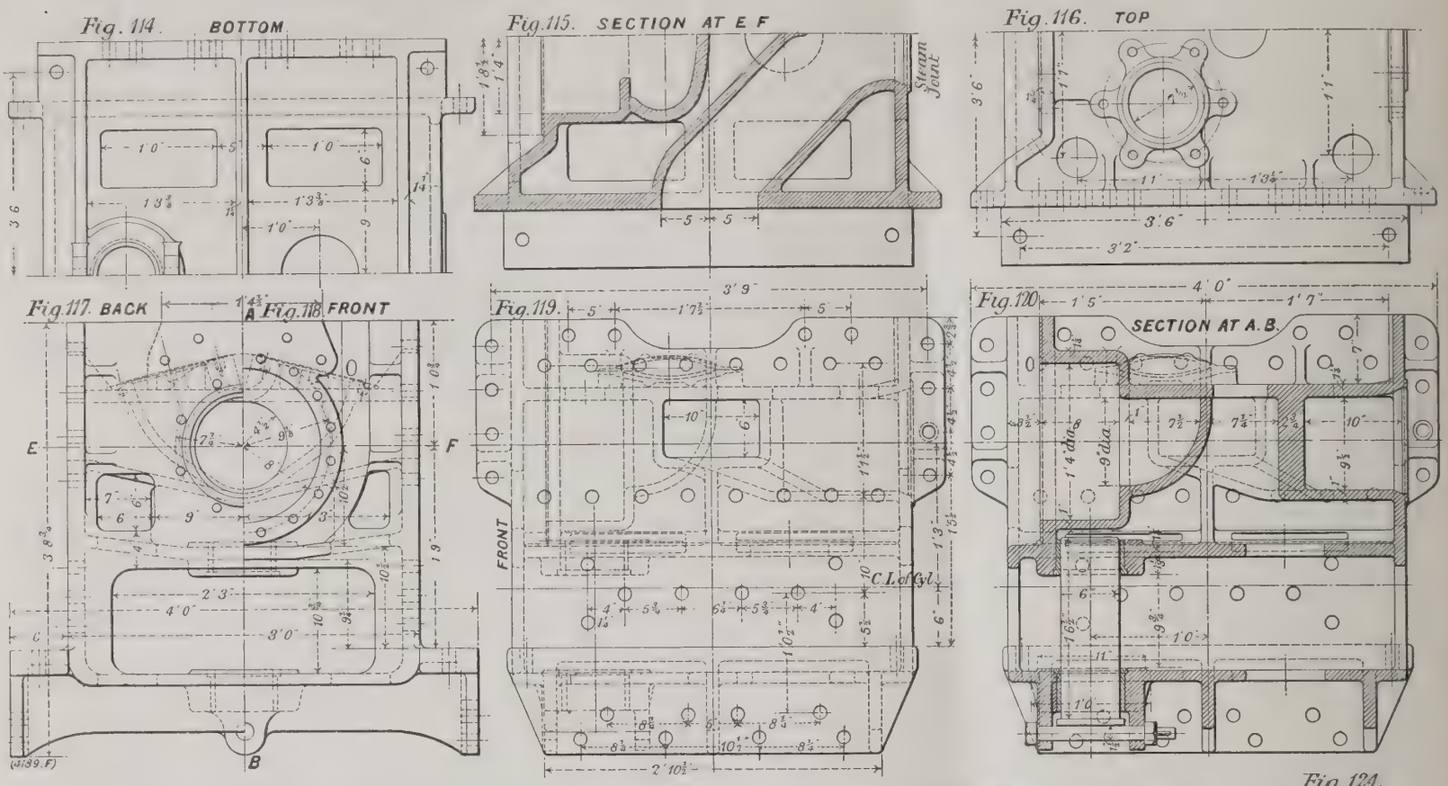
The Manufacture of Slate Pencils.—The Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, E.C., would like to get into touch with a firm capable of supplying a machine for the manufacture of solid, uncovered slate pencils, or with some person with practical knowledge of the details of the manufacture of such pencils. These pencils have hitherto been supplied from Germany. The opportunity now occurs to introduce their manufacture into this country, but the Board of Trade has found difficulty in getting into touch with persons or firms having the requisite detailed knowledge. Anyone capable of supplying the necessary machinery, or the information sought, is requested to communicate with the Commercial Intelligence Branch of the Board of Trade at the address given above.

The London Society.—Probably there are very few who realise that during the terrible period of the French Revolution, 1793, when work was practically at a standstill, and horrors of every sort were being committed in Paris, a committee of artists was formed, who prepared a scheme for the future improvements of Paris, a scheme which has been the basis of the various street improvements carried out from time to time. On the original plan can be seen the suggestions for many of the streets so familiar to us at the present time—the Rue de Rivoli, the Rue Castiglione, the Rue de la Paix, and many others. Stimulated by this example, the London Society has appointed a committee of experts to consider the problem of preparing such a plan for London, the need for which is apparent in the disjointed manner in which improvements in our city have been carried out in the past. With funds at its disposal the committee hopes to be able to obtain the services of men, well known in their professions, who are keenly interested in the subject, and who, in normal times, in consequence of their practice, would have been unable to devote their energies to the task. It confidently appeals to the public to enable it to engage in the preparation of a plan which would show how London could become a great example of the economic value and beauty which skilful town-planning extracts from every yard of a great city, while incidentally dealing with the relief of distress amongst others than the working classes. It is stated that the problem is exercising the minds of the Executive Committee of the Prince of Wales's Fund and all philanthropic people.

The Shortage of Automobile Parts Due to the War.—The difficulties, which now confront the automobile industry through their past reliance on the Continent for much of the material of which their cars are constructed, are now enhanced by the fact that all the big steel-makers in this country are inundated with orders for war materials, which naturally must take precedence over all others. The automobile engineer must, however, obtain steel castings, forgings, stampings, and other accessories, in order to be able to carry on his business at all, and he is therefore obliged to look for some new source of supply. What that source shall be is the immediate difficulty which the Institution of Automobile Engineers is making every endeavour to solve. The first step taken towards a solution of the problem was the reading of a paper by Mr. L. H. Pomeroy, of the Vauxhall Motor Company, in London, on October 14; but this paper, though it provoked a great amount of interest in the subject, did not actually provide a solution. Mr. Pomeroy has now been deputed by the Council to read a second paper on similar lines in Birmingham in December. A large number of firms connected with the steel industry have been invited by the Council to be present at the meeting in order that they may hear the views of the automobile engineer, and put forward their own criticisms or suggestions. It is hoped that a large gathering of automobile manufacturers will also be present, so that the whole subject may be thoroughly thrashed out from the two points of view. There is no doubt about the urgency of the matter at the present time, and the Council would urge all those who are interested, either from the seller's or the buyer's point of view, to do their utmost to be present. Full particulars of the meeting and copies of the paper may be obtained on application to the Secretary of the Institution of Automobile Engineers, 28, Victoria-street, Westminster, London, S.W.

DETAILS OF 2-8-8-8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD.

CONSTRUCTED BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA., U.S.A.

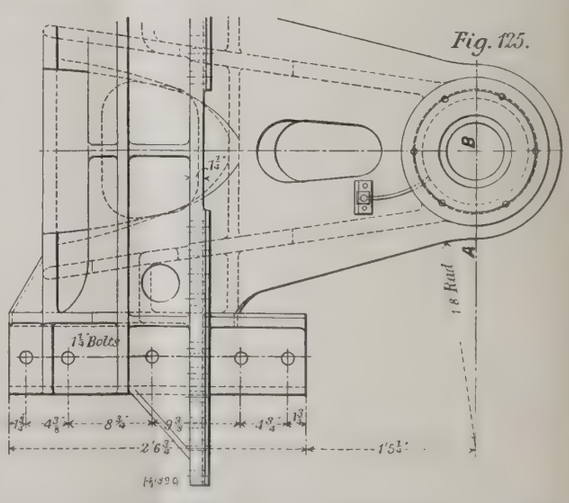


COMPOUND ARTICULATED 2-8-8 8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD.

(*Continued from page* 630.)

HAVING dealt with the steam-generating plant of the large articulated compound locomotive for the Erie Railroad, built recently by the Baldwin Locomotive Works, Philadelphia, Pa., U.S.A., we will now proceed to the frames and system of articulation. In this connection we give a series of illustrations on our two-page engraving, Plate XLIII., with this week's issue, and also on pages 674, 682, and 683. The views, Figs. 81 to 83, show the three sections of the machinery of the locomotive at different stages of construction. Fig. 81 shows the front articulated section, and as far back as the second, or high-pressure, pair of cylinders on the central section. Fig. 82 shows the second, or central, section, with the rear articulation. Fig. 83 shows the tender or rear section. In this view may be seen the long feed-water heater previously described, placed underneath the tender tank, and fed by the exhaust of the rear pair of cylinders. Together with the frames, typical drawings for which are given in Figs. 84 to 87, Plate XLIII., it will be convenient to deal with the saddles, radius-bars, &c., all of which are illustrated in Figs. 88 to 113, on Plate XLIII., and Figs. 114 to 131, on the present and opposite page.

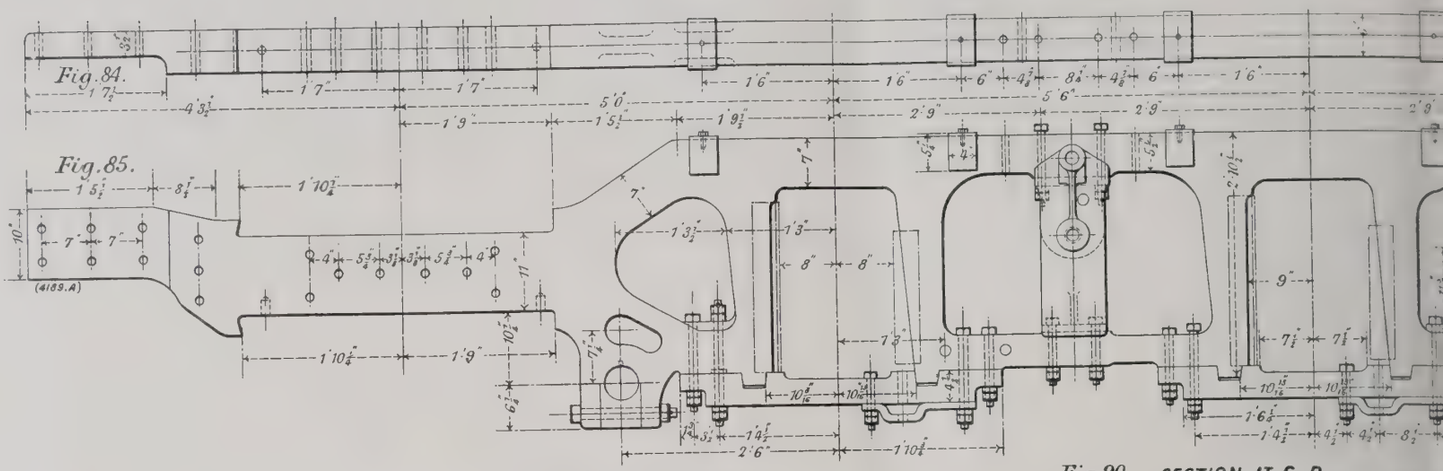
The frames for all three sections of the locomotive are vanadium-steel castings. Figs. 84 to 87 illustrate those of the front section. They are 6 in. thick and 7 in. deep over the boxes. At the front end there are no splice-bars, the frame, instead, taking the form of a slab 6 in. thick and 11 in. deep at the cylinders. The pedestals or horns are provided with shoes; behind the shoe of the rear pedestal of each pair is a wedge, tapered to 1 in 12. The horn-stays or pedestal-braces fit over lugs below the pedestals, also tapered to 1 in 12. All pedestal-bolts are 1¼ in. in diameter; the other frame-bolts are finished to a standard taper fit. The cylinders of the front section are attached outside the frames at the front end. Between the frames is a cast-steel saddle, shown in Figs. 88 to 95, Plate XLIII., and Fig. 128, page 683. This saddle is bolted to each frame by eight 1¼-in. bolts. The cylinders are bolted to the saddles, but not to the frames. In addition, however, each cylinder is keyed to the frame-seating by wedges at the front end. The saddle is cored with steam-passages for the supply to, and exhaust from, the front pair of low-pressure cylinders. The low-pressure steam is brought to the back of the saddle to a 10-in. circular opening. This forms part of a bifurcated right-angle bend, so that the one circular opening develops into two of 7⅛ in. diameter on the upper side of the saddle. From these, steam is taken through elbow-pipes to the cylinder steam-chests, there being, therefore, no live-steam joints directly between the saddle and cylinder castings. The connecting elbows may be seen in Fig. 6, Plate XL. *ante*. In addition the front saddle contains a V-shaped passage, this being for the exhaust from the cylinders on either side. The exhaust enters the saddle through rectangular openings in the side, 10 in. by 6 in., and, combining, leaves by way of the top through a circular opening 10½ in. in diameter. Thence it is carried to

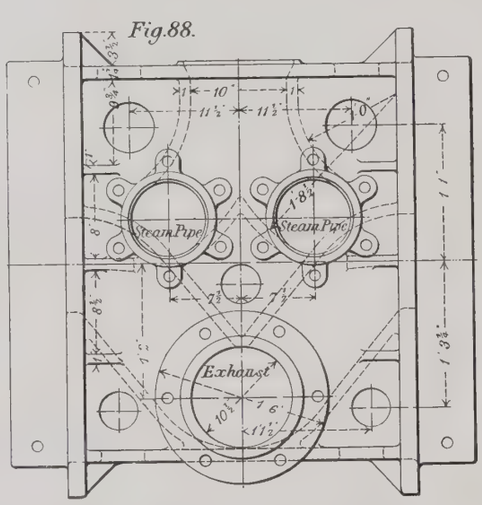


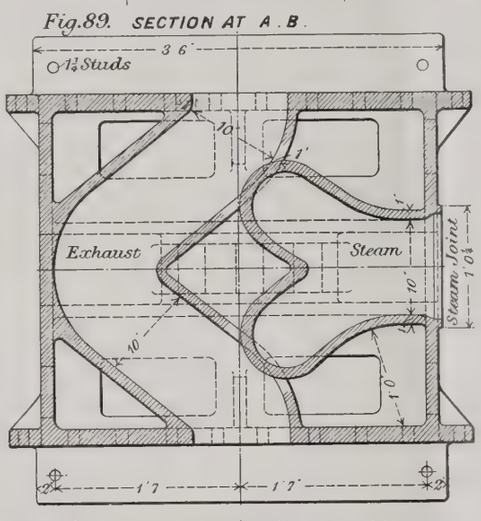
DETAILS OF COMPOUND ARTICULATED 2-8-8

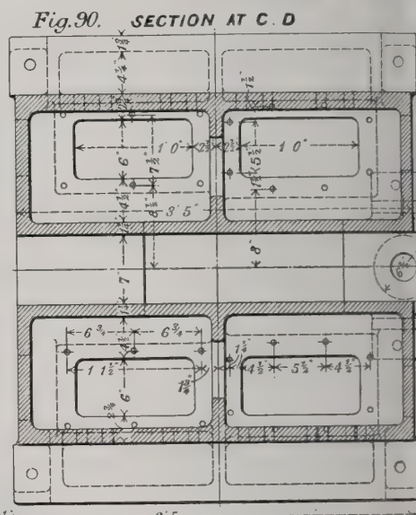
CONSTRUCTED BY THE BALDWIN

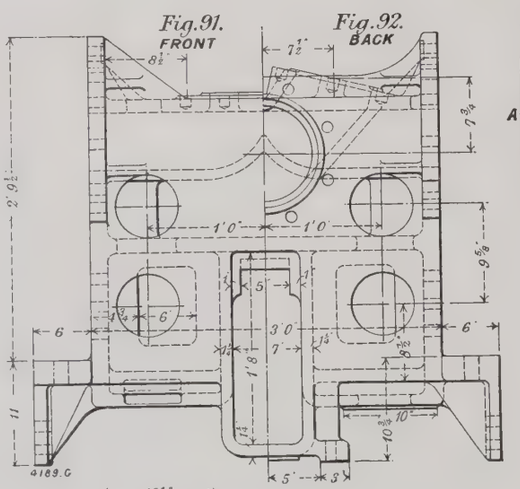
(For

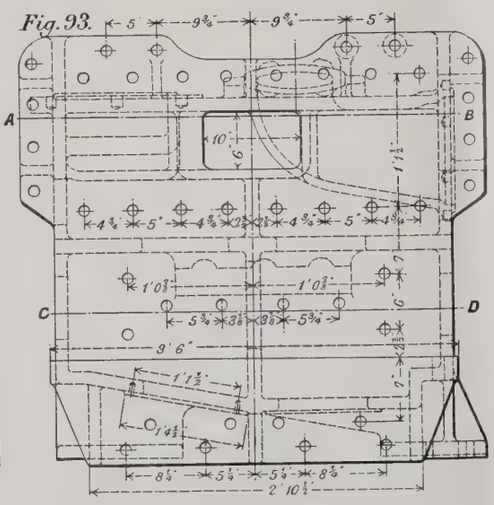


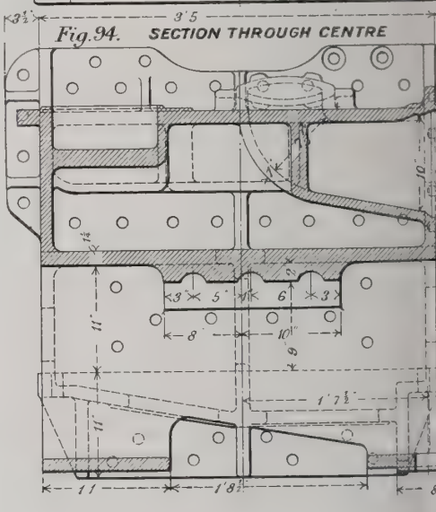


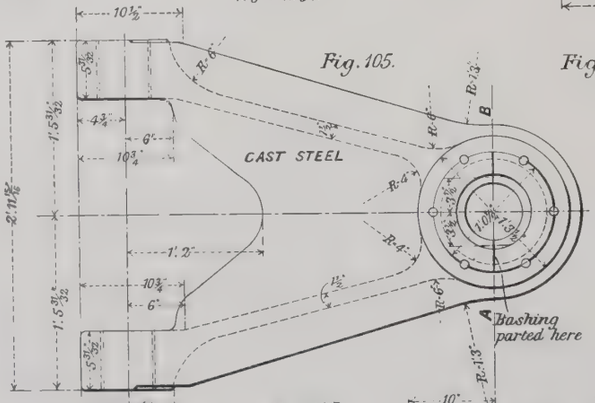


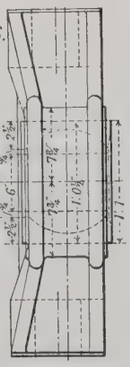


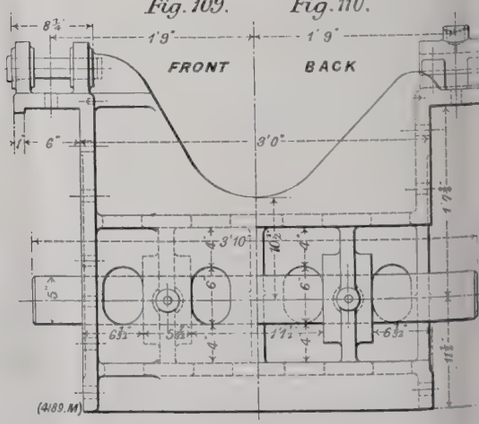


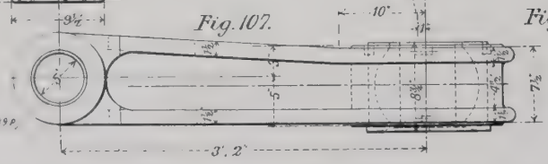


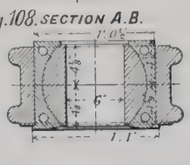












PE LOCOMOTIVE FOR THE ERIE RAILROAD.

WORKS, PHILADELPHIA, PA., U.S.A.

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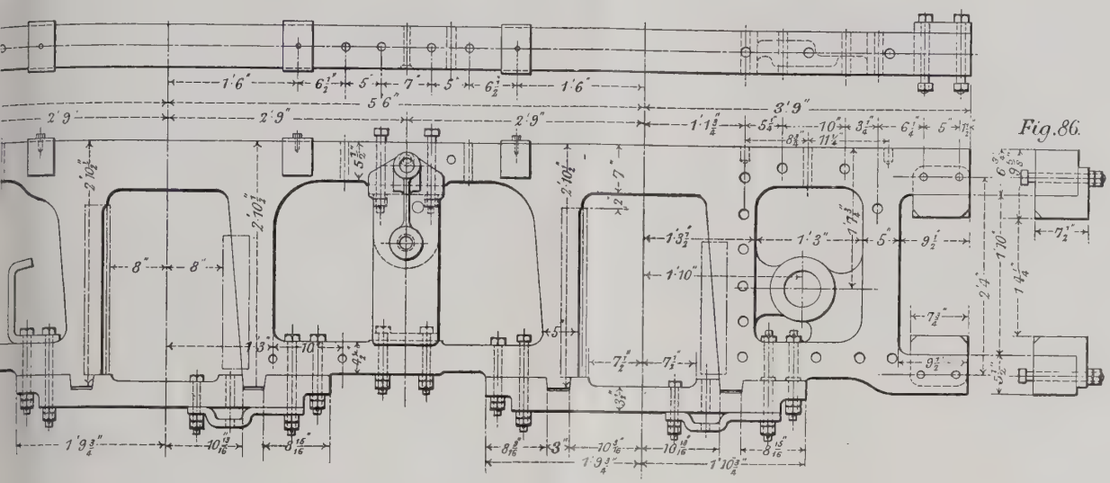


Fig. 86.

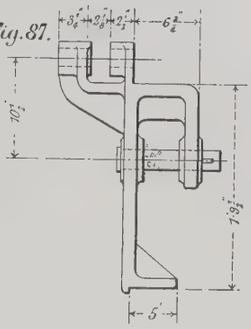


Fig. 87.

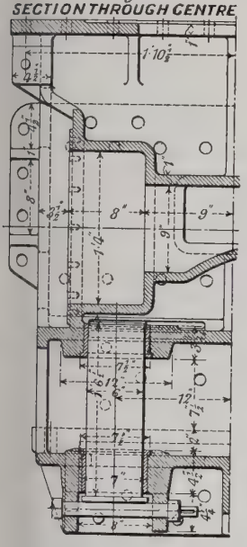


Fig. 96. SECTION THROUGH CENTRE

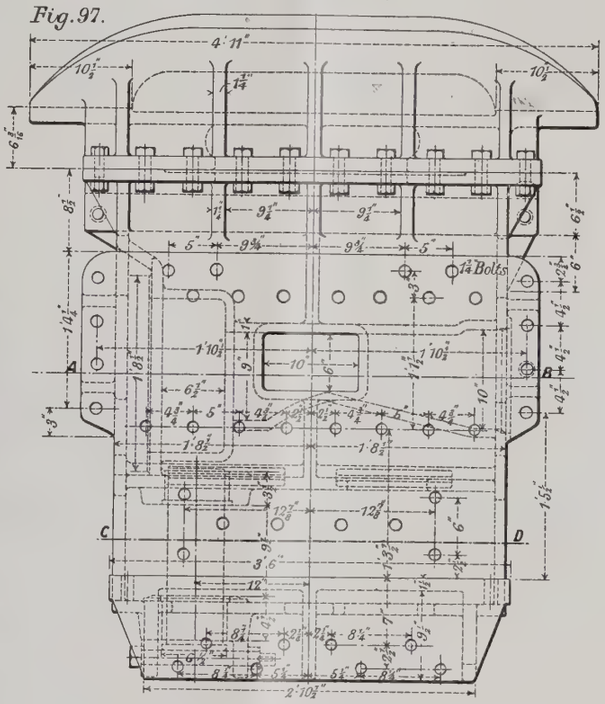


Fig. 97.

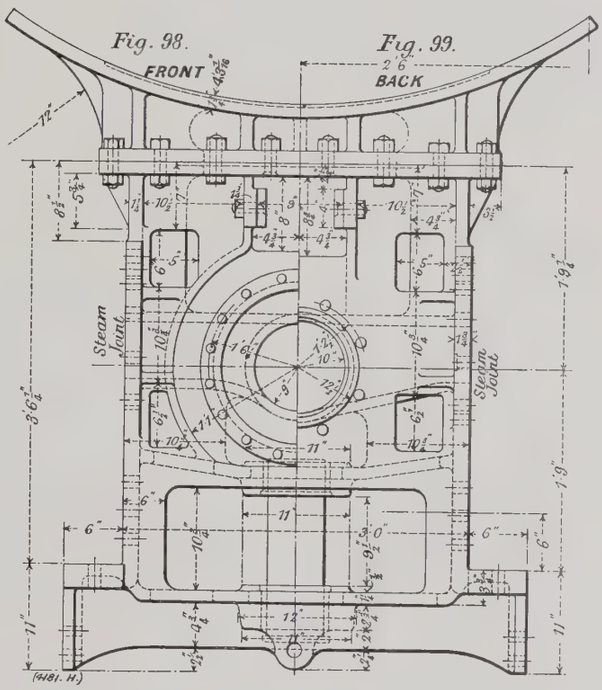


Fig. 98. FRONT

Fig. 99. BACK

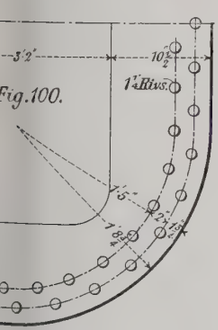


Fig. 100.

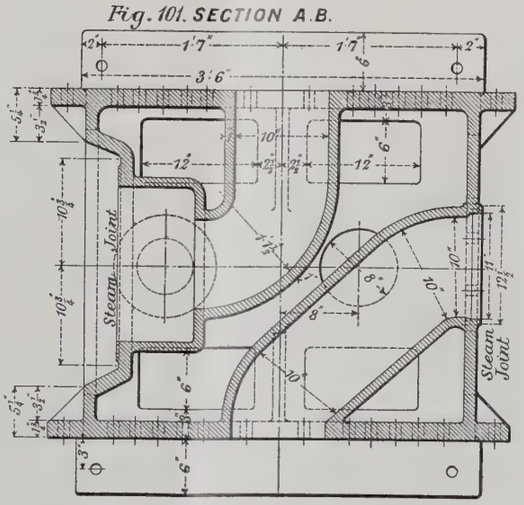


Fig. 101. SECTION A.B.

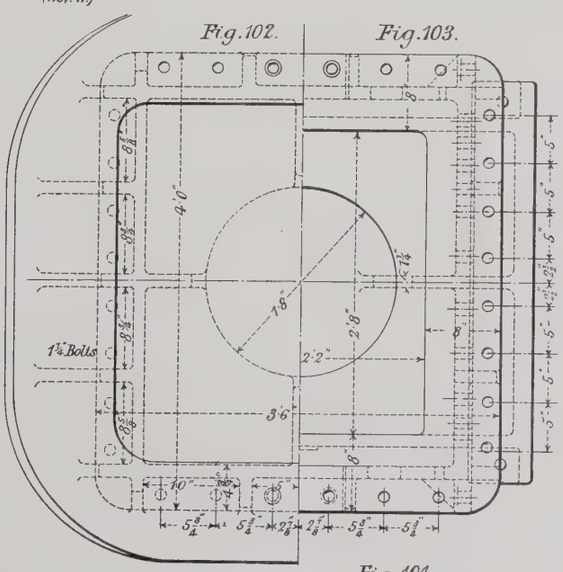
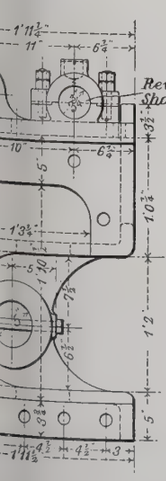


Fig. 102.

Fig. 103.



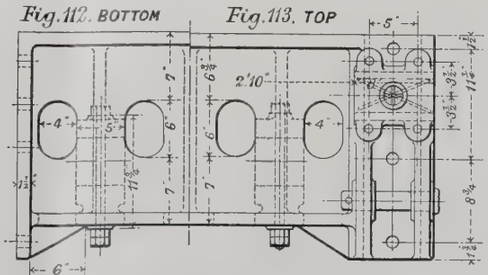


Fig. 112. BOTTOM

Fig. 113. TOP

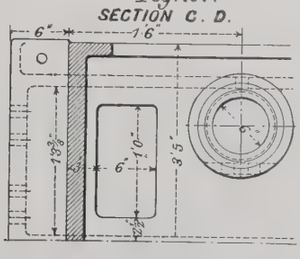


Fig. 104. SECTION C. D.

DETAILS OF 2-8-8-8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD.

CONSTRUCTED BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA., U.S.A.

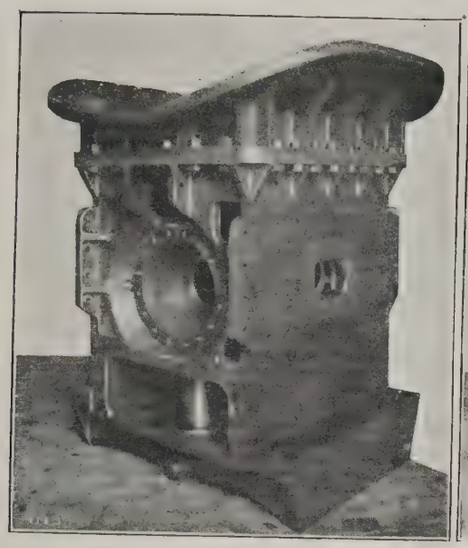


Fig. 126.

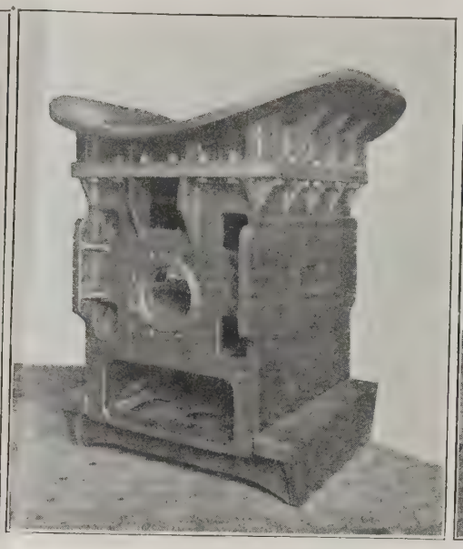


Fig. 127.

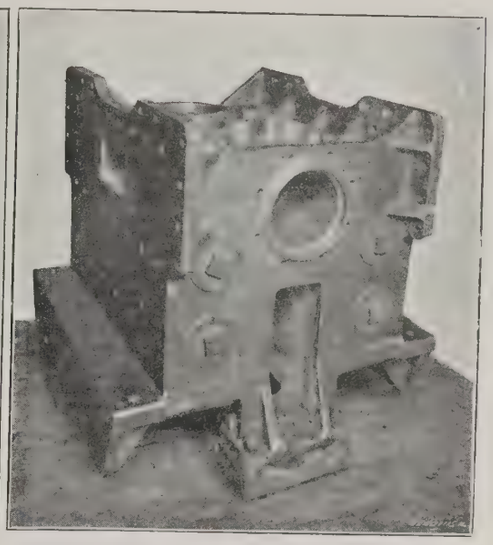


Fig. 128.

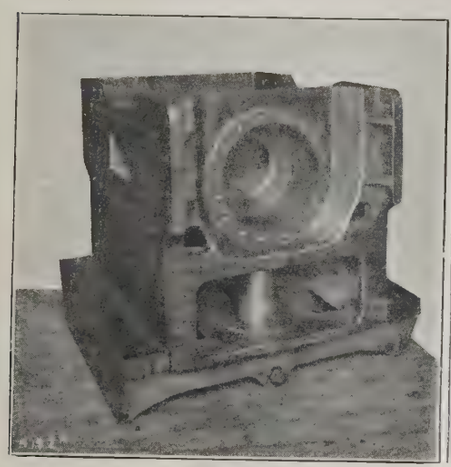


Fig. 129.

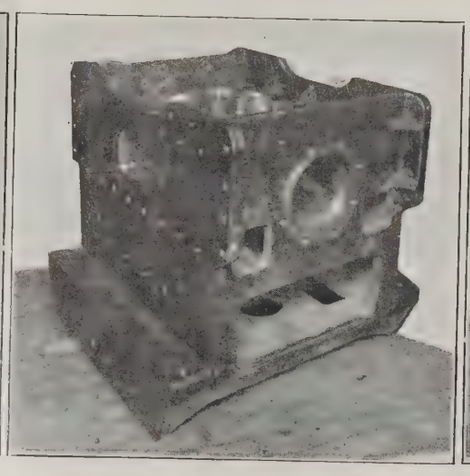


Fig. 130.

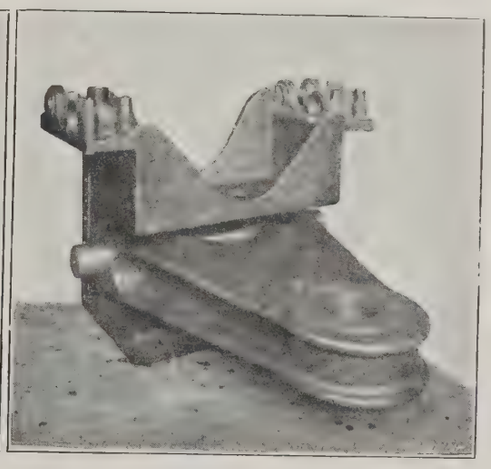


Fig. 131.

the smoke-box through a large swivelling pipe. The lower part of the saddle contains a large vertical opening for the equalising-beam connecting the spring rigging of the two-wheeled truck with that of the driving-wheels. These various features will be clear on reference to Figs. 88 to 94, of which Fig. 88 is a plan of the saddle. Fig. 89 is a horizontal section through steam-passages at A B, Fig. 93. Fig. 90 is a horizontal section taken at C D, Fig. 93, through the equalising-beam opening. Fig. 91 is a half elevation of the front of the saddle, and Fig. 92 a similar illustration of the back of the casting, which is shown also in the view, Fig. 128. A side elevation is given in Fig. 93, which shows the exhaust opening into the saddle from the cylinders; it also shows the housing of the equalising-beam and the three fulcrum points for this beam. These are shown more clearly in the longitudinal section, Fig. 94, taken vertically down the centre of the casting. The steam-passage is also shown in the latter figure. A detail of the attachment for the radius-bar pivot for the front truck is shown in Fig. 95. The pivot consists of a 2½-in. pin. It is held in place in a casting bolted to the under side of the saddle casting at the back end.

In addition to other cross-bracing, the frames of the leading section are held together by a steel casting which forms an integral part of the front articulation. Figs. 96 to 113, Plate XLIII., and Figs. 126, 127, and 131 relate to this connection. The steel radius-bar cross-tie, illustrated in Figs. 109 to 113, is fixed to the rear end of the frames of the front section. Figs. 109 and 110 are respectively half elevations of the front and back of this casting. Fig. 111 is a side elevation; Fig. 112 is a half view of the under side, and Fig. 113 a half plan of the upper side. The casting fits between the frames with flanges on the upper side which fit on the top rails. On these flanges are bearings for a spring-hanger (Fig. 109, and to the left in Fig. 111) and for the reversing shaft (Fig. 110, and to the right in Fig. 111). These are shown in plan in Fig. 113. This cross-tie casting houses a 5-in. steel pin, which extends also through holes in bosses at the rear of the frames (Fig. 85). This horizontal drag-pin is held in the cross-tie casting by two ⅞-in. bolts.

Working on this drag-pin is the radius-bar shown in Figs. 105 to 108. This is coupled at the other end to the saddle casting of the central section. The radius-bar is a steel casting of V form. At the open end it has bosses, through which passes the 5-in. steel pin in the cross-tie. These bosses have ½-in. steel bushes. At the rear end of the casting there is a ball-and-socket joint. This is composed of a case-hardened ball and bushing. The bushing is split on the line A, B, Fig. 105. It is fitted with match dowel-pins, shown in Fig. 108, and is held in place by six ⅞-in. dowel-pins screwed in. The ball of the radius-bar contains a 6-in. hole, in which fits the hinge-pin housed in the saddle of the middle section (Figs. 96 to 104), and provision is thus made for relative movement of the two sections, both in a horizontal and vertical direction. The radius-bar and cross-tie are shown in Fig. 131.

The saddle at the front of the middle section is illustrated in Figs. 96 to 104 and 126 and 127. It is composed of two steel castings. The upper forms a support for the boiler-barrel, to which it is riveted. The lower contains exhaust passages from the high-pressure cylinders outside the frames. The frames are similar in general character to those of the front section, shown in Figs. 84 to 87, except for a slight modification at the front end. The saddle is shown in side elevation in Fig. 97, and in half elevation, front and back, in Figs. 98 and 99. A half vertical section through the centre is given in Fig. 96. Fig. 101 is a horizontal section on A B, Fig. 97, through the steam-passages. Figs. 100 and 102 are plans of the flange riveted to the boiler-barrel, and Fig. 103 of the flange on the top side of the lower casting. A part horizontal section on C D, Fig. 97, is given in Fig. 104. Front and back views of this saddle are shown in Figs. 126 and 127, annexed. The high-pressure cylinders are attached to the saddle outside the frames at the front end of the centre section, and exhaust into separate passages. They are keyed to the frames. The right-hand cylinder exhausts into a rectangular opening in the saddle, leading to the right-angle bend facing forward (Fig. 101) To this is fitted a large steam-pipe, held in a gland fitting and leading to the front pair of low-pressure cylinders The exhaust from the left-hand cylinder passes through a bend to a 10-in. circular opening in the back of the casting, to which is bolted the pipe carrying the steam to the rear pair of low-pressure cylinders. In the lower part of the saddle is housed the hinge-pin for the front articulation. This is a 6-in. vertical steel pin, held top and bottom in ½-in. steel bushings, and kept in position by a 1½-in. bolt passing through lugs underneath the casting.

The rear articulation is composed of two parts only, instead of three, as in the case of the front one. These parts are illustrated in Figs. 114 to 125, page 682, and in Figs. 129 and 130, above. The radius-bar forms part of a cross-tie, which extends between the frames at the back end of the central section. This cross-tie is of cast-steel. It is shown in half elevation from the front and back respectively in Figs. 121 and 122. A side elevation is given in Fig. 123, a plan in Fig. 125, with a detail of the ball-and-socket joint in Fig. 124. To the vertical flange on the top of this casting, spreading across the frames, is bolted the buckle-plate support at the rear end of the fire-box. The ball and bushing details are similar to those already dealt with in connection with the front articulation. The

hinge-pin is housed in the saddle casting of the tender section. This is shown in Figs. 114 to 120 and Figs. 129 and 130, page 682. This saddle is of cast steel, and contains at the front, Fig. 129, a gland connection with the exhaust-steam pipe from the left-hand high-pressure cylinder supplying it. The steam entering through this large gland opening passes into a 9-in. passage, from which bifurcate two bends, ending in 7½-in. openings, connected by flanged bends to the cylinders, as in the case of the leading pair of cylinders. This arrangement is clear in Figs. 20 and 21, Plate XL. *ante*. The exhausts from the cylinders on either side are brought together in a V-shaped passage, Fig. 115, and out of the back of the casting, Fig. 130, where a connection is made with a steam-pipe illustrated in Figs. 63 to 66 *ante*, and leading to the exhaust feed-water heater. Of the illustrations of the rear saddle, Fig. 119 shows a side elevation, and indicates the position of the 10-in. by 6-in. exhaust-passage from the cylinders. Fig. 117 shows a half elevation of the back, and Fig. 118 of the front, of the casting. Fig. 120 is a vertical longitudinal section down the centre of the saddle. Fig. 115 is a horizontal section through the steam-passages, while Fig. 116 is a plan and Fig. 114 a drawing of the under side of the saddle. The hinge-pin is similar to that at the front articulation, and is likewise held in steel bushes, &c.

The frames for the rear section are of a character similar to those of the other sections to a point just behind the rear pair of coupled wheels. Here there is a splice and a steel cross-tie, beyond which the frames are continued in the shape of slabs, 2¼ in. thick and 13½ in. and 16 in. deep. This is the usual design adopted when a two-wheeled Cole pattern trailing truck has to be arranged for. At the trailing end of these slab-frames there are large transverse steel-casting brackets, which take the back end of the truck-springs, and a housing for the draw-gear. These are shown in Figs. 4, 26, 31, and 32 *ante*. All sections are provided with further cross-ties, which, however, space will not admit of being dealt with. We shall, however, describe and illustrate the two most interesting in a future article.

(*To be continued.*)

SOME POSSIBILITIES IN VENTILATION.*

By A. H. Barker, B.Sc., B.A.

No person who has carefully studied the problems of ventilation from the scientific standpoint can fail to have asked himself the question whether the theory of ventilation, as the ventilating engineer now knows it, can properly be called a science. Is there sufficient information on the subject of ventilation to make the application of that word to this knowledge appropriate? Modern practical science is nothing if it does not imply more or less exact knowledge. Some so-called sciences of the philosophical or metaphysical order appear to consist very largely of theories which never can be brought to exact tests. These are doomed by their essential nature to be what they are—namely, speculations more or less interesting and more or less probable, but always matters of opinion.

These, however, are not sciences as the term is understood by the engineer, but philosophies. They do not consist of exact experimental knowledge, but of intellectual theories. All true sciences in the engineer's sense in their initial stages probably pass through a period in which they consist largely of speculation and theories, some of which may or may not be borne out by subsequent experiments. Some of these sciences, such as chemistry or physics, at first consist of theories originally evolved in the effort to explain objective facts. If the facts are only partially observed, understood, or known, the theories will probably be erroneous. As the scientific world becomes better acquainted with the facts as they actually are, theories are modified to suit the known facts. They can be tested by specially-designed exact experiments. When, by a process of trial and error, theories are eventually evolved which will stand all known tests, some totally different in principle from others, and when the existence of facts previously unknown may be correctly deduced from the assumption that the theories are true; then, and not until then, can the science of which they form a part be said to be on a sound basis. There are other branches of science in which the theories cannot be put to exact tests, though their substantial truth is obvious from mathematical considerations.

Other sciences particularly applicable to engineering work are based on exact experimental science, though the conditions of practical application are such that it is in most cases impossible in practice to prove the accuracy of the theories on which they are based. Other experimental sciences, such as physiology, deal with problems of such extreme complexity that, though they are theoretically capable of investigation by exact methods, yet their complexity, and the number of known, though uncontrollable, factors are so great, and the number of unknown factors so doubtful, that it is difficult to obtain self-consistent experimental results to anything like the degree of accuracy which is considered necessary in other sciencee.

The science of ventilation, such as it is, partakes, to a certain extent, of all these characteristics. Its theories are at present in pretty much the same condition as were those of physics at the time of Newton. The number of uncontrollable factors is very great, greater than in most other branches of engineering. The number of unknown factors is probably considerable. The results which can be secured do not therefore approach in accuracy those which can be obtained in many other branches of engineering. All who have been practically engaged in the difficult task of securing generally satisfactory ventilation in occupied buildings know that it is impossible to lay down in exact terms the physical conditions which are required to be secured. Most of us could quote examples of buildings on which large sums have been spent in the effort to secure good ventilation, which, from the point of view of the comfort secured have been total failures. The reasons for these failures are not always easy to define.

The science of ventilation, properly so called, has as its first duty to elucidate all such matters. All of those who have thought on the subject, and have had some practical experience, have their own theories. The special peculiarity of this branch of engineering is that it is exceedingly difficult to bring any of these theories to a crucial test. It is the first duty of the science to overcome this difficulty, which is partly inherent in the subject itself, and partly arises from the fact that the criterion of success is at present very indefinite. The only object we can specify at present is to produce feelings of comfort and a healthy climate. We cannot at present lay down the conditions necessary to secure this end in terms of physics and chemistry. Our knowledge is only general, not exact; qualitative, not quantitative. How can one get a measuring instrument which shall indicate, for instance, the feeling of comfort, especially having regard to the fact that what is one person's comfort is another's discomfort? A refreshing breeze to one man is an ear-aching draught to another man. A bald-headed man is not on the same basis as a person with a shock of hair. Still more difficult is it to experiment on the effect of different conditions on health. The result, experimentally observed, does not arise perhaps for several years after the experiment is made, and it is complicated by the existence of a large number of other conditions which have a decided effect on the total result. Similar difficulties always must occur in any experiments on a human being.

I wish to consider the general direction of modern theories on these subjects, and the character of the investigations which we have in view for this year in this department for the purpose of putting some of them to the proof and the effect they must have on current practice if they are established. What are we really trying to do? What means are we adopting to enable us to do it?

Fig.1. DIAGRAM OF THE CALEOMETER.

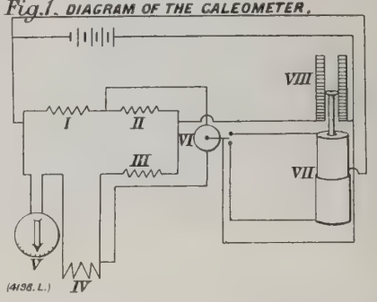


Fig.2. DIAGRAM SHEWING FINAL TEMPERATURE & HUMIDITY OF VITIATED AIR AT VARIOUS RATES OF AIR SUPPLY PER HEAD PER HOUR.

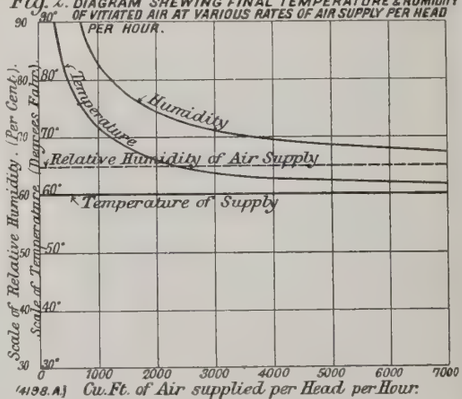
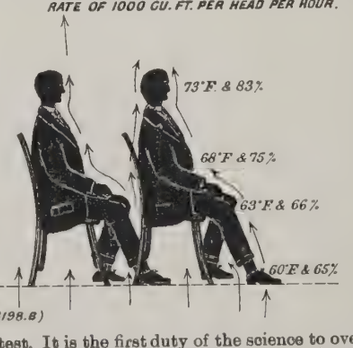


Fig.3. DIAGRAM SHOWING APPROXIMATE EFFECT OF PURE UPWARD VENTILATION AT THE RATE OF 1000 CU. FT. PER HEAD PER HOUR.



In the first place, so it seems to me, the science must direct itself to the investigation of the fundamental question, which is as yet far from being decided. How can we lay down quantitatively in terms of physics and chemistry the objects for which we are striving? It is only recently that it has been borne in upon us that all the old-fashioned theories about carbon-dioxide, organic poisons, and the like, have been blown to the four winds by such experimentalists as Dr. Leonard Hill and Dr. Haldane. In place of them we have had theories of ventilation, according to which its function has practically nothing to do with the elimination of carbon-dioxide and the chemical purity of the breathing air. Instead, its object is said to be to remove heat from our bodies, and water vapour which we have breathed out; in general terms to prevent us from getting too warm.

That is one group of questions which must be settled definitely—to what extent efficient ventilation consists merely in the adequate removal of heat from our bodies and organic smells and water vapour.

I do not think it is possible for any impartial person, who has critically studied the mass of experimental evidence in support of this view, to avoid the conclusion that if it is not the whole truth, it is, at any rate, very largely true that what Dr. Leonard Hill calls "heat stagnation" is responsible for many, or, perhaps, most, of the effects to which we have been accustomed to refer as those of defective ventilation.

For my own part I am, however, equally sure that this fact cannot be the whole truth—that there is something in ventilation over and above the loss of heat and the suppression of smell. I am quite convinced that all air of the same temperature, pressure, humidity, and velocity, has not the same effect on the human organism. That there is some quality other than temperature, humidity, and velocity, in the air itself which makes some air different in effect from other air. What it is can at present only be conjectured. I shall refer to this point later on. From experience I believe that air loses that quality, whatever it is, which, with present knowledge, we can only describe as "crispness," when it passes over accumulated dirt, or into close contact with metal, or through a long underground pipe channel, or when it is heated by hot surface, and that this quality of crispness is not merely a matter of temperature, humidity, smell, or velocity. Invalids feel the air of one place has a different effect on them from that of another place. If it were not so there would be no justification for sending people away to a special climate. It is important, however, not to lose sight of the fact that one cannot draw definite scientific conclusions from the sensations of any person, especially an invalid. Many of the sensations of every person are due to imagination and psychological influences, and not to objective facts, and these are most unreliable as a guide. There are persons not unduly sensitive, imaginative, or susceptible to differences of climate, who find certain places or certain buildings of which the air, hot or cold, damp or dry, moving or at rest, has a stimulating effect on them, and other places or buildings which have the reverse effect. So far as it is possible to tell, this is not a subjective effect at all. I am sure from observations I have personally made that such differences are not merely due to differences in temperature, humidity, or velocity.

Leaving out of count, however, for the moment the question whether or not it is the whole truth, I think we may provisionally accept the theory that temperature, humidity, and velocity of air in a room are points of a very great importance in ventilation, of far greater importance indeed than chemical composition, and that one of the chief, but not the only, reasons for this importance is that they determine jointly the rate of heat loss from the body.

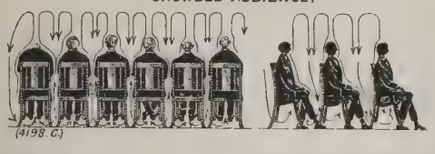
Let us consider where the acceptance of these facts leads us to in practice. If we accept the view that the object of controlling the temperature, humidity, and velocity of air is *solely* to regulate the rate of heat loss from the body, it will be evident that the only instrument we require to measure the effect of ventilation is one which will enable us to determine the joint effect of these three factors so far as they affect the abstraction of heat from the body. On this assumption the possession of such an instrument at once raises the science of ventilation to a higher plane, for it enables us to measure the success of a scheme of ventilation objectively. At present we rely on the expression by individuals of subjective sensations. Up till recently no instrument has been available which enables us to measure this illusive quantity objectively. Air analysis is well known to be most fallacious as an indication of the feelings of comfort. Professor Hill himself has devised two instruments, which have for their object the determination of the degree of joint influence of the surrounding conditions in abstracting heat from a surface as nearly as possible approximating to the condition of the skin of the body. The simplest of these, which Professor Hill calls the "katathermometer," is in essence a delicate calorimeter consisting of a thermometer with a large bulb. The instrument is read by noting the rate at which it falls when it is raised approximately to the temperature of the human body and placed in the conditions or surroundings which it is desired to investigate. This instrument appears to contain the essential principle of what is required, although, so far as I can judge from the little experience I have had of it, the theory of the instrument needs to be worked out more fully than it has been up to the present.

The second instrument is the joint invention of Professor Hill and Professor Griffiths, to which they have given the name of the "caleometer" (Fig. 1). It is an electrical instrument, the object of which is to determine the

* Lecture delivered at University College, October 13, 1914.

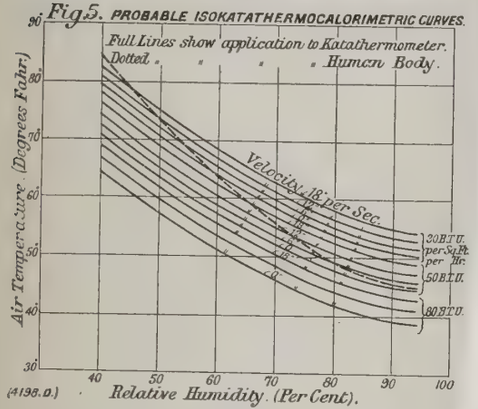
amount of electrical energy required to maintain a coil of wire at the temperature of the human body in the given surroundings. Fundamentally this instrument has essentially the same object as the katathermometer. Both of these instruments will, I think, need careful calibration, and perhaps development in some details before they will be generally accepted by the ventilating profession. It will be necessary to make the readings easier and more direct, to ascertain by experiment what are the respective effects on the readings of the instruments of variations in each of the factors separately; further, to investigate the question what relation the loss of heat from the instrument bears to the loss of heat from the body, and to the sensations of comfort. All these are points of fundamental importance. It is, for instance, the present custom to note with a stop-watch the time which the katathermometer takes in particular surroundings to fall from one temperature to another. The reading is the inverse of that which is required. Before this conveys anything very definite to the mind it is necessary to deduce from this observation a figure proportional to the positive rate of heat loss; and, further, to determine a coefficient to be provided with each instrument which will enable the indications of the instrument to be transformed into heat

Fig. 4. DIAGRAM SHOWING LOCAL AIR CIRCUITS ON CROWDED AUDIENCE.



(4198.C.)

Fig. 5. PROBABLE ISOKATATHERMOCALORIMETRIC CURVES.



(4198.D.)

units per square foot, or some other unit which is understood by the craftsman, and which will reduce separate instruments to the same scale, and which will enable the readings of the katathermometer to be co-ordinated with those of the calcometer. No man can think properly when he is standing on his head. It would, I think, be better to determine by observation the number of degrees the instrument at a given temperature falls in, say, one minute—that is, the rate of fall. I am not sure, too, whether the readings of the wet kata and the dry kata should both be necessary, nor what they respectively indicate. This point needs further elucidation. A man of ordinary ability cannot grasp the meaning of two readings at once.

At any rate, the invention of these instruments is manifestly an event of the utmost importance in our profession. If the control of heat-loss is the sole object of ventilation—a theory which, as I have said, I do not myself accept—then a modified form of these instruments is all that is needed to show whether a room is well ventilated or not. We do not need any chemical analysis. According to my own view, so far as present knowledge goes, we need at least, in addition, to determine the velocity of movement at all parts of the room, also what I have called in previous publications the "radiant temperature," and the absolute temperature of the air itself, the amount of dust, and perhaps, also, the amount of organic products in the air when the room is crowded. I have on the table instruments, mostly of our own design, for making all these determinations, the principle of some of which I have already explained in a paper read before the Institution of Heating Engineers in the early part of this year.

I believe, too, that when further knowledge of the functions of ventilation is available we shall need at least two other determinations, of which I shall speak later. These further requirements are obviously sufficiently formidable.

Leaving all these latter factors out of count for the moment, let us consider for the present only those factors which have an obvious effect on the heat lost, although with the reservation that the joint effect of the three factors in regulating the heat lost is probably not the only effect of importance which the individual factors have. One cannot avoid the conclusion that movement of air has a pronounced effect, quite independently of its effect in promoting loss of heat.

Let us examine the physical effect of different volumes of air in cooling one individual. An ordinary human body may, perhaps, be taken to give off heat at the rate of 350 B.T.U. per hour. Of this total quantity something like 200 B.T.U. is given off in the form of radiation and convection together, and 150 B.T.U. in evaporisation from the surface of the skin and from the lungs. If, therefore, we rely on the passage of air over the body to remove this heat and this vapour, we must examine the effect of these quantities on different volumes of air at, say, 60 deg. Fahr. and 65 per cent. humidity. The diagram shows the effect (Fig. 2). It should be noted that this is a purely physical result, dependent on definitely known, though somewhat variable, factors. It will be noticed that I have included the heat radiated from the body with the total heat. In fact, some of this radiation will be absorbed by the walls, and will not be communicated to the air. The amounts are difficult or impossible to determine. I have therefore thought it best to include the whole of the radiated heat with that convected, so that the diagram shall indicate the maximum possible effect. From these diagrams it will be evident that if we fix as an arbitrary limit a rise in temperature of 3 deg. and a rise in humidity of 5 per cent., both above our arbitrary standard, we shall find that not less than 3500 cub. ft. of air per hour per head must be supplied as a minimum for satisfactory ventilation on this basis, or roughly 1 cub. ft. per second per head. Let us take this as a provisional value for satisfactory ventilation. It is at least three or four times as much as is commonly now considered tolerable ventilation.

Fig. 6. DIAGRAM OF PURE HORIZONTAL VENTILATION WITH RE-CIRCULATED AIR FRONT TO BACK

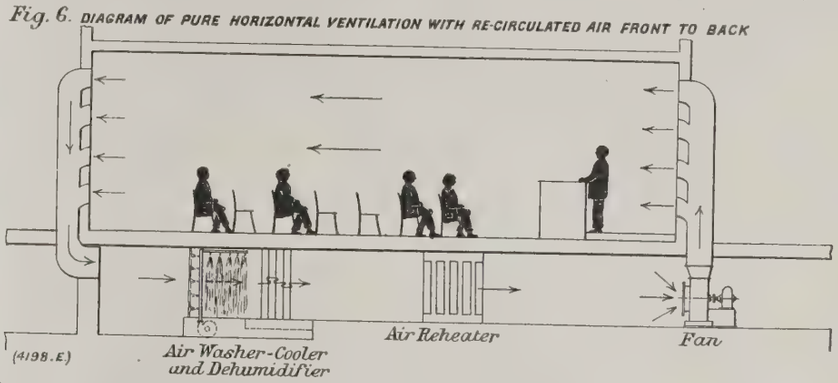


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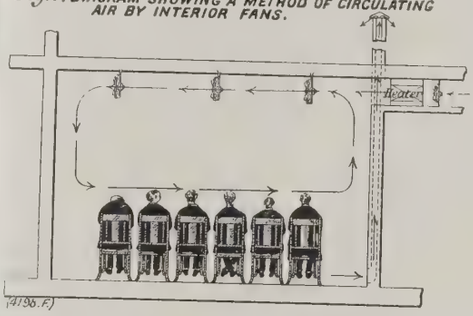
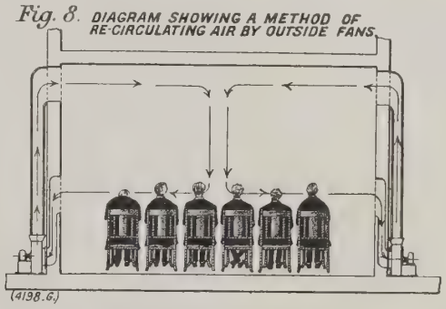
Fig. 7. DIAGRAM SHOWING A METHOD OF CIRCULATING AIR BY INTERIOR FANS.



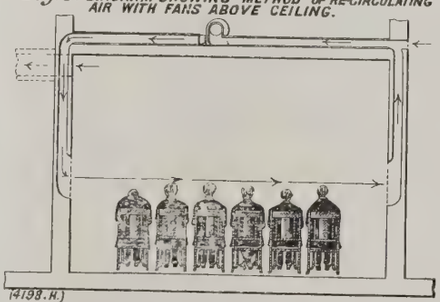
(4198.F.)

Fig. 8. DIAGRAM SHOWING A METHOD OF RE-CIRCULATING AIR BY OUTSIDE FANS.



(4198.G.)

Fig. 9. DIAGRAM SHOWING METHOD OF RE-CIRCULATING AIR WITH FANS ABOVE CEILING.



(4198.H.)

Let us now consider the possible different ways of introducing the air.

It may be imagined to be introduced in a vertically upward direction, the fresh air coming in uniformly round the person's feet and being removed at the ceiling. That is a state of things which is described in my book as being pure upward ventilation. There are very few buildings ventilated in this manner. The best-known example is the House of Commons. In spite of the enormous volumes of air passing through that chamber, the bad ventilation is notorious. It is clear that the effect of this method of introducing the air must be to drive the heat and vapour given off by a man's body up into his face, so that his face gets the hottest and most humid air, and his feet the coldest and driest (Fig. 3). This condition is the exact opposite of a desirable state of things. I believe that physiologists are all agreed that the rate of loss of heat from the face and hands ought to be far greater than that from the feet. This would seem to indicate that from this point of view downward ventilation, as it is called, is superior; and it has certainly been my experience that well-designed systems of downward ventilation cause less trouble and complaint than do those in which the direction is upwards.

But let us consider the effect of passing this quantity of air vertically in either direction over a man's body. Suppose each man occupies a floor space of 6 sq. ft. Taking his own mean cross-sectional area as 1 sq. ft. this leaves 5 sq. ft. for the passage of the air. The mean upward velocity of the air over this space will be about $2\frac{1}{2}$ in. per second. The air in actual contact with his body being entangled with his clothes will have a considerably smaller velocity than the mean. The heat from the body may cause a local circuit similar to a vortex-ring (Fig. 4), but in any case the velocity of the air close to the body can never exceed a very few inches per second if the direction of the ventilation is either upwards or downwards. As this is absolutely insufficient, it is my own belief that neither pure upward not pure downward ventilation is desirable; and this was the point of the chief criticism of the present ventilating arrangements of the House of Commons which I made recently before the Ventilation Committee. Neither the one nor the other represents Nature's method of ventilating the human body. This is in all cases done by a horizonta velocity of wind. My own view, which I hold very strongly, is that a horizontal velocity must also be produced before indoor ventilation can be regarded as satisfactorily accomplished.

For one reason, a vertical current does not admit of a sufficiently high rate of heat removal. It does not prevent the heat from stagnating round the body. I believe also that some horizontal velocity of the air is necessary, either to stimulate the nerves of the skin or for some other physiological purpose, quite independently of the loss of heat from the body. The reason is, of course, a question of physiology. Of the fact itself I am quite sure as a matter of experience—namely, that a generally satisfactory draughtless ventilation is a contradiction in terms.

If it be granted that a satisfactory feeling of freshness cannot be secured without some horizontal movement of the air over the face, the question at once arises—what movement of air is necessary? If we are engaged in the difficult task of ventilating big spaces where a large number of people are crowded, and where the air is very hot and moist, what velocity of air are we to aim at producing? As practical persons we can only answer this question by laying down that it is to be not greater than a velocity that all people will endure without complaining. If we produce a greater velocity than this, then sensitive persons will complain of draught, and we shall find ourselves in trouble. We must therefore find by experiment what is the maximum velocity which people will endure. That question can only be decided by elaborate experiment. We have devised some such experiments which we intend to carry out during this year on the effect of different air velocities under different conditions on human beings. These experiments are of very great difficulty because of the fact that the only observing instrument which can, in the nature of things, be employed are the sensations of the human body. This is a very mutable mechanism which, considered as a measuring instrument, is not itself constant.

What one would desire to be able to do in this connection is to prove by experiment, for example, that a certain person (A) could endure without discomfort in humidity conditions represented by, say, 65 per cent., an air current at a temperature of, say, 60 deg. and a velocity of 18 in. per second, but that a current at the same temperature and humidity, with a velocity of 22 in. per second, would begin to be felt as an uncomfortable draught. This condition would represent that person's maximum. The same person in the same conditions might find a velocity of 12 in. per second perceptibly refreshing, whereas a velocity of 9 in. per second would begin to be felt as rather stagnant and stuffy. This, therefore, would represent that person's minimum.

It will be evident that as these figures merge into one another by imperceptible degrees, and as the only possible measuring device is the sensation of the person under test, a correct determination will be of extraordinary difficulty. Such figures obtained from one person would not be sufficient. It would be necessary to subject as large a number as possible of persons of different physique to the same experiment, and take as careful note of the effect in each case as possible. By this means we may conceivably arrive at a certain medium velocity of air of suitable temperature and humidity, which should not be perceptible to anyone as an uncomfortable draught, while in all cases it produces a feeling not of cold, but of refreshment. This is the velocity of air which the ventilating engineer should aim at producing. This velocity must depend, to some extent, both on the temperature and the humidity of the air. For instance, a velocity of 18 in. per second, which, for want of a better, we may take as a provisional standard, would produce quite a different effect when the air was at 60 deg. and the humidity at 65 per cent. than when the temperature was at, say, 65 deg., and the humidity, say, at 80 per cent. To make our experiments complete, we should have to develop a set of equations showing the relation between the value of the three variables in respect of their effect on the sensations of the human being. For instance, possibly it might be found that an increase of 2 per cent. or thereabouts in the relative humidity might approximately neutralise a drop in temperature of 1 deg. at or about the standard temperature. I have no doubt that if such experiments were carried out it would be found that all persons could endure a velocity of air possibly 6 in. per second greater at 65 deg. and 80 per cent. than at 60 deg. and 65 per cent.

In determining, therefore, what is the desirable air velocity in a room, we must take count of the existing conditions of temperature and humidity. The kind of information that we require is that given on the diagram, Fig. 5, on the preceding page. This diagram represents about what one would expect to find, and not the results of experiments, which, as I have said, have not yet been carried out. These curves, which I have called by the somewhat awe-inspiring name of "isokatathermocalorimetric" curves, are really very simple in principle. Each curve indicates a set of conditions which would have the same effect on the katathermometer and on the human body respectively.

I suggest that the effect on the katathermometer of change of conditions is not, and cannot be, the same as on the human body, because, for one reason, the body is supplied with automatic self-regulating mechanism, whereas the katathermometer is not. Therefore it appears obvious that the isokatathermocalorimetric curve for the instrument must be less steeply inclined than the curve for the human body, or, in other words, the body in a constant current of air will maintain uniform heat loss under severer changes of temperature than will the katathermometer. In so far, therefore, the indications of the katathermometer may be misleading. This is, perhaps, an unsuitable subject for discussion in a public lecture, so I will resist the strong temptation to discuss it further.

Let us then assume the following rule for satisfactory ventilation so far as such can be secured by the control of these three conditions: That the air temperature should be, say, 60 deg. Fahr., and the humidity 65 per cent., and the general horizontal velocity should not be far from 18 in. per second. Present knowledge properly applied would enable us to ensure that the first two of these conditions were maintained—that is to say, a competent person could design a plant which should deliver any desired supply of air at 60 deg and 65 per cent. humidity. We have now to inquire how far it is possible to secure the third condition—namely, that the horizontal velocity should not be far removed from 18 in. per second. In what way can this horizontal velocity be secured in practice?

We may imagine air driven over the audience from front to back or from back to front, or from one side to the other (Fig. 6). My own view is that the best method would be from the front to the back. (Diagrams showing all these directions are to be found on the preceding page, Figs. 7, 8, and 9.)

It is the view of Dr. Hill that whatever the ventilation may be it ought not to be uniform—that is to say, that if at one time the current is from front to back, at another time it ought to be reversed, and perhaps, if possible, driven occasionally from side to side. This condition would, of course, greatly complicate the flues and apparatus necessary to produce the result, and it seems to me that as a practical proposition it would be impossible to carry out without very great expense. But it also seems to me that a current in one general direction, which would in practice be somewhat variable in velocity and direction, might provide by its variations for all the changes called for by Dr. Hill's requirements. It will be clear that if all parts of the room are to be equally satisfactory to inhabit, this velocity must be maintained over the whole of the audience. It will not do to maintain it over a certain portion and keep the rest of the air stagnant. We must have a general sweep of air over the whole. If there are local velocities of greater magnitude, then sensitive persons sitting in the path of these currents will complain of draught; if less, of stuffiness. It is clear that no system of rotating-fans fixed (Fig. 7) in the room itself is admissible. In the first place, such fans could not produce a uniform result, and in the second place, with our present ideas, it is not possible that any audience or any speaker would endure the presence of rotating-fans in a large building, which would distract the attention of the audience from the speaker. At present any visible rotating-fan, even in a restaurant, always gives rise to complaint. This, of course, may be a matter of habit, but it is certain that with present ideas such a proposal would be wholly out of the question. We are driven then to introduce the air through gratings in the wall (Figs. 8, 9, 10, and 11).

It is a general maxim that fresh or cold air must be introduced at a certain height, say 8 ft. or so above the floor. Even on this we are not agreed. There are persons who do not approve of the introduction of air overhead for fear of producing what is called a "down-draught" on people's heads. That there is something in this view cannot be denied. If one chief function of ventilation is the removal of heat and moisture, then it is clear that we can only ventilate a room by introducing air colder and drier than the average air of the room. The body of each person present in the room is continually warming and moistening the air, and this heat and moisture must be dispersed by the introduction of colder and drier, and the drawing-off of warmer and more moist, air. But air which is cold and dry is of necessity heavier than that which is warm and moist. It therefore follows as a mathematical certainty that if cold, dry air is introduced overhead it will fall to the floor so soon as it is free, and is surrounded by air which is warmer and more moist. In other words, it will produce a down-draught. This would only be tolerable if it were practically imperceptible. It could only be imperceptible if it were introduced not in a mass but in finely-divided streams. This implies that at least a large part of the wall through which it is introduced should consist of gratings. Any air which we introduce overhead must be at such a temperature and humidity that it does not cause a current round people's heads greater than the allowable maximum. We ought, therefore, to be informed under what precise conditions cold air can safely be introduced overhead. This is a matter quite capable of exact investigation, and we ought not to be compelled to rely on guesswork as we are at present.

Let us consider then the practicability of a scheme for driving the air from the front of a room to the back (Fig. 6). I will take a concrete case of a room in the country in which I was lecturing some time ago containing about 100 persons. The size of the room was about 20 ft. wide by 40 ft. long and 11 ft. high. This allows about 8 sq. ft. of floor space and 88 cub. ft. of air space per person. It would not be possible in practice to cause a horizontal current to occupy a shallow layer just over the heads of the audience, and keep the air more or less stagnant at a higher level, where, of course, the current is useless as far as its direct effect on the audience is concerned. We can only assume that the current must occupy the whole of the vertical cross-section of the room between the heads of the audience and the ceiling. If we are to imagine that a uniform current of 20 in. per second is maintained over this audience over the whole cross-section from front to back, the amount of fresh air called for even in this low room would be about 1,320,000 cub. ft. per hour, or about 150 interchanges per hour, or 13,200 cub. ft. per head per hour.

Such prodigal ventilation is practically unknown. There are probably not half-a-dozen rooms in the United Kingdom to which air is supplied at that rate. Compared with the size of the room the cost would be very great. It would require a multivane fan about 8 ft. 6 in. high. The cost of the fan and motor alone would be about 150*l.*, and the whole of the apparatus not less than 900*l.* The horse-power required would be 4 brake horse-power. The amount of fuel used if the air were warmed through 30 deg. would be nearly 1 cwt. per hour for warming the air only. It will be seen, therefore, that such requirements as this will be very expensive.

There are few persons who would advocate the spending of this amount of money in order to secure theoretically perfect ventilation for a room of this size, and I am sure there is not an architect in the world who would willingly consent to the whole of the front of the room being occupied by gratings in full view of the audience. Of course, if the audience were larger, the requirements would be proportionately heavier. An audience of 2000 persons would require at least ten of the largest size of multivane fans now catalogued by makers, each standing 12 ft. high. The total power required to work the fans would in this case be not less than 80 horse-power. The fan-power would, of course, be required whether the air supply were all fresh or were recirculated. If we are to imagine the air recirculated, it is clear that, in order to keep the humidity down, it would have to be de-humidified as it passed through the underground trunk.

The only practical way of de-humidifying the air to an

Fig. 10.

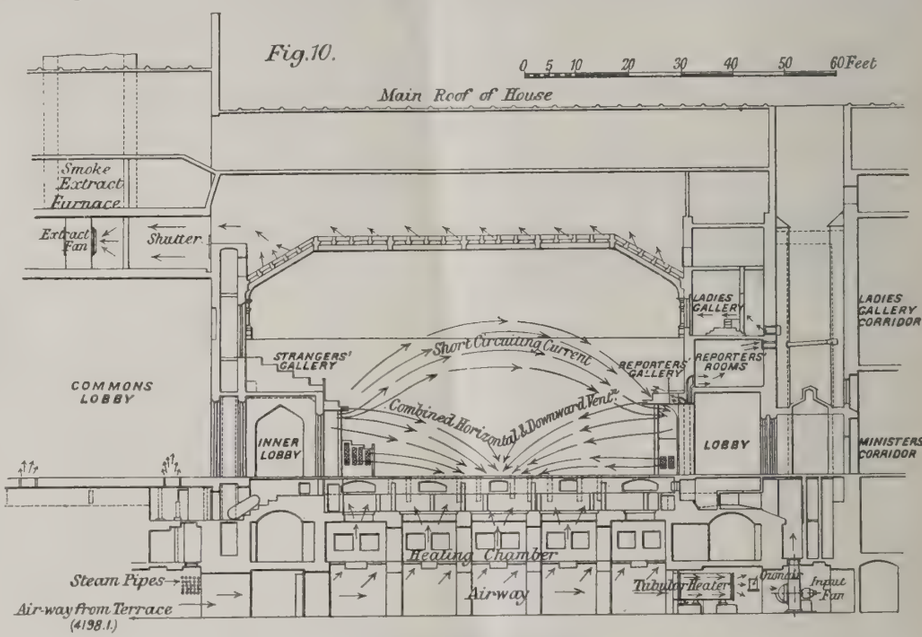
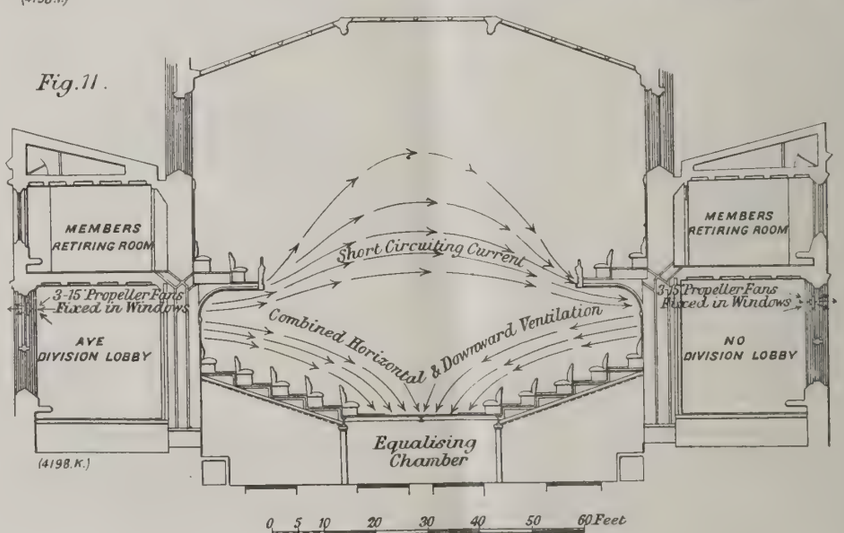


Fig. 11.


MEMBERS RETIRING ROOM
Short Circuiting Current
MEMBERS RETIRING ROOM
3-15' Propeller Fans Fixed in Windows
Combined Horizontal & Downward Ventilation
3-15' Propeller Fans Fixed in Windows
AVE DIVISION LOBBY
NO DIVISION LOBBY
Equalising Chamber
(4198.K.)
0 5 10 20 30 40 50 60 Feet

exact value at present known is to cool it to such a point that, when it is absolutely saturated at that point, it contains the requisite amount of absolute humidity. It is then warmed up to the desired temperature. Now, the plant for this apparatus would be very expensive indeed. In order to kill the possible smell of human beings in the air, it would be necessary not only to dehumidify, but also to pass it through a spray of disinfectant, such, for instance, as a solution of permanganate of potash, which would probably kill all the smell.

I think this analysis is sufficient to show that the new theories of ventilation, if they are carried into practice on a large scale, will greatly increase the expense both of construction and of maintenance. I think it shows, too, that a system of re-circulating air is impracticable, as it would be cheaper in all cases to take fresh air from the outside, and bring it up to our standard requirements of temperature and humidity, and discharge the slightly vitiated to the outside. At any rate, it appears certain that the new theories do not by any means lighten the task of the ventilating engineer. I have not considered in detail alternative methods of passing the air over the audience. I am at present engaged in experimenting on a method which would probably minimise the expense, and, at the same time, produce a certain movement in the air; but it would not be possible by any other means than those I have suggested to secure that uniformity which is desirable, and even necessary, if we are to be able to guarantee the ventilation of the whole of any given room on the lines I have proposed.

We have now to inquire whether any smaller requirements would serve the purpose. It will be remembered that, calculating from a certain arbitrary allowable rise in the temperature and humidity, we deduced the allowance per head per hour as 3500 cub. ft., whereas calculating from an arbitrary velocity over the audience in a room 11 ft. high, we arrived at 13,200 cub. ft. per hour. If we could reduce the height of the stratum of moving air, we could reduce the quantity of air in proportion, and still maintain the standard velocity. But it is impossible to conceive a large room for 100 persons less than 11 ft. high. If we have a higher room—such, for instance, as the Albert Hall or the House of Commons—even such an allowance as 13,000 cub. ft. per head per hour would of necessity be quite lost if we attempt pure horizontal ventilation. The main stream of air would follow the line of least resistance, as shown in Figs. 10 and 11. In ventilating a room of this kind, therefore, it seems that the only practicable solution is a combination of horizontal and downward ventilation when such is attainable, so as to pull the main stream of air into contact with the audience; otherwise it will be lost above the heads of the audience.

This was my main proposal to the Committee for Improving the House of Commons Ventilation. To carry it out it would be necessary to have one or more large gratings in the floor and a system of trunks for drawing air through them, whether or not the air were subsequently re-circulated or discharged to the open air.

I have dealt very briefly with the chief outstanding difficulties in adapting the modern ideas in practice which relate to the provision of the necessary quantity of air. There are other possible explanations of the difficulties of producing a satisfactory result, most of which are only speculations of my own. For instance, do we know everything of importance about the composition of our atmosphere? It is somewhat disconcerting to reflect that it is only a few years ago that the very existence of several important constituents in it was revealed for the first time by the investigations of Sir William Ramsay of this College. Are there any other constituents or conditions in the atmosphere which we do not know, the existence of which may have a great deal of effect on ventilation?

There is one physical fact, very real and very difficult to observe, of which I have never heard it suggested that it has any connection with ventilating problems, but which, so it seems to me, may have, and perhaps must have, some effect, great or small—that is, that the electrical potential inside a closed conductor is uniform.

The potential outside a conductor is not uniform. The potential in the open air increases by about 100 volts for every yard above the ground. Has this fact any relation to the difference in our feelings between outdoors and indoors. Consider a room having a large open window, on a hot summer's evening. The air outside being so still that hardly any known test will indicate any movement in it at all. One hangs a thermometer in the room and in the garden. The reading is the same. One goes into the room and finds it feels stuffy and stifling. One goes into the garden, and even when it is very hot one experiences a feeling of freshness and vitality which is totally absent in the room. What is the reason for this difference? It cannot be any difference in temperature or composition of the air. It may be partly a difference in what I have called the radiant temperature. Is it in any degree connected with the fact that in the room one is surrounded on all sides by what is in effect an electrical conductor, which produces the effect of constant potential well known to the physicist. In the open air there is a considerable difference of voltage between our heads and our feet. No such difference is observable in the interior of a room in which the walls form a practically continuous conductor. To determine whether there is anything in this, we have to investigate the question, what is the effect on the sensations of a difference in voltage between the head and the feet? If there is any effect, it is possible that the electrification of some large sheets of insulated metal in the ceiling of a room might produce a good effect on the ventilation. Again, is it possible that the *ionisation* of the air has anything to do with the difference in feeling between fresh and stale air? I am inclined to believe that it has. We have initiated some experiments on this matter, but are not sufficiently forward to enable me to speak on the subject with any confidence. Judging from what is known of its chemical character, it has always seemed to me that ozone, as such, is of no value at all as a constituent of ventilating air. I have certainly heard responsible people say that the *ozonisation* of air has a perceptible freshening effect. The method by which this ozone is commonly produced, by high-tension electrical discharge, may have the effect of causing the ionisation of the air. It may be that this has a freshening effect on the nerves. Ozone itself is, in my belief, only a sort of undesirable by-product of the electrical discharge. I believe that if ozone itself were manufactured chemically and discharged into the air, it would be recognised as the vile and poisonous gas that it really is, but being accompanied by ionisation of the air, it has I believe the effect of freshening the "feel" of the air. If this effect were produced without at the same time producing ozone—as, for instance, by the action of X rays—I believe it would be far better.

One of the main effects which the modern theories of ventilation will have on our practice, if they are carried out, will be to produce a sharp difference of opinion between the physiologist and the heating engineer in regard to the method of heating by means of hot radiators and pipes. The main effect which radiators and hot surface generally have on the condition of a room is to raise the temperature of the air, and, worse than this, they make the upper strata of air warmer than the lower.

The modern view which physiologists take of this matter is that the breathing of hot air is distinctly deleterious, in that it causes the membranes of the nose to get into such a condition as easily to absorb the germs which produce the disease known as cold in the head and other respiratory diseases. Within limits, the cooler the air breathed, the better it is from the point of view of pure hygiene. Physiologists also take the view that it is extremely undesirable that the temperature at head level should be higher than at foot level, since it causes certain movements of the blood in a contrary direction to what is desirable. It is quite obvious that since warm air is lighter than cold air, there cannot fail to be a tendency for the temperature at high level to be greater than at low level when the heat is introduced by warming the air. This effect is always found in a radiator-heated room. From this point of view, radiator-distributed heat may be regarded as undesirable from the point of view of hygiene. The effect is well known to be influenced very largely by the temperature of the radiator. The higher the temperature of the radiator the greater is the difference between the upper and the lower layers of air in the room.

The distribution of heat by radiators is, however, so convenient that it is impossible as a practical proposition to recommend its abandonment whether or not it conforms strictly to the requirements of hygiene. It is for this reason very desirable that the necessary amount of heat should be communicated to a room by large radiators at a low temperature, rather than by small radiators at a high temperature. It is also necessary that the feeling of warmth in a room should be properly maintained, but it is also very desirable in the interests of the individual that he should accustom himself to living in a relatively low temperature.

The only means whereby this feeling of warmth can be secured apart from the warming of the air is by increasing the amount of energy in radiant form passing through the room. This radiant energy is always expensive to maintain, firstly, because a large part of the heat given off from a radiant body is always convected heat, and because a large part of that which is given off as radiation at once passes away through the window glass and the cold walls of a room, and is thereafter largely lost, so far as its effect on the inhabitants is concerned. On the other hand, heat communicated to the air of a room is not only easier to produce but also remains in the room as heat for a much longer time. This is one reason why an open fire is so extravagant, desirable as it is in many ways. A large part of its heat is sent up the chimney as hot air. That part of the heat which is given off as radiation, unless it impinges on the body of the person in the room, is immediately lost, either by absorption or transmission through the window glass. It is difficult or impossible to obtain a correct balance-sheet of the heat given off when coal is burnt in an open fire, for the reason that the heat radiated is so illusive that it cannot easily be measured without very elaborate appliances such as we have just erected in the laboratory for this very purpose.

It will be seen therefore that the modern theories of ventilation, which at first sight appear to render possible a reduction in the heat cost of ventilating a room, in reality have a very marked tendency in the opposite direction. They increase to a very large extent the practical difficulties, the amount and expense of the plant required, and they increase also the cost of upkeep. If they are to be carried into practice they will call for something like a transformation in methods of building, and they will certainly be regarded with acute disfavour by every architect who is interested in the interior appearance of a large room.

I will summarise now the observations which appear to me to be necessary in order that we may get a complete idea of the state of the ventilation of any given room. We must have the wet and dry katathermometer readings. We must know the absolute temperature of the air, and the mean radiant temperature, as given by my instruments. We should have readings indicating the velocity of the air at all parts of a room when the room is full, as given by my micro-anemometers. We should have also the analysis of the air, and particularly know what amount of organic products and dust exist in the room. We should take the electrical readings, and determine the degree of ionisation of the air of the room.

It will be seen that this is a sufficiently formidable list. It would not be possible for anyone to take all these readings with any sort of care even for a small room under a couple of hours hard work. He should also be provided with very expensive and elaborate apparatus. I am not of course suggesting that such a series of observations would be possible in practice when a room is occupied, but it merely shows what a very extensive subject we are dealing with, and how little anyone would be justified in concluding that the subject of ventilation can be treated in a cut-and-dried manner. What is the physiological effect of each of these factors on the human body I do not think even Professor Hill himself would care to say at the present moment without a great deal of further investigation. It is essentially a matter for experiment, and those experiments will be expensive, tedious, and difficult, and it must be many years before they can be completed.

Our chief necessity in this department is for the requisite help to enable us to carry on this campaign of investigation vigorously. We have all the plant and instruments ready, but are badly off for persons qualified to operate it and obtain the results. For that reason we have this year decided that every person who attends the course of lectures shall also have the opportunity of carrying out laboratory work after the lecture and at other times, in the hope of finding recruits who are able to take these very interesting observations with intelligence and accuracy.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

South Africa: The office of H.M. Trade Commissioner reports that tenders are invited by the Johannesburg Municipal Council for the supply of renewals and spares for tramcar-motors, controllers, bogie trucks and brakes, also trolley and car fittings, &c. Sealed tenders, on the proper forms, will be received by the Town Clerk, Municipal Offices, Plein Square, Johannesburg, up to noon on January 5, 1915. It will be observed that the time for the receipt of tenders is limited, and owing to forms having to be obtained from South Africa, this intimation will be of use only to firms having agents in the Union who can be instructed by cable.

France (Equatorial Africa): The *Journal Officiel*, Bordeaux, publishes a Decree authorising the installation of telegraphic communications in French Equatorial Africa. A total sum of 760,000 francs is allotted for the construction of wireless stations at Oubangui (355,000 francs), Alima (130,000 francs), and Brazzaville (170,000 francs), as well as a telegraph line from Alima to Haut-Ogovué at a cost of 105,000 francs. (25 francs = 1*l.*)

Spain: The *Gaceta de Madrid* notifies that tenders were to be received at the offices of the Compañia del Ferrocarril del Tajuña, Calle de Jorge Juan, No. 35, Madrid, up to noon on November 30, for the supply of 125,000 bolts for fish-plates, and 755,000 dogspikes required for the secondary railway from Orusco to Cifuentes. This contract is reserved to national firms, but should tenders prove unsatisfactory, a second call for tenders will be made, in which foreign competition will be invited. The *Gaceta* also publishes a Royal Decree authorising the Junta de Obras del Puerto, of Ferrol, to carry out dredging and other improvement works at that port, at an estimated cost of 355,708 pesetas (about 13,170*l.*).

Colombia: The *Diario Oficial*, Bogotá, publishes a law authorising the Colombian Ministry of Public Works to proceed with the construction of a railway starting from Espinal or Girardot to connect Bogotá with the territory of Caquetá by way of the town of Neiva. When the line reaches Neiva arrangements will be made for its continuation in a southerly direction to the valley of the Cauca, where it will be linked up with the Pacific Railway.

Venezuela: The *Gaceta Oficial*, Caracas, contains the text of a contract entered into between the Venezuelan Ministry of Public Works and Senor W. A. Littell, of Valencia, State of Carabobo, for the construction of an aerial cable railway from Valencia to Nirgua. Work must be commenced within a year from the date of the approval of the contract, and completed within a further period of two years. All cables, standards, cars, machinery, coal, &c., required in connection with the work, which it may be necessary to obtain from abroad, will be exempt from import duty.

Argentina: The *Boletin Oficial*, Buenos Ayres, contains a decree approving the plans submitted by the Empresa de los Ferrocarriles de Entre Rios, for the construction of a railway, about 28½ km. (17½ miles) from Sauce Grande, to link up with the main line of the Central Córdoba Railway. The same *Boletin* contains a decree authorising the Empresa del Ferrocarril Oeste de Buenos Ayres to proceed with the electrification of its services between the port of Buenos Ayres and the station Once de Septiembre, and between that station and Moreno. It also contains a further decree, authorising the expenditure of 4,000,000 pesos currency (about 350,000*l*) on the reconstruction of the permanent way and bridges of various sections of the State Railways which have been partly destroyed by heavy rains and floods.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting held on November 13, 1914, at the Imperial College of Science, Dr. A. Russell, Vice-President, in the chair, a paper on "*A Bridge for the Measurement of Self-Induction*" was read by Mr. D. Owen. B.A., B.Sc.

1. An alternate-current bridge method is proposed for the determination of self-induction in terms of capacity and resistance. The inductance L is given by the relation $L = K_3 r_1 R$; in addition to which it is also necessary for balance of the bridge to satisfy the condition $K_3 r_1 = K_4 r_2$.

2. The two conditions of balance may be secured in practice without mutual interference. The end point is therefore rapidly attained. The possibility of effecting a balance is unlimited by the value of the unknown L.

3. The method is independent of frequency. This has the accompanying advantage that it is unnecessary to employ a pure sine voltage. Very good results may be attained with a buzzer as source and a telephone receiver as detector at, say, 500 periods.

4. The dependence of sensibility of the bridge on the frequency is discussed, and it is shown that over a wide range (say, 100 to 1000 periods) the sensibility is high.

5. The effects of residual inductance in the resistance coils and leads, and of absorption in the condensers, may be simply and correctly allowed for, the formula then becoming

$$L = K_3 r_1 (R - R_0).$$

This fact is of especial importance in the accurate determination of very small inductances.

6. Tests are quoted showing that with the same pair of condensers measurements over the full range from 1 microhenry upwards may be made. For inductances of the order of 10 microhenries the error may be kept within a few parts in 1000; whilst if the inductance is as high as a few millihenries, the error of any measurement may be reduced below 1 part in 10,000.

7. The application of this bridge to the determination of capacity in terms of self-inductance is discussed, and an example is given of a test of the temperature variation of capacity of a standard mica condenser over the range 0 deg. to 80 deg. Cent.

Discussion.

Mr. A. Campbell congratulated the author on his clear treatment of the general case. His method had several advantages, the most important of which was that he took a zero reading to eliminate the inductance of the leads by substituting a non-inductive resistance for the inductance to be measured. There is, of course, a difficulty in all such methods in obtaining a non-inductive resistance; but this can be got over by using a small inductance, of which the value can be calculated, such as a pair of parallel wires. He could not say how far the terms in equation 12 could always be neglected, as done by the author, with frequencies greater than 1000. Particular cases could be tried to see how far this was permissible. Among the disadvantages, he instanced the use of standard condensers in place of standard inductances. The latter could be obtained at less cost and of greater accuracy than condensers. Moreover, the values of condensers varied more rapidly with temperature and frequency than did those of inductances. The former defect was aggravated by the time required for a condenser to take up a steady temperature. The usual practice was to keep it at a given temperature for twenty-four hours or more in measuring to tenths or hundredths per cent. Another difficulty in bridge-work with condensers is caused by earth capacities. If the point of earthing be altered, different results may be obtained. He suggested that the galvanometer and battery might profitably be interchanged. The position described in the paper was the worst for disturbances due to earth capacities.

Mr. F. E. Smith mentioned that in Rosa and Grover's paper, quoted by the author, a figure practically identical with Fig. 3 in Mr. Owen's paper appeared. Some of the equations, also, were very similar, but Rosa and Grover had, apparently, overlooked the fact that by making one of the R's and one of the L's zero the bridge could be used for the measurement of self-induction. He was surprised that Mr. Owen appeared to prefer the telephone to the vibration galvanometer in many cases. He would have expected the latter to give more satisfaction in almost all cases. With regard to the discrepancy found by the author in the temperature curve for his condenser, he might say that in the case of paraffin-wax condensers it was always dangerous to cool to 0 deg., as a change occurred in the wax which introduced trouble. Curtis had gone into the matter of changes in the resistance of the old B.A. resistance coils when cooled to 0 deg., and had shown that these were due to changes in the wax.

Dr. Russell said that he had used Mr. Owen's method of measuring inductance in his laboratory and had found it simple, accurate, and most satisfactory. When ordinary alternating-current supply was available, good results were obtained either with a telephone or a vibration galvanometer. The theorem on which the method was based was extremely interesting from the theoretical point of view, and several curious results followed from it. Mr. Owen's method of proof was well adapted to the needs of electrotechnical students, but he preferred the analytical methods as they were more rigorous.

The author, in reply, referred to the variation of capacity with frequency. This was most marked at low frequencies, and as, to get sensibility, the bridge had to be used at frequencies of 100 or more, one was working outside the most dangerous region. With regard to the temperature variations, he pointed out that the condenser could always be tested against a standard inductance if need be. He had allowed four hours for his condenser to come to a given temperature. In ordinary use, as the daily range was not more than 3 deg. or 4 deg. Cent., and as 1 deg. only introduced an error of 1 in 10,000, he thought the trouble would be inappreciable. He had tried both positions of the galvanometer and battery, and sometimes one and sometimes the other proved most satisfactory. The difficulty about earth capacities was one that had to be guarded against in all balanced-bridge methods when the utmost accuracy was required. The effect was likely to be very small in the bridge described, since the capacities employed were comparatively great.

A paper on "*The Coefficient of Diffusion in Dilute Solutions*" was read by Mr. B. W. Clack, B Sc.

The paper details modifications made in the apparatus previously described (Proceedings of the Physical Society, XXIV., December 15, 1911) to determine the value of the coefficient of diffusion of salts through water, by means of which the steady state is hastened, and results obtained more quickly.

The single wide tube previously employed is replaced by a battery of shorter and narrower tubes. The error due to end-correction is investigated, and results are given for the salts KCl, KNO_3, and NaCl for various concentrations down to very dilute solutions.

Discussion.

Dr. Griffiths said that he wished he could detect some flaw in Mr. Clack's methods, as he had always got higher results than those of the author. It appeared, however, to be much easier to get results too high than too low.

Mr. Paterson did not see why, in a symmetrical arrangement, such as the diffusion-bulbs used by the author, the siphoning on which the maintenance of the concentration of the lower end of the diffusion-tube depended should take place.

Mr. F. E. Smith wished to know if the author's method would be suitable for measuring the rate of diffusion of one solution into another of very nearly equal concentration and density. The problem was met with in standard cells. There was a slight difference in composition of the liquid throughout the cell, and this appeared to become practically constant after some years, as though diffusion had ceased altogether.

Dr. Russell congratulated the author on having completed such a thorough investigation. When Glasgow University was removed to its new buildings at Gilmorehill in 1871, Lord Kelvin set up many long tubes containing liquids with the idea that the progress of the diffusion might be noted not only after years, but after hundreds of years. Although the author's earlier experiments had lasted months in some cases, he was now able to complete them in a few days.

The author, in reply, thought it was an accident which way siphoning started, but when started it would obviously go on. It would be difficult to apply the method to solutions of nearly equal concentration, although it would measure the diffusivity of a strong solution with respect to a weaker one of the same salt to the same degree of accuracy, as it measures that of a dilute solution with respect to water, the difference of concentration being the same in each case.

CATALOGUES.

Electric Motors.—A price-list giving full particulars of continuous-current motors of the protected type up to 50 horse-power has been issued by Messrs. Crompton and Co., Limited, of Chelmsford.

Fire-Bricks and Fire-Clay Goods.—Messrs. J. H. Sankey and Son, Limited, of Essex Wharf, Canning Town, E., have sent us a copy of their latest catalogue of fire-bricks, lumps, tiles, boiler-seating blocks, flue-covers, and other fire-clay goods.

Fans.—We have received from the James Keith and Blackman Company, Limited, 27, Farringdon-avenue, E.C., a booklet relating to Keith centrifugal steel-plate fans. These fans are suitable for delivering or exhausting large volumes of air through the resistance of pipes or flues for ventilation, induced and forced draught, dust removal, &c. The construction of the fans is fully described, and dimensions, capacities, and other particulars are given of fans in which the size of the outlet ranges from 5 in. by 4 in. to 5 ft. by 4 ft. Illustrations in the booklet show the fans arranged for belt-driving, and also directly coupled to steam-engines or electric motors.

Steel.—Messrs. Edgar Allen and Co., Limited, of Imperial Steel Works, Sheffield, have issued a catalogue giving particulars of some of their products, which include high-speed steels and several classes of water-hardened carbon tool-steels. These steels are supplied in various special sections for convenience in tool-making. Other products of the firm are iron-fibred mild steel (which is especially suitable for making machine parts subject to vibration and sudden shocks), special steels for motor-car construction, steel castings, and castings, forgings, sheets, bars, rails, and other sections in manganese steel. They also make circular saws, files, hammers, shovels, twist-drills, milling-cutters, and other tools.

Electrical Goods.—We have received from the Edison and Swan United Electric Light Company, Limited, of Ponder's End, Middlesex, the first copy of a little booklet entitled "Ediswan Electric Service," which they intend to issue periodically. Its object is to record the progress of the company, and to call attention to their products. The first issue deals briefly with the early history of the incandescent lamp, and traces its development down to the introduction of the half-watt lamp. It also contains articles on electric fans, electric-light fittings, and electrically-heated irons for domestic use. The booklet is very nicely got up, and the matter is written in a style likely to appeal to the general public, so that good results may be expected from its distribution.

Locomotives.—Record No. 79, from the Baldwin Locomotive Works, of Philadelphia, Pa., U.S.A., relates to locomotives of the Pacific (4-6-2) type, and illustrates a number of engines of this type recently constructed by the firm. In an interesting introductory article the special characteristics of the Pacific type are pointed out, and a comparison is drawn between the hauling powers of engines of the 4-6-2 and 4-6-0 types. A diagram shows that at starting speeds both types are practically equal in hauling power, but at higher speeds the superiority of the Pacific type is very apparent. The record then illustrates and describes seventeen Pacific-type engines, most of which are used for fast and heavy passenger traffic on American lines. This type of engine is, however, being used to a large and increasing extent for fast freight service.

Ozone Production and Utilisation.—A pamphet relating to the production and utilisation of ozone has been issued by Messrs. Ozonair, Limited, of 96, Victoria-street, Westminster, S.W. One of the most important applications of ozone is its use for air purification, and this subject is fully dealt with, the firm's well-known generators and fans being illustrated and described. Ventilation plants using ozonised air are also illustrated. Ozone is also used in connection with therapeutics, water purification, food preservation, copra drying, brewing, the treatment of oils and fats, and the conditioning of textile materials. All these and other applications are discussed in the pamphlet, and a long list of users, together with a number of testimonials from them, is printed. It is suggested that the pamphlet might be useful to central-station engineers desirous of increasing their loads.

Fire Cement.—A pamphlet giving particulars of "Pyruma" fire cement has been issued by the makers, Messrs. J. H. Sankey and Son, Limited, of Essex Wharf, Canning Town, E. This cement is claimed to have the fire-resisting properties of the best fireclay combined with the setting qualities of Portland cement. It is very adhesive, to prove which the firm reproduce a photograph showing five firebricks cemented together, end to end, with "Pyruma," and supported as a beam on two piers placed at the extreme ends of the row. The cement is used for setting firebrick work, and as a wash for coating the walls of furnaces. It is also suitable for repairing all kinds of retorts, kilns, furnaces, &c., and may be applied while they are red-hot. For firebrick work in locomotives and torpedo-boats, where the vibration is excessive, or in kilns, where the dislodgment of a firebrick might do considerable damage to valuable pottery, this cement is especially recommended. Ordinary fireclay may be made to set as hard as cement and still retain its heat-resisting properties if mixed with "Pyruma" cement. The latter is sold in 7 lb., 14 lb., and 28 lb. tins, and 1 cwt. kegs.

Roller-Bearings.—A copy of the latest edition of a little booklet relating to "Timken" roller-bearings has come to hand from the Electric and Ordnance Accessories Company, Limited, Warwick Chambers, Corporation-street, Birmingham. These bearings, it will be remembered, consist of a number of tapered rollers running between a pair of conical surfaces, and their two most important features are that they support end thrust as well as radial loads, and can be adjusted as wear takes place. They are thus especially suitable for use on motor-cars, and, if properly mounted and given a reasonable amount of attention, they may be depended on to last for the whole life of the car. Ball-bearings, on the other hand, must be replaced as soon as they become slack, as the wear cannot be taken up. The booklet explains the principles of the Timken bearings, points out their advantages, and illustrates their application to the different parts of a motor-car. It also deals with their manufacture, and explains what must be done to obtain the most efficient service from them. The reading matter is clear and interesting, and the free use of illustrations makes it comprehensible to persons entirely devoid of mechanical training. Although the booklet deals only with the application of Timken bearings to motor-cars, they are largely used on horse-drawn vehicles, as well as on electrical and other machinery.

Lifting Appliances.—We have received from the Yale and Towne Manufacturing Company, of 9, East Fortieth-street, New York, U.S.A., a catalogue giving full particulars, with prices, of the various lifting appliances manufactured by them. Yale triplex blocks are first dealt with. Their construction is illustrated and described, and prices are stated for blocks suitable for loads ranging from ½ to 20 tons. Duplex blocks for loads up to 10 tons, and differential blocks for loads up to 3 tons, are also listed. Overhead runways, or trolley hoists, are next dealt with, full particulars being given of trolleys, blocks, track, turntables, switches, and other accessories. We then come to overhead travelling-cranes equipped with triplex blocks. These cranes are composed of a rolled-steel joist with cast-steel truck-frames at both ends. They are listed for loads up to 5 tons, and for spans up to 36 ft. Particulars are also given of double-lift hoists, crabs and winches, and electric hoists; numerous examples of these and other lifting and transporting appliances, are illustrated. The catalogue is well printed and illustrated, and it gives all the information likely to be required by users and prospective users. A particularly useful feature is the price-lists of spare parts of blocks, &c. All the parts are numbered and illustrated, so that no mistakes are likely to be made in ordering them.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

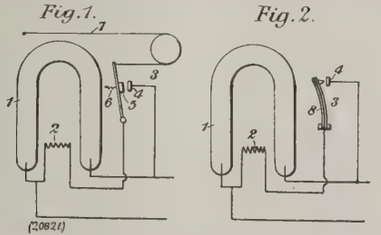
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

ELECTRICAL APPARATUS.

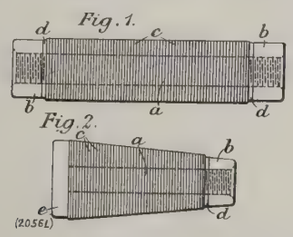
20,821/13. E. E. Darmois and M. A. E. Leblanc, Suresnes, France. Mercury-Vapour Lamps. [6 *Figs.*] September 15, 1913.—This invention relates to mercury-vapour lamps in which the positive and negative electrodes are electrically disconnected when the apparatus is inoperative, the starting operation being effected either wholly or partly by heating the bodies of vapourisable material constituting the two electrodes. According to the present invention, the heating device or its equivalent is arranged to be so controlled that its operation to raise the temperature of the electrodes, when the necessary electromotive force is applied to the terminals of the apparatus, is retarded or prevented so long as the temperature of the apparatus is above the temperature (lower than the normal operating temperature) at which restarting of the apparatus into operation after a temporary interruption is possible. A lamp 1 is shown provided with a heating coil 2 and an automatic switch 3 for controlling the circuit of the heating coil 2. The automatic switch 3 is provided with a stationary contact 4 and a movable contact 5, the latter of which is arranged to be held out of engagement with the stationary contact 4 by means of a spring 6. The movable contact 5 is arranged to be brought into engagement with the stationary contact 4 by means of a wire 7 composed of material having a suitably high thermal coefficient of expansion, the wire 7 being located adjacent to the heated portion of the lamp 1. This form of the invention operates in the following manner:—When the lamp is started into operation from a cold condition, the wire 7, being cold and therefore contracted, maintains the two contacts 4 and 5 of the automatic switch 3 in engagement with each other,



and upon the necessary electromotive force being impressed upon the terminals of the apparatus, current will flow through the circuit of the heating device 2, which is closed by the automatic switch 3. As soon as the apparatus attains its normal working temperature, the wire 7 located adjacent to the apparatus becomes heated and expands, thereby permitting the spring 6 to move the contacts 4 and 5 of the automatic switch away from one another and interrupt the circuit through the heating device 2. Assuming the lamp is operating under normal conditions, the temporary cessation of the flow of current between the electrodes will not immediately cause the automatic switch 3 to be closed, since this cannot occur until the wire 7, and consequently the container of the apparatus 1, has cooled below a certain temperature. In cooling to this temperature, the apparatus will in all probability restart spontaneously if the impressed electromotive force has been restored after only a short interruption; and since the heating device is inoperative until the lower temperature above referred to is attained, the cooling of the apparatus necessary to effect such restarting is freely permitted. Referring now to Fig. 2, a modification is illustrated in which the movable member of the automatic switch 3 is constituted by a spring-contact member 8 composed of two materials having different coefficients of expansion, this member being located adjacent to the container of the lamp 1, and its component elements being so arranged that so long as the container is at a temperature above that necessary to permit spontaneous restarting, the contact-member 8 of the automatic switch 3 is bent away from its fixed contact 4 and the circuit of the heating device 2 is interrupted. (*Accepted September* 16, 1914.)

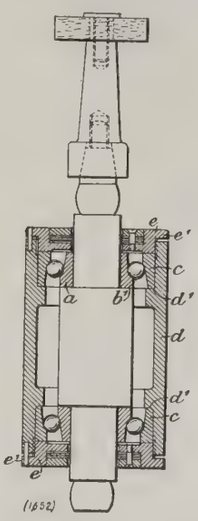
MACHINE AND OTHER TOOLS, SHAFTING, &c.

20,561/13. S. Z. de Ferranti, Baslow. Roller-Bearings. [2 *Figs.*] September 11, 1913.—This invention relates to roller-bearings, and especially to the construction of the rollers themselves. In order to overcome certain difficulties in the working of roller-bearings, believed to be due to abrasion or other effect caused by the action of steel on steel under concentrated loads, it has been proposed to construct the rollers of



other materials of a non-metallic character, and it is the object of the present invention to provide a form of roller specially suitable for such materials, but applicable with advantages in certain cases to steel also. With this object the invention consists of a roller for the purpose indicated, constructed of a number of laminæ or thin plates of a metallic or non-metallic material held together axially under considerable pressure. In carrying the invention into effect, according to one form, as shown in Fig. 1, a central spindle *a* running through the roller is screwed at both ends for the reception of the pressure nuts *b*, *b*. On the spindle *a* are threaded a large number of laminæ *c*, *c*, pressed together axially by the nuts *b*, *b*, it may be in conjunction with washers *d*, *d*. Referring to Fig. 2, which shows a form of conical roller, the spindle *a* at one end has formed integrally with it a heavy disc or plate *e*, against which the laminæ *c* are forced by the nut *b*. The spindle *a* is preferably cylindrical, so that all the central holes through the laminæ are the same diameter. (*Accepted September* 16, 1914.)

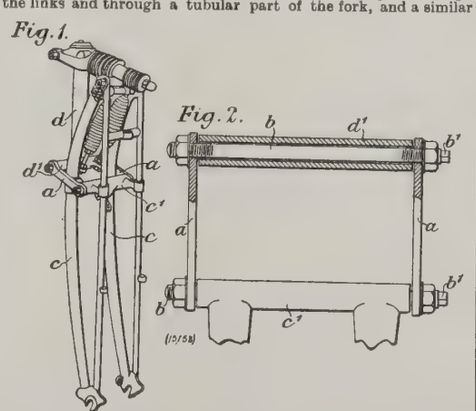
1652/14. The Auto-Machinery Company, Limited, and H. S. Wood, Coventry. Bearings for High-Speed Spindles. [5 *Figs.*] January 21, 1914.—This invention relates to ball-bearing spindles for grinding-machines, and spindles of similar machines that are required to run at very high speeds, and consists in combining means whereby the bearings can be accurately adjusted for running, with means for positively locking the parts in position, so that the adjustment cannot be easily altered or tampered with by unskilled or unauthorised workmen. The invention comprises the combination of a spindle having inner bearing-rings pressed thereon, or races formed integral with the spindle, a housing, fixed or adjustable shoulders within the housing, outer bearing-rings located against such shoulders, locking-nuts screwing into the housing for pressing the outer bearing-rings against the said shoulders, and means for positively locking said nuts, so that no readjustment of the bearing



can be made without destroying the locking means. The inner rings *a* of the bearings are pressed upon the spindle *b* against locating shoulders b^1, or the parts *a* may be made integral with the spindle *b*. The outer rings *c* are held in a housing *d*, in which locating shoulders d^1 are also provided, and against which they are held by rings or nuts *e* screwed into the ends of the housing *d*, the whole being positively locked. The correct adjustment is obtained by a process of measurement and trial, the distance between the locating shoulders d^1 in the housing being gradually reduced until the bearings run satisfactorily. The nuts *e* are provided with flanges e^1, and, having been tightened up, holes are drilled through the flanges e^1 into the housing *d*. Pins are then driven tightly into the holes, and are filed off flush with the outer faces of the nuts *e*. A space is left between each flange e^1 and the end of the housing *d* to enable the pins to be sawn through when it is desired to readjust the bearings or take them apart. (*Accepted September* 16, 1914.)

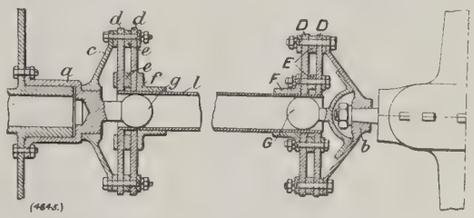
MOTOR ROAD VEHICLES.

15,158/14. H. S. Yoxall and J. J. Richardson, Birmingham. Motor-Cycles. [2 *Figs.*] June 24, 1914.—This invention comprises improvements in spring forks for motor-cycles, and refers to that class of such which are known as "link forks"—*i.e.*, in which the fork is connected to the steering-posts by links in such manner as to permit the fork to rise and fall relatively to the steering-post. In this type of fork it has been the practice to connect the fork to the post by a pair of links, one on each side, long spindles being provided which pass through the links and through a tubular part of the fork, and a similar



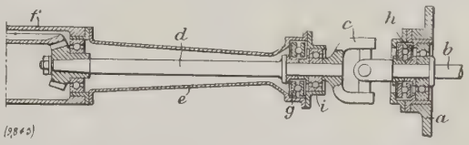
long bearing carried by the steering-post. In accordance with this invention, the spindles are screwed with a right-hand thread at one end and a left-hand thread at the other end, the links being similarly screwed to engage the extremities of the spindles, so that by rotating the spindle the two links are positively drawn nearer to each other, or further from each other, in order to adjust for wear, lock-nuts being provided on the outside of the links, making it impossible for the links to become loose. The links *a* are of the usual form, but are screw-threaded, one link being screwed right hand, whilst the other link is screwed left hand. The spindles *b* are similarly screwed right and left hand to engage with the links, these spindles being provided with a squared or equivalent extremity b^1, whereby they may be rotated to draw the links nearer to each other, or further from each other, in order to get a fine lateral adjustment, so as to prevent lateral movement or shake between the fork proper marked *c* and the steering-post marked *d*. The spindles pass through the tubular bearing portions marked c^1 and d^1, being provided with lock-nuts and washers. It will be obvious that the two links cannot laterally separate unless the spindle is rotated, and it is practically impossible for such rotation to take place involuntarily owing to the vibration when in use, particularly if the lock-nuts are screwed up tight. (*Accepted September* 16, 1914.)

4645/14. Societe Anonyme des Automobiles Unic, Puteaux, France. Shaft-Couplings. [1 *Fig.*] March 4, 1913.—The present invention relates to universally flexible couplings for co-axial shafts of the kind which permit their axes of rotation to be at an inclination, and wherein a tubular connecting member is interposed co-axially between a pair of discs which have their peripheral margins attached to arms or equivalent members secured respectively to the ends of the two shafts. The invention consists in improvements according to which each of the discs connected by the tubular member is replaced by a pair of supple rings, which are separated from each other by means of interposed washers, which prevent friction, and consequent wear, between them, the tubular member connecting the pairs of rings being supported at each end by means of a rounded member integral with or fixed to the driven or driving-shafts respectively.



The invention is described with reference to the drawing, which is a part sectional plan of the improved coupling. In the drawing, *a* is the driving-shaft or change-speed gear box-shaft; *b* is the driven shaft. *d*, *d* constitute one pair of rings, which are of a supple nature, and are kept apart by means of washers *e* of suitable material, and are connected to the shaft *a* by the arms *c*. The driven shaft *b* is similarly connected to the discs D, D, separated by the interposed washers E. The tubular coupling member *l* is connected to the rings by means of the flanged sleeve-pieces *f* and F, which are secured in suitable manner to the member *l*, and bolted to the rings and interposed washers. The member *l* rests with its ends on balls *g* and G integral with or fixed to the shafts *a* and *b* respectively, and is thus capable of ball-jointed movements. (*Accepted September* 16, 1914.)

9845/14. Societe Th. Schneider et Cie., Boulogne, France. Motor Road Vehicles. [1 *Fig.*] June 30, 1913.—This invention relates to the method of connecting the rear axle to the chassis in motor road vehicles employing a Cardan shaft mounted in a tube fixed to the casing which encloses the gear on the live axle. In Specification No. 2905, of 1911, is described a system of mounting consisting in utilising the Cardan shaft itself for the purpose of transmitting the thrust of the driving-wheels and compensating the reaction of the motor couple, leaving the suspension springs absolute freedom to fulfil their functions. According to the present invention, both the Cardan shaft and the tube surrounding it receive the thrust of the driving-wheels and balance the reaction of the driving couple while still leaving the suspension springs free to fulfil their functions. *a* is the gear-box casing, or some other part immovably fixed to the chassis, and supporting the shaft *b*, at the extremity of which the Cardan joint *c* is situated. *d* is the Cardan shaft, which is guided in a tube *e* rigid with the rear bridge *f*. The thrust of the driving-wheels is transmitted to the rear bridge *f*, and consequently to the tube *e* rigid therewith; this thrust is received by a ball-bearing *g* mounted freely between two shoulders integral with

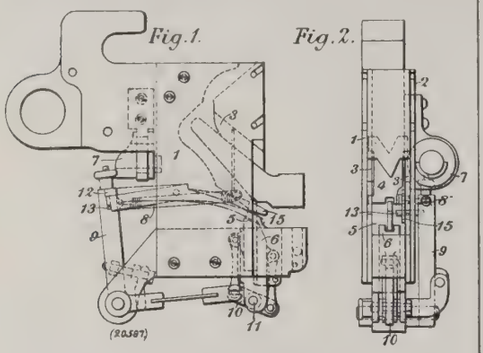


the tube *e*, and consequently with the bridge *f* and two shoulders integral with the shaft *d*. In this manner this bearing is housed in a cage slightly larger than itself in such a manner that it is able to bear upon one or other of the four shoulders that surround it indifferently. This arrangement renders it possible to transmit through a single bearing both the thrust and tractional strains, and thereby serve the same purpose as two ordinary bearings with opposed actions. The thrust of the Cardan shaft is transmitted by the joint *c* to the shaft *b*, and by the latter to the gear-case or the frame rigid with the chassis by the intermediary of a ball-bearing *h* mounted and acting in the same manner as the bearing *g*. The reaction of the axle or bridge, which would tend to cause it to rotate in the opposite direction to the driving-wheels, is balanced by the Cardan shaft *d* and the tube *e* rigid with the bridge, whose extremity is provided with a plain or ball-bearing *i*. This method of mounting the rear bridge amounts to jointing to the chassis at a single fixed point, which is the centre of the Cardan joint. The bridge is thus free to oscillate in all directions around this point, as the suspension springs mounted upon double shackles are in no way impeded in their functions. (*Accepted September* 16, 1914.)

PRINTING AND ALLIED MACHINERY.

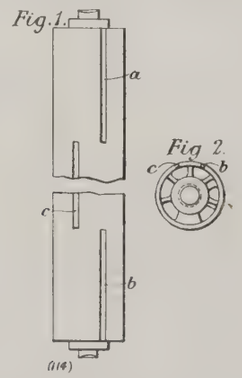
20,587/13. Linotype and Machinery, Limited, London, and J. R. Burgess, Broadheath. Typographical Machines. [2 *Figs.*] September 11, 1913.—This invention relates to typographical machines, such as those known under the trade-mark "Linotype," and others of a kindred character, and particularly to the devices known as separator-boxes, by which the successively leading matrices of a line or plurality of matrices descending by gravity down inclined guides are, by a pair of vertically reciprocating dogs, separated from the immediately following matrix preparatory to their being engaged by the distributor mechanism which delivers them each into its respective magazine channel. The invention comprises the combination with matrix-separating dogs and means for operating them for effecting such separation, of devices actuated by the matrices for automatically controlling such operation so that the dogs shall be operated only when matrices are presented to them for separation. 1 is the front wall, and 2 the back wall of the

separator-box, which is of ordinary well-known construction, and which, when hereinafter referred to as a whole, is identified by the numeral 1. The walls 1 and 2 are provided with the usual inwardly-facing inclined guides 3, which serve as tracks along which the lugs of the matrices 4 travel during the descent of the latter to the vertically reciprocating dogs 5, 6, these dogs serving, as ordinarily, to separate the successively leading matrices of the line which is at the time descending by gravity down those guides; this separation is a step preparatory to the matrices being engaged by that part of the distributor mechanism which delivers them each to its respective magazine channel. The dogs 5, 6 are reciprocated in alternation, as ordinarily, by means of a cam 7 and spring 8 acting antagonistically to each other, the cam being rotated directly by one of the distributor-screws or by other convenient means. The cam 7 acts upon a lever or arm 9, and serves to move it in one direction, while the spring 8, attached to the said cam-lever, serves to move it in the opposite direction and, during the operation of the dogs 5, 6, to maintain the engagement between that lever and the cam. The two dogs 5, 6 are both connected to the same lever or levers 10, which, as ordinarily, are rocked about the pivot 11 by the cam-



lever 9. For the purpose of preventing the operation of the parts 5, 6, 9, and 10, in accordance with the present invention, there is provided a trigger or detent 12 which is capable of engaging with a stud or projection 13 on the cam-lever 9 to hold that lever out of reach of the cam 7, this condition of engagement being that which obtains when there are no matrices to be acted upon by the dogs 5, 6, and consequently when there is no necessity for the latter to be operated. The trigger 12 is pivoted to the wall 2, and is provided with a tail 15 extending into the path of the descending matrices 4, and the weight of the trigger and tail is so distributed as to present a preponderance on its lever-engaging end; this preponderance, however, is only such that the weight of the lightest matrix will serve to tilt the trigger 12, and thereby cause it, as shown in dot-and-dash lines in Fig. 1, to release the cam-lever 9 which thereafter, in the known manner, is reciprocated by the cam 7 and spring 8, this operation continuing only so long as the on-coming matrices retain the trigger 12 out of engagement with the cam-lever 9, the cessation of the supply of such matrices allowing the trigger to again drop into engagement with the stud 13 and hold the cam-lever 9 out of operative contact with the cam. (*Accepted September* 16, 1914.)

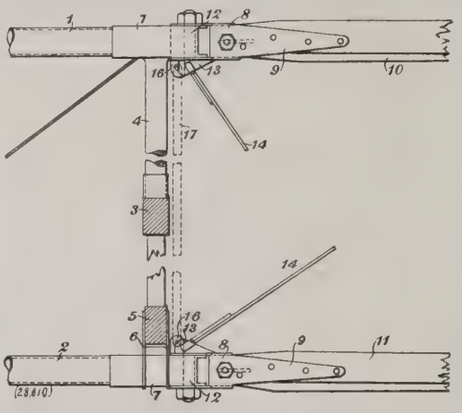
114/14. E. J. Smith, London. Printing-Machines. [2 *Figs.*] January 2, 1914.—In impression-cylinders of extreme length, particularly in those running at a high speed, it is undesirable to make the gap wherein the blanket is secured extend in a straight line from end to end of the cylinder. It is usual, therefore, to make two slots or gaps extending from the ends of the cylinder up to the middle thereof, the slots not being in the same straight line. According to this invention, the principle of breaking the continuity of the straight line of the gap in impression-cylinders is adhered to, but sideway drag on the paper



and vibration are avoided by so arranging the gap that it occurs symmetrically of the width of the web. Fig. 1 is a plan view, and Fig. 2 is an end view, the gap is in three symmetrically arranged parts. *a* and *b* are two end parts placed in a straight line and extending each from the ends of the cylinder for about a quarter of its length. The middle portion of the cylinder has a gap portion *c* placed in a line parallel to the line of the parts *a* and *b*. With this arrangement the web, when released from pressure at the sides, will be drawn by the middle, and *vice versâ*, so that there will be no lateral drag. (*Accepted September* 16, 1914.)

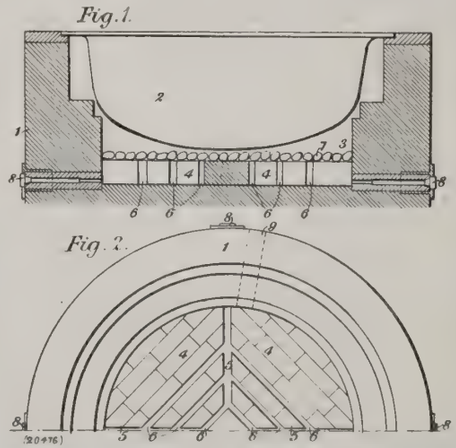
MISCELLANEOUS.

28,610/13. H. L. Short, A. E. Short, and H. O. Short, London. Biplanes. [1 *Fig.*] December 11, 1913.—This invention refers to aeroplanes of the biplane type, in which two planes are employed one above the other, and are held apart by means of struts, and the invention particularly refers to those machines in which the right and left-hand wings are hinged, in order to enable such wings to be folded or turned upon pivots, and thus occupy less space than would be occupied with the wings fully extended. In biplanes, according to this invention, a vertical strut is provided extending between the hinged rear spars of the upper and lower wings, and adjacent to the hinges thereof, the strut being employed for the purpose of retaining the spars at a definite distance apart when the wings are removed from the central frame. 1 and 2 are respectively the upper and lower rear tubular spars of the central frame, which each support the rear of a central fixed wing portion. The frame spar 1 is supported from the top rail 3 of the fuselage by means of a vertical strut 4, while the lower frame spar 2 is supported from the bottom rail 5 of the fuselage by a suitable bracket 6, so that by the fuselage frame fuselage and the strut 4 the upper and lower central frame spars are retained at a definite distance apart. The outer end 7 of each spar 1 and 2 is preferably formed thickened, and may be sweated into a tube of larger diameter, whereby the thickness is increased, the said tube, in the case of the upper spar 1, being rigidly connected to, or formed in one with, the upper end of the vertical strut 4, by which means the said upper end of the strut is formed T-shaped, the cross-piece of which extends coaxially with the upper spar 1 of the central frame and outwardly beyond the plane containing the vertical strut 4, while the thickened end of the lower spar 2 also extends in the same direction and likewise beyond the vertical plane containing the vertical strut 4. These thickened ends 7 of the upper and lower spars 1, 2 are formed rectangular in cross-section and semi-circular in plan, the said ends entering, when the wings are placed in position on the machine, between upper and lower walls of hinge-boxes 8, one of which latter is fixed, as by ears 9, to the inner end of each of the rear spars 10 and 11 of the upper and lower hinged wing portions. The bolt 12 passes through apertures formed in the upper and lower walls of each hinge-box 8 and



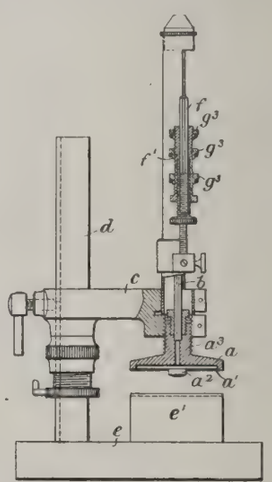
through vertical holes formed in the rectangular tubular end 7 of the central frame spars 1 and 2, upon which bolts 12 the wings are adapted to be turned. The bolts 12 are each formed at one end with a plate 13, which, besides performing the office of the bolt-head, provides means for attachment of tensioning wires 14. Each hinge-box 8 is at its rear wall cut away as shown, while the forward wall extends to such a distance inwardly beyond the hinge-bolt as to form an abutment to contact with the forward face of the central frame rear spar, to which the said box is hinged when the wings have been extended to their flying position. A lug 16 is formed on or attached, in any suitable manner, to the outer end of each hinge-box 8, the lug 16 on the hinge-box of the upper spar 10 projecting downwardly from the bottom wall of the said hinge-box, while the lug 16 on the hinge-box 8 of the lower spar 11 projects upwardly from the upper wall of the said hinge-box. A temporary strut 17, shown in dotted lines, is provided, the opposite ends of which are adapted to be connected to the upper and lower lugs 16, the said strut 17 being of such a length that when placed in position, and the wings are removed from the machine, the inner ends of the rear spars 10, 11 are prevented from movement towards or away from one another. For the purpose of readily connecting the said strut 17 to the lugs 16, the ends of the said strut are formed with holes which are adapted to register with corresponding holes formed in the lugs 16, and through which registering holes any suitable fastening device, such as a bolt and nut may be passed. (*Accepted September* 16, 1914.)

20,476/13. P. St. G. Kirke, and Bonecourt Surface Combustion, Limited, London. Heating Apparatus. [9 *Figs.*] September 10, 1913.—This invention of improvements in or in connection with the combustion of combustible mixtures has reference to that process of combustion wherein use is made of the accelerating influence which hot surfaces exercise on combustion, and further has reference to that process of combustion which is known as surface combustion. For the purposes of this invention, and in accordance therewith, a combustion-bed is so



constructed and arranged that the mixture of fuel and air, however formed and supplied to the combustion-bed, enters a passage or duct open on one side for free escape of the products of combustion and of a cross-sectional area that is larger than that of the inlet-duct or introductory means, the containing-walls of said passage or duct being formed of material adapted to become incandescent, so that surface combustion takes place in contact therewith or in the neighbourhood thereof. The combustible mixture flows freely along the passage or duct, and the direction of flow is changed gradually and/or in portions at a time if near the inlet-duct or introductory means, and suddenly only after combustion of a considerable portion of the combustible mixture has been completed. Fig. 1 is a vertical section, and Fig. 2 a half-plan view of a heating or melting furnace provided with a combustion-bed in accordance with this invention. 1 is the main structure of the furnace enclosing or containing the tank or receptacle 2 intended to contain the body, liquid or solid, to be heated. The furnace-structure 1 is provided at its lower part with a deeply recessed portion 3, which may be circular, as shown in plan, or may be otherwise—for instance, rectangular. This portion 3 is practically filled with bricks, blocks, or other bodies of refractory material 4, and these bricks 4, which may be loose or fixed, are so disposed and arranged that ducts or passages 5 and subsidiary ducts or passages 6 are formed thereby and therebetween, such ducts or passages being open on one side. In the example now being described, there are four ducts or passages 5 extending radially. The ducts or passages 5 are connected together by the subsidiary ducts or passages 6, and these ducts or passages 5, 6 may be likened unto a main or backbone and ribs. 7 is refractory material conveniently in granular or fragmentary condition, and this refractory material may be piled or arranged above the combustion bed and in relation to the tank or receptacle 2 so that the products of combustion will pass thereamongst and accelerate the transmission of heat contained in the products of combustion to the body, liquid or solid, contained in the tank or receptacle 2. Combustible mixture is introduced through the inlet means 8 and passes along and burns in the ducts or passages 5, and from these ducts or passages 5 into the subsidiary ducts or passages 6. 9 is a lighting orifice communicating with the ducts or passages and with the exterior of the furnace. This orifice is normally closed by a plug. The combustible mixture introduced through the inlet means 8 is ignited by a torch through the orifice 9, and surface combustion takes place on or in the neighbourhood of the containing-walls of the ducts or passages, and the burning combustible mixture, or rather the heated products of combustion, pass from the ducts or passages to the refractory material 7, when employed. The combustion of the combustible mixture on or in the neighbourhood of the containing-walls of the ducts or passages is not accelerated to the same extent as heretofore, and is spread along the ducts or passages for a considerable distance from the inlet means 8, with the result that the maximum local temperature is not so far in excess of the temperature of the furnace as a whole as heretofore. (*Sealed November* 26, 1914.)

20,660/13. J. A. Prestwich, London. Gauging-Instruments. [4 *Figs.*] September 12, 1913.—This invention relates to gauging apparatus, and comprises an indicating-tube, which is in communication with a chamber having a flexible diaphragm, the said chamber being provided with a micrometer-screw and carried on a bracket or arm so as to be adjustable to and from a member which, when the gauge is in use, is normally stationary. In the construction shown, a circular vessel *a* is adapted to contain fluid, in communication with which vessel is a transparent indicating-tube *b* of small cross-section. This apparatus is carried by an arm *c*, which is adjustably mounted on a vertical standard *d* fixed to a base-plate *e*. Immediately under the fluid-containing vessel *a* is a fixed abutment e^1, fastened to the base-plate *e*, and the under-side of the fluid-containing vessel *a* is formed of a partially flexible diaphragm a^1, which diaphragm is preferably provided with a suitable projection a^2 at its centre. It is preferred to graduate the upper surface of the circular liquid-containing vessel *a*, and means are provided for adjustment to and from the fixed abutment e^1 on the base-plate *e* by a screw a^3 working in the arm *c*, which carries the vessel *a*, a fixed pointer being situated adjacent to the graduations. A scale may also be provided on the indicating-tube. In proximity to the indicating-tube *b* is preferably provided a device comprising a rod *f*, which is arranged parallel to the indicating-tube, and upon which screws a series of pointers which extend to the indicating-tube *b*. There



are three of these pointers, which are both separately adjustable and also adjustable altogether. The rod *f* carries a screwed sleeve f^1, upon which are screwed three nuts g^3, g^3, and g^3, to which are attached the pointers. In using the apparatus as a gauge, the lowest pointer is set to indicate the level of the liquid in the tube *b*, and the apparatus is then adjusted with an article of correct size between the diaphragm and the fixed abutment, so that the diaphragm a^1 is pressed upwardly and the level of the liquid rises in the tube *b*. The other two pointers are then moved so that one is above and the other below the level of the liquid, each being at a suitable distance therefrom, which distance depends upon the limits to which it is intended to work. If the total volume of liquid in the apparatus should be decreased or increased by leakage, evaporation, or variation of temperature, the three pointers are lowered or raised together, so that the lowest of them indicates the level of the liquid when the diaphragm a^1 is not being pressed. When using the apparatus as a gauge, the fluid-containing vessel *a* is adjusted at a distance from the fixed abutment e^1, such that when an article of the correct desired dimensions is placed in position on the fixed abutment, it will cause by deflection of the diaphragm on the vessel the liquid to rise to a certain point in the indicating tube. Each subsequent article it is desired to gauge is now placed on the abutment, and the accuracy of its dimensions can be judged from the level in which the liquid rises in the indicating-tube. The fixed abutment may be shaped in any desired manner to facilitate the gauging process. (*Accepted September* 23, 1914.)

THE BRITISH ASSOCIATION IN AUSTRALIA.

(*Concluded from page* 667.)

SECTION B.—CHEMISTRY—*concluded.*

NATURAL CLASSIFICATION OF THE ELEMENTS.

In introducing his paper on "A Device for the Representation of the Natural Classification of the Elements," Professor Orme Masson, F.R.S., remarked that he would hardly call his communication a paper. It merely concerned a device he had resorted to in exhibiting the periodical table (after Mendelieff) to his students in Melbourne. The original table was somewhat confusing, because manganese came, in the same column, between chlorine and bromine, and chromium between sulphur and selenium, &c. To render the classification clearer he had attached a folded flap, printed with names like the table, to the centre of the table: turned to the left the flap would cover certain elements in the larger lower half of the table; it would cover other elements when turned to the right, whilst it left the table unchanged when standing out at right angles. The advantage was that no sharp break then occurred in the natural sequence of certain horizontal series, that metals and metalloids appeared duly separated, and that crystallised and gaseous elements fell into line. He also placed hydrogen at the head of the halogen column, not above the alkali metals; and he had a special flap for the rare earths which seemed to be a new departure of Nature. During the discussion by Professor Pope, Dr. Holt, Mr. Tizard, and others, it was acknowledged that such devices which might appear trivial were of considerable assistance to the teacher.

SPECIFIC HEAT OF LIQUIDS.

Mr. E. J. Hartung, B.Sc., described "A New Method for Determining the Specific Heat of Liquids," a modification, suggested by Professor Orme Masson, of the usual method of mixtures. The calorimeter was a thin glass vessel of 100 cub. cm. capacity, supported inside a Dewar flask. The ice-vessel was a thin glass cylinder, sealed, containing a definite amount of distilled water, and as much silver gauze as possible, both for ensuring rapid heat conduction and for making the bulb sink in the liquid. The liquid was introduced into the calorimeter by a pipette, and the ice-bulb was frozen in a mercury bath. The method was simple, rapid, and accurate, though not, so far, suitable for viscous liquids. The results of experiments made with water at 25 deg. Cent. had agreed within 0.4 per cent.

DETERMINATION OF VAPOUR PRESSURE.

The apparatus which Mr. F. H. Campbell, M.Sc., of Melbourne, described in a paper on "A New Method for the Determination of Vapour Pressure and an Examination of a Source of Error in Certain Dynamical Methods," was based upon the principle that a liquid, saturated with a suitable gas (usually hydrogen), was allowed to evaporate into an enclosed space filled with the same gas approximately at atmospheric pressure. The extra pressure exerted by the vapour was measured by means of an open mercury manometer after restoring the original volume. The liquid was contained in a tube which was deeply scratched, so that it could be broken when the proper temperature had been reached in the bath. Experiments had been made with alcohols, ether, chloroform, water, &c., as liquids, evaporating into carbon dioxide, air, hydrogen or nitrogen. The results obtained were concordant, but lower than those obtained by other methods, and the error, which amounted to less than 1 per cent. in the case of hydrogen, depended upon the solubility of the particular liquid in the particular gas. With water at 60 deg. Cent. practically identical results had been obtained with air and with hydrogen.

OCCLUSION OF HYDROGEN BY CHARCOAL AND PALLADIUM.

Dr. A. Holt presented a paper on "The Comparison of the Phenomena of the Occlusion of Hydrogen by Charcoal and by Palladium," a subject on which he has already addressed several communications to the Royal Society, partly in conjunction with J. H. Andrew, E. C. Edgar and J. B. Firth. Comparison of the isothermals, he pointed out, showed that with charcoal continuous curves were obtained, whilst with palladium discontinuity was observed, though the isosteres in both cases had similar curvatures. With hydrogen and charcoal these isosteres yielded constant values throughout their length, when compared with vapour-pressure curves by means of the Ramsay-Young formula; but with palladium this was only so up to a certain temperature. The results were difficult to reconcile with the hypothesis of Hoitsema, who suggested that the hydrogen existed in palladium in two solid solutions, the miscibility of which varied with temperature, or with the view of McBain, that the occlusion of hydrogen by charcoal was a case of sorption. By sorption Dr. Holt understands adsorption by the surface, the adsorbed gas being given off again in a vacuum, combined with diffusion of the gas into the absorbent. The adsorption equilibrium was too rapidly established probably to determine its rate; but when the absorbed layer was maintained at constant concentration by surrounding it with an unlimited supply of gas, the rate of inward diffusion could be measured. Experiments had also been made on the thermal effects produced by heating and cooling palladium in hydrogen. From these varied experiments Dr. Holt was inclined to conclude that palladium existed in two allotropic modifications (as did many other metals, according to E. Cohen, and also charcoal, according to Firth), one of which had a greater affinity for absorbing hydrogen than the other; above 150 deg. Cent. the two affinities became equal, and Dr. Holt suggested that the difference was merely one of the closeness of packing of the metallic particles.

CORROSION OF IRON BY ARTESIAN WATERS.

Professor C. E. Fawsitt, D.Sc., of Sydney, presented a paper on "The Corrosion of Iron and Steel by Artesian Water in New South Wales." We mentioned in our second article of this series* that the matter of corrosion of bore-casings was serious in New South Wales, especially in the Coonamble district, less so in Queensland, and that, so far, no proper remedy had been found. An Interstate Conference on Artesian Water, meeting in Sydney in 1910, went fully into the matter, and a great deal of experimenting has been done since by various departments. But though the corrosion of iron may fairly well be understood in the laboratory, its prevention advances little. Professor Fawsitt stated that he had found no characteristic difference in analysing pieces of corroded and of uncorroded iron from the same very badly corroded casings; the two specimens had corroded to an equal extent afterwards in distilled water saturated with carbon dioxide; the Coonamble district waters contained more sulphates than others, and the sulphates were met with there at smaller depths than elsewhere; but that point seemed to be of no importance. The corrosive water was rich in gas (chiefly nitrogen, probably atmospheric), and its carbon dioxide seemed mainly to come from bicarbonates. The corrosion was due to the oxygen and carbon dioxide in the water; it was probably facilitated by the mechanical erosion due to sand and pebbles. Various kinds of iron and steel, enamelled or painted, having failed, pipes lined with cement had been tried.

* See ENGINEERING, page 515 *ante*.

WASTE COMBUSTION GASES FOR FIRE-EXTINCTION.

In presenting his paper, on "The Use of Waste Gases of Combustion for Fire-Extinction," Mr. G. Harker, D.Sc., of Sydney, said that gases could only be applied in enclosed spaces, but they were very effective in basements, ships' holds, oil-tanks, &c., where water was hardly useful or applicable. Water spoiled the goods too much, and might generate explosive water-gas; water also percolated too slowly through many ships' cargoes, such as grain and cotton-wool, moreover. The principles of using gases for fire-extinction had been dealt with in two papers which Clowes and Feilman had brought before the British Society of Chemical Industry some years ago. They had determined the minimum percentage of nitrogen and of carbon dioxide which would stifle combustion, and also the composition of the residual atmosphere in which a flame had been extinguished. The latter data are produced in the annexed table.

Thus wick-fed flames which produced their own gas were all extinguished when the oxygen percentage in their atmosphere fell to about 15 per cent., while a coal-gas flame would be extinguished when the oxygen sank below 11.4 per cent. In practice the oxygen percentage was reduced by replacing the air by some incombustible gas. On shipboard steam, carbon dioxide, and the gas from burning sulphur had so far been used. Steam condensed too readily and would not displace the air unless supplied in quantities large enough to raise the temperature of the atmosphere. The central plant to supply the gases for extinction was, on board, generally installed in the boiler-room. But much more gas had to be used than the theoretical amount necessary to reduce the oxygen proportion to 15 per cent., because the holds, &c., could not be made gas-tight, and the hot gases had to be removed; unless this was done, a red-hot mass continued to smoulder and to break into flames again as soon as air regained access; the importance of this point was not always appreciated.

Composition of Residual Atmosphere.

Substance Burnt.	Percentage Composition of Atmosphere in which the Flame was Extinguished.		
	O_2.	N_2.	CO_2
Alcohol	14.9	80.7	4.35
Methylated spirit	15.6	80.2	4.15
Paraffin oil	16.6	80.4	3.0
Kolza and paraffin	16.4	80.5	3.1
Candles	15.7	81.1	3.2
Hydrogen	5.5	94.5	—
Carbon monoxide	13.4	74.4	12.2
Methane	15.6	82.1	2.3
Coal-gas	11.4	83.7	4.9

Dr. Harker himself used the flue-gases because they were available in large volumes, without any additional cost. A ton of coal yielded about 45,000 cub. ft. of flue-gas, containing 9 per cent. of oxygen. That gas had only to be cleaned; it was fatal to animal life, particularly because it contained up to 1 per cent. of carbon monoxide, and formalin vapour could further be added to make it a powerful germicide. The first installation of this kind had been put on a steamer of the Colonial Sugar Refining Company, trading between Sydney and Fiji. The United States Public Health Department had adopted the process for quarantine work, and two steamers had been fitted with such plants, the one for 90,000 cub. ft., the other for 180,000 cub. ft. of gas per hour. The Melbourne Harbour Trust Commissioners were equipping a fire-float with a plant. Yet the practical development of the method was slow. The public did not trust extinction by flue-gases, or was frightened by his insisting on a plant of adequate capacity. That waste flue-gases would extinguish a coal-bunker fire had recently been demonstrated in London, and the reliability of the method for fumigation was to be investigated by the London School of Tropical Medicine.

The discussion by Dr. H. B. Dixon and others proved that the process had been confounded with Dr. Harker's suggestion* of reducing the oxygen contents of the air in mines below the point at which explosions were likely. Dr. Harker stated that he himself had tried to work in a gold-mine in which the oxygen content was 19 per cent., and the carbon dioxide proportion 0.5 per cent.; but he had to lie down by the fresh-air pipe every two hours. As regards fire-extinction, he added that it was very difficult and very slow work to extinguish coke at 500 deg. Cent.

EXTRACTION OF RADIUM FROM AUSTRALIAN ORE.

Mr. S. Radcliffe described the "Extraction of Radium from Australian Ores." Radium, he stated, occurred only in two spots in Australia, both in Southern Australia, and the Radium Hill Company, of Sydney, worked an ore found at Radium Hill, near Olary, situated on the Broken Hill Railway, 55 miles from the famous mines. The chief ore was carnotite, a very complex uranium ore from pre-Cambrian pegmatite dykes. It contained about 46 per cent. of titanium oxide, over 3 per cent. of rare earths, 2.6 per cent. of uranium, and only 0.05 per cent. of thorium. The radium content was about 1 part in 200 million. The presence of mesothorium had not been expected from the ratio of the constituents, and none was found. As mined, the ore could not be treated chemically. It was concentrated, mechanically and magnetically, and then smelted with salt cake in a half-ton laboratory furnace. The crushed product passed, together with cold water, through dissolving vats, in which a separation by gravity was chiefly

* See ENGINEERING, vol. xciii., page 812.

aimed at. The settled product was treated with strong sulphuric acid, when the whole of the actinium and the bulk of ionium were precipitated, together with the sulphates of lead, barium, and radium. These "crude sulphates" were fused with caustic soda, and the melt was digested with water to remove the bulk of lead sulphate; the insoluble residue was digested with sodium carbonate in a rotating boiler under pressure; the carbonate precipitate was washed and dissolved in hydrochloric acid, which dissolved Ra, Ba, some Pb, actinium, the bulk of ionium, and a considerable amount of rare earths, mainly cerium, lanthanum, and didymium, yttrium being absent. On saturating this solution with gaseous hydrogen chloride, only the chlorides of barium and radium fell out quantitatively, actinium and ionium (which resembled the rare earths thorium in their properties) remaining in solution. The rare earths had then to be obtained by fractionation and other ways from the acid solution, and the ionium was finally separated together with thorium; the balance of the rare earths, containing most of the actinium (whose atomic weight was not yet known), was reserved for further treatment; according to Moseley, actinium would not be a rare-earth element after all. The original solution from the settling-tank was treated with sulphuric acid and hydrogen peroxide and then with ammonia to precipitate the uranium, which was very awkward to handle.

In reply to questions by Sir Ernest Rutherford and others, Mr. Radcliffe added that they had also found some polonium; the chloride (not the bromide or iodide) of radium had proved most suited for fractionation. They had at Woolwich, and in the new more spacious works at Sydney, so far smelted 120 tons in 12 months; he hoped to get 100 milligrammes of radium per month. Professor Rutherford remarked that the process was very remarkable, because a special very poor ore was submitted to special treatment, and because the ionium and actinium were gained which elsewhere were allowed to run to waste. He had examined the process, and Mr. Radcliffe seemed to be able to prepare pure actinium.

Nitric Acid in Rainfall.

Mr. V. G. Anderson, of Melbourne, stated in a paper on "The Influence of Weather Conditions upon the Amount of Nitric Acid and of Nitrous Acid in the Rainfall, near Melbourne," that the concentration of oxidised nitrogen seemed to vary inversely as the rainfall, that the product of this concentration and the rainfall was constant, and that the amount of nitrogen oxides brought down by the rain on any day was a function of the weather, and in a certain measure independent of the amount of rain, because the soluble gases were washed out of the air by the first portions of a shower. He distinguished several types of weather: antarctic, tropical, and combinations of the two.

Organic Chemistry.

In addition to the papers on organic chemistry already noticed, organic chemical reactions were discussed at Sydney in papers by Mr. G. J. Burrows, Professor R. Robinson, Mr. G. M. Robinson, and Dr. H. McCombie. Dr. A. Holt also read a paper on "The Colouring Matters of Certain Marine Organisms." The Ascidian diazona violacea, he explained, found near the Outer Hebrides by Professor W. A. Herdman (Senior Secretary of the British Association), was green while alive, but turned violet when put into alcohol, the alcohol itself becoming green. The green substance gave a spectrum like chlorophyll; the violet substance, when isolated, was a purple powder of a coppery lustre, resembling the dibromo-indigotin which Friedländer had discovered in murex brandaris about ten years ago, and which Dr. Holt had also found in purpura lapillus. The purple pigment was apparently present as a colourless chromogen in the living animal and acted as an oxygen-carrier.

The Economics of Marine Fuel.

We cannot attempt to report the proceedings of the other sections. We have already noticed several discussions and papers in special articles, and we will here mention one more paper, on "The Economics of Marine Fuel," which Professor A. W. Kirkaldy, M.A., of Birmingham, brought before Section F, Economics and Statistics. It was a general discourse dealing with the limitations of the utility of steamers, with coaling-stations, their equipment and supply, and the economies of oil fuel. It referred also to the development of marine engines, and pointed out, among other features, how the transports and troop-ships returning empty from the Boer War had opened markets for the South African coals, and had modified the routes of the Australian trade and the trade itself. Ships bound homeward from Australia had formerly gone round Cape Horn, taking up British coal in South American ports; now the preferred route was *via* South Africa.

Discourses and Lectures.

The number of discourses for members only, and of general lectures open to the public, far exceeded anything done on former visits abroad. We mentioned some of the lectures in our article of August 14; the original list was not curtailed, but extended. Lecturing, unofficial, of course, really began on the steamers on the way out. Members of the advance party gave discourses in Western Australia in July, and the lectures did not cease with the official closing of the meeting in September. Under the circumstances we must refrain from entering into particulars.

State or University Research.

Yet we will single out one discourse—that delivered at Brisbane, by Mr. A. D. Hall, M.A., F.R.S., of the Development Commission, Dean's-yard, London. The title was "Tropical Agriculture," and the discourse was, as such, as remarkable as Mr. Hall's presidential address to Section M (Agriculture), which dealt with the reclaiming of waste lands and afforestation. At Brisbane, Mr. Hall discussed the food problem in tropical countries. What we wish to notice, however, concerns his general remarks on the question whether the organisation and control of agricultural research should remain with the State direct, or be placed in the hands of semi-official bodies like the universities. The investigator, he pointed out, was a man of individuality; he could better work under the loose control system of a university than under the official hierarchy of a Government department, which had to insist upon a certain deference to its official views. A scientist in Government employ might have to decide between his salary and his conscience. The atmosphere of a university, though not always a temple of free thought, was more open. The greatest objection, however, to making research a Government function was that such research was, of necessity, subjected to a detailed annual justification of expenditure to a non-expert legislative body. Only a talent for advertisement came to the front under such a *régime*; a university man would have the co-operation, and also the criticisms, of scientists of all branches. These remarks found a warm echo in an audience most of the influential members of which were probably attached to some State department. Australians like to joke about being too much governed, and they deserve general attention.

Concluding Remarks.

In his presidential address to Section A, Professor Trouton had spoken of "the scientific coming of age of Australia." In a good many respects scientific Australia had come of age long before this meeting. The old universities of the Commonwealth have been doing excellent work; some of the best-known members of the British Association were revisiting the country of their birth and education. Higher education had been fostered in the early days, and munificient donors had not been lacking. The Royal Society of New South Wales was founded in 1821; every State of the Commonwealth has now its Royal Society or its equivalent. The Australian Association for the Advancement of Science was established in 1888, and the meeting we have commented upon was also a meeting of this body, and not inappropriately styled "the Science Congress" by the Australians. The general schooling is placed upon a sound basis in Australia. Museums devoted to natural history, ethnology, geology, and technology exist in all the States; some of them reflect the greatest credit upon the men who achieved so much without trained assistance, and with for long periods very scanty means. The meteorological service of the country is very well arranged. That scientific research concerning the nature and resources of the country is not neglected our report may have helped to show.

But there remains a great deal to be done. Some departments of the young universities are waiting for their equipment, and the man in the street may be more ready to direct the inquirer to the Grammar School than to the University. It was to stimulate scientific interest and to make the country better known generally that the Commonwealth made the great sacrifices which the visit of the oversea party involved. Australia suffers in the first instance from its position far out in the East and South. The emigrant from Western Europe can reach America in a week at moderate cost, while he must be prepared to spend more than four weeks on board at considerable cost to reach the sunny shore of Western Australia. The immediate neighbours of the Australians are not of the white race, and Australia is determined to remain a "White Continent." The present generation remembers Kanaka labour on the sugar plantations of Queensland; but no one advocates going back to what is coarsely styled all over the world "coloured labour." The Australian aboriginee is an insignificant factor. The white man, who has taken his land, as elsewhere, now provides for him and takes good care of him—whatever may have been done in the past—and would like to study him and his customs more closely, if it were not almost too late. Many of the problems that the Australian has to solve may be summed up under the head "dearth of population." If Inner London could be dropped on Australia, the population of a Continent little smaller than Europe would be doubled.

We have said something on the great problem of dearth of water and irrigation. Some problems of the Australians are occasionally called problems of their own creation. We do not wish to allude to the introduction of rabbits, foxes, and of the prickly pear, a cactus which kills all other vegetation. But astonishment is sometimes expressed, *e.g.*, at the shortsightedness of the different Australian States in having adopted different railway gauges. The shortsightedness might, to a certain extent, be charged to the critics; they forget how the Colonies grew. At the time when the first Australian railways were built the different centres over there were almost isolated from one another, and the engineers were justified in considering local features above all others. The gauge question had not been settled in Europe, moreover. We have dealt with this question on other occasions. We have also pointed out—in the second of these articles—that many Australian railways attain high altitudes. Ben Lomond Station, on the Sydney-Brisbane line, lies 4473 ft. above the sea-level, 70 ft. higher than the top of Ben Nevis. Some local difficulties might have been attacked more boldly. The general introduction of a standard gauge was decided upon some years ago. When the time for its adoption comes, it may in many cases be found preferable to lay new tracks on new routes than to change the gauge of the old tortuous tracks. All such projects and industrial progress depend largely upon the development of the iron and steel industry. A promising start has been made with smelting the splendid hematite from Iron Knob in the new furnaces near Newcastle. The war will delay the industrial development of the Australian resources; indirectly it may stimulate it, as it brings home to the Australians how much they are dependent upon other divisions of the world.

Thanks to the unprecedented number of members who joined in Australia, the grants for research which the British Association was able to pass this year exceeded the sum of 1500*l*. This is in addition to two special grants from further donations by Sir J. K. Caird, who presented the Association with a cheque for 10,000*l*. when they met at Dundee in 1912. Out of this latter fund 1000*l*. have been earmarked for the study of radioactivity and entrusted to a committee comprising Professors Rutherford, Soddy, and J. J. Thomson; and 500*l*. more are allowed for radiotelegraphic investigation. These sums will only partly benefit Australia, and the question may be asked: Will Australia have any return for all she has done in grave times? Old members would probably answer that question in the affirmative. Canada invited the British Association first in 1884, and disappointed critics were not altogether wanting afterwards. Yet invitations to Canada came again from Toronto in 1897 and from Winnipeg in 1909, and those members who had recently revisited South Africa were glad to find that the stimulus given to the advancement of science by the South African meeting of 1905 was still gratefully ac-

GRANARY AT GLASGOW HARBOUR; GRAIN-CONVEYING MACHINERY.

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Fig. 92.

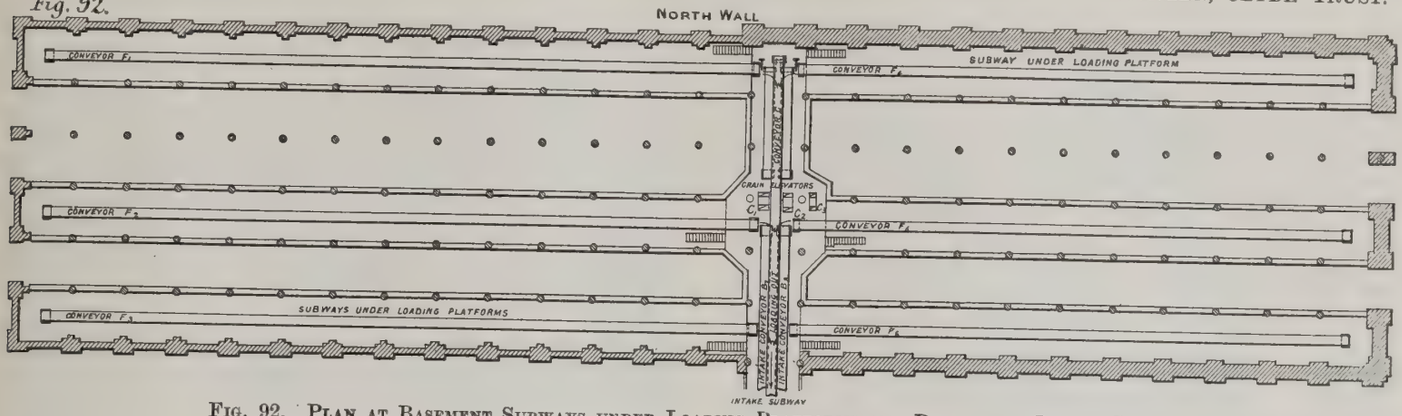

FIG. 92. PLAN AT BASEMENT SUBWAYS UNDER LOADING PLATFORMS AND PORTION OF INTAKE SUBWAY.

Fig. 93.

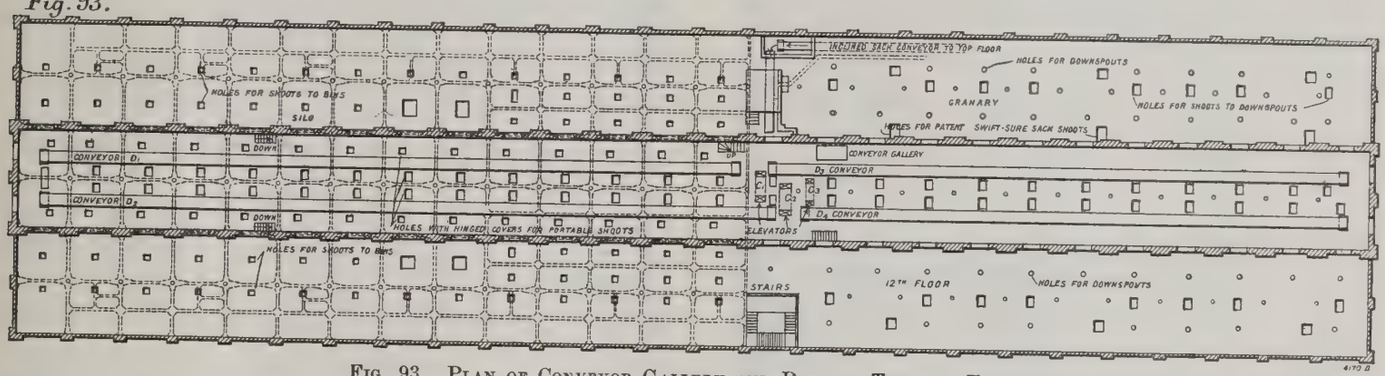

FIG. 93. PLAN OF CONVEYOR GALLERY AND PART OF TWELFTH FLOOR.

Fig. 94.

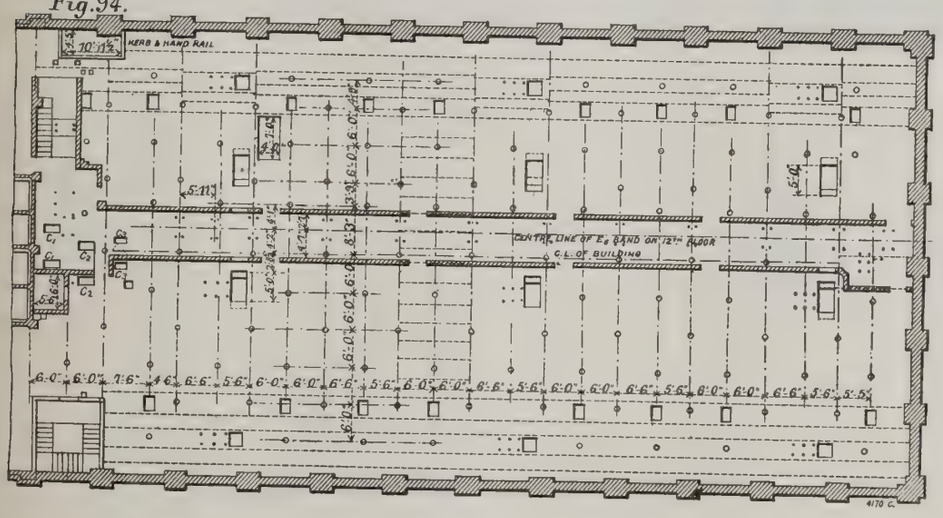

FIG. 94. PLAN OF EASTERN PORTION OF TWELFTH FLOOR.

knowledged. Let us hope that it will be so in Australia.

The British Association is to reassemble at Manchester on September 8, 1915. Dr. Arthur Schuster, Sec. R.S., late Professor of Physics in the University of Manchester, is the President Elect.

GRANARY AT GLASGOW HARBOUR.

(*Concluded from page* 634.)

IN the preceding article we described the machinery for discharging grain from the vessels alongside the wharf, and its delivery on the band-conveyors B 1 and B 2 (Fig. 92) to shoots feeding the two main elevators in the centre of the building marked C 1 and C 2, which in turn raise and deliver it to conveyors D 1 to D 4 (Fig. 93), two of which extend over the silo portion of the building, and enable grain to be deposited in any one of the 150 separate bins, while the two others extend over the floor section of the building and deposit the grain through down-spouts (Fig. 94) on any of the eleven storage floors. We now continue our description in detail of the remaining portions of the grain-handling machinery. On the present page are plans showing the general arrangement of various conveyors, some of them already referred to.

Fig. 92 shows a portion of the intake conveyors leading to the main elevators, and also the basement bands F 1 to F 6 beneath the loading-platforms, for turning over grain in the granary, and for conveying grain, in bulk or in bags, in process of delivery to vessels at the quay. Fig. 93 is a plan of the conveyor-gallery, showing the bands D 1 and D 2 over the silos, and D 3 and D 4 over the floor granary. The same figure also shows a portion of the twelfth storage floor, and, in dotted lines, the general arrangement of the bins. Fig. 94 is a constructional plan of the eastern portion of the twelfth floor. The enclosure for the horizontal sack-band on this floor, referred to below, is shown along the centre of the floor.

Fig. 137, on page 697, gives a good view of two of the bands, D 1 and D 2, in the conveyor-gallery, with movable throw-off carriage and side-shoot, by means of which grain can be delivered into any of the bins. The other two bands, which command the floor granary, are similar. Figs. 95 to 97, on Plate XLIV., illustrate the method by which grain is fed on to these bands from the main elevators; and Figs. 98 to 100 show the arrangement of inclined shoots and specially-constructed vertical down-spouts, by means of which grain is passed from the bands to the storage floors or the bins, as the case may be. The down-spouts, which are shown in the view of a typical floor, Fig. 136, page 697, are spaced 12 ft. apart, and are continued vertically downwards through all the floors to the first, or sacking-off, floor (see Fig. 139, page 697). They are provided with spreaders near the ceiling of each storey, by means of which grain from the top conveyor-bands, or from a higher storey, can be spread out on the floor desired. They have also sleeve-valves near the floor-level of each storey, through which grain can be drawn off, and so passed by the down-spouts below to a lower floor for storage, to the first floor for weighing, sacking if desired, and loading out to carts and railway-wagons, or to the basement conveyor-bands, for turning over or loading out to lighters at the quay.

After grain has been stored in the silos, or on the granary floors, it may be desired to condition it by "turning it over." This has been provided for in the plant, and grain can be dealt with in this way at the rate of 100 tons per hour from any silo bin, or from any floor of the granary. By means of portable shoots under the bins, or in continuation of the down-sprouts, as the case may be, the grain is delivered on to one of the basement conveyors F 1 to F 6, already referred to, and shown in Fig. 92. The centre conveyors F 2 and F 5 deliver direct into the boot of the main elevators at the centre of the building; grain carried by the side conveyors is brought to the same point by means of short transverse bands at the north end of the intake subway, shown in Figs. 82 to 86, accompanying our previous article, or by the inner length of the main intake bands from the quay, as the case may be. By the main elevators, the grain is raised to the conveyor gallery and is distributed to bin or storage floor, as in the case of grain entering the granary ex-ship.

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Fig. 109. Steel Shoots to Floor Granary Down-Spouts.

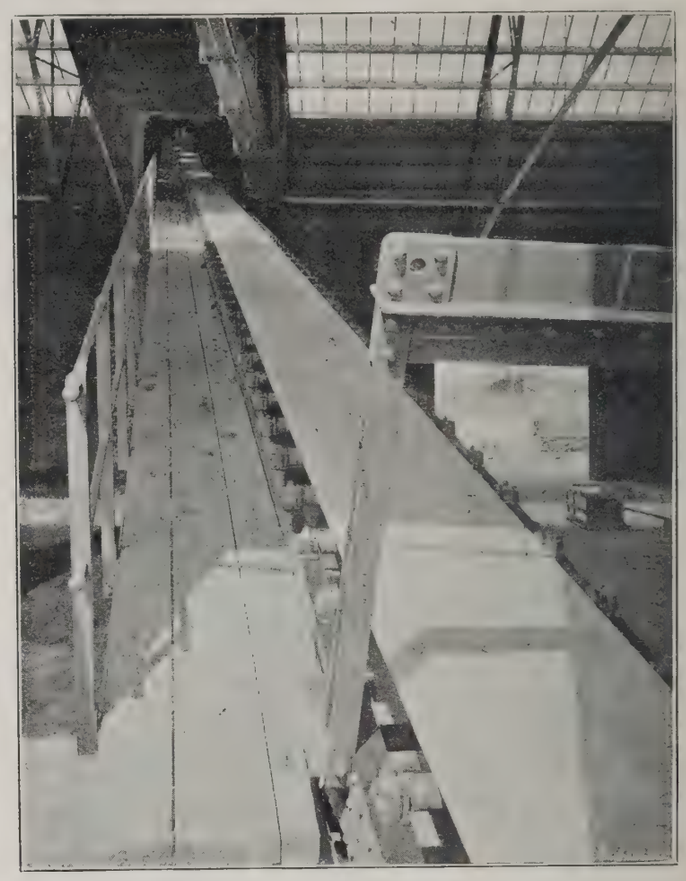
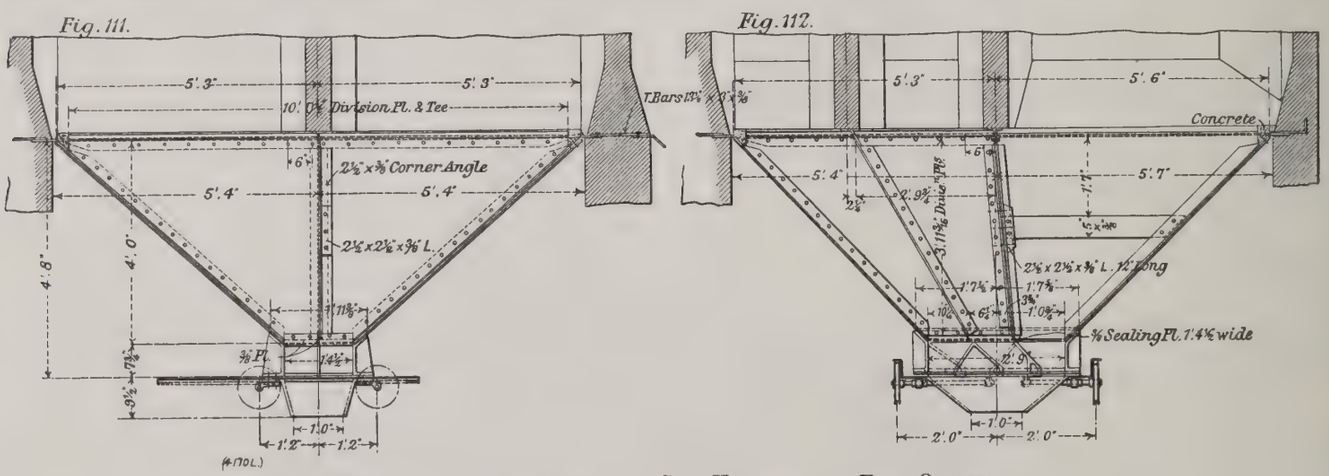


Fig. 110. Hinged Portion of Inclined Conveyor; Sack Intake Gantry.



Figs. 111 and 112. Details of Silo Hoppers with Four Outlets.

The basement conveyors can also be arranged to deliver to an auxiliary elevator C 3, discharging into an automatic weigher (shown in Figs. 106 to 108, on Plate XLIV.) placed on the ninth floor. This automatic weigher has a capacity of 3000 lb. per weigh, and can be used for weighing parcels of grain that are being turned over in the granary, or for weighing large parcels of grain being discharged direct to railway truck, or direct to craft through the loading-out band in the intake subway, to be described later.

The auxiliary elevator is carried up to the same height as the main elevators, and so is available for turning the grain over either from the silo or granary in the event of the main elevators C 1 and C 2 being engaged in taking in grain from the ship elevators, provided that one of the appropriate bands in the conveyor-gallery is not in use in connection with the main elevators.

We come now to the machinery for loading out the grain in bulk or in sacks. Grain brought from any floor by vertical down-spouts, or drawn from bins, is weighed on the first floor (for which purpose 14 automatic weighing-scales, as shown in Fig. 139, page 697, are provided), then sacked, if required, and discharged by gravity, in sacks or in bulk, into carts outside the granary, or into railway wagons on the three lines of rails inside. Provision is made for loading simultaneously 24 carts or lorries, 12 along each side of the granary. The loading is done under cover of an overhanging veranda roof projecting 16 ft. from the face of the main building. Ten railway wagons on each line of rails, or 30 in all, can be loaded simultaneously if required.

To enable grain to be loaded out into lighters a band-conveyor, designated G in Fig. 92, and capable of carrying 100 tons per hour, is provided in the intake subway at a higher level than the main intake bands, as indicated in Figs. 82 to 86 accompanying our previous article. Under the goods-shed on the quay, this band is run on an upward incline, so as to deliver to a continuation band carried in a travelling gantry, which runs on the same rail-track on the quay as the ship elevators. The top portion of this gantry, which is fully illustrated in Figs. 133 to 135, on page 696, is at such a height as will clear railway wagons running on possible future lines on the quay. The inclined portion of the band inside the shed is carried on a lattice framework hinged on the front eaves girder of the shed, and provided with lifting tackle at the inner end, by which it can be raised up towards the roof of the shed when not in use, so as to leave the shed floor clear for other uses. This portion of the band is shown in plan in Fig. 131.

The loading-out band is fed at its inner end by any of the longitudinal basement bands in the granary (Fig. 92), on to which the grain has been discharged by shoots, as described above, for the

GRANARY AT GLASGOW HARB

MR. W. M. ALSTON, M. INST. C.E., ENGINEER TO THE CLYDE NAVIGATION TRUST, GLASGOW; MR. G. H. B

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Fig. 95. SECTION LOOKING EAST

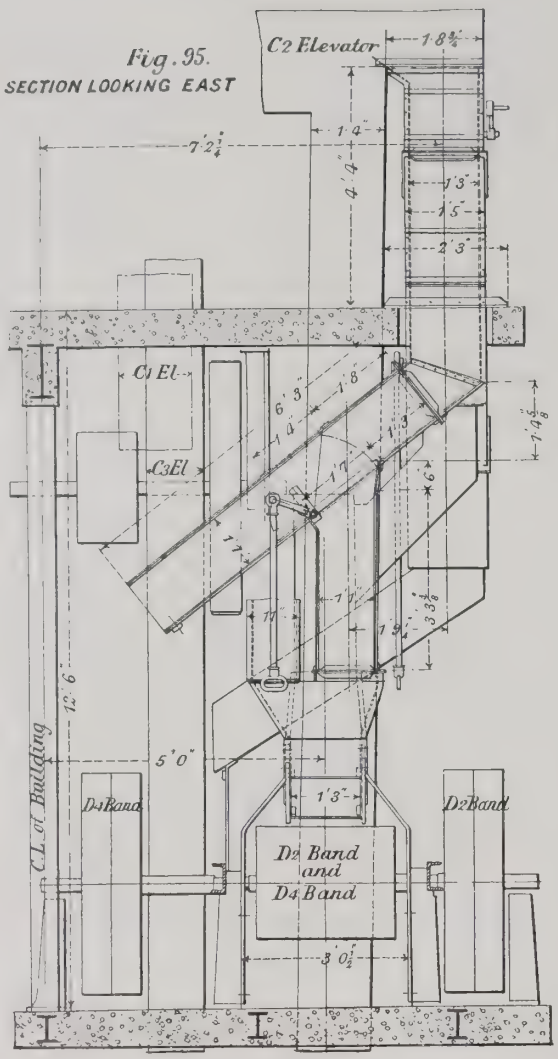


Fig. 96. SECTION LOOKING NORTH

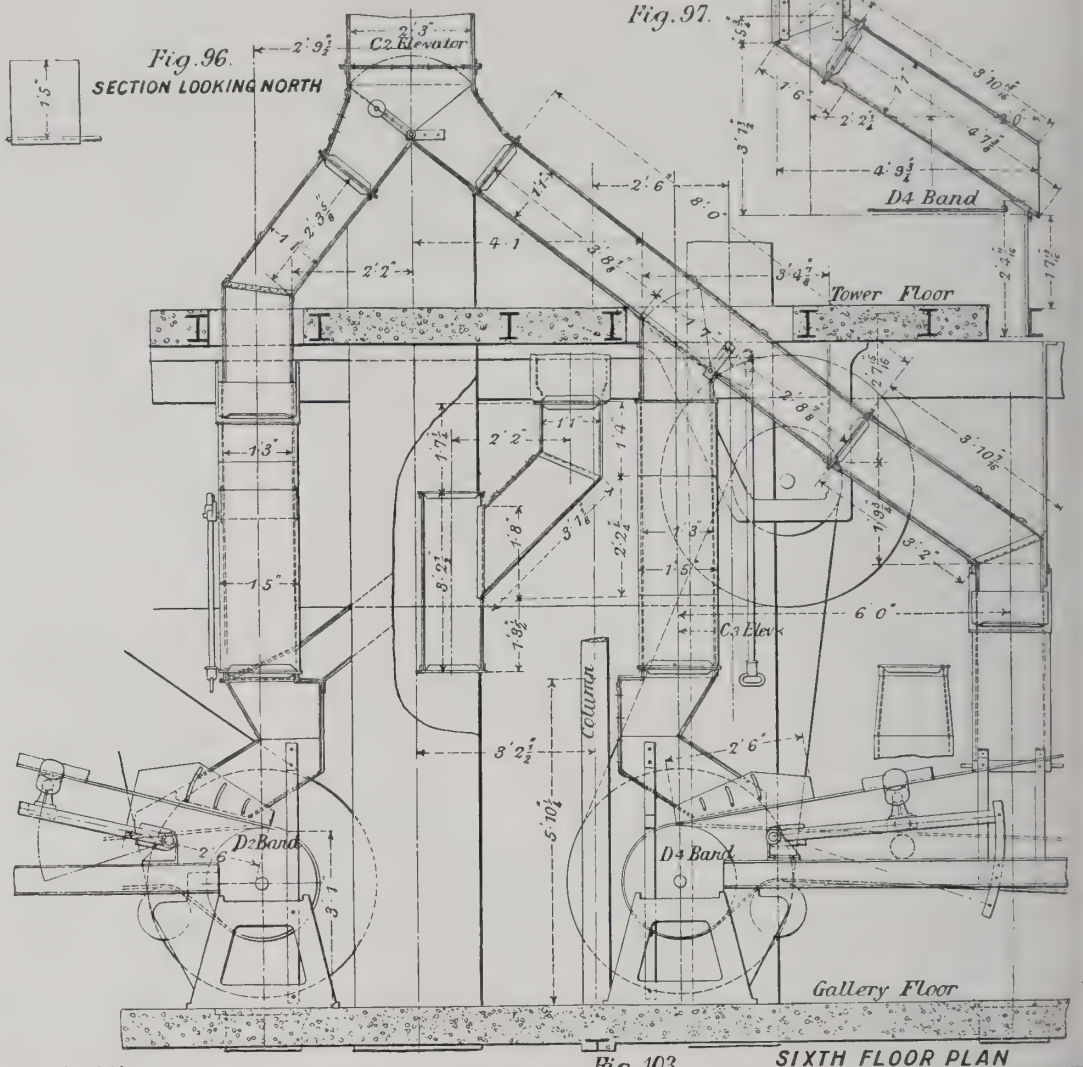


Fig. 97.

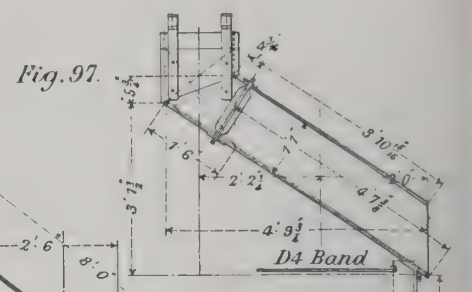


Fig. 102. FIFTH FLOOR PLAN

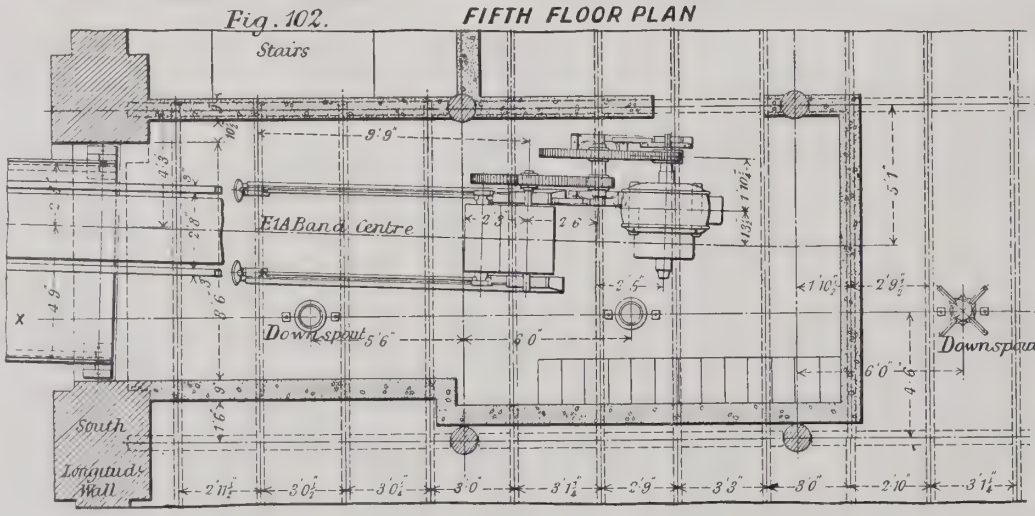


Fig. 103. SIXTH FLOOR PLAN

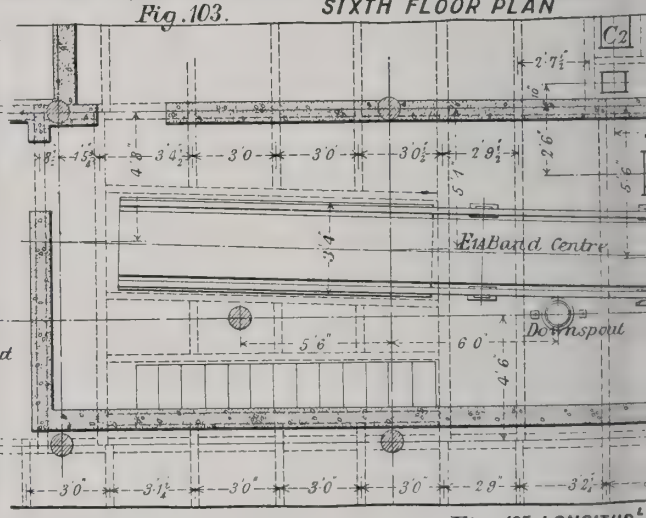


Fig. 104. CROSS SECTION ON LINE X.X. (LOOKING WEST)

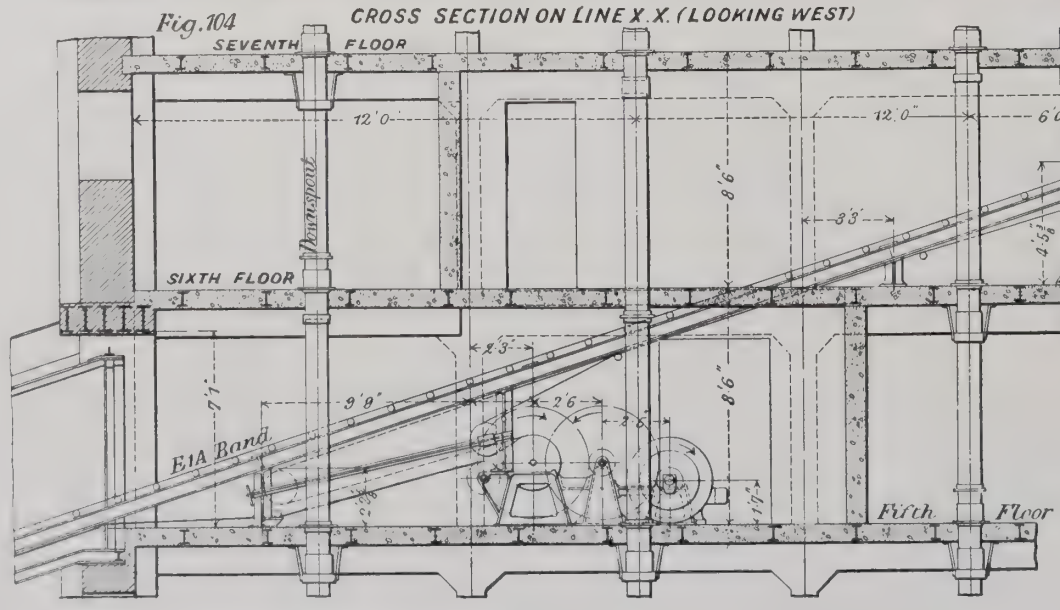
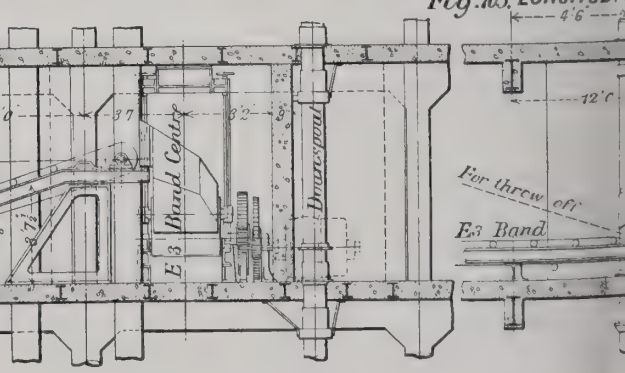


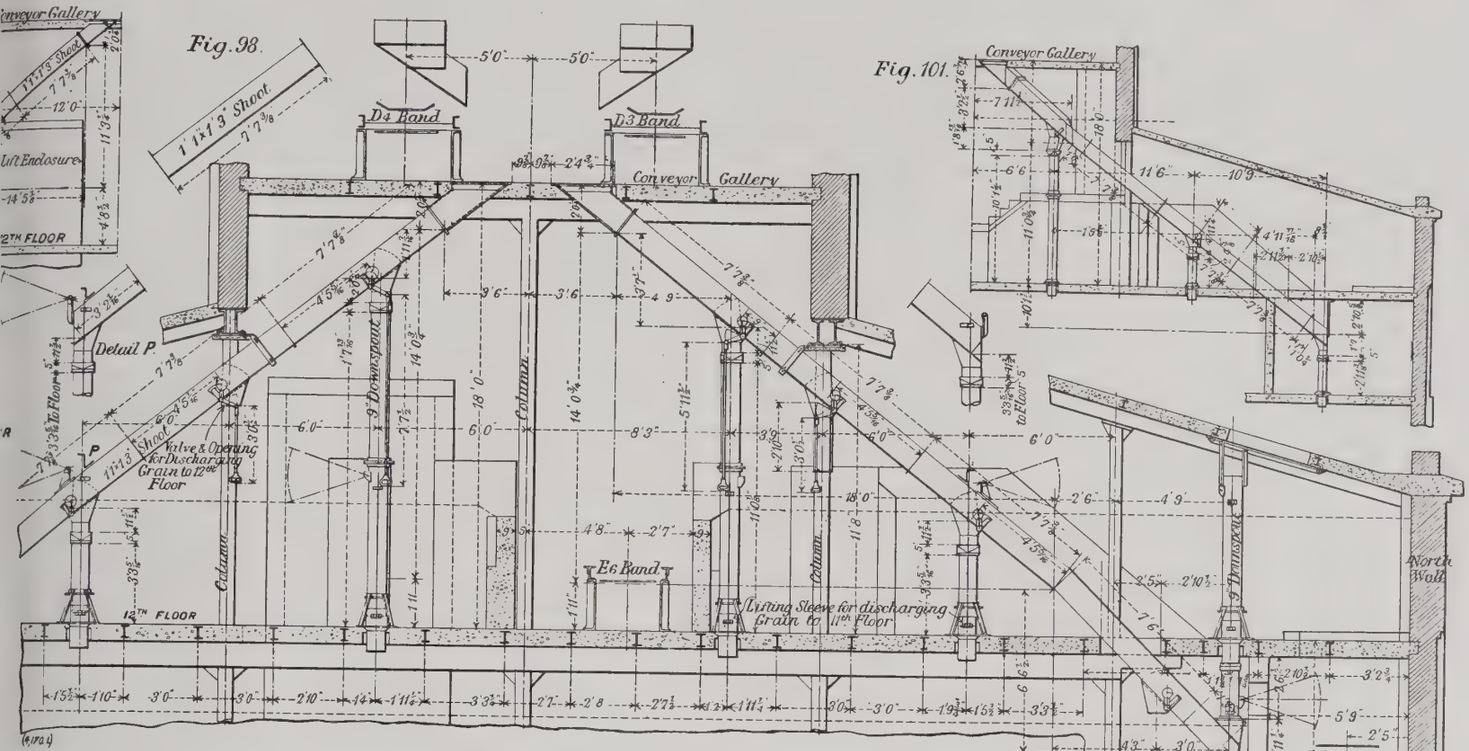
Fig. 105. LONGITUD.

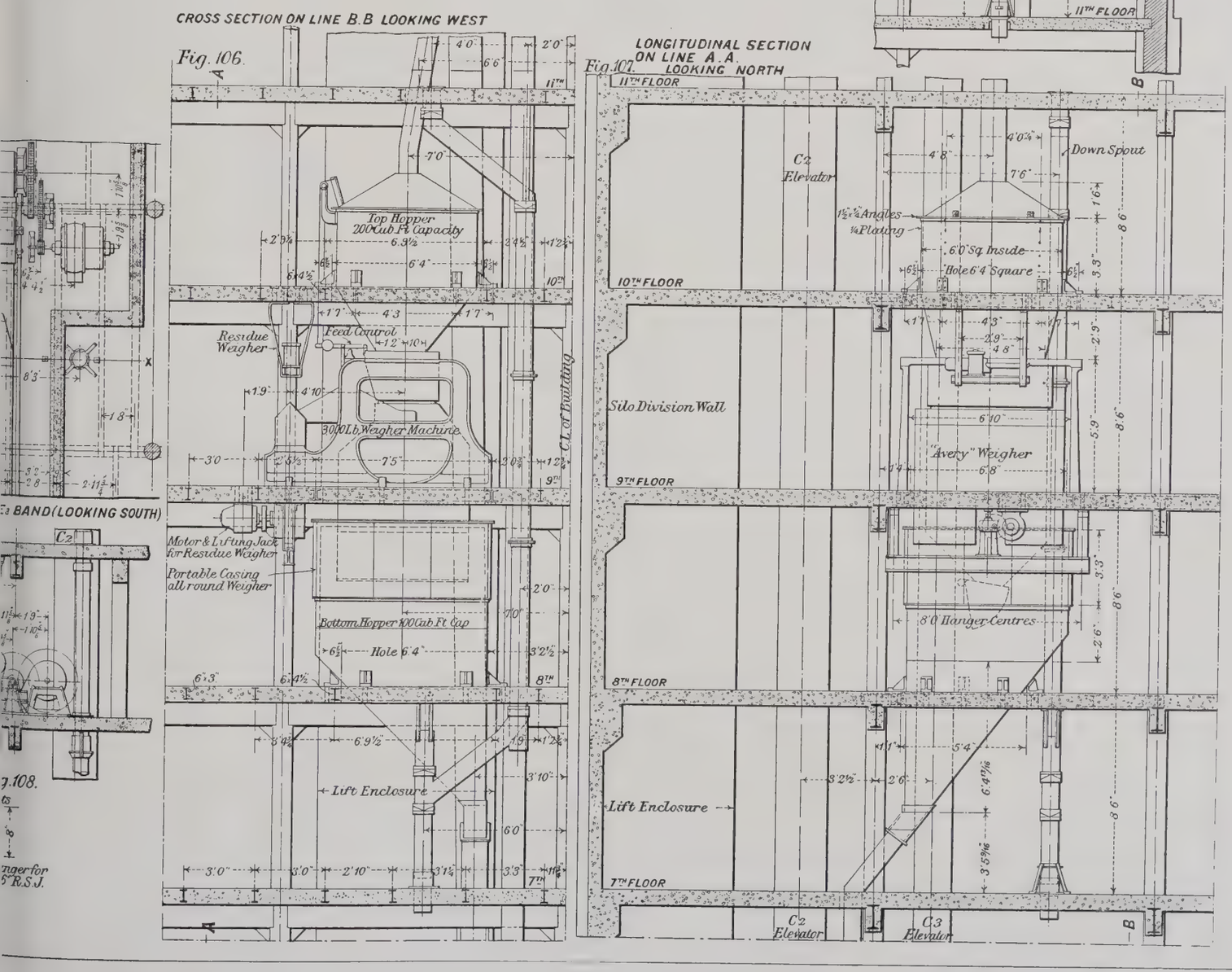


GRAIN-CONVEYING MACHINERY.

MECH. E., MECHANICAL ENGINEER; MESSRS. SPENCER AND CO., LIMITED, MELKSHAM, WILTS, CONSTRUCTORS.

Page 693.)





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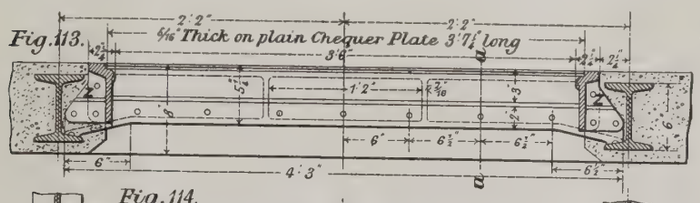
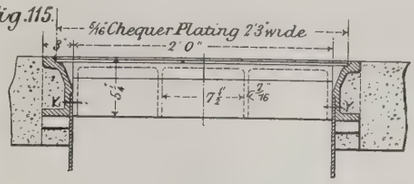
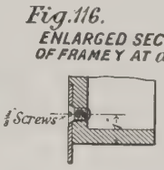
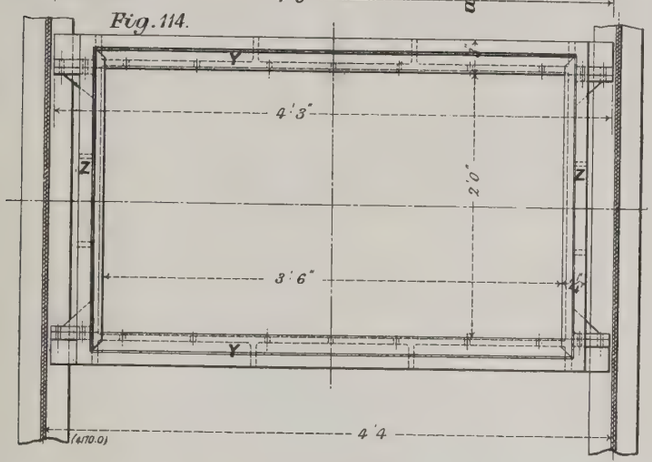
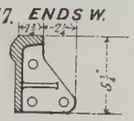
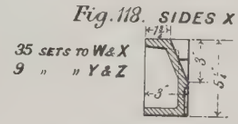


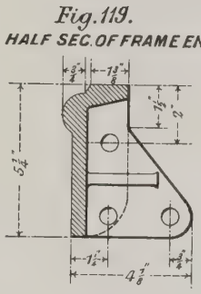


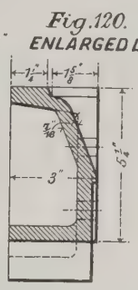


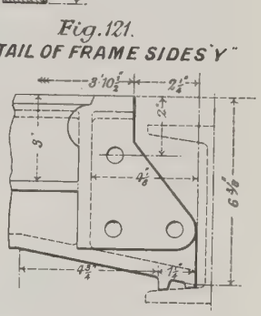


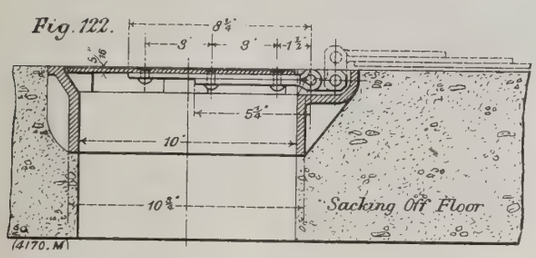


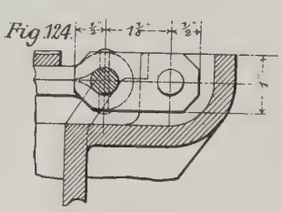


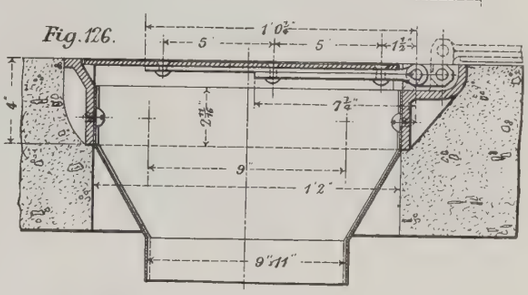


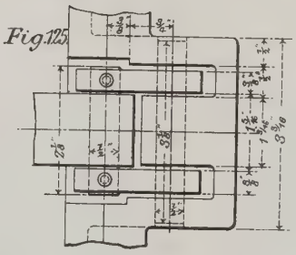


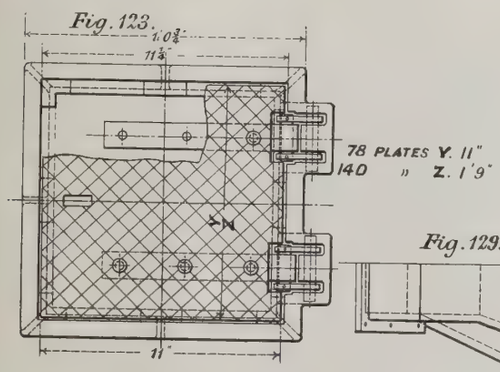


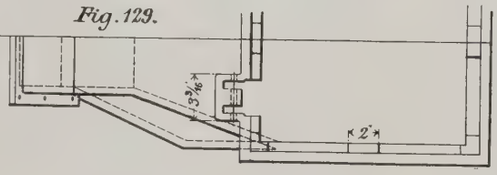


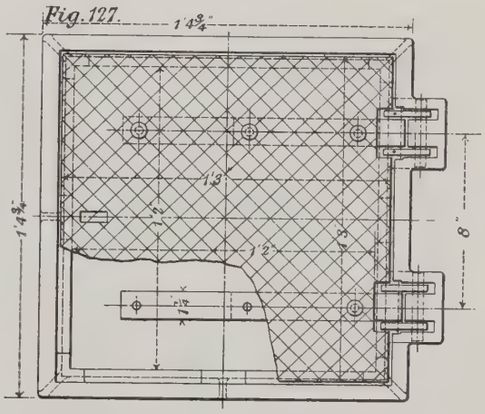


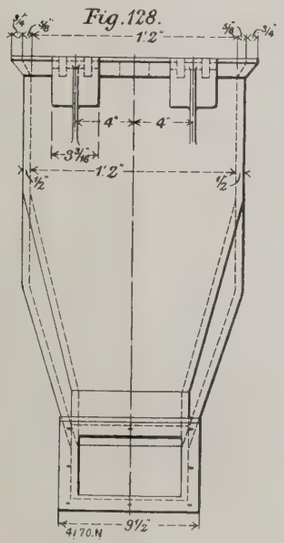


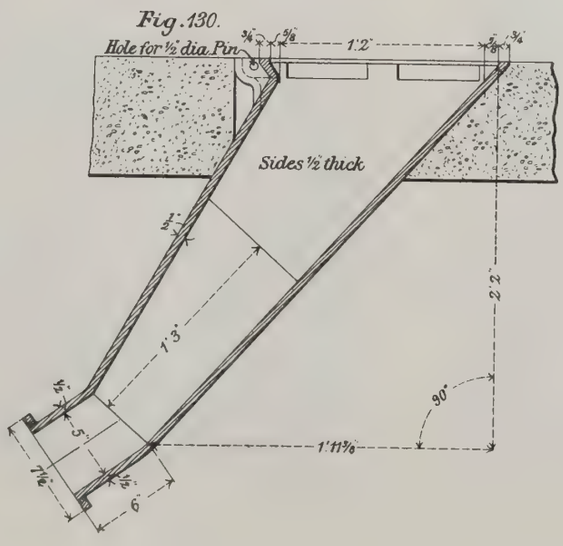












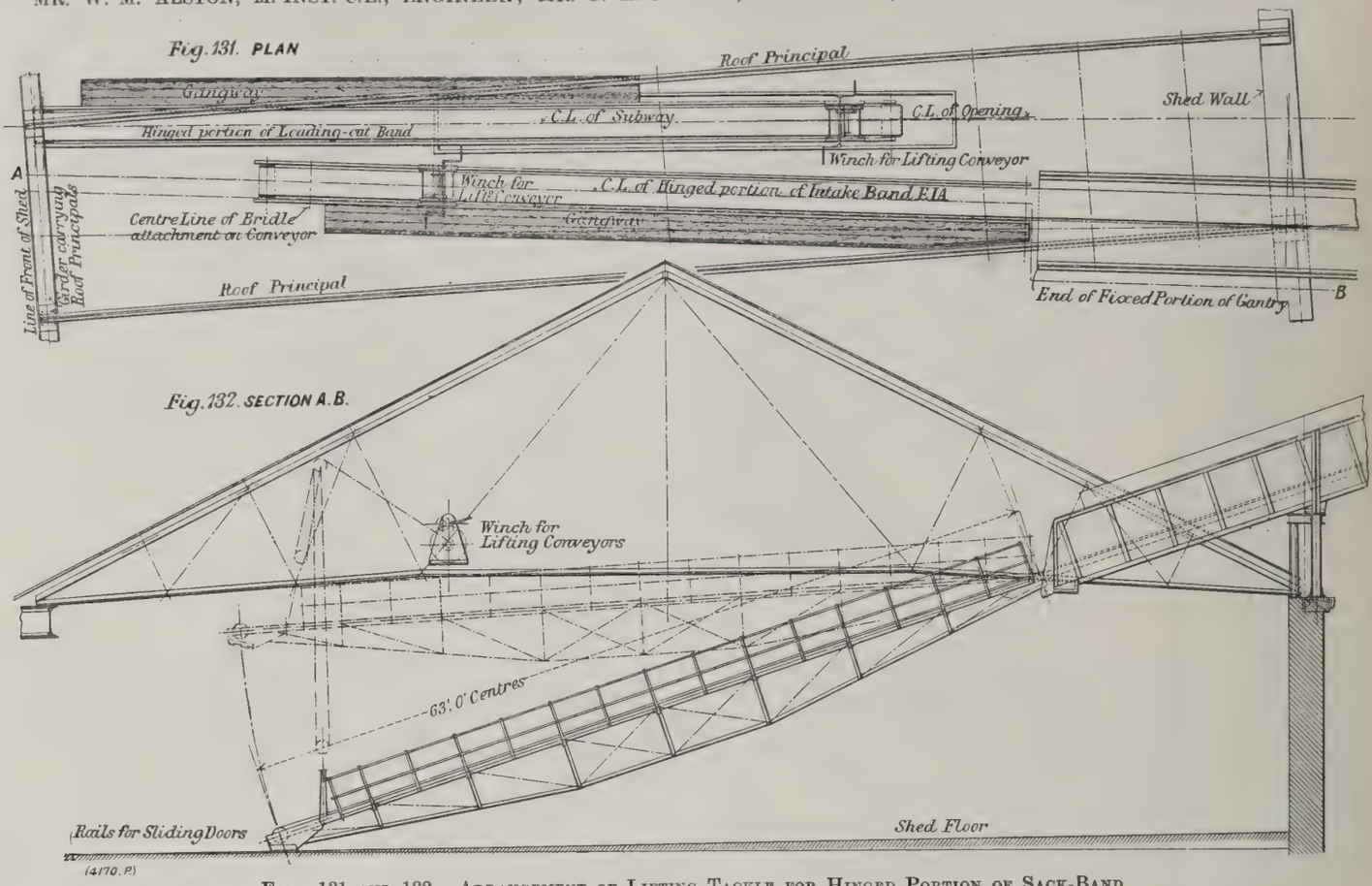
"turning-over" process and the loading into railway wagons. Instead of being weighed by the portable machines on the first floor, the grain, if in a large parcel, may be weighed by passing through the automatic weigher on the ninth floor, above referred to (Figs. 106 to 108, Plate XLIV.), and the relative shooting discharging on to the centre basement band F 5. From the travelling gantry in front of the goods-shed the grain, whether in bulk or in sacks, is discharged by fixed and portable shoots into the craft lying alongside the quay.

Up to this point we have been dealing almost exclusively with the movement of grain in bulk, and we have now to refer to the arrangements for handling flour or grain in sacks. At the east and west ends of the floor granary, two inclined band-conveyors are provided, each capable of dealing with 500 sacks per hour; these conveyors run from the quay-level, near the front of the goods-shed, to the granary, which they enter at the fifth floor level, and deliver on the sixth floor.

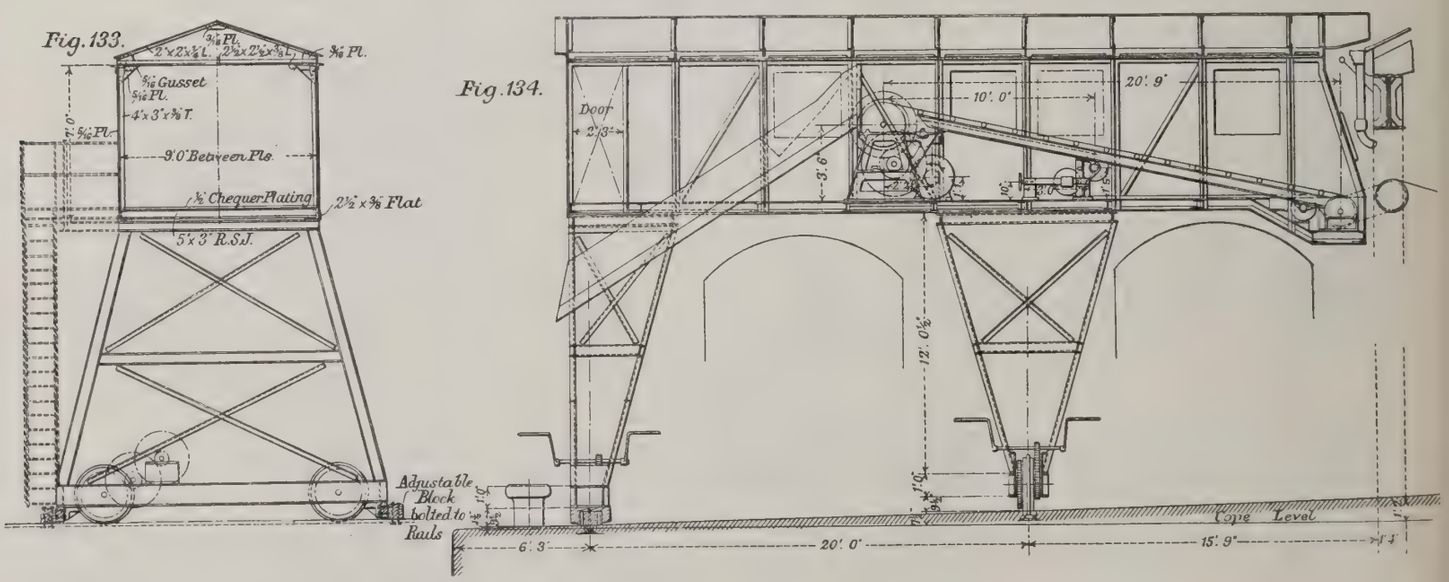
The lower ends of the conveyors inside the shed are carried on framed gantries hinged on the adjoining roof principals, and capable of being lifted up towards the roof, so as to leave the floor of the shed

GRANARY AT GLASGOW HARBOUR; GRAIN-CONVEYING MACHINERY.

MR. W. M. ALSTON, M. INST. C.E., ENGINEER; MR. G. H. BAXTER, M.I. MECH. E., MECHANICAL ENGINEER, CLYDE TRUST.

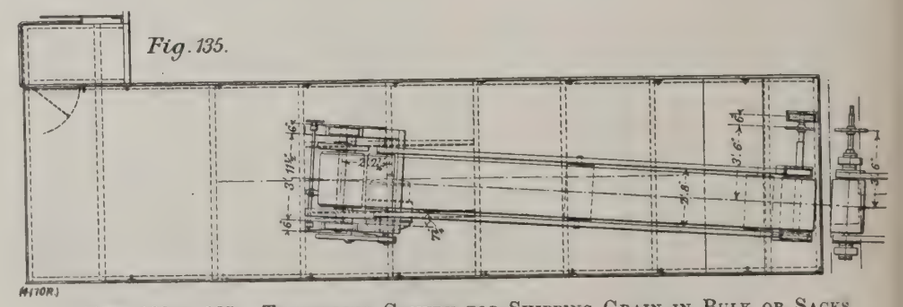


Figs. 131 and 132. Arrangement of Lifting Tackle for Hinged Portion of Sack-Band.



free for ordinary goods traffic. Fig. 110, page 694, gives a view of one of the inclined conveyors, looking upwards from the shed floor, with the hinged portion in the foreground; Figs. 131 and 132, annexed, show details of this portion, and also the lower end of the steel-plate gantry supporting the band across the interval from the back of the shed to the south wall of the granary. Figs. 102 to 105, Plate XLIV., show the details at the upper end of the bands, with the driving motors and band-tightening gear on the fifth floor, and the terminal on the sixth floor.

Sacks taken from the ship's hold or from the shed are placed on these inclined bands and delivered by them, through suitably-arranged curved trough-shoots, on to a horizontal sack-band, marked E 3 on Figs. 103 to 105, Plate XLIV., running east and west on the sixth floor, which is capable



Figs. 133 to 135. Travelling Gantry for Shipping Grain in Bulk or Sacks at West End of Quay.

GRANARY AT GLASGOW HARBOUR AND GRAIN-CONVEYING MACHINERY.

MR. W. M. ALSTON, M. INST. C.E., ENGINEER; MR. G. H. BAXTER, M.I. MECH. E., MECHANICAL ENGINEER, CLYDE TRUST.

(For Description, see Page 693.)

FIG. 136. TYPICAL VIEW OF FLOOR GRANARY.

FIG. 138. SACKING-OFF FLOOR, SHOWING HOPPER-BOTTOMS OF SILOS.

FIG. 137. CONVEYORS IN GALLERY OVER SILOS WITH THROW-OFF.

FIG. 139. SACKING-OFF FLOOR UNDER FLOOR GRANARY.

of being run in either direction, as required, and, by the operation of a movable throw-off carriage and curved shoots, can deliver sacks where desired on the sixth floor. From this floor, by means of nine patent "Swiftsure" sack-shoots, bags can be passed to any of the lower floors for storage, or to the first floor for weighing, if required, and loading through wall-shoots into carts outside the building, or through specially-designed shoots into railway-wagons. By means of the same "Swiftsure" sack-shoots, bags at the rate of 500 per hour can be delivered to any of the six basement bands, Fig. 92, and so to the loading-out band G, and the travelling gantry, Figs. 133 to 135, from which, by means of suitable trough-shoots, they may be discharged into lighters at the quay, the operation being the same as described above for grain in bulk.

Along the east and north walls of the building there is an upper inclined sack-band extending from the sixth to the twelfth floor, which forms a direct continuation of the eastern sack-band from the quay. At the right-angle turns in this conveyor, the sacks are transferred from one section of the band to the next by means of suitably-curved shoots. The conveyor runs within an enclosure formed with partition-walls and sloping floors and ceilings, which were illustrated by Figs. 10 to 15, on page 525 *ante*, in a previous article.

The sixth-floor horizontal sack-band E 3 is equipped with a hinged portion at its eastern end, and by the raising of this it is made capable of delivering on to the upper inclined band, and in this way the west as well as the east sack-band from the quay is able to deliver on the twelfth floor. On this floor there is a distributing sack-band serving the same purpose as that already described on the sixth floor. Fig. 94, page 693, shows the position of this band with its enclosure walls, and a perspective view is given in Fig. 109, page 694, which shows the travelling throw-off carriage and side shoot in the foreground. By this band sacks are distributed where desired on the twelfth floor, and from there, by means of "Swiftsure" sack-shoots, to any of the lower floors for storage, or for disposal otherwise, as described above, in connection with the sixth floor distributing-band. The delivery of sacks to lighters does not in any way interfere with the taking in of grain in bulk or sacks; the entire equipment has been so designed that several operations can be carried on simultaneously.

The "Swiftsure" sack-shoots, nine in number, are placed in continuous vertical lines, extending from the twelfth floor to the basement bands. The principle upon which they are arranged is that the sack has first a vertical drop for about half the height between floors, and then slides on to a nearly horizontal portion of the shoot, the change in direction of movement being made through a properly designed curve. If the bag is at an intermediate stage in its journey, it retains sufficient velocity to carry it forward to the next vertical drop pertaining to the floor below, followed again by the horizontal portion of the shoot. The complete movement of the bag through a number of floors is therefore a zig-zag. On the floor at which it is desired to intercept the bag, the side of the shoot is opened up and the movement of a lever moves a baffle-plate which brings the bag to rest on the horizontal portion of the shoot, from which it can be taken by hand and disposed of. Fig. 139, page 697, shows one of the sections of this type of shoot; in this case, the side-door is open for taking out the sack, and the position of the baffle-plate may also be seen.

In Figs. 111 to 130, on pages 694 and 695, are shown constructional details in connection with the silos and shoots. Figs. 111 and 112 show the silo hoppers, which are built up of steel plates and angles of the dimensions given, and are secured to the ferro-concrete by T-bars and angles. The hopper illustrated has four openings; other hoppers have only one, two, or three outlets, according to the number of divisions in the silo. In each case the hopper-mouth is so constructed as to take the portable automatic weighing-machines, and the outlets are controlled by valves operated by chain-wheels and chains from the sacking or weighing-floor. Figs. 113 to 130 illustrate frames and covers for sack-shoots and bulk-grain shoot on the weighing-floor; there are about 400 openings fitted with frames, and the covers are hinged and arranged so that when shut down they are flush with the floor, in order that there may be no obstruction to trucking.

Fig. 138, on page 697, is a perspective view of the west portion of the sacking-off floor, showing the steel hoppers mentioned above. If bulk grain from a silo requires to be delivered to carts, railway wagons, or to the bands for turning over or delivery to craft at the quayside, suitable spouts are provided for these various operations from the weighing-machine, or from the hopper direct if weighing is not being done.

The granary is equipped with two separate dust-extracting plants—one for dealing with the quayside and intake subways, the other for subways in the basement. The dust trunking, with connections, is shown in Figs. 88 and 89 accompanying our previous article. The trunks are coupled to fans placed on the second floor of the granary. The fans are direct-driven by motors, and are of ample size to deal with all dust arising from the grain at the feeding-on and delivery points on the conveyors, so that the subways are kept perfectly clear. The dust is discharged from the fans through the north wall of the building into two large cyclone dust-collectors, from which it is led by means of spouts to the loading-platform, where it is sacked

The whole of the above-described grain-handling plant at the granary is driven by electricity, direct current at a voltage of 500, supplied from the Glasgow Corporation Electricity Supply system. On the second floor of the granary a main switchboard is placed in a special room. This board consists of seven enamelled slate panels supported on steel angles, and mounted in a polished wood frame. Two feeder-panels are arranged to take the Corporation's incoming mains, one for power and one for lighting. Three of the other panels are for power distribution to the granary, and the other two for lighting distribution. The incoming power-feeder panel is fitted with voltmeter and ammeter, recording wattmeter, two single-pole circuit-breakers, and single-pole switch and fuse. Each power-distributing panel is fitted with an ammeter, single-pole circuit-breaker, and single-pole switch and fuse. Two of these distributing panels supply the quay subway, where, owing to the long cable run, it is necessary to have two sets of feeders to a central distributing point in parallel, to keep within the specified voltage drop. The other distributing panel supplies the granary through sub-distribution boards fixed at the second, fifth, and tenth floors. Multiple bus-bars are fitted at the back of the switchboard, on porcelain insulators, for carrying the current.

There are thirty-nine motors, all of which are totally enclosed, the total horse-power being 678. All motor-starting panels, except those in the quay subway, are of the ironclad type, consisting of a rheostat (with no-volt and overload release) operated by means of a handle from the outside of the casing, and a double-pole magnetic circuit-breaker, which is closed by the starting-switch. The motors driving the quay subway conveyors have automatic control panels consisting of an enamelled slate base fitted with a solenoid-operated starting-rheostat, double-pole throw-off switch, single-pole magnetic circuit-breaker, double-pole single throw-over main switch, and a no-volt and overload release. These panels are designed for remote control, being operated by master switches, four in number, fixed on columns of the goods-shed facing the river. These eight panels are all electrically interlocked, making it impossible to start up the two bands at the far end of the subway—*i.e.*, B 1 and B 2—without all the preceding bands starting up simultaneously. In like manner, should the bands nearest to the intake elevators—*i.e.*, B 7 and B 8—be stopped for any reason, then all the other bands bevond will also stop, and if bands B 5 and B 6 be stopped, then B 3, B 4, B 2 and B 1 will also stop, but B 7 and B 8 may be kept running. Also, should bands B 3 and B 4 be stopped, then B 1 and B 2 will stop with them, and bands B 5, B 6, B 7 and B 8 may be kept running. Thus all fear of a choke of grain in the subway is reduced to a minimum. The remote control may, if necessary, be cut out and the panels operated locally by means of the double-pole throw-over switch mentioned above.

The ship elevators are electrically connected by means of a flexible cable, protected in a metallic flexible tube, fitted with a plug to connect up to plug-boxes (21 of which are built into the surface of the quay), these plug-boxes being fed from the mains in the quay subway. A driver's cabin is provided, where all the control-gear for the different motors are grouped together conveniently for the operator. Trimmer-winches are included for bringing the grain in the ship's hold up to the elevator boots, and are provided with magnetic clutches, which are operated by means of push-buttons fixed at the bottom of the elevator legs.

The lighting is carried out on the three-wire system, 250 volts, direct current, the circuits being distributed so as to balance on each side. There are 800 60-watt metal-filament lamps. The incoming feeder-panel on the main switchboard is fitted with an isolating link for connecting the middle wire from the power-station. This panel is also provided with two ammeters, one for each side, and two single-pole circuit-breakers. There are also two distributing panels, one for the positive side and the other for the negative side, each fitted with voltmeter, recording wattmeter, two double-pole switches (one for granary lighting, the other for the quay subway lighting), and two double-pole fuses. Two pairs of lighting mains are run the full height of the building, with T connections to sub-distributing boards on each side.

There is a complete telephone system installed, there being one instrument on each floor, and one at each master-switch along the quay; all are connected through a central exchange. The ship-elevators are provided with an electric bell signalling apparatus from the driver's cabin to the quay-level, so that the driver may be warned in case of emergency.

INDUSTRIAL NOTES.

In a former paragraph (see page 641 *ante*) we dealt with the employment of Belgian refugees. We are now informed that the Local Government Board has drawn attention to some important principles that have been laid down by the Government Belgian Refugees' Committee concerning the employment and the treatment of Belgian refugees. The Committee have stated the following:—

That it should in all cases be borne in mind that the refugees are the guests of the nation, and that any attempt to obtain Belgian labour gratuitously or at a lower rate of wage than paid to British workpeople is strongly to be deprecated.

That any attempt to secure Belgian labour without making every possible effort first to secure British labour is also strongly deprecated.

That in all cases where a Belgian is placed in regular employment, and is receiving hospitality, he should be called upon to pay the cost of his board and lodging, or such contribution thereto as the local committee may consider just and reasonable.

That in all cases where temporary or intermittent work is performed, or regular personal service given to the person or persons from whom hospitality is being received, the refugee ought to receive remuneration not less than that which is customarily paid for such work or service, but that the value of the board and lodging received might equitably be taken into consideration in these cases.

That it has been brought to the notice of this Committee that in some cases the wages earned by the refugees are not paid over to them, but are, either in whole or in part, being saved for them for their return to Belgium; considering the thrifty habits of the Belgian people, no compulsory system of saving should be instituted in any case, but each refugee should be asked to decide for himself whether he would wish any part of his earnings saved for his future use.

The Local Government Board states that some part of the gifts of flour, cheese, and potatoes from Canada will be available for distribution among the refugees if the local committees will undertake the distribution.

The *Liverpool Courier* deals with the St. Helens glass trade in the following terms:—"Among those trades which have received distinct benefit from the war is the glass-making industry. Owing to foreign competition in the past, and especially to scientific "dumping" on the part of competitors in Protectionist countries, the British makers of glass have been sadly reduced in number. One of the principal, if not actually the foremost, strongholds of the industry is St. Helens, Lancashire, where Messrs. Pilkington Brothers employ many thousands of hands in making plate and sheet-glass, and where there are also several substantial firms engaged in the manufacture of bottles, &c. St. Helens has for years found fairly steady employment in glass manufacture, but the war has now produced there an unprecedented boom. The cost of glass has gone up in some cases about 50 per cent., if not more, and large stocks in extensive warehouses are being quickly depleted. The men in Messrs. Pilkington's employ are receiving an addition

of 2s. a week to their wages, while women, girls, and boys are getting 1s. extra, as also are the labourers. This is described by the firm as a war bonus.

"There is a considerable shortage of both skilled and unskilled labour in the town, due in part, no doubt, to the fact that so many men have gone to the war. At one time there used to be in St. Helens a not inconsiderable flint-glass trade, but this is practically non-existent, and notwithstanding that there is now no German competition for the time being, there seems to be no local tendency to take advantage of the situation. Considering the enormous trade in lamp-glasses, chimneys, &c., done by Germany and Austria in this country, this seems singular. A local gentleman with intimate knowledge of the subject, however, informed the writer that the fault lay with the trade unions, who would not allow flint glass to be made in moulds. Until this restriction was removed, it was hopeless to rehabilitate the industry to any great extent."

The returns issued by the accountants to the Midland Iron and Steel Wages Board, which controls wages in Staffordshire, Worcestershire, Shropshire, Lancashire, Derbyshire, Yorkshire, and South Wales, show that for September and October last the output of the seventeen selected firms whose books are examined was 30,989 tons of iron and steel of all descriptions, compared with 28,828 tons in the previous two months, or an increase of 2161 tons. The average net selling price for September and October was 7*l.* 6s. per ton—an increase of 9s. 8d. per ton compared with the selling price for July and August.

In accordance with the sliding scale, the wages for puddling have advanced 6d. per ton, making the rate 9s. 6d. In addition to the puddling rate a bonus of 6d. is allowed, which brings the actual wage to 10s. The advance commenced to take effect on Monday last, the 7th inst.

The quarterly report for July, August, and September, issued by the Ship-Constructors' and Shipwrights' Association, to which we referred on page 669 *ante*, states that its members have been fully employed during the quarter, especially in those districts where war work has been completing, and where hospital-ships, troop-ships, and other requirements of war have had to be provided. The demand for shipwrights and drillers has been, and still is, abnormal, and there is not the slightest reason for either a shipwright or driller to be out of employment. By the transference of men from different places where work has been quiet we have been able to meet a considerable portion of the demand, especially on Admiralty work; but in certain places it would appear to be almost impossible to persuade certain of our members, even when unemployed, to recognise how they fail in their duty to the State and cause detriment to their craft by refusing to go to other places where men are urgently required. This is not a time for people to quibble over paltry excuses, when their craft is in danger and the need of the nation vital; therefore we do trust that our members everywhere will assist their representatives to obtain every available member in their departments. It is to their interest as individuals, to that of their craft and association, and, above all it is their duty to the nation. We must also point out another way in which our members can materially protect their interest as a craft, also materially help in the accelerating of Admiralty work, and that is by keeping regular time. In connection with this matter of better time-keeping, might we also be permitted to make a special appeal to the different firms during the present emergency, when so much overtime has to be worked? Instead of closing their gates immediately after starting-time in the morning, and not allowing men to enter the yard until breakfast-time, which means that the men are losing a quarter, drifting in some cases into a full day, could not the firms, as was the practice in the old days, make special temporary arrangements by which men who are 5 or 10 minutes late, by reasons over which they have little or no control, be allowed to start, and lose only a quarter or half an hour? When men having to come considerable distances by tram or train are delayed *en route*, through no fault of their own, we would respectfully urge that firms should take the fact into consideration, and arrange for the men to be admitted into the yard and allowed to start work. It has also been stated to us, when complaining to the men of lost time, that a considerable amount of time is lost, especially in the piece-work department, through want of power for the machines. If this is correct, then we hope that steps will be taken to remedy the point. At this period it is most desirable that regular time should be kept, and we trust that by co-operation between workmen and employers, especially in warship work, lost time will be reduced to a minimum."

We have received a copy of the pamphlet No. 152, issued by the United States Department of Labour, giving the decisions of courts and opinions affecting labour for the year 1913. The pamphlet deals with a very large number of cases, from which we take the following:—

Employer and Employee—Trade Secrets—Injuncture to Prevent Disclosure—Macbeth-Evans Glass Company v. *Schnelbach.*—This case involved the right of the company named to procure an injunction to prevent a disclosure of important secrets connected with the manufacture of a peculiar quality of glass. The defendant, Schnelbach, had occupied a position of confidence and trust with the company, by reason of which he had become possessed of a knowledge of the secrets in question. Subsequently he had entered the employment of another company, which immediately engaged in the manufacture of a similar glass to that made by the plaintiffs. Investigation disclosed the fact that the formula used by the new company was practically identical with that which had been perfected by the Macbeth-Evans Company as the result of prolonged and expensive experiment. The Court of Common Pleas of Allegheny County had awarded the plaintiff company an injunction restraining the further manufacture of this glass under any name whatsoever, or of any other glass made by substantially the same process, mixture, or formula. It also forbade the disclosure of information as to processes with which the defendant had become familiar while employed by the company. On appeal from this injunction, the action of the Court was affirmed, Judge Elkin, speaking for the Court, saying:—

"It may now be accepted as settled law, under the authority of English and American cases, that courts of equity, if the facts warrant, will restrain an employee from disclosing or from using trade secrets communicated to him in the course of a confidential employment. The character of the secrets, if they be peculiar and important to the business, is not material. They may be secrets of trade, or secrets of title, or secret processes of manufacture, or any other secrets important to the business of the employer. They, however, must be the particular secrets of the complaining employer, not general secrets of the trade in which he is engaged. The duty of the servant not to disclose the secrets of the master may arise from an express contract, or it may be implied from their confidential relations.

"There was no express contract on the part of Schnelbach not to disclose the trade secrets of his employer; but the testimony shows that he was a trusted and valued employee; that for many years he had general supervision of the plants and manufacturing end of the business; that his employers reposed great confidence in him and communicated to him without reserve all the secrets of their business; that in the manufacture of glass there are many trade secrets; and that nothing was withheld from him in connection with these secrets, but that he was treated at all times on the basis of a confidential relation. The knowledge of the secret formula involved in this controversy came to him by reason of the position he occupied with, and the confidence reposed in him by, his employers. The secret formula was communicated to him, not for his personal use, nor that he might profit by the knowledge thus obtained, but for the sole benefit of his employers, whose interests he was in duty bound to protect. It therefore would be inequitable and unjust that he should either disclose it to others, or make use of it himself, to the prejudice of his employers, who were entitled, as against him and those associated with him, to whatever advantage the manufacture of glass by the secret process gave."

CONFERENCE BETWEEN STEEL-MAKERS AND AUTOMOBILE MANUFACTURERS.—In further reference to the recent announcement that a conference would take place in Birmingham in December between makers of steel castings, stampings, forgings, &c., and automobile manufacturers, in order to discuss the shortage of automobile parts, it has now been arranged that the meeting shall be held in the hall of the Y.M.C.A., Dale End, Birmingham, on Friday, December 11, at 7.30 p.m. A card of invitation for the meeting may be obtained on application to the Secretary of the Institution of Automobile Engineers, 28, Victoria-street, London, S.W.

SMALL TUBING.—Many of our readers will, we imagine, be glad to note the fact that they can obtain very fine tubing suitable for laboratory work, model-making, instrument-making, and many other purposes from the Specialities Supply Company, of Warwick-road, Greet, Birmingham. We have received from this firm a sample of solid-drawn brass tubing, the external diameter of which is only $\frac{1}{16}$ in. The tube had been twisted into the form of a small helical spring, with coils about $\frac{1}{2}$ in. in diameter, without suffering any visible injury from the treatment it had received. Similar sized tubes, and larger ones up to $\frac{3}{4}$ in. outside diameter (either solid-drawn or brazed), can be supplied in copper, steel, aluminium, and German silver, as well as in brass. Solid-ended tubes, radiator tubes, nickel boxes and cases, and small stamped, pressed, or spun metal parts, are also supplied by the firm.

THE "SENFROT" CHEMICAL INJECTOR.

IN many cases of water supply, particularly from rivers, it is found impossible to obtain a clear filtrate after treatment with sand filters, and it is necessary to employ some form of coagulant, such as aluminium sulphate or alumino-ferric. The problem of adding the chemical to the water is of some importance, since if too little is used the water is not properly clarified, and if too much is used, not only may there be serious waste, but corrosion of the mains may result, and even injury to the health of the population depending on the water supply. As in practically all cases the rate at which water is delivered to the mains will vary greatly over the twenty-four hours of any day, it is clear that the rate of supply of the chemical must be correspondingly varied, and for the best results must be added as a constant proportion of the water used. In many cases the salt is added at the discretion of the works superintendent, who makes an attempt to approximate the chemical added to the water consumption, but the results are not, in general, very satisfactory. The Hon. R. C. Parsons, who was consulted some time ago by the directors of the Water Works Company of Rosario de Santa Fe, in the Argentine Republic, in connection with this matter, designed an apparatus for automatically adding the chemical in absolutely direct proportion to the water flow. The apparatus, which is known as the "Tiltometer," we illustrated and described some time ago.* Several "Tiltometers" are now in practical operation, and working entirely satisfactorily.

In many plants employing mechanical filters, the water to which it is necessary to add the salt is flowing through mains under pressure, and a reference to our description of the "Tiltometer" will show that it is not suitable for use under such conditions. In view of this, Mr. Parsons has devised a further apparatus, which, while performing the same work as the "Tiltometer," is able to inject the chemical into the mains against any pressure. The new piece of apparatus, which Mr. Parsons terms the "Senfrot," a high-pressure chemical-injector, is illustrated on pages 700 and 701. Fig. 1 shows the device set up complete for demonstration purposes, while Fig. 2 is a cross-section of its essential parts. The action of the appliance may best be described by reference to Fig. 2. As will be seen, there are two cylinders *a* and *b*. The cylinders are of equal diameter, and are always full of water, or of water and the chemical solution which is to be injected into the mains. Each cylinder contains a solid piston, made of material slightly heavier than the liquid displaced. The pistons, which have wide circumferential grooves, move quite freely in their cylinders. A valve-gear, which controls the admission and exhaust of the water from both cylinders, is situated below the cylinder *a*. It is operated by a fork carried by a rod *c* attached to the bottom of the piston of the cylinder *a*. This fork engages the tappet-rod *d*, which has adjustable tappets, and by means of it moves the slide-valve *e* each time the piston completes a stroke in either direction. The operation of this slide-valve *e* controls the movements of a second slide-valve *f* by admitting pressure-water above or below it, The casing of the valve *e* has a connection to the pressure-main through the pipe *g*, and a further connection to exhaust.

Slide-valve *f* is cylindrical, and in that sense is a piston-valve; but it has ports only on one side, like a slide-valve. The object in using the cylindrical construction is to enable the valve to operate like a piston and to move up or down as pressure water is supplied below or above it by the movement of the valve *e*. The valve has cup leathers at top and bottom to prevent leakage of water past the ends. It will be clear from the figure that the movement of the valve *e* admits water alternately to each end of the valve *f*, and simultaneously puts the other end to exhaust. It will further be clear that the ports in the valve *f* are so arranged that, as it moves up and down, it alternately supplies pressure-water to the cylinders *a* and *b*, and at the same time connects the other cylinder to exhaust. In addition to the valves *e* and *f*, there is a further controlling-valve *h*. This is fixed at the bottom of the cylinder *b*, and is kept open by means of a spiral spring, except when it is forcibly closed by the piston, in its lower position, coming down on top of the spindle. The valves we have so far dealt with control the water which operates the pistons. There are, however, further valves in the apparatus which control the chemical which is to be injected into the water-main. These are fixed in casings at the top of the cylinders. As will be seen from Fig. 2, connection is made to these casings by an inlet pipe for the chemical solution, and an outlet pipe to the water-main. The valves of the two cylinders are similar, and in the figure the arrangement for the cylinder *a* is shown in cross-section. For each cylinder there is an inlet and outlet valve. They are respectively marked *k* and *l* in Fig. 2. All the valves consist of thin discs of pure soft rubber. Connection is made between the

* See ENGINEERING, vol. xciii., page 416.

THE "SENFROT" CHEMICAL INJECTOR FOR WATER SUPPLY.

CONSTRUCTED BY THE STEREOPHAGUS PUMP AND ENGINEERING COMPANY, LIMITED, LONDON.

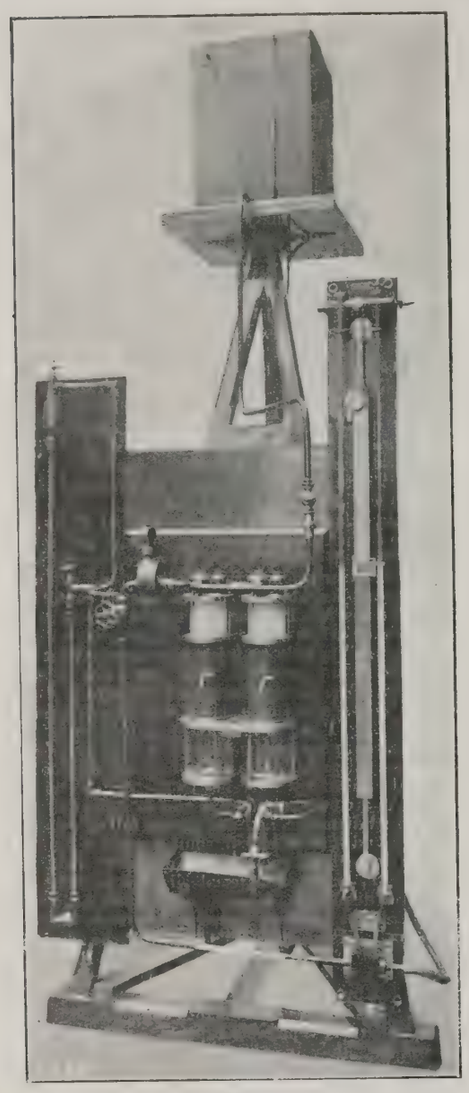
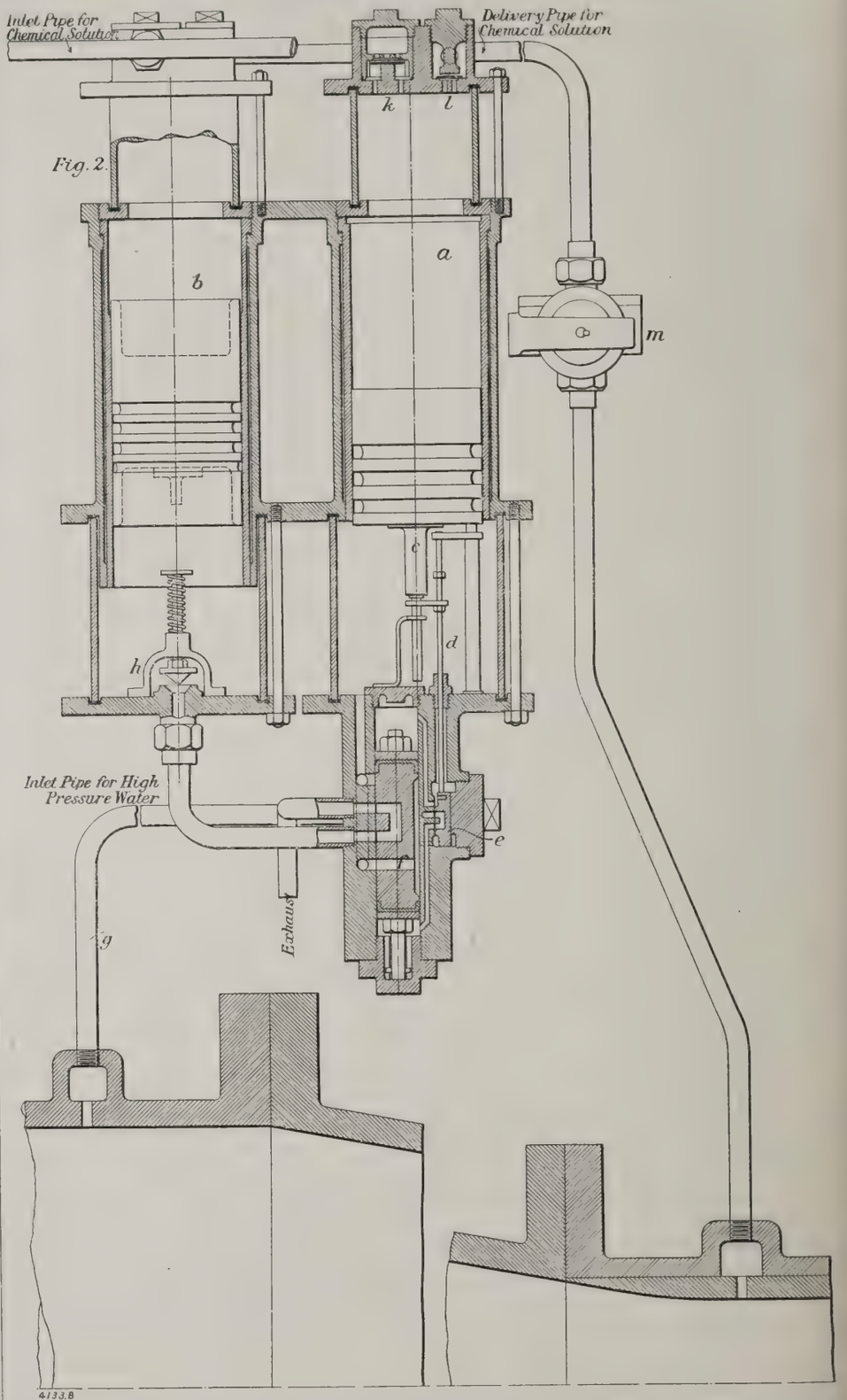


Fig. 1.



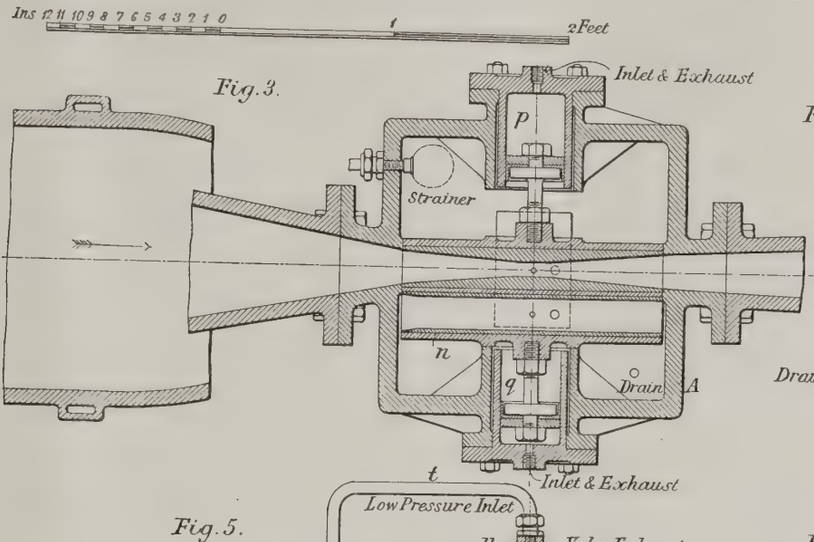
cylinders and the upper and lower valve-boxes by cylinders of glass, which enable the attendant to observe the important working parts of the apparatus. These glass cylinders are shown in cross-section in Fig. 2, while they can clearly be seen in Fig. 1.

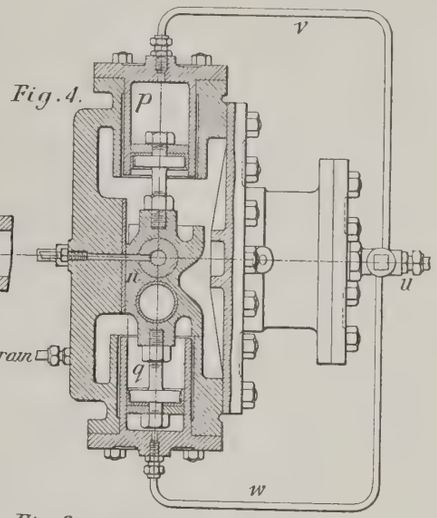
The standard solution of chemical, which is to be injected into the main, is stored in a tank fixed some 10 ft. above the apparatus. This tank is connected to the upper valve-box by the pipe already mentioned, and which is shown in Fig. 2. The delivery-pipe from these same valve-boxes is connected to the main through a special valve shown at *m* in the figure. This valve has a diamond-shaped orifice, which does not alter its form as the valve is opened or closed, so that a practically constant coefficient of flow is maintained for all openings. A further essential part of the apparatus is a Venturi tube, which is placed in the water-main. This tube is indicated by two broken parts in Fig. 2. As will be seen, the delivery-pipe from the upper valve-boxes is connected to the main at the throat of the Venturi tube—that is, at the region of lower pressure. The inlet pipe which supplies water to the lower valve-casing is, on the other hand, connected to the main at a point outside the Venturi neck, and is consequently subjected to the full pressure of water. In order to prevent any deposit of the chemical occurring in the passages and chambers of the upper valve-boxes, care is taken that stagnant liquid shall not exist at any point. A vortex action is maintained in the chambers by the in-and-out flow of the chemical.

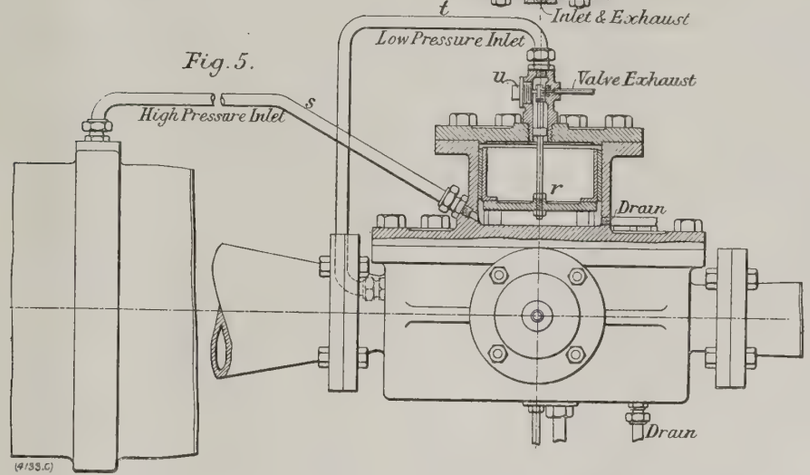
To describe the action of the apparatus, it may be assumed, in the first instance, that the pistons of both cylinders are at the bottom of their strokes, and that the upper valve-boxes are full of chemical. Both cylinders would be full of water below the pistons, and of chemical mixture above. The lower valves would be in the positions shown in Fig. 2, and if pressure water were supplied to the casing, it would be admitted below the piston in cylinder *a*. This piston would consequently rise and inject the solution above it through the delivery-valve *l* into the main. It would be able to do this against the pressure of the main, as the delivery-pipe is connected to the Venturi throat, and the pressure in the delivery-pipe and above the piston would consequently be less than the pressure below the piston. When the piston reached the top of its stroke, the valve *e* would be operated so that pressure water would be admitted to the lower end of the valve *f*, while at the same time its upper end would be put to exhaust. This valve would accordingly rise, and would connect the lower end of the cylinder *a* to exhaust, and at the same time would connect the lower end of the cylinder *b* to pressure. The piston of the cylinder *a* would consequently begin to descend, while that of the cylinder *b* would rise and continue the injection of chemical to the main. The upward stroke of the piston of the cylinder *b* would continue only until the piston of the cylinder *a* had reached the bottom of its downward stroke and again operated the valve *e*. The cylinder *a* would then again begin to deliver the chemical, while the piston of cylinder *b* would begin its downward stroke. This would cover the whole cycle of operations. It will be clear that the injection of the chemical is constant except for momentary

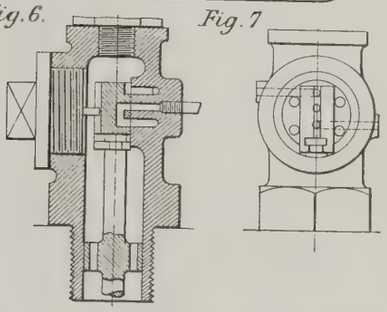
THE "SENFROT" CHEMICAL INJECTOR FOR WATER SUPPLY.

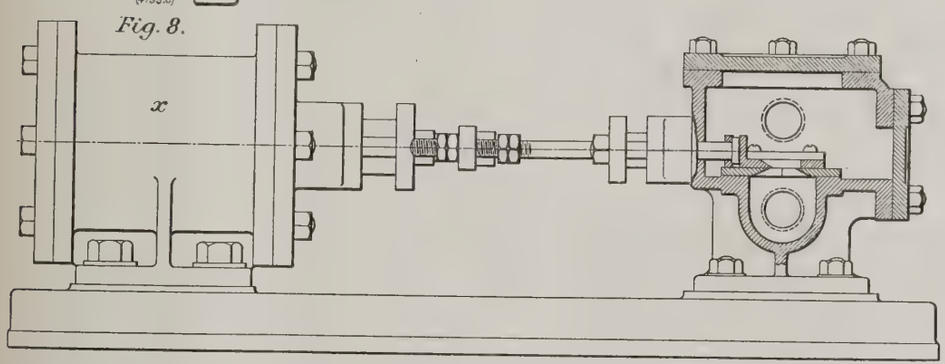
CONSTRUCTED BY THE STEREOPHAGUS PUMP AND ENGINEERING COMPANY, LIMITED, LONDON.

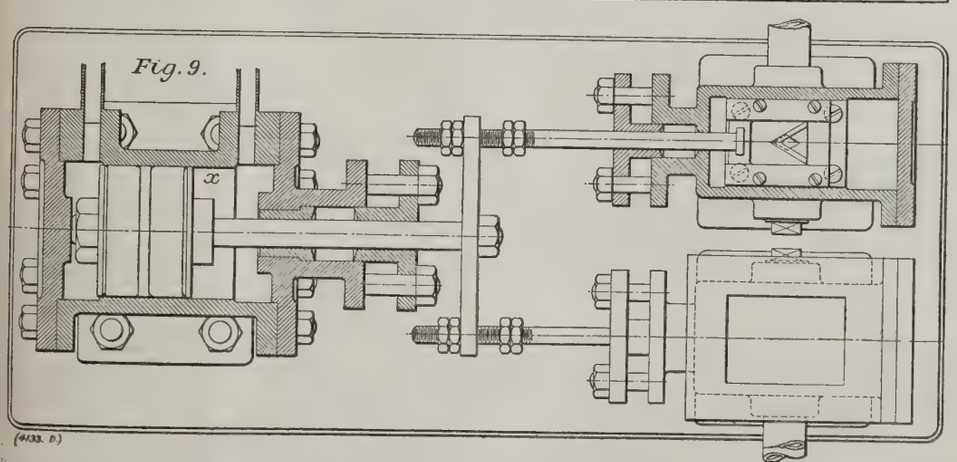












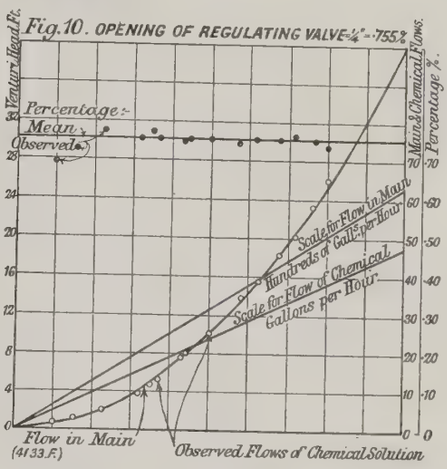


Fig. 10. OPENING OF REGULATING VALVE-¼" = 75.5%
Venturi Head Ft.
Main & Chemical Flows. Percentage %.
Percentage :-
Mean
Observed
Scale for Flow in Main Hundreds of Gall. per Hour
Scale for Flow of Chemical Gallons per Hour
Flow in Main
(4133.F.)
Observed Flows of Chemical Solution

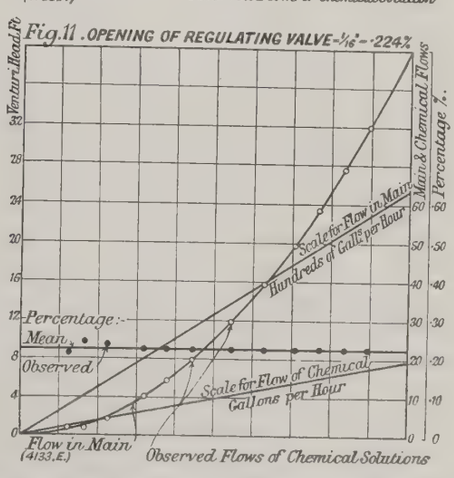


Fig. 11. OPENING OF REGULATING VALVE-1/16" = 22.4%
Venturi Head Ft.
Main & Chemical Flows. Percentage %.
Scale for Flow in Main Hundreds of Gall. per Hour
Percentage :-
Mean
Observed
Scale for Flow of Chemical Gallons per Hour
Flow in Main
(4133.E.)
Observed Flows of Chemical Solutions

pauses during the shifting of the valves. The stroke of the piston of the cylinder a is constant, but that of the cylinder b is variable, and depends on the rate at which the injector is working.

The apparatus shown in Fig. 1 has cylinders 3 in. in diameter, and the piston of cylinder a has a stroke of about 4 in. It is capable of injecting 70 gallons of chemical an hour against any pressure. It will be noted that there is certain additional apparatus in this figure which has not yet been referred to. At the right-hand side there is a small Venturi tube, with a manometer above it. This is employed to indicate the amount of chemical which is being injected by the apparatus at any time. As will be seen from the pipe connections, the chemical flows through the small

Venturi tube, and by reading the manometer which is connected to the Venturi throat and to the full-bore pipe it is possible, from the discharge diagram of the Venturi tube, to ascertain the flow of chemical at any time. On the left-hand side of the apparatus there is a second manometer, which is connected to the main Venturi tube; from it the flow of water can be read. A comparison of the two sets of readings at any time gives the percentage of chemical being injected. Any necessary regulation may be made on the diamond-notch discharge-valve m. Diagrams Figs. 10 and 11, on page 701, embody experimental results, and show the relation between the movement of water in the main and the chemical discharged by the injector. The parabolic curve in each case is that universally used for ascertaining the flow through a main in which a Venturi tube is inserted. The pressures are read off from the manometer on the left-hand side of the injector. The main used for the experiments was 2 in. in diameter, with a throat ratio of 4 to 1. The small circles, which form a curve which practically coincides with the full-line parabola, are readings of the flow of chemical as indicated by the manometer on the right-hand side. The two sets of readings were taken simultaneously, and the coincidence of the curves shows the accuracy of the apparatus. On each diagram there are, further, two straight lines starting from the origin. The upper one shows the water flow calculated from the manometer reading, and the lower one similarly shows the flow of chemical. The horizontal straight line shows the percentage of chemical it is desired to inject into the main, and the circles along it indicate the actual observed results, These all, it will be seen, practically coincide with the theoretical line.

The remarkable accuracy which this apparatus exhibits is not the least interesting of its features. The results embodied in the diagrams are achieved with a range of flow in the water-main of 1 to 13, and a range of flow of chemical of 1 to 10. Greater ranges than this can be dealt with, but additional apparatus is necessary, which is described later. The cause of the great accuracy of the injector is easily explained. The chemical is forced into the main by the difference in pressure due to a Venturi head. This head varies as the square of the flow. The resistance of the apparatus consists of the fluid friction in the various passages and the mechanical friction. The first of these resistances also varies as the square of the flow, while the latter, owing to the construction of the apparatus, is negligible. This is proved by the fact that the instrument will work with a water pressure of less than ½ in. of mercury. Further than this, however, the measurement of the discharge of chemical is also by a Venturi head, which again varies as the square of the flow. The combination of these various conditions results in the accuracy which is exhibited in the diagrams. The pistons are quite loose fits in their cylinders, and are slightly heavier than the liquid they displace. There is therefore a slight leak of water past them, which is in an upward direction except at the conclusion of the downward stroke, when, at the moment of reversing the valves, there is a leak of chemical in a downward direction. To prevent any passage of the chemical into the spaces below the pistons during this momentary action, the pistons are provided with the deep circumferential grooves which have already been referred to. These grooves trap any chemical which tends to leak past the pistons, and it is returned above the piston again on the reversal of flow when the valves have changed over. There is consequently no loss of chemical. It should be noted that the movements of the valve f, which controls the pistons, are worked entirely by the pressure in the main, and not by the Venturi head. As a consequence this valve introduces no error into the apparatus.

As we have said, the apparatus so far described is capable of giving accurate results with a variation of flow in the main of 1 to 13. In some instances, however, in water supplies, the variation may reach 1 to 30. To deal with such cases the additional apparatus, shown in Figs. 3 to 9, has been designed. The arrangement used consists essentially of a main Venturi tube, the diameter of throat of which can be altered to correspond with increased or decreased flow. This Venturi tube is shown in Figs. 3 to 5. As will be seen, it has a sliding internal part n termed the "shuttle." This contains two cylindrical passages or throats, the ends of which are each of the same diameter as the Venturi tubes leading away from it on either side. One throat is the same diameter throughout; the other is contracted in the middle. If the flow of water through the main is small, the small throat is used; while if it increases to a definite amount, the large throat is brought into operation. This is effected by releasing the water pressure at the outer end of the cylinder p, and at the same time supplying pressure to the outer end of the cylinder q. The internal pressure against the two cylinder pistons is equal. At right angles to the cylinders p and q there is a further cylinder r, which is shown in cross-section in Fig. 5. This cylinder is fixed with its axis vertical. The under side of the piston of the cylinder r is connected by a pipe s to the main. Its outer side is connected by pipe t to the Venturi throat.

Assuming that the smaller throat is in operation, and that the flow in the main increases, this increases the Venturi head between the main and the shuttle-box, and at a predetermined point the piston of cylinder r rises. This piston is quite a loose fit in its cylinder, and is weighted to any desired amount, preferably equivalent to a Venturi head of 30 ft. of water. When the piston of the cylinder r rises it operates the slide-valve u. This valve releases the high-pressure water from the outer end of the cylinder p by means of the pipe v shown in Fig. 4. At the same time the outer end of the cylinder q is put to pressure by the valve u through the pipe w. As a consequence the shuttle slides and brings the larger throat into operation. If the flow of water in the main decreases below the predetermined limit, this operation is reversed, and the smaller throat is again brought into operation. The shuttle, as it moves to and fro, slides upon the flat surface of the box, in which there is a port connecting either with the wide or narrow throats, whichever is in operation at the time. This port is connected by a pipe with the outlet ports of the injector. Valve u, which is fixed above the cylinder r, is shown to an enlarged scale in Figs. 6 and 7.

As the admission of chemical to the main is much larger when the large throat is in use than when the smaller is in service, it is necessary that the operation of changing the throat should also change the regulating-valve, which is shown at m in Fig. 2. This is done by means of the arrangement shown in Figs. 8 and 9. Two regulating-valves are used, as shown to the right-hand side of these figures. They are connected up to the cylinder x. The valve u, which admits pressure-water to cylinders p or q, does the same thing for the cylinder x, so that its piston moves one way or the other in conformity with the shifting of the shuttle. This moves the diamond-notch valves as may be required to suit the variation of flow. Tappets on the diamond-valve spindles allow for adjustments in the percentage of chemical. In conclusion, we should say that the appliance is made chiefly of brass, unless the chemical being used is of a nature to attack this metal. In that case the parts of it exposed to attack are made of vulcanite or of one of the non-corrosive alloys. The appliance is manufactured by the Stereophagus Pump and Engineering Company, Limited, of 39, Victoria-street, London, S.W.

NOTES FROM THE UNITED STATES.

Philadelphia, November 25.

For the first week since mid-summer there has been increased buying on domestic account in pig-iron, which is in part due to slight concessions, which the trade believes is the last possible shading in prices. Export business continues exceedingly light, as measured by earlier expectations. Inquiries for steel rails are pending from Russia, 40,000 tons; Norway, 20,800 tons; and Finland, 10,000 tons. Speaking broadly, the steel condition has not improved. Shipments on old orders are in excess of new business. The railroads are buying the least possible. Shipyards contract for small tonnages to cover new work. Locomotive builders are seldom in the market, and car-builders have about all the supplies contracted for that they need for two months. Bridge-builders have less winter work under contract than for years. Considerable oil-pipe line work begun in the summer will soon be completed. Notwithstanding all these unfavourable conditions, and that much over one half the productive capacity is idle, a spirit of optimism is manifesting itself in all directions, but the surface and common-sense evidences of coming activities are lacking. In 1912 monthly exports of steel in all shapes were 245,000 tons; now they are about 100,000 tons. The railroads were then heavy buyers, now they are not. Farmers are sowing increased areas in wheat; this is a good 1915 sign. Cotton acreage, if the planters will accept the inundation of advice, will be one-third less at least. Night-and-day activity prevails in those industries identified with the manufacture of military supplies for export. Not for years have iron and steel stocks been as low. Banking facilities are now of ample proportions for all needs, and business programmes for 1915 are being laid accordingly.

The Institution of Electrical Engineers. — A special meeting of the Yorkshire Section of the above Institution will be held at the Hotel Métropole, Leeds, on the 17th inst., to welcome the President, Sir John Snell. This meeting has been arranged at the instance of the President, who, owing to the cancelling of the annual dinner, would otherwise be unable to meet the members of the Section. There will be a speech of welcome by Mr. Thos. Roles, the chairman of the local Section, and both the President and the Hon. Treasurer, Mr. Robert Hammond, will address the meeting. Time allowing, the discussion of Mr. Selvey's paper on "Power-Plant Testing" will be continued. The meeting will commence at 7.15 p.m.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market was quiet and easier, and the dealing consisted of one lot of Cleveland warrants at 52s. 3d. one month. Closing sellers quoted 52s. cash and 52s. 3d. one month. In the afternoon the tone was weak, and sellers of Cleveland warrants quoted 51s. 11d. cash and 52s. 2d. one month. There were no dealings. On Friday morning business continued on the small side, and only one lot of Cleveland warrants changed hands at 51s. 9d. cash, with sellers over at that figure, and at 52s. one month and 52s. 6d. three months. The afternoon session was also dull, and Cleveland warrants again showed a decline. The turnover consisted of 1000 tons at 51s. 10½d. twenty-eight days, and the closing quotations were 51s. 8d. cash and 51s. 11d. one month sellers. On Monday morning a firmer tone prevailed, and 2000 tons of Cleveland warrants were put through at 51s. 7½d. and 51s. 10d. cash, and sellers' closing quotations were 52s. cash and 52s. 3d. one month. In the afternoon the market was quite idle, and prices slipped back a little. Sellers of Cleveland warrants named 51s. 10½d. cash and 52s. 1½d. one month. On Tuesday morning there was again nothing doing in Cleveland warrants, and prices were unchanged. For three-months iron sellers quoted 52s. 7½d. The afternoon session was also idle, and quotations for Cleveland warrants were a shade easier at 51s. 9d. cash, 52s. 0½d. one month, and 52s. 6d. three months. When the market opened to-day (Wednesday) the easier tone was again in evidence, but little change was made in prices. The turnover consisted of one Cleveland warrant at 51s. 7½d. cash, and closing sellers quoted 51s. 9d. cash, 52s. one month, and 52s. 6d. three months. In the afternoon the tone became firmer, and 1000 tons of Cleveland warrants were done at 51s. 9d. and 51s. 9½d. cash, with closing sellers at 51s. 10½d. cash and 52s. 1½d. one month.

Sulphate of Ammonia.—There has been rather a better demand for sulphate of ammonia within the past week, and the price is a shade firmer round 11*l.* 1s. 3d. to 11*l.* 2s. 6d. per ton, for prompt delivery, Glasgow or Leith.

Scotch Steel Trade.—Little change falls to be reported this week in the conditions existing in the Scotch steel trade. A certain amount of activity in booking contracts still prevails, and makers have been securing better specifications for ship-plates and other shipbuilding material, while inquiries are again more numerous. The outlook is most promising, and quite an optimistic feeling is general. Makers of black sheets are doing fairly well, although some of them could turn out more work than they are being asked to do at present. As structural engineers are busy, there is an excellent demand for structural material. The export markets are still on the dull side, but both orders and inquiries show an increase, and a steady improvement in this direction is freely anticipated. Prices all round are firm, and the advance of 5s. per ton made at the end of the week in ship-plates made little difference in the position, as a further advance is more than likely on an early date. Ship-plates are now called 7*l.* per ton, less 5 per cent. for local delivery, and 7*l.* per ton, less 2½ per cent., for export lots.

Malleable-Iron Trade.—Business in the malleable-iron trade of the West of Scotland, while better, is not as brisk as makers would like. Some establishments are doing very well, but others are hard put to it to secure a full week's running. The outlook is, nevertheless, much brighter, and the prospects are encouraging, "Crown" bars are still called 7*l.* 12s. 6d. per ton—less 5 per cent. —but a rise in price is very probable before long.

Scotch Pig-Iron Trade.—Fairly active conditions continue to exist in the Scotch pig-iron trade, and the demand for special brands has been very good of late, both on home and export account. Hematite has been a subject of interest during the past week, and sales amounting to quite a respectable tonnage have gone through round 75s. per ton delivered. Prices all over are firmer, and the following are the market quotations for makers' (No. 1) iron:—Clyde, 68s. 6d.; Calder, Gartsherrie, Summerlee, and Langloan, 69s. (all shipped at Glasgow); Eglinton, 63s., and Glengarnock, 70s. (both at Ardrossan); Shotts (at Leith), 69s.; and Carron (at Leith), 71s. 6d.

The Concrete Institute.—In a paper entitled "Shear and the Problems Arising Therefrom," read before the Concrete Institute on December 3, Mr. H. K. Dyson said that there were various theories as to the resistance of materials. One view was that rupture took place when the principal stress exceeded a certain limit, whilst the theory adopted by St. Venant was that it was the value of the strain produced which constituted the best criterion of strength. Still another view was that the strength of a material was measured by the maximum shear it was capable of resisting. The auther said that this latter hypothesis appeared to be fairly well confirmed in the case of ductile materials, whilst experiments with brittle materials were more in accord with the view that the maximum direct stress measured the strength of the material. With certain bodies the plane of rupture differed considerably from the plane of maximum shear, and it had been suggested that the discrepancy was attributable to a sort of internal friction which supplements the resistance offered to shear by the elasticity of the material. He himself advanced the view that in the case of such substances as concrete the resistance was measured by the shear, but modified by a certain cohesion between the surfaces sheared. He claimed that this view was supported by numerous experiments.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The difficulties of the position in which producers find themselves on account of the shortage of suitable pit timber are increased by the attitude of the miners, whose officials have intimated that if certain coal-owners and managers persist in their alleged determination to take advantage of the times, and enforce the use of steel props and bars, without sanction or consideration by the men, the outcome will be a strike at the collieries concerned. At the moment, however, the shortage of empty wagons is by far the more serious problem. The output at pits throughout the district is being hindered, and as a natural result, the demand being about the same, prices are quickly rising. Advances varying from 3d. to 1s. have already been made on market quotations, and the prospect is that they will be materially enlarged unless there is a marked improvement in deliveries. The house-coal trade is at its busiest. Orders are coming in freely from local, country, and London consumers, and at the local dépôt more business is being booked than for two months past. The steam-coal position is remarkably steady, having regard to the weakness of the export trade. Very little is being sent away, freights being high and shipping difficult. On the other hand, the home demand is robust, and for local manufacturing purposes consumption is on a record scale, several of the big armament concerns having been obliged to augment their contract supplies. Slacks are now quite active. Manchester taking bigger supplies has had a stiffening effect. Cokes are in fair demand, and prices firmer. Quotations:—Best branch hand-picked, 16s. to 16s. 6d.; Barnsley best Silkstone, 13s. to 14s.; Derbyshire best brights, 13s. 6d. to 14s. 6d.; Derbyshire house, 10s. 6d. to 11s. 6d.; best large nuts, 11s. to 11s. 6d.; small nuts, 9s. to 10s.; Yorkshire hards, 10s. to 11s.; Derbyshire hards, 9s. 6d. to 10s. 6d.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.; smalls, 2s. to 3s.

Iron and Steel.—A general improvement is noted in business in raw material, the prospect of higher prices having induced consumers to make bigger purchases for current use, and also to show a keener interest in forward bookings. Consumption of hematites continues on an enormous scale at the armament works, and further price advances are recorded. West Coast brands are marked up 1s. at 80s., and East Coast mixed numbers 2s. at 71s. West Coast sorts are now only 1s. below the figure quoted at the outbreak of war, but East Coast mixed numbers have still to make an advance of 5s. to reach that level. The quotations of district associations dealing in common irons have for several weeks been nominal, but the official figures have now been reduced to accord with actual selling values, which in some instances show an advance on the week. Lincolnshire No. 3 foundry is quoted at 54s. 8d., Lincolnshire forge at 53s. 8d., Derbyshire No. 3 foundry at 55s., and Derbyshire forge at 52s. As for the past five months, South Yorkshire bar-iron is quoted at 8*l.* 5s. Steel-billet prices are again hardening, in keeping with the increased cost of hematites. Siemens acid are quoted at 8*l.* 5s., and Bessemer acid at 7*l.* 5s.—an advance in each case of 5s. on the week—hard basic at 6*l.* 10s., and soft basic at 6*l.* Canadian and American billets are being offered in the district, but the conditions of purchase are decidedly against anything in the way of serious competition with local makers. Steel-makers have little to complain of in the circumstances. Conditions have improved at foundries and rolling-mills, and, indeed, in virtually every department. Orders for railway material are not too plentiful, but, on the other hand, there are sections in the engineering industry that are working at "boom" pressure, principally, of course, on Government account. Big work is on hand for the shipbuilding centres. Ordinary trade in motor construction is at a low ebb, but the War Office has placed orders for fleets of motor vehicles, principally ambulances. Our Russian, French, and, to a smaller extent, our Belgian allies are also ordering freely all classes of tools and other light steel products, chiefly for the use of military engineers. This unusually heavy influx of orders compensates in some degree for the slump in business with Canada and South America.

THE ROYAL INSTITUTION.—A general meeting of the members of the Royal Institution was held on Monday last, the 7th inst., Sir James Crichton-Browne, Treasurer and Vice-President, in the chair. It was announced that the managers had elected Mr. Charles Scott Sherrington, M.D., D.Sc., F.R.S., Fullerian Professor of Physiology, for a term of three years, the appointment to date from January 13, 1915.

CONTRACTS.—The General Electric Company, Limited, have again been successful in securing a twelve months' contract for the supply of Osram ship-lighting lamps from the Cunard Steamship Company, Limited. — Messrs. Brunner, Mond and Co., Limited, alkaline manufacturers, Northwich, have placed an order with Messrs. Edward Bennis and Co., Limited, Little Hulton, Bolton, for an elevator, 62 ft. long, with buckets 15½ in. long, for their Middlewich works.

THE SALES MANAGERS' ASSOCIATION.—At the next meeting of the above association, to be held at the Holborn Restaurant, on Thursday, the 17th inst., a discussion is to take place on the "Position of the British Electrical Industry and Methods of Extension in the Markets of the World." The discussion will be opened by Mr. H. Scholey, and it is expected that several prominent members of the electrical profession will be present. Persons wishing to attend should communicate with the hon. sec., Mr. F. R. Jones, Sardinia House, Kingsway, W.C.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—As is generally experienced, there is a lull in buying after a brisk business in pig iron. Substantial sales for both early and forward delivery have recently been made, and producers are no longer particularly pressing business, as they believe they are likely to do better by waiting. With all the consuming industries full of work, home demand for pig iron promises to be good for some time. No. 3 g.m.b. Cleveland pig is steady at 52s. f.o.b.; whilst No. 1 is 54s. 3d.; No. 4 foundry, 51s. 6d.; No. 4 forge, 51s.; and mottled and white iron, each 50s. 6d.—all for early delivery, 6d. above these rates being named on forward account. Encouraging accounts are given of the East Coast hematite branch of the staple industry. Producers take a very firm stand, and some of them now ask up to 70s. for Nos. 1, 2, and 3, at which figure they are prepared to do forward business. Second hands are still prepared to sell at 67s. 6d. Buyers consider that the price should not be above 66s. 6d. It is almost impossible to fix foreign ore prices. Several sellers will not quote at all, declaring that prevailing conditions would compel them to ask rates that would prohibit business. Nominally market quotations are on a minimum basis of 22s. ex-ship Tees for Rubio of 50 per cent. quality. Some sellers quote on a basis of as high as 25s. Ore steamers are hardly obtainable, and freights are very high, as much as 5s. 6d. and even 7s. being named, Bilbao-Middlesbrough. Imports of foreign ore to the Tees are on a very limited scale, the total to date this month being only 18,482 tons. Coke is in fairly good request for local use, and prices show an upward movement. Whilst buyers state that they can place orders to practically any extent at 17s. 6d., and even less, for Durham bee-hive blast-furnace coke of average quality, delivered at Tees-side works, many sellers are now holding out for 17s. 9d.

Stocks and Shipments.—Stocks of Cleveland pig iron in the public warrant stores now stand at 105,786 tons. Since the beginning of the month the stock has been increased by 292 tons. Shipments of pig-iron from the Tees are on only a very moderate scale. To date this month they average 558 tons per working day, the total despatches being returned at 4465 tons, all of which have gone from Middlesbrough. To the same date last month the loadings were given at 16,966 tons, or a daily average of 2120 tons, and for the corresponding part of December a year ago the clearances reached 25,045 tons, or an average of 3130 tons per working day.

Manufactured Iron and Steel. — Very satisfactory accounts are given of all branches of the manufactured iron and steel trades. Works are kept busy, and a lot of material is being turned out. Producers are full of orders, and they report that very extensive contracts for shipbuilding material have been booked. Principal market quotations stand:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 5s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 8*l.*; iron ship-rivets, 8*l.* 7s. 6d.; iron girder-plates, 7*l.* 5s.; steel bars (basic), 7*l.* 10s.; steel bars (Siemens), 7*l.* 15s.; steel ship-plates, 7*l.* 10s.; steel ship-angles, 7*l.* 5s.; steel boiler-plates, 8*l.* 5s.; steel strip, 7*l.* 5s.; steel hoops, 8*l.*; steel joists, 7*l.* 2s. 6d.—all less the customary 2½ per cent. discount; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 7s. 6d.; steel railway sleepers, 7*l.*—all net at works; galvanised corrugated sheets, 24 gauge, in bundles, 14*l.* f.o.b.—less 4 per cent.

Northern Shipbuilding Orders. — Large orders for tonnage have been placed during the past week with North-East Coast shipbuilders. Mr. E. J. Sutton, of Newcastle, has ordered a 6000-ton steamer from the Tyne Iron Shipbuilding Company, and the same company is also to build a vessel on the Monitor system, but of larger size than those already constructed. A large collier, of 3000 tons, is to be built by a Sunderland firm for London owners. Messrs. Swan, Hunter and Wigham Richardson, of Wallsend, are reported to have secured an order from the Royal Mail Steam Packet Company for two high-class refrigerated steamers for their South American trade. The Moor Line, Limited, have placed orders with Messrs. John Redhead and Sons, South Shields, for three large steamers; and Messrs. Pyman and Co., of West Hartlepool, have also contracted with North-East Coast builders for two large steamers.

Works Improvements.—The Palmer's Shipbuilding and Iron Company, Limited, are making extensive improvements and additions to their plant. The alterations concern primarily the iron and steel works at Jarrow, and they have been devised with the object of effecting large savings in the cost of steel production, and will generally bring the works up to a state of efficiency. The improvements already undertaken include a large gas-driven power-house, in which will be installed approximately 15,000 brake horse-power of gas-engines, all driven by the waste gases from the blast-furnaces; a new lay-out of the heavy cogging-mill, which it is intended to drive electrically, together with the conversion of all the steel works auxiliaries from steam to electricity, by which large savings in the cost of coal will be effected; a new gas-producing plant for the steel-melting furnaces, together with modern soaking-pits for same.

THE JUNIOR INSTITUTION OF ENGINEERS.—At the usual Friday evening meeting, held on December 4, at the Rooms of the Junior Institution of Engineers, Mr. S. E. Hutson described the Hutson-Ford Reversible Steam-Turbine. A keen discussion ensued.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has continued quiet, buyers having held orders back for the week-end. In consequence of stormy weather the arrivals of steamers due to load have been unsatisfactory, and stoppages at the collieries have been numerous. The best Admiralty large has made 20s. to 22s.; best secondary descriptions have brought 18s. to 19s.; other secondary qualities have realised 17s. to 17s. 6d.; best bunker smalls, 10s. 6d. to 11s.; and cargo smalls, 6s. to 7s. per ton. Best household coal has been quoted at 19s. to 20s.; good households have made 17s. to 18s.: No. 2 Rhondda large has brought 12s. 6d. to 14s.; and No. 2 smalls have realised 6s. 6d. to 7s. 6d. per ton. Patent fuel has brought 16s. 6d. to 17s. 6d. per ton. Special foundry coke has made 27s. to 30s.; good foundry coke, 20s. to 24s.; and furnace coke, 17s. 6d. to 18s. 6d. per ton. As regards iron ore, Rubio has realised 19s. to 20s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Blaenavon.—The accounts of the Blaenavon Company, Limited, for the year ended September 30, including 31,998*l.* brought forward, showed a balance (which it is proposed to carry forward) at the credit of profit and loss of 19,598*l.* It will be seen that this year's trading, properly so-called, showed a loss. The development of the company's business has continued to call for a large capital expenditure. Locomotives and rolling-stock were also increased during the year. A new washery has been proceeded with, and has now reached an advanced stage. Intermittent working of the company's collieries, coupled with the expenditure caused by recent legislation, has increased the cost of production. On the other hand, the pig-iron trade continued depressed during the whole of the past financial year. The company's tyre works have been completely modernised, and can now secure a considerable annual output of tyres of all sizes and qualities. During the five years ending with 1914 inclusive the dividends paid upon the company's ordinary shares came out as follows:—1910, 5 per cent.; 1911 and 1912, nil; 1913, 5 per cent.; and 1914, nil.

South Wales Engineers.—A meeting of the South Wales Institute of Engineers was held at Cardiff on Thursday. It was announced that Principal E. H. Griffiths had been elected President of the Institute for 1915. Principal Griffiths was born at Brecon in 1851, being the son of the Rev. H. Griffiths, President of the Brecon Theological College. He received some of his education at Owen's College, Manchester, and he graduated in 1873 at Cambridge, where he became a successful private "coach." He is LL.D. of the University of Aberdeen. He was elected a Fellow of the Royal Society in 1895; and was appointed Principal of University College in 1901. A report was submitted by Mr. R. G. Clark on "Arching in Collieries." Mr. Clark recommended a system of arching based on a compromise between ferro-concrete and concrete blocks. Mr. T. G. Watts submitted a paper on "Investigations into a System of Electric-Bell Signalling for Use in Collieries." In the course of discussion (which was eventually adjourned) it was observed that this was a subject which had come into considerable prominence as a result of the Senghenydd disaster.

Newport.—Buyers of steam coal have held back inquiries, and tonnage has been delayed by stormy weather. The best Newport Black Vein large has realised 16s. to 16s. 9d.; Western Valleys have made 15s. 9d. to 16s. 3d.; and Eastern Valleys 15s. 6d. to 15s. 9d. per ton.

Nantyglo and Blaina.—The report of the Nantyglo and Blaina Iron Works Company, Limited, for 1913-14 states that the output of coal and other minerals for the twelve months was 1,655,936 tons. The report adds that satisfactory arrangements have been made for working the collieries after the expiration of existing leases. The bulk of a mineral area held from the Marquis of Abergavenny has been leased for a long series of years, and a large portion of the freehold minerals have also been leased to be worked in conjunction.

PATENT SPECIFICATIONS.—A notice in the Illustrated Official Journal (Patents) of the 9th inst. states that the price of printed specifications of inventions is to be reduced from 8d. to 6d. a copy, including inland postage. This reduction is to come into force on and after January 1, 1915. It may be recalled that when the Government first printed specifications of inventions the charge per copy varied according to the number of pages of letterpress and the number of sheets of drawings; in some cases a copy of a single specification cost as much as 1*l.* or 1*l.* 5s. When the uniform charge of 8d. was introduced, this charge applied to all specifications, including those previously published at much higher prices, and the new charge of 6d. will also apply to all specifications.

PERSONAL.—We are informed that on and after January 1, 1915, the address of the Agent-General for Western Australia will be Savoy House, 115 and 116, Strand (corner of Savoy-street), London, W.C.—We are informed that Mr. Robert Stanley Brailsford, Mr. William Wycliffe Spooner, and Mr. Alfred Brailsford have been appointed directors of Messrs. Cole, Marchent and Morley, Limited, Prospect Foundry, Bradford, as they have purchased the entire share-holdings of the late directors—Mr. H. W. Morley, Mr. G. H. Hodgson, and Mr. D. H. Illingworth—who, owing to the pressure of other engagements, have now retired from the directorate and management of the firm.—Messrs. Scholey and Co., Limited, of 151, Queen Victoria-street, London, E.C., have been appointed the British representatives of the Taylor stoker interests, these being controlled in the United States of America by the American Engineering Company.

EXHIBITS AT THE SMITHFIELD CLUB SHOW.

(*For Description, see Page* 707.)

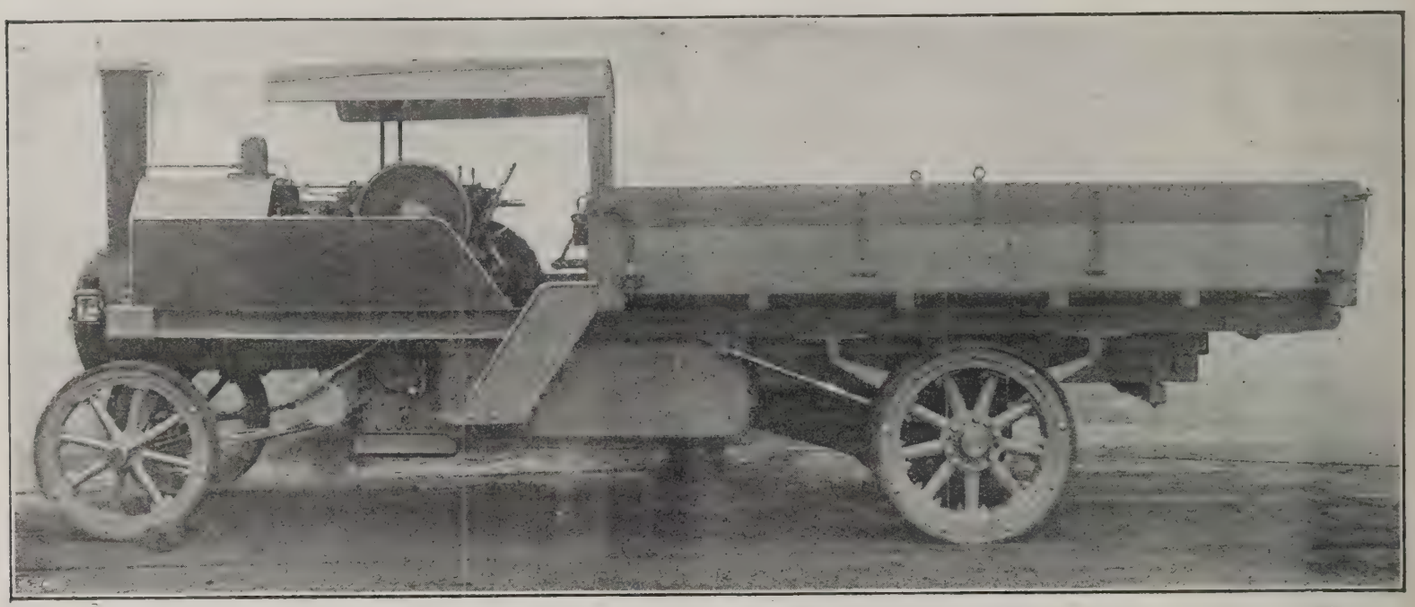


Fig. 1. 5-Ton Steam-Wagon; Messrs. Robey and Co., Limited, Lincoln.

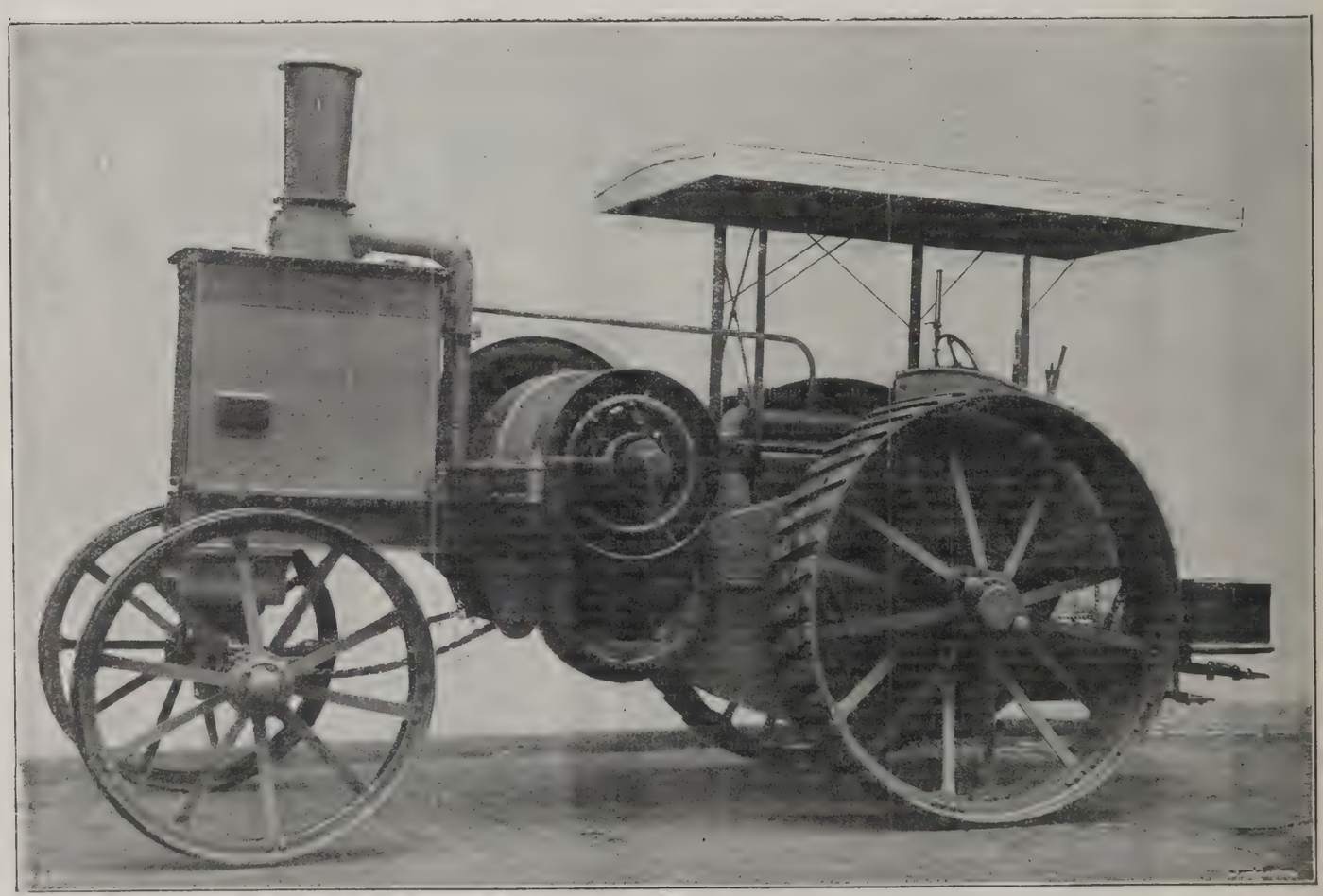


Fig. 2. 35 to 40-Brake-Horse-Power Single-Cylinder Oil-Tractor; Messrs. Ransomes, Sims and Jefferies, Ipswich.

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ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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With a Two-Page Plate of the GRANARY AT GLASGOW HARBOUR; GRAIN-CONVEYING MACHINERY.

NOTICES OF MEETINGS.

THE INSTITUTION OF AUTOMOBILE ENGINEERS: MIDLAND CENTRE.—Friday, December 11, at 7.30 p.m., in the hall of the Y.M.C.A., Dale End, Birmingham. Mr. L. H. Pomeroy will read a paper entitled "Automobile Manufacturing and the War."

THE MINING INSTITUTE OF SCOTLAND.—Saturday, December 12, at 3 p.m., in the Institute, 39, Elmbank Crescent, Glasgow. Mr. James Black's paper on "The Rosehall Signalling Indicator" will be discussed. Mr. Thomas Bryson's paper on "Fan-Testing, with Special Reference to the Measurement of Pressure" will be discussed. Mr. John T. Wright's paper on "Tests on False Links for Cut-Chain Braes" will be discussed. A paper on "Modern Developments in By-Product Coking" will be read by Mr. G. S. Cooper. The following visual signalling indicators will be exhibited and explained:—Barclay signalling indicator; Chambers signalling indicator; Somerville signalling indicator; Guardian signalling indicator.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, December 12, at 2 p.m., in the Wood Memorial Hall, Newcastle-upon-Tyne. The following papers will be open for discussion:—"A Portable Electrical Gas-Detecting Device for Use with Miners' Lamps," by Mr. George J. Ralph. "Notes on Coal-Mining in the State of Illinois, United States of America," by Mr. Samuel Dean. "Hydraulic Stowing in the Gold-Mines of the Witwatersrand," by Mr. B. C. Guliachsen. The following papers will be read or taken as read:—"The Maikop Oilfield, South Russia," by Mr. William Calder. "The Killingworth Colliery (New South Wales) Explosion," by Mr. James Ashworth. "Coal-Mining in the State of Pennsylvania, United States of America," by Mr. Samuel Dean.

THE ROYAL SOCIETY OF ARTS.—Monday, December 14, at 8 p.m. Cantor Lecture: "The History and Practice of the Art of Printing," by Mr. R. A. Peddie (Lecture IV.). Wednesday, December 16, at 8 p.m. "Testing Pigments for Permanence of Colour," by Sir William de Wiveslie Abney, K.C.B., D.C.L., D.Sc., F.R.S. Colonel Sir Thomas H. Holdich, R.E., K.C.M.G., K.C.I.E., C.B., D.Sc., Vice-President and Chairman of the Council of the Society, will preside. Thursday, December 17, at 4 30 p.m. Indian Section. "The Indian Indigo Industry," by Dr. F. Mollwo Perkin, F.I.C., F.C.S. Sir Steuart Colvin Bayley, G.C.S.I., C.I.E., Vice-President of the Society, will preside.

THE SURVEYORS' INSTITUTION.—Monday, December 14, at 8 p.m., when short papers will be delivered by Mr. Andrew Young (Member of Council) and Mr. L. O. Mathews (Fellow), on "The Report of the Land Enquiry Committee on the Acquisition of Land."

THE INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.—Monday, December 14, at 8 p.m., a paper entitled "Conditions Governing the Power of the Petrol-Engine," will be read by Mr. C. B. Dicksee, Graduate, of London. Chairman: Dr. H. S. Hele-Shaw, F.R.S. (Member of Council).

THE JUNIOR INSTITUTION OF ENGINEERS.—Monday, December 14, at 8 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C., Address by the President the Most Honourable the Marquis of Graham, D.L., C.V.O., C.B., on "The War and Engineering." The chair will be taken by the retiring President, Sir Boverton Redwood, Bart., D.Sc., F.R.S.E., F.I.C., F.C.S., &c.

CLEVELAND INSTITUTION OF ENGINEERS.—Monday, December 14, at 7.30 p.m., in the hall of the Cleveland Literary and Philosophical Society, Corporation-road, Middlesbrough, when the following papers will be read:—"A Study of Cast Steel," by Mr. J. W. Whiteley, Stockton. "Metallographic Methods for Detecting Phosphorus in Steel, and on the Origin of Ghost Lines," by Dr. J. E. Stead, Middlesbrough.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 15, at 8 p.m. Papers to be further discussed:—"Tests of Reinforced-Concrete Structures on the Great Central Railway," by Mr. James Benjamin Ball, M. Inst. C.E. "Corrosion of Steel Wharves at Kowloon," by Mr Somers Howe Ellis, M. Inst. C.E. "Concreting in Freezing Weather and the Effect of Frost upon Concrete," by Mr. John Hammersley-Heenan, Assoc. M. Inst. C.E.

THE INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, December 16, at 7.30 p.m., at the University, Edmund-street. Mr. E. B. Wedmore, M.I.E.E., will read a paper entitled "Automatic Protective Switch-Gear for Alternating-Current Systems."

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, December 16, at 7.30 p.m., in the Surveyors' Institution, 12, Great George street, Westminster Papers to be read: 1. "Distribution of Relative Humidity in England and Wales," by Mr. W. F. Stacey. 2. "Observations of the Upper Atmosphere at Aberdeen by Means of Pilot Balloons," by Mr. A. E. M. Geddes, M.A.

NOTTINGHAM SOCIETY OF ENGINEERS.—Wednesday, December 16, at 8 p.m., Mr. Edwin Renyoor, of Dukinfield, will deliver a lecture on "Mechanical Stoking."

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Thursday, December 17, at 8 p.m., at the house of the Royal Society of Arts, John-street, Adelphi, W.C. The following paper will be read:—"Notes on the Development of the Trinidad Oil-Fields," by Professor John Cadman, D.Sc., M. Inst. C.E. The chair will be taken by the President, Sir Boverton Redwood, Bart., D.Sc., F.R.S.E.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, December 17, at 8 p.m., at the rooms of the Geological Society, Burlington House, Piccadilly, London, W. The following paper will be discussed:—"Persistance of Ore in Depth," by Mr. T. A. Rickard, Member.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, December 18, at 7.30 p.m. Mr. Wilson's paper entitled "The Remarkable Failure of a Consignment of Steel Plates," which was read at the meeting on the 27th ult., will be discussed.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 18, at 8 p.m. Five brief papers on "Audible and other Cab-Signals on British Railways," by Mr. W. C. Acfield, Member, Midland Railway; Mr. Leon P. Lewis, Caledonian Railway; Mr. Vincent L. Raven, Member, North-Eastern Railway; Mr. W. A. Stanier, Member, Great Western Railway; and Mr. W. Willox, Metropolitan Railway.

ENGINEERING.

FRIDAY, DECEMBER 11, 1914.

PUMPING MACHINERY.

THE exceedingly interesting and notable Thomas Hawksley lecture written by the late Mr. W. B. Bryan, and read at the Institution of Mechanical Engineers last Friday by his son, emphasises how heavy has been the loss sustained by the corps of British engineers in the death of the author. It was eminently apt that the choice of the Institution should have fallen where it did. If Mr. Thomas Hawksley was a great pioneer in the extremely important field of water supply, Mr. Bryan played a prominent part in developing the maxims and precepts laid down by one whom he was, with most other water-works engineers, proud to recognise as his master. The fact, moreover, that Mr. Bryan's earlier experiences were gained largely in works designed by Mr. Hawksley made his selection as lecturer still more appropriate.

The lecture was devoted to the development of pumping machinery, and it illustrated anew the very large part played in the development of methods of power production by the demand for efficient pumping machinery. In times past, indeed, practically the only large demand for power arose in this connection, and here only was there sufficient prospect of profit to stimulate enterprise in this direction. Mining risks have always attracted the more courageous and adventurous type of investor. Pepys, writing some two and a half centuries ago, notes, for example, the case of an acquaintance who ventured and lost 20,000*l.* in an attempt to improve methods of coal-mining. The windmill, though for its output costly to instal, was capable of meeting not ineffectively the inconsiderable requirements of the old-time flour-miller, since the territory tributary to his mill was straitly limited by the absence of decent roads and the consequent high cost of transport. For the drainage of level districts the windmill again proved justly popular. Its limited output of power was not in such cases a drawback, since in level countries it was commercially impossible to drain large areas to a single pumping-station, as the requisite fall could not be secured. Sub-division of plant would therefore in such cases be imperatively imposed, even had old-time engineers been in a position to build large units. The intermittency in the working of the windmill was, in land-drainage practice, no very fatal drawback, and, as is well known, wind-operated pumping plants were adopted for this purpose on a very large scale.

Mine drainage, however, stood on a different basis; the lift was often large, the quantity of water to be raised great, and intermittency in operation would, in most cases, spell ruin to the success of the venture. Hence for many centuries mining operations were restricted to nearly water-free strata or to cases in which natural drainage by means of adits was possible. Water power might perhaps have been developed for this purpose had there existed any method by which it could be transmitted from the power-station to the mine. Possibly an earlier invention of the teledynamic system of power transmission might have retarded by several generations the advent of the steam-engine.

The seriousness of the situation is well illustrated by the fact that many Savery steam pumping plants were installed at mines during the latter half of the seventeenth century. These pumps, as is well known, were direct ancestors of the pulsometer. They were worked with steam supplied at a pressure of as much as 12 atmospheres from boilers unprovided with safety-valves. Their steam consumption was enormous, and it was only the very great intrinsic value of the minerals to be won that made their use possible in face of their inherent danger and costliness. Newcomen's engine abolished the danger and reduced the fuel consumption, but it involved much heavier fitting and machine work. The cost of working metals a couple of centuries ago must have been enormous. Moreover, even after Murdock's improvements in the matter of boring cylinders, Watt considered it a great feat to secure a cylinder true within the thickness of a crown-piece. In view of this, it is really difficult to understand how the earlier Newcomen engines managed to work at all, yet quite large ones were erected by Smeaton. The difficulties encountered led, of course, to the use of timber wherever possible, and Mr. Bryan described in his lecture a pumping-engine built at Philadelphia, in 1801, where probably the resources available would correspond, more or less, with the conditions in England half-a-century earlier. Even the boiler in this case was of timber, being built up of 5-in. pine planking bolted together. The fire-box was of cast iron, with wrought-iron flues. Wood was also used wherever possible for the engine. The cylinder had to be made in two pieces, and though only 6 ft. 6 in. long by 36 in. in diameter, took nearly four months to bore. Everywhere faults in the castings had to be made good with cement or hard solder. Important parts of the pump-barrel

had to be lined with sheet copper, and when, nine years later, air vessels were added to the pumps, the castings were so porous that it was necessary to line them with lead. This extraordinary engine, it should be borne in mind, was built nearly a century after the first Newcomen engines, and must have benefited to some extent by a century's progress in the art of the metal-worker. What the difficulties met with and overcome by Newcomen and his associates were can only be surmised. The efficiency of the Philadelphia engine is of interest. It is credited with raising 962,520 gallons of water per diem to a height of 50 ft. on an expenditure of 55 bushels of coal. The output, therefore, was equivalent to a steady development of about 10 water horse-power, and taking the bushel as equivalent to 94 lb. of coal, the consumption was between 21 lb. and 22 lb. of coal per water-horse-power hour. It is not surprising to learn from Mr. Bryan that this coal-eater was superseded in 1815 by a Boulton and Watt engine having a steam-cylinder 44 in. in diameter by 6 ft. stroke, driving a double-acting pump 20 in. in diameter by 6 in. stroke delivering against a head of 102 ft. The boiler was of cast iron with vertical uptakes of wrought iron, and the steam pressure was 2½ lb. to 4 lb. (gauge). From the figures given, it appears that this engine worked at about 30 water horse-power for a fuel consumption equivalent to about 10½ lb. of coal per water-horse-power hour. This coal consumption, it may be noted, is of nearly the same order as the water rate per kilowatt now obtainable with turbo-generators of the largest size. Since James Watt undoubtedly effected an enormous improvement in the steam-engine, the above figure of 10½ lb. of coal per water horse-power with an engine embodying these improvements shows in a very striking way how impossible would have been the development of the steam-engine had not the enormity of the coal-bill been compensated for by the high profits of the mine-owners.

In his lecture Mr. Bryan stated that two jet-condensing rotary beam pumping-engines were installed at Old Ford in 1807. They had cylinders 36 in. in diameter, with a 99-in. stroke, and were not dismantled till 1890. A similar pair erected in 1812 at Deptford are still used, it appears, to pump into the Woolwich Common Reservoir. The working costs of these engines during the 'thirties, inclusive or fuel, labour, and stores, but neither interest nor depreciation, is stated to have been about 0.712d. per horse-power hour, coal being procurable at 12s. a ton. Mr. Hawksley has given figures quoted by Mr. Bryan showing the following costs per water horse-power for engines in use at Trent Bridge :—

	Pence per Water-Horse-Power Hour.
Coal	0.4495
Oil and tallow	0.0710
Sundries	0.0202
Hemp, leather, &c.	0.0177
Wages	0.2540
Total...	0.8124

Between 1816 and 1828 two Boulton and Watt engines were installed at Old Ford, and the working costs of these was, it appears, about ⅔d. per water-horse-power hour. This shows substantial improvement on the former figures, and the builders took, by the terms of their contract, a proportion of the saving effected. The engines were supplied from "wagon-top" boilers, fitted with mechanical stokers. These, however, appear to have been unsuccessful.

It was not till 1835 that the Cornish engine was adopted for water-works service. Prosperity in Cornwall had led to very great improvements in the pumping machinery installed, the published figures being far in advance of anything recorded up to that date with water-works engines. An engine installed at Fowey was asserted to have shown a duty of 125 million gallons raised 1 ft. high per bushel of fuel consumed under the boilers. Taking the bushel as 94 lb., this is equivalent to the development of one water horse-power per 1.45 lb. of fuel. No doubt the Cornish cycle is a very efficient one. The steam entered the cylinder at the top, doing work on the down stroke, with a relatively large ratio of expansion. On the completion of this stroke, an equilibrium valve established equality of pressure between the top and bottom of the piston, and the up stroke was made under the influence of a counterweight. On the completion of this the exhaust-valve opened, and the steam passed away to the condenser. The top of the cylinder was accordingly never in direct communication with the condenser, and did not acquire the temperature of the latter, so that initial condensation was reduced. Secondly, valve leakage, the other great source of waste, in the slide-valve engine was small. The valves, being of the drop type, could be ground absolutely tight, and steam temperatures being low, they were little liable to distortion when under steam, so that the initial tightness was probably well maintained. Finally, any steam that did leak had to pass two other valves before reaching the condenser.

Nevertheless, making the fullest allowance for all these favourable factors, it is impossible to admit that any such figure as that recorded at Fowey was really attained. With steam supplied at 35 lb. gauge pressure, and exhausted to a 26-in. vacuum, the theoretical steam consumption per indicated horse-power is about 12 lb., a figure irreconcilable with the actual fuel consumption claimed. It is, moreover, common knowledge that the duty of Cornish engines installed in the 'fifties and 'sixties never attained the results previously reported, and it is more than possible that the apparent falling-off was really attributable to greater experience in engine-testing. The same phenomenon was observed in the case of the triple-expansion marine engine. In the early 'eighties trial-trip reports quite commonly claimed a fuel consumption of 1⅛ lb. to 1¼ lb. of coal per indicated-horse-power hour, whereas in the careful trials carried out some years later by the Institution of Mechanical Engineers, the best figure recorded was 1.46 lb., and it attained 2.66 lb. in that of the Iona. There is thus every reason to believe that the performances of the older Cornish engines were nothing like so good as represented, but at the same time their economy was marked as compared with the Boulton and Watt engines, in which the boiler pressure was commonly restricted to 2 lb. or 4 lb. above the atmosphere.

This is well shown by the figures quoted by Mr. Bryan. The two Boulton and Watt engines had a duty of only 28 million gallons. In 1836 they raised 5,900,000 gallons per day at an annual cost for labour, coals, stores and repairs of 4940*l*. The replacement of one by a Cornish engine with an 80-in. cylinder and 11-ft. stroke cut down the annual cost to 2825*l*., although the output was raised to 7,100,000 gallons per day. Other Cornish engines were accordingly installed, and there are twenty-six still in use or reserve at the various stations of the Metropolitan Water Board. One of them is sixty years old. The endurance of these engines is extraordinary, and is no doubt partly attributable to the deliberation of their movements, and to the great accessibility for repairs of both pumps and steam-cylinders.

For water-works purposes, Mr. Bryan remarked that engines of the Cornish type or its variant, the Bull engine, suffer under the disability that they do not work well against a varying head. They are accordingly ill-adapted for pumping into a main from which water is being drawn off in varying quantities, and are at their best when delivering into a reservoir against a constant head.

Compound beam rotary pumping-engines were erected by Hawksley at the Basford Works, Nottingham, in 1857. They had cylinders 18$\frac{3}{16}$ in. and 31$\frac{3}{16}$ in. in diameter by 4-ft. 6-in. and 6-ft. strokes respectively. These pumps are still in use. A number of a similar type were put in at stations now owned by the Metropolitan Water Board, and are still in constant use, giving fair duty; and by increasing the area through the pump-valves, allowing of great speed of working, their original output has been improved.

Engines with Riedler valves on the pumps were installed, Mr. Bryan stated, at the Grand Junction Water Works some twenty years ago. They had cylinders 21 in. and 39 in. in diameter by 3 ft. stroke, and were designed to run at sixty revolutions per minute. It is of interest to note that the Riedler gear has been dismantled, the engines being run at a somewhat lower speed than originally intended. It appears, however, that smaller engines of the type are running satisfactorily in one of the Board's stations at 120 revolutions per minute.

In his lecture Mr. Bryan spoke well of the Worthington triple-expansion hydraulic balance-pump, which has, he says, a duty comparable with that of a good triple-expansion rotary engine. The latter is now that most in favour with water-works engineers. Owing to the use of three-throw pumps the pressure in the discharge main is almost free from fluctuation. The engine can, moreover, be run at various speeds with little effect on the steam consumption. A consumption of 9.38 lb. of steam per indicated horse-power per hour has been recorded, the steam being superheated by 112.8 deg. Fahr.

A serious rival is, it appears, being found in the steam-turbine-driven centrifugal pump. A De Laval turbine driving such a pump was installed by the Metropolitan Water Board ten years ago. It developed 110 brake horse-power. The turbine ran at 10,500 revolutions per minute, and the pump was geared down to 10 to 1. There were two pumps in series designed to deliver 3,300,000 gallons per diem against a head of 130 ft. This pump proved so satisfactory that a larger plant was ordered; the turbine in this case was rated at 325 brake horse-power, running at 7500 revolutions per minute.

In his lecture, Mr. Bryan expressed the view that though the type requires more fuel than a good triple-expansion pumping-engine, yet this is offset by the low first cost and compactness of the pump. The cost of installation is, in fact, only about one-quarter that of a plunger pump of equal capacity, and the saving in interest and sinking charges quite offsets the greater economy of its rival. At Montreal the turbine-driven high-lift centrifugal pump, installed by Messrs. Mather and Platt, raises 405 million gallons per day to a height of 405 ft., the steam consumption per water horse-power being 19.6 lb. per hour. At Petrograd four steam-turbines have been installed, lifting each 16 million gallons per day 158 ft. to 160 ft. With steam supplied at 12 atmospheres and at a temperature of 263 deg. Cent., the consumption on a 72-hour test was only 15.4 lb. per water horse-power. Other large centrifugal pumping plants are in use at Lyons on lifts ranging from 162 ft. to 512 ft. These are driven electrically by current supplied by the Société Grenobloise de Force et de Lumière at ⅓d. per unit.

In the conclusion of his lecture Mr. Bryan referred to the Humphrey pumps at Chingford, of which four were designed to lift 40 million gallons a day, and the fifth 20 million gallons a day against a head of 30 ft. The guaranteed fuel consumption was 1.1 lb. of anthracite per water-horse-power hour on test. The discharge has been greater, Mr. Bryan stated, and the fuel consumption less than that required by the contract. The average consumption on test was, we understand, just over $\frac{9}{10}$ lb. of anthracite per water horse-power.

A very remarkable plant was, Mr. Bryan stated, now in course of erection at New Orleans for getting rid of flood-water, the general level of the town being 15 ft. to 16 ft. below the high stage of the river. The installation of the plant now on order will bring up the total pumping capacity to five times that of the average flow of the Thames at Teddington. The lift is low—about 5 ft.—and in the new additions screw-pumps are being mainly employed. Each is designed to raise 500 cub. ft. per second. The suctions are 12 ft. in diameter, and the delivery end 14 ft. 6 in. They are to be driven electrically with current supplied from an electric power-station, where a generator rated at 8000 horse-power is being installed.

PETROL AND PETROL-SUBSTITUTE COMPARISONS.

Much has been written and said on the petrol question. The claims of benzol and alcohol as rival fuels for internal-combustion engines have been discussed in many technical publications and before many technical societies. The sources of supply of these liquids, and their cost of production on a scale commensurate with the petrol output, has been the subject of very many papers and addresses. All these efforts, combined with the present price of petrol, have resulted in some progress in the employment of the substitutionary fuels, especially benzol; but there is still an enormous field available for attack, and any additional data on the whole question are always welcome. A good deal of the information published has been expressed in rather general terms, and any definite information bearing on the relative properties and performances of petrol and its rivals is doubly welcome. Motor-users know, in a general way, that an engine run on benzol will give as much power as when run on petrol. In some circumstances it will apparently give more. They also know that there are starting difficulties with benzol, especially in cold weather, and that matters may

be improved by mixing some petrol with the benzol. Any information helping to reduce this general knowledge to a more scientific and precise level is, however, always of value.

Professor W. Watson, whose title to speak on these questions is beyond dispute, added something to the stock of definite knowledge of the relative properties of petrol and its substitutes in a paper read before the Institution of Automobile Engineers on the 9th inst. The paper dealt, in the main, with the results of experiments on a 101.6-mm. bore and 130-mm. stroke single-cylinder Knight sleeve-valve engine, which was loaned to the Royal College of Science by the Daimler Motor Company. Tests were carried out with benzol, alcohol, and various mixtures of these substances, between themselves and with petrol, and were compared with similar tests made with petrol alone. The benzol used was a coke-oven product, and was presented by Messrs. Pease and Partners. As bearing on practical operations, it may be mentioned that the benzol commenced to form crystals at −4 deg. Cent., that it formed a pasty mass at −8 deg. Cent., and was practically solid at −12 deg. Cent. Similar results were found with two samples of benzol purchased at different garages. It is thus clear that at temperatures much below freezing, in any part of the fuel supply system, there is likely to be trouble owing to an accumulation of crystals. A measurement of the viscosity of the benzol showed, as might be expected, that it increased with fall of temperature much more rapidly than did that of petrol, Pratt No. 1 spirit being taken for the comparison. The result of mixing one part by volume of petrol to three of the benzol was to lower the point at which crystal formation started to −14 deg. Cent., while a mixture of equal parts of each spirit gave no separation even at −21 deg. Cent.

When running engine tests with the benzol, it was found that with strong mixtures—*i.e.*, those containing less than 12 parts of air to one of benzol by weight—the carbon deposit became excessive. In particular, the exhaust-port in the inner sleeve became rapidly choked, and, as a result, the volumetric efficiency of the engine, and hence also the horse-power developed, fell considerably. For example, with an air-benzol ratio of 10 5, after four gallons of benzol had been consumed, the brake horse-power at 1000 revolutions per minute fell 18 per cent., due to throttling at the exhaust-port. As long, however, as the mixture strength was so adjusted that there was no carbon monoxide, or only a very smallquantity, in the exhaust, the carbon deposit was no worse than with petrol. No signs of corrosion were found when using benzol.

The paper contained curves comparing the mean effective pressures, at 900 revolutions per minute, for petrol and benzol with different air proportions. The figure obtained under any condition with benzol did not materially exceed that obtained for petrol, and yet, as is well known, a car appears in many cases to develop markedly more power with benzol than with petrol, particularly when ascending hills. Professor Watson explained this matter by saying that actually there was no such greater power production from benzol. When running at low engine speeds and with an open throttle, however, an engine would knock violently with petrol, so that it became necessary partly to close the throttle and retard the spark, thus reducing the power. With benzol this knock did not appear, so that the throttle could be kept open and the spark advanced, with a result that there was no corresponding reduction of power. If with a petrol-fed engine on a test-bed the knock was allowed to go on, nearly as great a power could be obtained as with benzol, at any rate for a short time, and with a single-cylinder engine.

The author considered that, wherever the actual seat of the knock, the cause was undoubtedly a too rapid spread of the flame in the charge, resulting in an almost explosive rise of pressure. His paper contained some indicator diagrams illustrating how this effect produced pressure waves in the pipe connecting the indicator to the cylinder. The diagrams were purposely distorted by altering the phase of the indicator-piston motion, and showed the pressure waves very clearly. The matter was further investigated by measuring the time between the passage of the spark and the attainment of maximum pressure under ordinary conditions—*i.e.*, when there was no knock. The measurements were carried out in a low-compression engine with an L-shaped combustion chamber, in which the rate of flame propagation was much less than in the Knight engine. Experiments made with petrol and benzol showed that the rise of pressure was more rapid with the former, but the difference was not great. The time between the firing of the charge and the attainment of maximum pressure with petrol was about 0.013 second, and with benzol about 0.015 second. The difference in the case of the Knight engine was even less, which is to be explained by the rate of flame propagation being more dependent on the turbulence of the charge than on its nature.

Professor Watson appears to think that the absence of knock when using benzol is not, however, due to differences of speed of ordinary flame propagation in benzol and petrol, but is due to the charge firing in an entirely new manner when its temperature is raised above a certain critical value. This new manner of firing is a detonation rather than an inflammation, and the critical temperature is much lower for petrol than for benzol. The admixture of benzol with the petrol raises the critical temperature very markedly. The subject is being further investigated. That benzol requires a higher temperature than petrol to cause it to ignite was shown experimentally by fitting a thin platinum wire in the combustion space of an engine, and passing a current through it. The spark being retarded, the current through the wire was gradually increased until the indicator diagram showed that the charge was being fired by the wire. Under these conditions a larger current had to be passed in the case of benzol than was required with petrol. Further, with petrol the current strength could be easily adjusted so that the engine continued to fire and run quite regularly with the spark turned off. With benzol it was difficult to get the engine to run in this way, and a greater current was required.

For the experiments made with alcohol ordinary methylated spirit was used. The Daimler two-jet carburettor required a much larger jet than was used with either petrol or benzol, and it was found necessary to supply additioual heat to the carburettor, by passing a current through a wire wound round the pipe leading from the jet-chamber to the throttle. Even so, the supply of heat was insufficient and the vaporisation was somewhat irregular. The mean effective pressures obtained with alcohol were slightly higher than those obtained with either petrol or benzol, while they increased more rapidly with the strength of the mixture. Even with the strongest mixture used (six of air to one of alcohol), which gave 6 per cent. of CO in the exhaust, the mean effective pressure still showed signs of increasing with the strength of the mixture. The lower calorific value of the methylated spirit used was 9750 B.Th.U. per pound. The maximum thermal efficiency, as also the thermal efficiency at complete combustion, increased slightly from petrol to benzol and from benzol to alcohol.

With a view to studying the cause of these different thermal efficiencies, the mean temperature of the gases in the cylinder was worked out from the indicator diagrams. Two indicators were used, connected to the cylinder with a three-way cock. One indicator, with a thick diaphragm, was used to give the pressure on the compression and expansion strokes; and the other, with a thin diaphragm, those on the exhaust and suction strokes. A calculation of the exhaust temperature was first made, assuming a suction temperature of 147 deg. Cent., and from the measured amount of fresh charge taken in at each stroke the suction temperature obtained, by mixing this amount of fresh charge, at the temperature at which it was taken in, with the quantity of the residual gases, at the temperature just calculated, was determined. From this suction temperature, allowing for expansion owing to chemical changes during combustion, the temperature corresponding to any point on the diagram could be calculated. The pressures and temperatures read off the indicator diagrams, plotted to a logarithmic scale, gave a straight line, showing that both compression and expansion followed the law $P V^n$ = constant. The temperatures attained with the three fuels did not differ much, but those with alcohol were a little lower than the other two, particularly towards the latter part of the expansion stroke. This difference might account for the slightly higher thermal efficiency obtained with alcohol, but there was nothing to account for the fact that benzol gave a higher thermal efficiency than petrol.

As is well known, and as we have already mentioned, starting difficulties are experienced in cold weather when using benzol. The same thing applies to alcohol. This is because the fuel does not contain the volatile constituent, present in petrol, necessary to give sufficient evaporation to form an explosive mixture. To examine this point closely, Professor Watson had a steel vessel constructed in which air saturated with any of the fuel vapours could be fired by a spark. The vessel was surrounded by a water-jacket, which enabled the temperature to be varied, and was fitted with a pump by which the air pressure could be regulated. It also had a manometer and an arrangement by which the observer could tell if the mixture fired when a spark was passed. The method of work consisted in placing some of the fuel to be tested in the vessel, and then pumping in air until the pressure was higher than the maximum at which the mixture would fire. The vessel was then brought to the required temperature, and well shaken to saturate the air. A spark was then passed, and if no explosion took place, the pressure was slightly lowered, the vessel again shaken, and allowed to stand for some time. A further spark was then passed. This procedure was continued until the pressure at which explosion occurred was reached. Work was carried out with petrol, benzol, alcohol, and various mixtures, and resulting curves were given in the paper.

A study of these curves gives considerable insight into the starting-from-cold problem. With Bowley's special petrol, a very volatile fuel, an explosive mixture can be obtained at 0 deg. Cent., and under 40 lb. per sq. in. pressure by gauge. With Pratt No. 1 there is a rapid drop in the limiting pressure below 10 deg. Cent. down to 16 lb. at 0 deg. Cent. This is, of course, quite a reasonable pressure. The pressure is practically a linear function of the temperature. Benzol gives quite a different type of curve. There is a point of inflection somewhere about 20 deg. Cent; above this temperature the pressure rises rapidly; below, it falls equally rapidly. At temperatures below 1 deg. Cent., even at atmospheric pressure, air saturated with benzol vapour is incombustible. Methylated spirit gives a regular curve, but at all temperatures less than 20 deg. Cent. air saturated with the vapour is incombustible, even at atmospheric pressure. A mixture of Pratt three parts and benzol one part behaves, to all intents and purposes, like pure petrol, while a mixture of Pratt one part and benzol three parts resembles pure benzol, except at low temperatures, when the influence of the petrol is quite marked. Methylated spirit one part and benzol three parts resembles benzol, but is slightly better, and methylated spirit three parts to benzol one part approximates to the benzol curve at higher temperatures, but falls much below it at lower temperatures. The bearing of these data on starting problems is obvious, but their definite application must depend on the starting conditions under consideration. If an engine is turned sharply by hand or mechanically, it is possible to draw fuel into the cylinder and afterwards vaporise it by the heat generated owing to the compression. With the Knight engine turned fairly rapidly with a starting-handle, and with an initial temperature of 15 deg. Cent., a maximum mean temperature of 158 deg. Cent. was obtained, about 15 deg. below top dead centre.

THE SMITHFIELD CLUB SHOW.

THE Smithfield Club Show opened on Monday last, at the Agricultural Hall, Islington, N. The space allotted to machinery exhibits and appliances was, as usual, fully occupied, and in spite of the general upset of business through the war, the tone of makers was distinctly cheerful. The war having drawn a number of the farm workers away, makers are confidently looking forward to good orders for appliances which offer advantages in the labour-saving direction. As the past year has been a good one, farmers are, at the moment, probably more willing to give consideration to these matters than when labour is sufficient and crops are poor. Many firms turning out tractors, motor-ploughs, &c., are well off for orders. Although much of the Continental business is temporarily suspended, more than usual seems to be doing at home, and the only trouble in some cases is that

of turning out the work fast enough. Engineering works in normal times often employ a large percentage of Reservists, and these have all returned to the Army or Navy. In addition the new Forces have been swollen by substantial contingents from the shops, with the result that works are short-handed, and though firms are turning out as much as they can, the output is not quite up to what they would like.

Most of the standard makers are represented at the Show, though the variety is, perhaps, a little limited. The makers of ploughing-engines, thrashing-engines, and steam-tractors are well represented. Messrs. John Fowler and Co. (Leeds), Limited, have an exhibit which includes a 14-horse-power non-compound steam ploughing cable-engine, fitted with a drum and 600 yards of wire-rope. The engine has a two-speed gear for the ploughing motion, controlled by one lever, so that only one speed can be in at once. There is a brake on the ploughing-clutch, operated from the foot-plate. Another engine shown at this stand is a compound steam-tractor with a Belpaire fire-box, the boiler working at a pressure of 200 lb. per sq. in. The valve-gear is a constant-lead pattern, with one eccentric to each cylinder. Another firm showing thrashing-engines, tractors, &c., is Messrs. Aveling and Porter, Limited, Rochester, who exhibit a single-cylinder thrashing-engine, a compound ploughing-engine, and a compound tractor.

Various firms exhibit characteristic machines in the form of small steam-tractors and steam-wagons. Among these are Messrs. Fodens, Limited, Sandbach, and Messrs. Mann's Patent Steam-Cart and Wagon Company, Limited, of Hunslet, Leeds. The latter firm has a compound steam-tractor, a light agricultural tractor, and a 3-ton steam-wagon embodying the well-known features of this firm's standard designs. A new model steam-wagon is shown by Messrs. Robey and Co., Limited, Lincoln. This is illustrated in Fig. 1, page 704, and is a very nice-looking machine. It is a 5-tonner with compound engines and a Belpaire boiler working at 200 lb. per sq. in. The machine is fitted with a smoke-box superheater. The cylinders are mounted on a pressed-steel seating riveted to the boiler-barrel. Two levers are provided at the foot-plate; by means of one the superheater can be cut out if this should be necessary through the failure of a tube, and saturated steam admitted to the steam-chests direct. By means of the other lever the engine can be worked either normally as a compound, the high-pressure exhaust passing to the low-pressure cylinder, or high-pressure steam can be supplied to the low-pressure cylinder, with a common exhaust for the two cylinders, the high-pressure exhausting direct. The engine is fitted with a feed-water heater of the tubular type, supplied with the cylinder exhaust, which then passes to the chimney. The safety-valve is enclosed, as in all Messrs. Robey's road-engines, and the escaping steam is conducted to the chimney. The feed-pump is driven off the intermediate gears. The crank-shaft bearings are fitted with ring-oilers, and the axles are arranged with pad lubrication and oil-baths. Two speeds of about three and six miles per hour are provided, the transmission being by roller-chain running in an oil-bath. A long tank capable of containing 160 gallons of water is placed between the frames under the body, which is 12 ft. long by 6 ft. 6 in. wide, the sides being 1 ft. 6 in. high. The bunker is large enough to carry fuel sufficient for 40 miles. The road wheels consist of cast-steel centres, on to which are bolted hard-wood felloes. The felloes are slightly coned, and the internal fit of the tyres into which they are forced is also coned. By means of bolts passing through a flange on the inside of the tyres and through the felloes, the two parts can be drawn up together tight in the taper, in case of any tendency to work loose.

Motor tractors and appliances are represented in a few cases, though motor-lorries are conspicuous by their absence, doubtless on account of the large demands made on makers by the War Office at the present time. Messrs. John Fowler and Co. (Leeds), Limited, again show one of their Fowler-Wyles motor-ploughs, which we described in Engineering some time ago (see vol. xcvi., page 20). The example shown has an additional attachment at the back in the form of a seat supported by a small wheel. The position is within easy reach of the plough-handles.

Messrs. Wyles Motor-Ploughs, Limited, 5, Carr-street, Manchester, whose motor-plough we thoroughly described and illustrated in connection with the Royal Agricultural Society's Show at Shrewsbury (see page 38 *ante*), show one of their machines embodying a few alterations recently introduced. The frame has been somewhat changed, and the machine will take any standard make of two-furrow plough. The firm are now also fitting steering-gear and seat to the machines at the side, as these are considered essential features in some countries. The weight of the machine is only 18 cwt. Work during last autumn has shown a single machine to be capable of doing the work of two good horse-teams, and, using a two-furrow plough, three acres have been ploughed in an eight-hour day. This interesting machine has, from all accounts, already won a good footing for itself, and the prospects of a successful future seem to be assured.

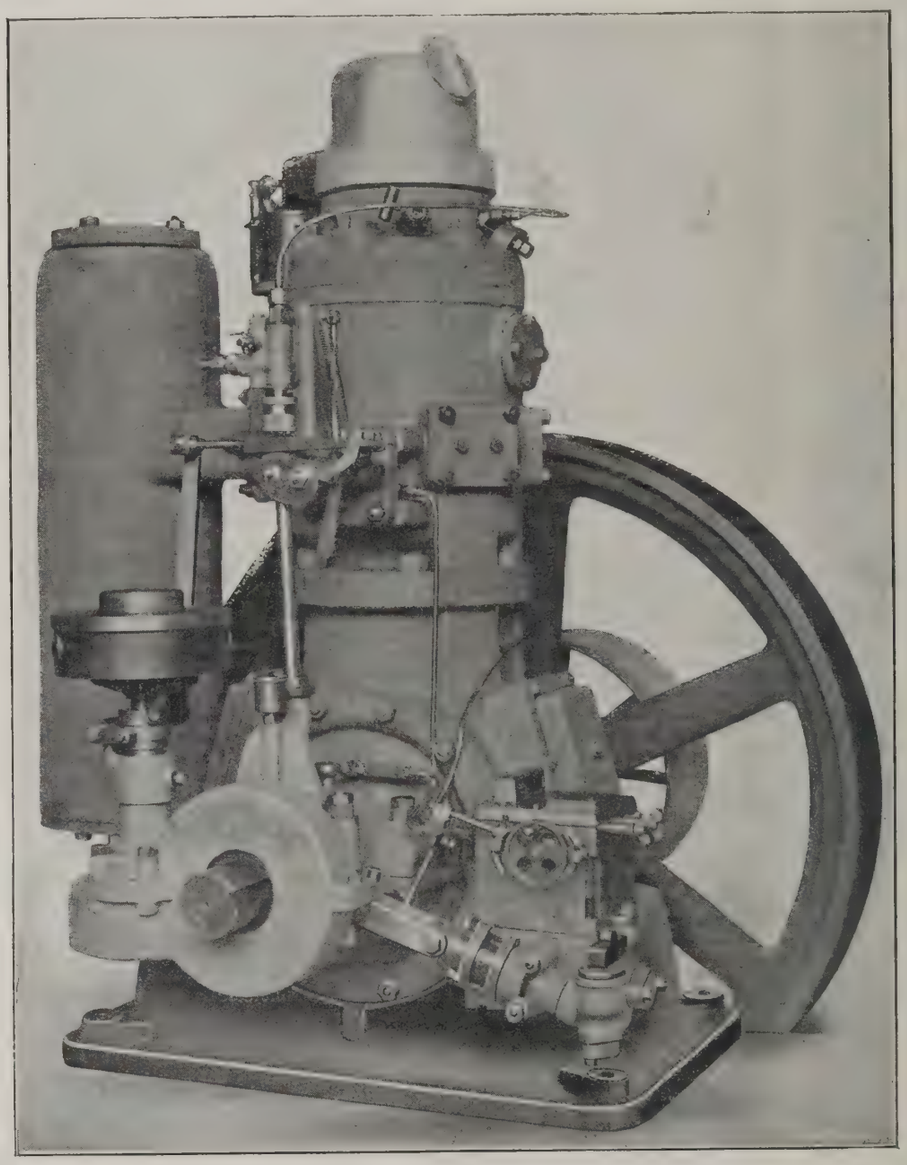

Fig. 3. 20-Horse-Power "Invincible" Semi-Diesel Engine. Messrs. A. and E. Woodward, Keighley.

Messrs. Saunderson and Mills, Limited, Elstow Works, Bedford, who are also as busy as their works can be at the present time, show one of their standard agricultural tractors. The machine exhibited is a model "G," with a twin-cylinder engine, giving 20 brake horse-power. This machine has three speeds forward and one reverse—viz., 2, 3, 5, and 3 miles per hour. The engine cylinders are 5½ in. by 8 in. stroke. The back wheels are 12 in. wide on the tread and 4 ft. in diameter. The cooling surface provided is liberal. The cooling-tank contains a large vertical flue, across which run gilled tubes. For cleaning purposes the whole flue can be dropped and the mud cleared out of the tubes. The exhaust is turned into the upper portion of the cooling-tank, and induces an air-current through the flue. The engine is provided with a simple half-compression arrangement, consisting of an ordinary cock and ball-valve. When the cock is opened, the engine draws in its charge, but on the return stroke the increasing pressure causes part of the charge to pass out through the cock and valve until the port leading to the cock is covered by the piston, after which compression continues in the ordinary way. Another simple device used on these motors concerns the starting-handle. The engine-shaft has a rather sharply tapered end. As soon as the engine starts, the starting-crank, in consequence, is promptly freed; and if the operator let go of it, it would be immediately dropped off instead of possibly turning round with the shaft. Messrs. Saunderson's motors have this last autumn been doing excellent harvesting work with binders. With a new special harvester coupling, it has been possible for one of these machines to haul and work properly a string of five binders. The model "G," exhibited at the Show, although one of the lighter patterns, can haul three binders satisfactorily.

The Ivel Agricultural Motors, Limited, Biggleswade, show one of their light tractors, a three-wheeled machine with *vis-à-vis* engine and single speed. This pattern embodies no novelties, the design having been reduced to a satisfactory standard. The firm also exhibit one of the Ivel-Bauche motor-hoes, of which we gave a description in connection with the Show at Shrewsbury (page 19 *ante*).

Messrs. Ransomes, Sims, and Jefferies, Limited,

Ipswich, have an exhibit of some variety, the most noticeable feature of which is probably their single-cylinder oil-tractor. This is shown in Fig. 2, page 704, and is a machine primarily intended for the foreign market; it is of 35 to 40 brake horse-power. The engine is a horizontal hot-bulb oil-engine, with a cylinder 12½ in. in diameter and 14 in. stroke, running at a normal speed of 270 revolutions per minute. The engine is started with a lamp. The fly-wheel is 4 ft. 6 in. in diameter by 6 in. wide. The machine is provided with front wheels 4 ft. 6 in. in diameter by 9 in. wide, the rear, or driving, wheels being 6 ft. 6 in. in diameter by 18 in. wide, provision being made for extensions, if necessary. The machine is arranged for two speeds forward, of about 2 and 3½ miles per hour, and a reverse speed of 2 miles per hour. The fuel-tank has a capacity of 30 gallons (crude oil), and the cooling-tank a capacity of 70 gallons. Water is drawn from the cooling-tank by a belt-driven centrifugal pump, and returns to the tank, passing over a series of cooling-weirs. The whole machine has a length of 18 ft. 8 in., a width of 7 ft. 2 in., and a height of 10 ft. 10 in. to top of chimney. The weight in working order is about 10 tons. The control from the foot-plate is by two levers, one controlling the belt, driving-clutch, and brake, and the other the speed change and reverse. The mounting of the machine is virtually the same as for steam-tractors, the regular traction-engine steering-gear being adopted.

As at other recent exhibitions of agricultural machinery and appliances, the small petrol or paraffin-motor is much in evidence. Most of the well-known British makers are represented, as well as several American. We have at one time and another dealt with the more interesting types of this class of engine, and our readers are therefore familiar with their various features as well as with the names of the makers. The larger type of stationary oil-engine is also shown by several well-known firms. Of this class of engine, the vertical two-cycle hot-bulb engine seems to be steadily gaining ground. Several firms exhibit engines of this class. Among them are interesting engines at the stand of Messrs. Martin's Cultivator Company, Limited, Stamford, who show a single-cylinder engine, a twin-cylinder, and a portable. As we propose to give shortly a more complete description of these engines than is possible in this connection, we will defer till then a discussion of their design. The Campbell Gas-Engine Company, Limited, Halifax, stage a 15½-horse-power high-compression crude-oil engine, a 7¾-horse-power engine with compressed-air starter, and a 13½-horse-power two-cycle hot-bulb vertical engine. The latter engine is governed by a single eccentric gear. Normally a striker moves vertically up a cam-plate, and comes in contact with the pump-plunger. On the face of the cam-plate is a short incline. If the speed increases, the striker is flicked out by this as it rises and misses the pump-plunger. Messrs. Robey and Co., Limited, show one of their two-cycle semi-Diesel engines of 25 brake horse-power. This engine has a single cylinder, 11 in. by 13 in., and runs at about 350 revolutions per minute. It is governed by a shaft-governor, which increases or reduces the eccentricity of the single eccentric, thus giving the pump a variable stroke. The water for injection is mixed with the fuel before entering the cylinder. The water-injection fitting forms part of the fuel-pump fitting. Metallic disc air-valves are fitted on the crank-case. The engine embodies sundry recent improvements, notably in the hot-bulb vaporiser, which is of a new form, and in the water-circulation pump, which is now a small belt-driven centrifugal.

Another firm showing a new model of this type of engine is Messrs. A. and E. Woodward, Invincible Engine Works, Green-street, Keighley. This exhibit is a 20-horse-power engine running at 400 revolutions per minute. It has no water injection. It is shown in Fig. 3, page 708. This engine is governed by varying the fuel supply by means of a wedge inserted between the tappet and the pump-plunger. The wedge is unusually long, and of a comparatively fine taper. It is arranged horizontally, and is moved out and in by the action of the governor weights, the governor being driven by gears off the main shaft. The tappet or striker is connected to a single eccentric on the shaft close to the governor. The wedge and governor together form a very sensitive system of regulation, and it is claimed that the speed variation between no load and full load with this engine is within 1 per cent. The consumption is stated to be approximately half-a-pint of crude oil per brake-horse-power hour. Forced lubrication is provided to bearings, gudgeon-pin, &c. The gudgeon-pin is furnished with a wiper scraping the oil off the cylinder wall at the point where it is supplied by the mechanical lubricator. The engine is built in single-cylinder sizes up to 20 horse-power, and above that to 40 horse-power with double cylinders. Pump circulation is arranged for, the cylinder head being cooled.

The exhibits of Messrs. Petters, Limited, Yeovil, and of Messrs. Blackstone and Co., Limited, Stamford, embody several models with which we dealt at the time of the Shrewsbury Show.

An interesting machine-tool is to be seen at the stand of Mr. John Wilder, Yield Hall Foundry, Reading. This is a machine for grinding lawn-mower cylinders and blades. This machine is illustrated in Fig. 4. It is capable of grinding simultaneously two lawn-mower cylinders or runners of equal or unequal size, varying from 6 in. to 50 in. in length, the bottom blades being ground at the same time. As will be seen from our illustration, the machine has two heavy pillars placed 6 ft. apart, and rigidly connected by two steel circular slide-bars 2⅞ in. in diameter, placed one above the other. The grinding-wheel saddle, of cast iron, moves from end to end of the machine on these slides. The travelling-saddle is provided on its upper side with bearings for the spindle of the grinding-wheel, which is 14 in. in diameter by 2 in. wide. On the under side of the saddle there are also fixed two pedestals, in which are fitted bushes. Between the pedestals is a sliding pulley fitted with a square-holed bush. The pulley is free to revolve between the pedestals on the square shaft which revolves in bearings near the base of the columns. The main drive of the machine is by fast and loose pulley direct on this bottom shaft. With this shaft running at 320 revolutions per minute, the grinding-wheel, which is driven off it by the sliding pulley, runs at 1500 revolutions per minute. At the belt-pulley end of the machine there are two leather-faced cone clutches on the main shaft. These are belted to pulleys on a secondary shaft above, which is driven either backwards or forwards, according to whichever clutch is engaged. The clutches can be thrown in by moving a weighted lever by hand, or automatically. At one end of the secondary shaft is a small pinion in mesh with a larger gear keyed to the end of a large screwed steel shaft carried by the two columns and fitted with ball-thrust bearings. This revolving screw carries a nut housed in the saddle,

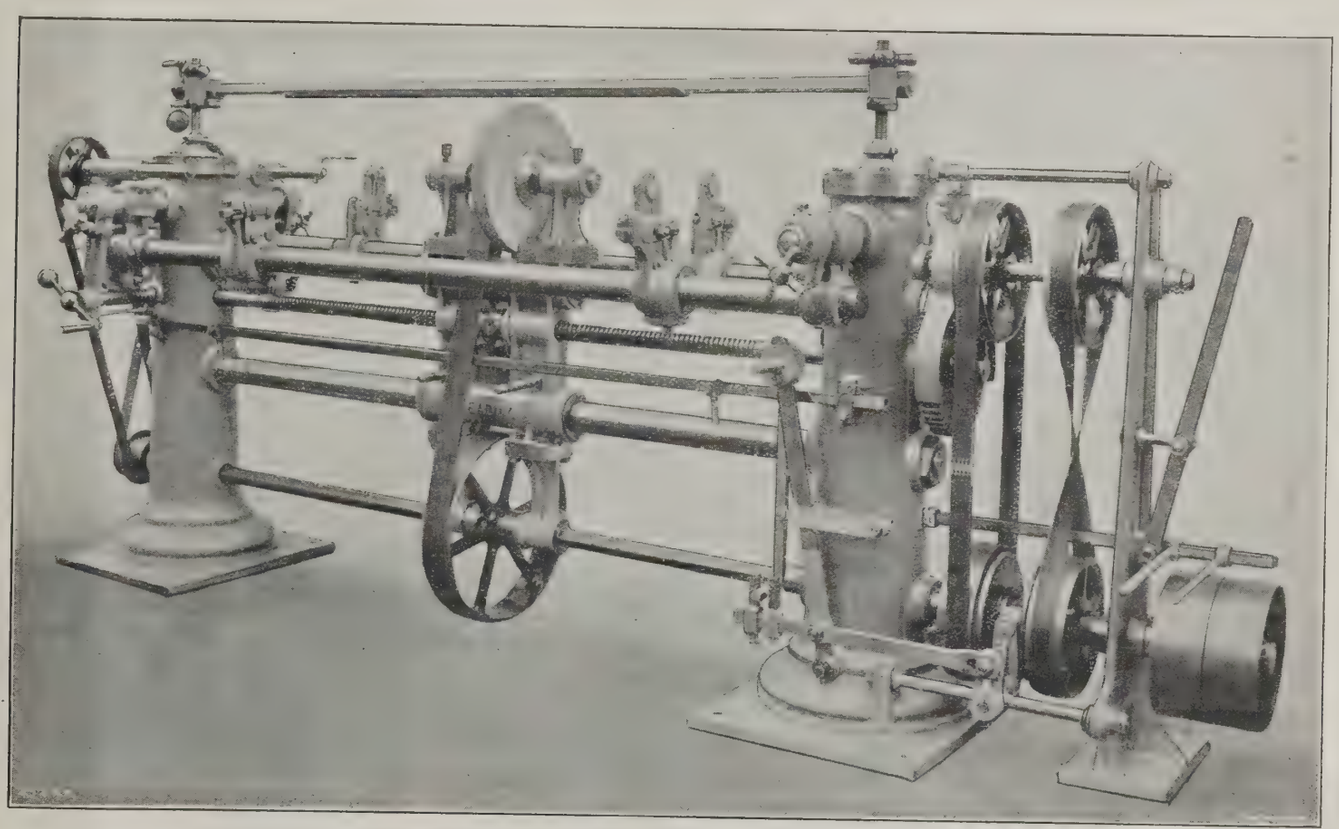

Fig. 4. Automatic Multiple Lawn-Mower Cylinder and Blade-Grinding Machine; Mr. John Wilder, Reading.

which is thereby caused to move up or down the slides, its motion being reversed by the clutches. The saddle carries two strikers, and there are two corresponding adjustable tappets on a square sliding-bar running the length of the machine in brackets fixed to the pillars. This sliding-bar moves the belt-thrower, the actual operation of shifting the belt being accelerated by play allowed to the weighted hand-lever. When the gear is moved by the saddle a short distance, the weighted lever falls over and completes the movement.

Near the top of the columns are two arms of steel 2½ in. in diameter, placed at right angles to the main slides. Sliding on these arms are brackets which can be moved in or out by adjusting-screws. These moving brackets are connected by long cylindrical steel shafts 2½ in. in diameter. On each of these shafts are two jaw bearings which carry the spindle of the lawn-mower cylinder to be ground. The jaws of these bearings are opened and closed by a right and left-handed screw, and can be clamped in position. At one end of each of the shafts just referred to is a worm quadrant meshing with a screw carried by the pillar. The quadrant is extended beyond its centre in the form of an arm which constitutes a bearing for a pulley spindle, driven by belt from a pulley on the end of the main square driving-shaft below. A carrier is fixed on the spindle of the runner to be ground, and is driven by the pulley spindle at a speed of 280 revolutions per minute. The runner or cylinder is placed in the jaws, which are then clamped. The shaft is then adjusted by moving the bracket at one end in till the blades just touch the grinding-wheel. The wheel is then traversed and the shaft adjusted at the other end, both ends being clamped. Subsequent adjustment of the runner nearer to the wheel, or the withdrawal of the runner from it, is secured by the screw and quadrant radial gear, which moves the whole runner and pulley spindle in or out at once parallel to the main slides.

The bottom blades are fastened for grinding to a square shaft to be seen at the top of the machine, extending between two vertical screws. A plate is fixed to this shaft and the blades are set on this. The square shaft can be moved vertically, and can also be rotated, so that any desired angular adjustment may be secured for the ground edge. Once set, the blade can be clamped in position. The movements provided allow of the inspection of the blades or runners at any time during the process of grinding.

NOTES.

The Panama Canal Slides.

Some interesting details have recently come to hand regarding the two slides which occurred on the Panama Canal on October 14 and 31, and necessitated the temporary suspension of traffic through the waterway. We gave some particulars of these slides in our issue of November 6 (page 566 *ante*). The first extended for a length of 2100 ft., and broke back on the bank to about 1000 ft. from the centre line of the Canal. It was situated on the east side of the Canal north of Gold Hill, at a point where there had previously been a great deal of trouble. The old movement appeared, however, to be quite dead, and the channel at this spot had been cleared practically to the final dimensions. The movement of October 14 involved some 750,000 cubic yards of material, and it was anticipated that its removal might bring down more. This appears to have been what happened, for the second slide at the end of the same month wiped out all the headway gained. As the material came down from the bank there was an upward movement of the bottom, such as we have previously described in connection with these slides. It is interesting to note that in our comments on this subject on November 6 we spoke of the risk of vessels grounding in the Canal if such upheavals occurred, and pointed out that this would be difficult to guard against. When the second slide occurred and the bottom rose, the S.S. Arizonan, which was passing through the channel at the time, actually did ground opposite the slide, showing the risk to which we drew attention to be real and not merely an imaginary one. Five dredgers were promptly got to work clearing the channel again, including the two large 15 yard dipper-dredgers, Gamboa and Paraiso, which were illustrated and described in our issue of September 4 (page 303 *ante*). The dredgers were worked on the slide in three eight-hour shifts, and during the first blockage of the Canal (*i.e.*, between October 15 and 20, when it was possible to resume traffic), the largest amount removed by the Gamboa in one day of twenty-four hours was 7800 cubic yards, the best day of the Paraiso accounting for 7625 cubic yards. The best day's work for the five dredgers was 25,620 cubic yards, and in the course of the six days 119,605 cubic yards were excavated. An inquiry having been made with regard to demurrage due to the temporary closing of the Canal, the Governor of the Canal Zone has replied that the Panama Canal is not to be held responsible for such delay. The date originally fixed for the opening of the Canal was January 1, 1915, but work was so far advanced that "it was decided to offer vessels the privilege of using it before the official opening."

Improvements in Textile Machinery.

The employment of pneumatic and electrical forces in textile mills is undoubtedly growing, and there is every reason to believe that further applications will be made in the immediate future. Probably no industry has been less subject to outside progressive influences than that devoted to the production of textile yarns and fabrics, and a strong conservatism has been proof, hitherto, against the attempted introduction of revolutionary ideas. The present mechanism, in many instances, appears entirely illogical to the mechanical mind unbiassed by long acquaintance with spinning and weaving plant, and the only possible reason for the use of many parts is that they are merely power-driven equivalents of those originally manually-operated. In a paper on "The Possible Increased Application of Pneumatic and Electrical Forces to Textile Processes and Machinery," read before the British Association of Textile Works Managers on December 5, Mr. Frank Nasmith made it clear that the improver of textile machinery has at the outset to overcome the great difficulty presented by the low cost of textile machinery and its comparatively high efficiency. From this paper it is abundantly evident that the somewhat advanced improvements sought cannot be made solely either by the electrical, mechanical, or textile engineer. There must be co-operation, and it is only by a combination of effort that any lasting success will be secured. What is undoubtedly necessary, in order to secure the results sought, is the absolutely unbiassed, but scientifically-trained, mind. Textile machinists will have to disabuse their minds of the present form of machine altogether, because immediately pneumatic and electrical forces are applied to an existing machine, the limitations of the machine itself offer handicaps and tend to make the work commercially impossible. This was confirmed in the discussion, one member recalling that thirty or forty years ago a loom fitted with a shuttle pneumatically picked was shown in Manchester, but failed for various reasons. The chief reason such a loom failed lay in the fact that pneumatic means were applied to an existing type of loom, in which they were handicapped, and from which no good result could ever be secured. Machines, then, will, in many cases, have to be redesigned if the full advantage of the use of these two forces, pneumatic and electric, are to be secured. It was stated that experiments have been carried out in relation to an entirely new type of loom, and, so far as the picking was concerned, the results were excellent. By the pneumatic means outlined in the paper the power required has been much reduced, four times the weft supply can be carried, and the mechanism is practically noiseless. If no other result has been secured by the time and money spent in research work on this new loom, it is justified by the improvements in picking secured. Other examples of the possible use of pneumatic force outlined were new cleaning and opening means, and spindle-driving. Dealing with the possible increased uses of electricity, Mr. Nasmith first dealt with improved means employed in Germany for driving calico-printing machines which are certainly valuable and worth installing in this country, where the old method of small steam-engine drive still exists. Electrical jacquards for producing figured cloths were stated to be inefficient if a momentary contact has to be relied upon, and the disadvantage of employing such a method was strongly emphasised. The removal of metal from cotton by means of magnetic attraction was described, and the neutralisation of static electricity generated by the friction of one fibre against another when under treatment was dealt with at length. A new method of neutralising this static electricity lies in the use of a radioactive mud spread over an earth-connected iron plate placed below the yarn or cloth. The air is ionised and becomes a continual conductor, through which the electricity discharges. Very considerable advantages were estimated as being possible if these two forces were carefully adopted by and through the agency of co-operation between the textile machinist and the scientifically-trained engineer whose mind is not biassed in the use of the present type machine.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. XV.*

By Frederick William Lanchester, M. Inst. C.E.

The Command of the Air, and Its Limitations.

The term "command of the air" can never be taken to carry a meaning so wide or far-reaching, or in any sense so comprehensive, as that understood when we speak of the "command of the sea." Sea-power has its origin and secret in the fact that (as rightly insisted by Mahan) the seas control the main highways of international commerce and communication; thus sea-power is necessarily world-power. It would not, strictly speaking, be true to say that the command of the sea essentially involves world-wide supremacy; but so far as a navy is provided with fully-equipped bases, so far will its power extend in its plenitude. It has sometimes been rashly assumed by writers that in the future air-power is not only going to exercise an influence as widespread and decisive as sea-power, but is, in fact, about to take a superior position, and that the latter will lose some of its present character and importance. No such conclusion can at present be justified. It is, of course, to-day considered bad form to call any engineering project *impossible*; but in view of the fact that, after making every reasonable allowance for possible developments, the maximum distance that can be flown by an aeroplane without replenishment is less than 2000 miles, it is clear that the range or radius of action of an air fleet must be regarded as permanently imposing strict limitations to its employment. The large airship, even should it be found to be of greater military or naval importance than suggested in the present articles, is scarcely likely to be better situated, and suffers from the not inconsiderable disadvantage of requiring accommodation of an elaborate and expensive kind. Hence we see that the command of the air is, from a world-wide standpoint, a local condition. It might conceivably be secured and asserted by a European Power over half the Continent of Europe, or the whole of the south and east of the African continent might be dominated by air fleets having their bases in Egypt and other territory in British occupation. Even this, however, is looking a great way ahead. For the time being we may take it that the object of the policy of any of the Great Powers in time of peace will be to secure unquestioned supremacy within their own territorial limits, with such bases in the vicinity of their coast lines and frontiers as will suffice to ensure the respect of hostile aircraft in the event of war being declared. When a state of war exists, the task of an air fleet will be to maintain its air supremacy at home, and to extend and carry the command of the air over land or water in support of the Army and Navy, wherever operating. Hence the Aeronautical Service is not to be considered as a new kind of Navy, or otherwise as a self-contained Service to which large-scale independent duties can be assigned; it is definitely, in the words of our title, a new or Fourth *Arm*.

Neutral Aircraft. International Regulations.

It has been believed from the earliest days of the modern aeronautical movement that the military (and naval) uses of the flying-machine would prove to be one of the most important of its earlier applications. This view has been more than justified, so much so that to-day there is scarcely a machine that "takes the air" in Europe that is not on Service duty. This is a fact that probably the most ardent supporter of the military usage of the flying-

* No. XVI., the concluding article of the series, will appear in the issue of December 25.

machine would have scarcely ventured to predict prior to the outbreak of hostilities. Certainly, if five or six years ago anyone had been bold enough to assert that at the beginning of the year 1915 there would be scarcely a machine flying in Europe on other than military duty, it would have sounded incredible. That the present situation is not representative of the future in this respect we may take for granted. On the other hand, it is becoming clear that we may quite dismiss from our minds any general usage of the air as a commercial highway; the traffic in merchandise that will be air-borne will never become a great percentage of the world's total. We may anticipate that lines will be established for the rapid conveyance of mails, and to some extent we may look to the development of passenger services in different parts of the world. But for the time being the inconvenient (and, in the case of shipping, contentious) question as to the rights of neutrals in the air can scarcely be said to have been established; commercial usage of the air is virtually non-existent. The obligations imposed by international law and convention on both belligerents and neutrals are, at the best, of such an arbitrary and makeshift character that it is doubtful if anything is to be gained by attempting to lay down any code or set of rules to control a form of locomotion in its application to warfare of which little or no experience is available. However, the writer has had a book placed in his hands (published early in the present year) on "Aircraft in War," in which the whole contents, from cover to cover, relate to nothing else but the international aspect of the subject and rival codes of proposed "legislation." It seems, therefore, that this side of the subject requires discussion. Without wishing to belittle work of the type in question, it may certainly be said that the discussion of anything more than the barest generalities of the subject can only be time and effort wasted. A new Arm requires to work out its own salvation in warfare, and the machine that has won for itself and mankind the freedom of the air is not to have its future proscribed or fettered by the scratchings of an unofficial quill.

Belligerent Aircraft and the Rights and Obligations of Neutrals.

The point which appears likely to lead to the greatest trouble in practice is the question of the propriety of belligerent aircraft operating over the territory of a neutral Power. Without discussing such academic subjects as the territorial sovereignty of the air, it seems clear that eventually neither belligerent can be prevented from passing over neutral territory except by the air and counter-air forces of the neutral Power in question. If such Power should elect not to use his forces to prevent such aerial violation of his territorial air, it will be impossible in practice to make him do so or hold him responsible. Beyond this, if the neutral Power should subsequently make claim against a belligerent for using his air, it is difficult to see how any such claim could have more ground than an ordinary civil claim for trespass, in which the only admissible basis of an award is for damage done. If the aircraft has flown at reasonable altitude and has done no injury by dropping anything, or by gun-fire, it is difficult to see how any claim could be substantiated. If the neutral Power should elect to employ his aircraft and counter aircraft artillery to assert a presumed right to his territorial air, he not only puts himself to very considerable expense and inconvenience, but at the best his efforts are unlikely to be wholly effective; in thick weather the whole of a belligerent air fleet might pass over his territory without once being sighted. Hence it will be possible that at any time he may be plausibly accused of favouring one side or the other, and thus find himself in difficulties of a diplomatic kind far worse than would have been possible had he left his air undefended. A host of other difficulties spring into one's mind in connection with the defence of territorial air by a neutral Power; aircraft may encounter above the clouds: a belligerent fleet and the neutral air-sentry force. How shall they decide in what way to act? They cannot stand still and hold a palaver whilst the matter is tested by a plumb-line. Clearly any attempt to enforce neutrality in territorial air would be more likely to drag the neutral Power into the war on one side or the other than a rigid abstinence from interference; and since this is one of the most important contingencies to be guarded against,* it seems evident that, *as a matter of expediency*, the rights (if they be admitted) of neutrals over their territorial air should be regarded as not involving any obligation of action against belligerent aircraft. On the other hand, it is equally clear that the ordinary powers of enforcing restrictions in such matters as flying over prohibited areas, &c., will in nowise be weakened by the existence of a state of war, and neither belligerent will have cause for complaint if his aircraft, after due warning, should be fired upon. In brief, whilst it would appear to be impossible to deny the right to a neutral of chasing away—or, if necessary, even of destroying—belligerent aircraft if found in occupation of territorial air, it would appear to be equally impossible to impose the duty of doing so as an obligation. A corollary to this would appear to be that the use of a neutral's territorial air will only become a violation of neutrality if persisted in in the presence of aircraft or air forces of the neutral Power.† Put in a few words, the position, as above, is in every way analogous to the ordinary law of trespass; the owner is entitled to turn the trespasser off, using only such force as is necessary, and can claim damages only on account of actual injury sustained.

Other International Questions Relating to Aircraft. Distinctive Marks.

It has been suggested, or stated, by most previous writers on the subject that aircraft will be required to carry a distinctive mark or colours, indicating their nationality and their character as military or belligerent—*i.e.*, not civilian—machines. This view is clearly based on the practice which is presumed to obtain in the case of ships-of-war, and which is, to some extent, necessary owing to the fact that the ocean being the common highway of all maritime nations, some declaration of nationality is obligatory, or at least desirable, from the point of view of neutrals as well as of belligerents. History has shown again and again that when a state of war exists, no rules, codified or otherwise, will compel a war-vessel or fleet to display its national flag, or prevent it from using the flag of any other nation that may commend itself at the moment; and if it were not for the interests of neutrals, the practice of employing any distinguishing flag or mark in war-time might fall into desuetude without affecting anything or anybody. Now, in the case of aircraft, it is not only improbable, but quite inconceivable, that civilians or neutrals will be permitted to fly at all in or near the zone of hostilities. It is even probable that on the declaration of war all private aircraft will be requisitioned or impounded (as now done in the case of wireless telegraphic apparatus), and that neutrals will be advised that they will use the territorial air of the belligerent countries entirely at their own risk and peril; in fact, that they will be shot down if detected. We cannot for an instant admit a state of things such as would arise were neutral or private aircraft (with war correspondents and suchlike) allowed to fly in any area in which fighting might be in progress; there would be continual uncertainty as to the nationality of such alien aircraft, and no means of checking the abuse of a neutral flag by spies or impostors. The position is totally different from that which obtains at sea. There is no possible means of investigation, and no time to ask questions; if there is any doubt, instant action is imperative. It is only too evident that even if distinguishing marks were agreed, no reliance would be placed upon their genuineness in real warfare, and their disuse, sooner or later, may be considered to be a foregone conclusion.

It will be part of the business of the airmen and gunners of both belligerent armies to be fully conversant with the peculiarities of the various types of aircraft in their own service and in that of the enemy, and to be sufficiently "fly" to detect any attempts at disguise or deception. It is, of course, always open to the aircraft of either army to carry a distinguishing mark or sign which can be displayed at will, and the nature of this may either be known or unknown to the enemy; it may, to ensure secrecy, be changed from time to time like a "pass-word." This, however, is an entirely different matter to the wearing of a badge, like a uniform or a national flag, by which the nationality will be openly declared as a matter of obligation.

Other questions of an international character relating to aircraft do not appear to present any serious difficulty. Evidently a belligerent aircraft descending into neutral territory will be interned, just as would a cavalryman or an armoured motor-car. To treat an aeroplane or airship according to the rule established in the case of a warship would clearly be to admit its right to have been in the territorial air of the neutral Power concerned, which, we may assume, will be considered quite inadmissible. Already, in the course of the present war, we have seen the hospitality of neutrals greatly abused. It certainly is not just or expedient that the cruisers of a nation which has ceased to possess any coaling-stations, or bases, of its own should be allowed to roam indefinitely at large, interfering with the commerce of an enemy, when such action would have been impossible without neutral assistance. The proof of the inexpediency of the existing rule in such a case is to be found in the fact that the difficulty could be soon ended by a few declarations of war against some of the minor neutral Powers, with the bombardment of the ports by which the enemy is served. The very fact that this becomes the logical reply, which, but for humanitarian considerations, would, without doubt, be pursued, demonstrates an inherent deficiency in the present international code, and one which perhaps may, in due course, be remedied. Any rule by which aircraft would be enabled to utilise neutral territory or neutral resources for repair, refit, or replenishment would almost certainly be the cause of great friction, and might result in a position so impossible as to drag the neutral Power into the conflict, the precise eventuality that it should be an object of international convention to avoid.*

In other respects there would seem to be no reason to treat the flying-machine or dirigible differently from arms or armament of other kinds, or belligerent airmen differently from other combatants. It is at least clear that any modifications in the accepted code that may perhaps eventually be found necessary may well be left to come as the natural outgrowth from experience in warfare. With regard to the manufacture and supply of aircraft by neutrals to belligerents, or the granting of facilities of transport, the same considerations will govern the decision of the neutral Power as are at present involved where arms and munitions of other kinds are concerned. The Power affected requires to consider in what way its own interests and those of neutrality are best served.

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* It is, in fact, one of the main benefits of an international code that the friction between neutrals and belligerents should be minimised.

† If this view be accepted, the recent action of the British naval airmen in passing over Swiss territory is quite permissible and in no way irregular. Switzerland, had she so willed, could have employed aircraft to police her frontiers, in order to prevent the "borrowing" of her territorial air. Failing this, and not having suffered actual, *i.e.*, material, injury, she has no ground of complaint.

* It would often appear from the framing of clauses and debates in connection with the various international conferences that the above (in the writer's opinion the most important object of achievement of international conventions) is almost lost sight of in a quagmire of dangerous and namby-pamby sentimentality. In many cases the desire seems to be vaguely to *do something that will be thought humane*; no clear idea seems to exist as to right and proper grounds on which regulations of restrictions should be based. Thus, for example, in the Brussels Conference of 1874, Article 13 *e*, and in the Hague Conference of 1899, Article 23 *e* (already cited, Article VII.), the same restriction appears for the prohibition of bullets of the dum-dum or expanding type; in the first (the abortive Conference of 1874) the prohibition is worded:—"The use of arms, projectiles, or material *of a nature to cause unnecessary suffering*; the wording adopted at the later Conference is ". . . *of a nature to cause superfluous injury*." At the 1874 Conference the assembly was, it appears, imbued with feelings of horror for pain and suffering, but in 1899 this seems to have become changed for a dread of disablement and death—a totally different matter. The suggested prohibition of bombs or missiles from aircraft is an illustration of the same infirmity of purpose that appears to reign supreme at peace conferences and the like; again we see the dictates of fear mistaken for those of benevolence. There is, and was, no evidence that bombs from aeroplanes or balloons are any more barbarous or inhumanly destructive than the shells from artillery or howitzer batteries, yet clauses were debated and framed, and (with a time-limit restriction) were actually signed by certain of the representatives of the Powers. The *fear of the unknown* is without doubt more widespread and potent than its victims realise. A cavalryman is killed in peace time by a fall from his horse, it scarcely excites comment; an army airman falls and is killed and a thrill of horror goes through the country—it is *a new kind of death*.

OIL-FUEL IN WARSHIPS.

To the Editor of Engineering.

Sir,—In the issue of Engineering of the 4th inst., under the headline "The German Navy," the following passage occurs on page 669:—

"Whilst recognising the marked advantage of liquid fuel over coal, in that it takes up 40 per cent. less space, whilst having 25 per cent. more efficiency for an equal weight consumed, and reducing the number of stokers, the *Suddeutsche Zeitung*, says the *Rivista*, records that Germany has decided to maintain the use of coal for firing her ships' boilers in ordinary circumstances, having recourse to liquid fuel as an adjunct when high speeds are required. The use of liquid fuel on a larger scale would render Germany dependent upon the United States or Roumania."

Apart from the above considerations, I would venture to remark that boilers of German design for warships that I have had an opportunity of inspecting are not at all suitable for the use of liquid fuel, and that in boilers which are properly designed for liquid fuel the advantages are more pronounced than stated.

As evidence of this fact I enclose herewith a copy of a table of results obtained on a Yarrow-type boiler, which, however, was not designed for liquid fuel, but for coal. The figures point to the fact that oil-fuel will do considerably more than 25 per cent. more than coal.

German engineering and German organisation has been very much vaunted in this country for a number of years past. The Germans, I take it, are not nearly so clever as popular opinion gives them credit for, and, I believe, if the ships of the German fleet had had the hardihood to come out on the ocean and remain in commission at sea for the length of time that the British Fleet has been at sea, we would have heard of many of them having to return to port owing to boiler troubles. It is perhaps fortunate that the Germans are not so *au fait* with the use of oil-fuel as we are in this country, and our British men-of-war certainly hold a great advantage in this direction.

The data in connection with these tests was supplied to us by Messrs. Yarrow, and a brief reference was made to the trials in the issue of Engineering at the time. It is significant that boilers of British design are now being largely adopted by the navies of other countries, especially those of our Allies.

I remain, yours faithfully,
J. J. Kermode, M.I. Mech. E.

35, The Temple, Dale-street, Liverpool,
December 7, 1914.

TORQUE-TRANSMISSION INDICATION.

To the Editor of Engineering.

Sir,—In Engineering for June 12, page 821, Dr. K. Suyehiro, of the Tokio University, prefaces his paper on "A Torsion-Meter with Visible Scale" by a brief note as to the first use of the visual-torque method in steam-turbine indication.

Might I be permitted to point out that the general principle of indication by visualising the torque of the transmitting shaft had been communicated to the Institution of Mechanical Engineers (London) by me at an earlier date?

The contribution will be found in the Proceedings of the above Institution for November, 1903, page 759. Dr. T. E. Stanton, in a paper on centrifugal pumps, had shown how the maximum effort during a test could be shown by the trace left by a stylus upon a surface, stylus and surface being attached to the opposite ends of the transmitting shaft and rotating therewith. My own contribution to the discussion disclosed my application of the principle of synchronous, interrupted illumination to the observation of the torque at any instant; the first adaptation, so far as I am aware, of that principle to such use. The text is as follows:—

"Mr. James A. Smith, of Melbourne, wrote that he could endorse the view that transmission dynamometers based upon the torsion of a relatively slender shaft—a principle first brought into prominence by Hirn in 1867—had many points of excellence. [Hirn measured the torque by mechanical devices.] It would be found that readings might be made during the course of an experiment if a graduated arc and pointer were substituted for the two discs illustrated in Fig. 4, page 721, and their relative positions noted by the use of a system of interrupted illumination. This was effected by the rotation with the shaft of a radially-slotted disc, running in proximity to a correspondingly-slotted fixed plate screening a source of light; the slots should not exceed $\frac{1}{50}$ in. in width.

"The general effect was that the arc and pointer appeared constantly illuminated, and at rest so far as axial rotation was concerned; but use in a darkened room was necessary."

Yours truly,
Melbourne, October 20, 1914. Jas. Alex. Smith.

TOOL-DESIGNERS AND THE WAR.

To the Editor of Engineering.

Sir,—The status of the machine-tool or jig-designer was never of a very high order. He was regarded by the management as a sort of glorified mechanic; one who could make rough sketches of "cast-iron boxes with holes in them," or order cutters from a catalogue in a manifold book. The clerical staff always looked upon him from a virtuously elevated attitude as "one of those shopmen."

Is it not time that such old-fashioned notions were dispelled? A little reflection will prove what is the real value of a jig-designer in the present European disturbance. The speedy manufacture of automobiles for service, medical or victualling transport, has only been rendered possible by the hitherto despised "jig-man."

A glance through the advertising columns of any of the current issues of our leading mechanical journals will suffice to show that he is in great demand all over the country. Why? Because speedy manufacture is impossible without him. What is it that you require to manufacture in quantity, and so quickly? Ammunition, small arms, guns, scientific naval and military instruments, motor-cars, wagons, sewing-machines for harness work, press-work for canteen utensils, naval and military accoutrements in diverse forms?

This is a war of machinery, and now is the chance of the jig-designer to prove by his work that he is the indispensable factor in light engineering production. Not only for speedy manufacture is the need of the jig-designer's services felt, but also on the score of interchangeability. Government limits need to be fine when we consider the trouble likely to be caused, say, by a batch of automobiles whose units were not transferable in case of a small breakage. It would be an easy matter to disarrange a whole command in such an eventuality. Moreover, the war has brought about in some shops a complete upheaval. What was considered three months ago to be the staple and never-ending product of certain firms has been relegated to the background, and they are now feverishly dispatching batches of component parts of small arms, aeroplanes and automobiles, &c., either under sub-contract to the leading armament firms, or direct to the War Office and Admiralty. Such a state of affairs has only been rendered possible by the versatility and ubiquity of the jig-designer.

Furthermore, it is undoubtedly true that a large number of "repeat orders" have been secured, not by the plausibility of the salesman, but by the works manager's assurance that tools are made for the first order which are just as suitable for further sets of the same components, and has been able to guarantee times of delivery, relying upon the ability of the tool-designer to discover the most economical methods of handling the job.

He is a patient sort—this jig-man of ours. He has been content to proceed on his course in a very complacent manner. He is expected to be an expert draughtsman, because one mistake of his means a whole batch of scrap in the shops; a competent mechanic with a knowledge of machinery equipment from an engine lathe to a manufacturing auto, and the variety of jobs which he undertakes to tackle would indicate that he is somewhat of a "Star Protean turn."

He must possess a certain knowledge of pattern-making and of the art of the moulder and the smith. The fact is that however multitudinous and complex the various operations carried out in the factory, he must know a "little of all and a lot of some." Before he can hope to attain to a really good executive position, he must also become *au fait* with the works system, the sanctioning, purchasing, costing, inspecting, assembling, and selling departments, and possess an amount of tact only to be equalled by a rising politician canvassing an adverse constituency.

In short, who is so well qualified to fill the highest executive posts as the qualified tool-designer? He has only one limit to his ingenuity—that is, the amount of money the financier is prepared to risk in the exploitation of any one particular standard line.

If the capitalist is prepared to allow the jig-designer latitude to make parts in larger quantities, we have the men who are capable of reducing the cost of manufacturing articles in an astonishing degree. The one drag upon the science of interchangeable production is to be found in the smallness of the orders as found in English shops. We generalise too much. We market and accept orders for too many different types to be able to afford to give the tool-designer a free hand. The remedy is, of course, to be found in specialisation; but that is too wide a subject to be tackled in its entirety in the scope of an article of this description.

To revert to the jig-designer; he is broad in his ideas, is prepared and open to receive new ideas, and possesses the qualification of being able to decide upon the merits of two opposing arguments, because, as his life is made up of the eternal settling of rival claims, in his own mind and from his own experience, he is able to make decision quickly and accurately.

"Credit to whom credit is due."

Yours truly,
J. H. J.

OIL-FUEL IN WARSHIPS.

Trial of Yarrow Boiler, Designed and Constructed by Yarrow and Co., Limited, for a Battleship Ordered by a Foreign Power, Fitted with Kermode's Liquid-Fuel System, Mr. Clanahan, of Messrs. Kermode's, Limited, Superintending the Trial.

The boiler was fitted with Yarrow's latest feed-heater, and the Yarrow latest system of patent angle baffles on the tubes for the better distribution of furnace gases.

Heating surface, 4440 sq. ft.; capacity of combustion-chamber, 610 cub. ft.; fuel used, Texas oil; flash-point, 220 deg. Fahr.; specific gravity, 0.955.

Number of Hours.	Steam Pressure Lb. per Sq. In.	Air Pressure. Inches of Water.	Temperature of Feed-Water. Deg. F.	Oil-Fuel Pressure at Burners.	Oil-Fuel Temperature at Burners.	Actual Water Evaporation per Hour. Lb.	Oil Burnt per Hour. Lb	Pounds of Water Evaporated. Actual. Per Lb. of Oil Burnt.	Pounds of Water Evaporated. Actual. Per Sq. Ft. Heating Surface.	Pounds of Water Evaporated from and at 212 Deg. F. Per Lb. of Oil Burnt.	Pounds of Water Evaporated from and at 212 Deg. F. Per Sq. Ft. Heating Surface.	Pounds of Water Evaporated from 80 Deg. F. to Steam at 250 Lb. Per Lb. of Oil Burnt.	Pounds of Water Evaporated from 80 Deg. F. to Steam at 250 Lb. Per Sq. Ft. Heating Surface.	Oil per Sq. Ft. Heating Surface.	Mean Uptake Temperatures in Deg. F.	Flue-Gas Analysis. CO_2 Per Cent.	Flue-Gas Analysis. O Per Cent.	Flue-Gas Analysis. CO Per Cent.	Smoke: Black Smoke being 10.
April 23, 1913.																			
1	250	0.65	44	98	222	16,076	1261	12.74	3.62	15.73	4.47	13.13	3.73	0.284	350	9.15	8.05	—	2
1	250	2.26	44	203	218	41,541	3724	11.15	9.35	13.77	11.55	11.49	9.64	0.839	795	11 3	5.55	0.35	2
1	250	4.17	44	107	217	57,828	5682	10.18	13.02	12.57	16.08	10.49	13.42	1.280	1060	11.65	5.15	—	2
From 12.56 *p.m. until* 10 *p.m.*, *April* 24, 1913.																			
1	250	0.614	44	75	215	15,531	1197	12.98	3.5	16.03	4.32	13.38	3.61	0.269	307	10.2	7.0	0.1	2
2	250	0 6	44	75	221	14,929	1197	12.47	3.36	15.40	4.15	12 85	3.46	0.269	324	10.2	7.3	0.15	2
Mean of 2 hours			—	—	—	—	—	—	—	15.72	—	13.12	—	0.269	315	—	—	—	—
3	250	1 1	44	75	218	25,466	2261	11.26	5.73	13.91	7.08	11.61	5.91	0 509	605	10 4	7.3	0.25	2
4	250	1 1	44	75	218	24,786	2204	11.25	5.58	13.89	6.89	11.60	5 75	0.496	622	8.35	9.15	0.1	2
Mean of 2 hours			—	—	—	—	—	—	—	13.89	—	11.60	—	0.502	613	—	—	—	-
5	250	1.03	44	75	218	22, 600	2144	10.30	5.09	12.72	6.25	10.62	5.21	0.494	659	9.5	8.2	0.2	2
6	250	1.03	44	75	218	23, 511	2175	10.81	5.30	13.35	6 53	11.14	5.46	0.490	667	9.0	8.75	0.1	2
Mean of 2 hours			—	—	—	—	—	—	—	13.02	—	10.87	—	0.492	663	—	—	—	—
7	250	3.1	44	75	219	33, 256	3429	9.7	7.49	11.98	9.25	10.00	8.00	0 772	789	7.4	10.7	0.15	—
8	250	3.38	44	175	218	34, 428	3467	9.93	7.75	12.26	9.57	10.23	7.72	0.781	772	9.3	8.75	0.2	—
Mean of 2 hours			—	—	—	—	—	—	—	12.12	—	10.12	—	0.776	780	—	—	—	—

"THE INFLUENCE OF BANKS ON INDUSTRY."

To the Editor of Engineering.

Sir,—We have read with much interest your leading article of the 4th inst., which agrees so thoroughly with our letter that appeared in *The Times*, under the heading "Capital for British Trade Extension," on October 13. Nearly two months have now elapsed, and we have seen very little done, with one exception. The reason, in our opinion, appears in your article: "The passing of the Joint-Stock Acts, together with several disastrous bank failures, decided the fate of private banks."

The very many millions of capital which is necessary for an enterprise of this description will not be supplied by the British public until one or more of the financial leaders whom they can trust as regards ability and discernment come forward to support and carry through the campaign. Surely the Government up to the present have done their utmost. Must everything be left to them?

We are, Sir, your obedient servants,
Robinson, Williams and Burnands.

89, Mount-street, W., and Halton House,
20-23, Holborn, E.C., Dec. 9, 1914.

Westinghouse Employees and the War.—We are informed that a total of 1046 men have left the Westinghouse Company to join either the Army or the Navy, and two of them have been killed in action. The greater number have, of course, joined the Army Regulars and Territorials, many have joined the Public Schools Battalion, others have joined the newly-formed Naval Brigade as electrical engineers, and one ex-Westinghouse man has highly distinguished himself—*i.e.*, Mr. Sippe, who was one of the three who set out to fly over, and drop bombs on, the German airship hangars at Düsseldorf in October. From the commencement the Westinghouse Company has appointed a representative committee to deal with the men's dependants. In addition to this action by the Company, a sum of 1166*l.* 5s. 3d. was contributed during the first month of the war by the staff, and distributed to the various public relief funds, and a further sum is contributed regularly each week or month by the office and works employees for a stand-by fund; this amounted up to November 17 to no less than 1705*l.* 10s. 8d.

IMPROVEMENTS IN TRAMCAR DESIGN.

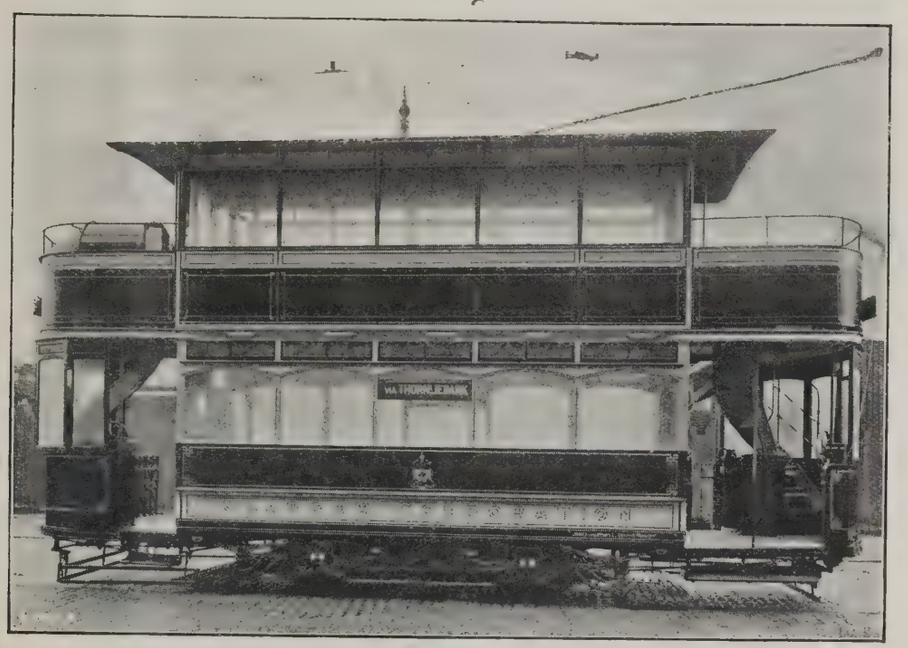
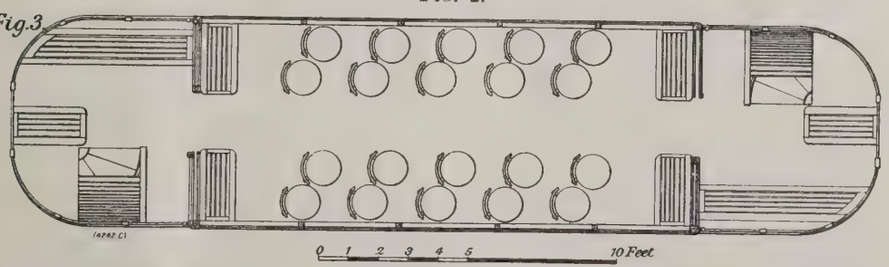


FIG. 1.

FIG. 2.

Fig.3



THE increased competition experienced by tramway systems from electric railways and motor-buses is a matter of serious import to the London County Council, more perhaps than to the municipal authorities of any of the provincial cities. But in London the problem has been met by increasing the capacity, in many cases, at busy times of the day, by adding trailers to the ordinary cars. In this way the possible revenue per mile is increased without corresponding augmentation of the wages cost. At the same time fares have been reduced in order to increase the number of passengers. On the other hand, the frequency of the stopping-places, and the larger number of passengers who have to leave and enter the car at each stopping-place, tend to increase the time taken in the journey between termini. The time occupied in transit by a tramcar is thus considerably augmented.

The stopping-time could be reduced if passengers could leave the car at one end while those entering boarded the car at the other end. There have been several proposals to modify the design of the car to suit this arrangement, and one of the most successful is that devised by the general manager of the Glasgow Corporation tramways, Mr. J. Dalrymple. The new design of car is illustrated on this page. Generally it conforms with the type adopted in the city, where the whole of the upper deck of the car is not covered in, the ends having only a canopy, so that the passengers have the advantage of sitting outside with partial protection from the weather. At the same time, a roller covering is provided at the top of the stairs, in order that it may be closed at the forward end for the protection of the driver of the car. The driving-platform at each end is now arranged with a front exit for the passengers on the lower deck of the car, so that they may leave on the near side of the road, while passengers entering the car do so on the near side at the rear platform. The arrangement is well shown in Fig. 1. The passengers' gate seen under the stairway is of the hinged type, and the step is geared with the gate in such a manner that the opening of the gate lowers it, while the closing of the gate raises it. Passengers are prevented from leaving the car on the wrong, or off, side by a hinged bar, secured on the platform. In order to provide head room for this exit, the stairway has been moved forward close up to the dashboard, while to increase the area of the platform for the exit of passengers, the ordinary brake-handle has been dispensed with, and a capstan wheel introduced, with a suitable gearing, for the operation of the hand brake. Inside, the heel-boards have been set back 2 in. on each side, in order to give more room for passengers and for the conductor moving about.

Another interesting feature has been introduced into this car, and this is illustrated by Figs. 2 and 3. In all tram-cars and omnibuses great inconvenience is involved by passengers moving along the gangway when there are two passengers on opposite seats. The arrangement of the seats in this new Glasgow car is therefore very commendable. Instead of two passengers sitting in a common seat which is barely long enough to accommodate both, each is provided with an independent chair with back-rest mounted on a pivot, which allows it to be turned round to suit the direction in which the car is travelling. Each pair of seats is not in line, but is staggered to the extent of 8 in., thereby allowing the shoulder of one passenger to overlap the shoulder of his neighbour. This arrangement considerably increases the width of the passage, and consequently conduces to the comfort of passengers either seated or moving along the gangway. The outside seats under the canopy at each end of the car have been increased in length. The long seats accommodate four passengers, and the short seats two passengers.

It may be added that route-number indicators are fixed below the canopies, and that a trial car made to this design has given great satisfaction. The Board of Trade has sanctioned the use of the car experimentally.

SUPPLIES FOR THE ALLIED GOVERNMENTS.—All questions relating to the purchase and export of food supplies, munitions of war, and field equipment for the French, Belgian, Russian, and Serbian Governments are now dealt with by the International Commission for the Purchase of Supplies (Commission Internationale de Ravitaillement). The executive office of this Commission, and the offices of the French, Belgian, and Serbian delegates thereon, are at India House, Kingsway, W.C., while the offices of the Russian delegates are temporarily at 192, Cromwell-road, S.W. Application for permission to export goods the export of which from the United Kingdom is prohibited should, if such goods are required by the Allied Governments or their accredited agents, be addressed in writing to the Commission.

THE SURVEYORS' INSTITUTION.—The Council of the Institution have been asked by the promoters of the Architects' Volunteer Training Corps to give it their official recognition, and to bring its objects to the notice of members. The council are persuaded that the corps is fulfilling a useful office, and would urge all members in the London district and suburban area who are eligible, and who have not already joined a military organisation, to give it their support. Even those who are unable to train can render assistance by becoming members and by assisting the corps to obtain and classify recruits, and advise men wishing to join the regular forces of the units most suitable to their knowledge and physical ability. It is proposed that the title of the corps should be changed to "The Architects' and Surveyors' Training Corps," but this still lacks official confirmation. The corps is recognised by the Architects' War Committee, the Royal Institute of British Architects, the Architectural Association, the Society of Architects, the Surveyors' Institution, and the London Master Builders' Association (under negotiation), as the official corps for these professions and kindred trades. The Colonel-Commandant is Lieut.-Colonel J. W. Marsdin Newton, and the Adjutant Lieutenant A. Courtenay Peach. The headquarters are:—The War Bureau, the Architectural Association, 18, Tufton-street, Westminster, S.W. Inquiries and applications for membership should be addressed to the Recruiting Officer, Mr. Allan Potter, at the above address.

FAILURE OF STEEL SHIP-PLATES.

*The Remarkable Failure of a Consignment of Steel Ship-Plates.**

By W. J. B. WILSON, Member.

FROM time to time the rules for testing iron and steel for shipbuilding purposes have been discussed and criticised, but the rules laid down by Lloyd's are probably the most generally used for testing steel for shipbuilding. Steel thus tested and passed is regarded as reliable material, which will stand a lot of very rough usage in the shipyard before developing any defects.

In 1907 the author's firm received an order for an ice-breaking cargo and passenger steamer, to be built to Lloyd's highest class under special survey. The material for the shell, which had been tested and passed by Lloyd's, and characterised by the surveyor as excellent, failed entirely to stand the ordinary work of the shipyard, and was subsequently condemned by their surveyors, notwithstanding that it fulfilled all the requirements of the rules as regards testing.

The vessel was begun in November, 1907, but, owing to delay in obtaining material, the shell plating was not taken in hand till the end of December. B strake was first worked, but, owing to the difficulty with the flanging of the garboard strake plates, several of which cracked, the rest of the shell was practically completed before the garboard strakes were in place. The garboard strake plates which cracked were carefully examined, but as the results of both bend and tensile tests were excellent, the failure at the time was put down to the severe cold prevailing (about – 25 deg. to – 28 deg. Celsius, or – 13 deg. to – 18.4 deg. Fahr.). The riveting of the shell was well in hand before the keel riveting was begun, but after a few garboard plates had been riveted, cracks were noticed between the rivets and the edge of the plate in the flange portion. These plates were condemned by Lloyd's surveyor, and cut out. During the process two of them cracked badly in the neighbourhood of the keel rivets, and appeared to be little better than hard baked clay, as a single blow with an ordinary hand-hammer knocked pieces out of the flanged portion (Fig. 1).

This sudden change in these plates, which had withstood flanging, punching, riveting, and in some cases also caulking, was very remarkable, and the job of riveting the keel was at once stopped until a thorough hammer-test of the flanged portion of all the remaining garboard plates had been made. This proving perfectly satisfactory, the riveting was resumed, and the riveters were ordered to report immediately any cracks; but only one or two occurred, and these were of a minute description.

About this time the cold again became very severe, and on January 11, 1908, garboard plate No. 4 starboard, which had then been riveted in the ship three weeks, was found to be badly cracked. The crack started from a rivet-hole in the flanged portion, and went off into the plate in a transverse direction, being about 10 in. long and about $\frac{5}{32}$ in. open at the widest part (Fig. 2, crack marked at X). This was clearly a case of spontaneous rupture; in fact, the conditions were precisely as those described in Holmes' "Practical Shipbuilding" (page 575, paragraph 562). When this plate was cut out, the material in the way of the keel-rivets cracked in the same way as those described above, and a new hammer-test was therefore made, with startlingly different results to the previous one, as every plate in the garboard strakes (with the exception of those previously replaced) cracked, pieces falling out in some cases. These plates were therefore condemned and cut out. So far the cracks had been entirely confined to the flanged portion of the garboard strakes; but during the cutting-out of the edge-rivets connecting the above plates to B strake, several of the plates in B strake also cracked. A new survey was then made by Lloyd's, and pieces cut out of plates in the ship, rolled from different charges, were tested. The tests are given below, and all proved satisfactory to the surveyor.

Mark.	Breadth (mm.).	Thick (mm.).	Area in Sq. Mm.	Length (mm.).	Broke at Kg.	Kg. per Sq. Mm.	Tons per Sq. In.	Elongation per Cent.	Fracture from Nearest End.
A.S.6 ..	37.9	8.7	329.73	200	13,920	42.2	26.5	23	55
E.S.2 ..	38.0	12.8	486.4	200	18,350	37.7	23.7	21	34
E.P.8 ..	38.0	7.8	296.4	200	10,660	35.95	22.6	26	30
D.P.1 ..	38.0	9.8	372.4	200	16,700	44.84	28.4	21	82

Bend tests were excellent so long as the test-pieces were not taken near any rivet-holes. Chemical analysis for phosphorus gave a percentage of 0.063, which cannot be regarded as affecting the material. After these tests, one may judge the astonishment created when one blow of a heavy hammer was sufficient to knock large pieces out of the flanged portion of plate A.S.6.

The net result of this survey was that all plates rolled from the same charge as the garboard plates, together with several plates which had bad surface defects, were condemned. The latter had been filled with some composition, which fell away during riveting. One plate had two large holes which had been filled up. A thin feeler pushed into these holes penetrated 1½ in., while the maker's brand was not 12 in. away, on the same side of the plate. This plate was returned to the makers, after having been specially pointed out to Lloyd's surveyor. The condemned plates, twelve in number, were in various strakes of the shell-plating, and during their removal, despite the care taken, the trouble spread over the whole of the bottom of the vessel. As an example, plate E.P. 3, ½ in. thick, which had been punched, sheered, bent, riveted, and caulked without any trouble, had to have the rivets in its lower edge removed in order to take out a plate in D strake. When the rivets were centre-punched preparatory to drilling them out, the plate E. P. 3 cracked, although it was not actually touched by the hammer, which was only an ordinary hand-hammer. In the lower edge of this plate, when all the rivets had been drilled out and driven, the author found sixteen cracks.

This plate was afterwards examined by Lloyd's surveyors, when it was plainly shown that one blow with a sledge-hammer was sufficient to cause cracks to appear between the edge and butt rivet-holes; but although the hammering was continued, not a single crack would travel far into the plate away from the rivet-holes. The failure still continuing, a new survey was made by two of Lloyd's surveyors, one of whom had previously tested the steel. Tests were made, which are annexed; but these, like all the others, threw not the slightest light on what was really wrong with the steel. The treatment of the steel was criticised, and the author passed three days of severe cross-examination, but was able successfully to refute all charges.

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders, November 27, 1914.

Sample No.	Mark.	
3	C.S.6.	Worked cold. This plate has only small cracks, but a bad surface.
4	C.P.5.	Worked cold. These plates crack when beaten between the rivet-holes with a sledge-hammer.
5	E.P.3.	

Tensile Tests.

Sample No.	Mark.	Breadth in Mm.	Thick (mm.).	Area (sq. m.).	Length (mm.).	Broke at Kg.	Kg. per Sq. Mm.	Tons per Sq. In.	Elongation Per Cent.
3	C.S.6	35	12.35	432.25	200	16,100	37.2	23.6	24.5
4	C.P.5	35	9.9	346.5	200	15,800	45.6	28.9	21.0
5	E.P.3	35	12.3	430.5	200	16,250	37.7	23.9	25.5

Fig. 1.

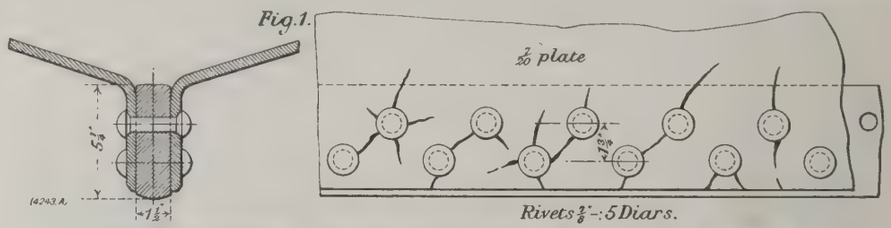


FIG. 2.

Fig. 3.

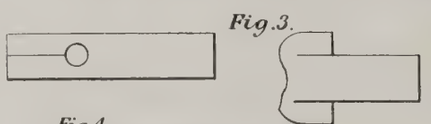
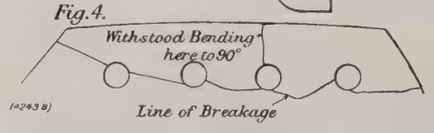


Fig. 4.



EXTRACT FROM OFFICIAL REPORT.

Five test-pieces were taken from each of five plates, one for bending with rough sheered edges, two for temper bend, three for tensile, four for forge, and five for punching tests. These test-pieces were taken from the condemned plates. The remarks "worked hot" or "worked cold" are to distinguish between plates which had been in the furnace and those that had not.

Cold-Bend Tests.—All the above samples with rough sheered edges bent double.

Temper-Bend Tests.—The samples were heated to a low cherry-red and tempered as per rules. Sample No. 3 was doubled and cracked slightly; sample No. 4 was doubled and cracked shortly before being doubled; sample No. 5 was doubled without cracks.

Forge Tests.—A hole was punched in each sample after it had been heated to a low red-heat. Then the sample was cut lengthways from the hole to the end of the sample, and the two ends were bent on the small edges through 180 deg. (see Fig. 3).

Punching-Tests.—Sample No. 4.—A row of holes was punched in one side of sample. Two holes were drifted so as to enlarge the original diameter by ¼ in. At the end of the rows punched in this sample two old holes were existing. The plate was now bent (flanged) hot to an angle of 90 deg. and allowed to cool slowly. It was then hammered so as to call forth bending over the row of holes. The metal between the old holes and the next new holes cracked first, and the next blow broke the sample over the line of holes, an end piece breaking right off. The other side of the sample was punched in the same way, and it was tried to bend the material cold over the line of holes; the material bent through 45 deg. without any cracks appearing.

Sample No. 1.—A row of holes was punched in the plate, and two old holes, one at each end of the row, were cut away. The sample bent (cold) over the line of

holes, and broke almost directly. The piece broken off withstood bending to 90 deg. (see Fig. 4).

After these tests had been made, the surveyors maintained that as the steel passed the tests laid down in the rules, they were not justified in blaming the material, unless a test could be devised which would, in their presence, prove the steel to be at fault.

The author, who had made scores of tests with a like object, had found one that gave the required results, and the description of this test, taken from the official report, is here given, together with photographs of the plate :—

'At last a butt-strap, which had not been worked into the vessel, and a plate of material made in a Swedish steel works (both stamped LR and branded with maker's name and charge numbers), were placed in a mixture of snow and salt, and the temperature of these plates reduced to −20 deg. Celsius (−4 deg. Fahr.). The plates were then quickly punched on one side for double riveting, and riveted together, care being taken that the edges of the plates opposite the holes were kept cool with ice (as much as possible to represent conditions when working in a low temperature). After the plates were allowed to cool down, the rivets were driven out, during which operation the one plate cracked badly, and a piece fell out. The broken plate is shown in the foreground of Fig. 2, and a detail photograph is given in Fig. 5. The plate from the Swedish steel works was also inspected, but did not show the least signs of cracks.

"From another plate two strips, 60 mm. wide, were cut, and four holes, $\frac{5}{8}$ in. in diameter, and $4\frac{1}{2}$ diameters apart, were punched, and the strips riveted together. The same was done with two similar strips, but with drilled holes, the temperature at the time being about + 4 deg. Celsius (39.2 deg. Fahr.). After cooling, the strips were bent through an angle of 25 deg.; the outer strip was found to be broken right through in the punched sample (Fig. 6), and cracks found in the drilled sample (Fig. 7)."

These butt-strap tests were sufficient to convince all concerned that the material was really entirely spoilt by riveting, as the extracts from the report of the surveyors given below show, and in which the builders are relieved from all blame, the workmanship being characterised as first class. A further proof that the material was bad is the very conclusive one of the new Swedish material, which, although worked in the same way, gave no trouble at all.

EXTRACTS FROM SURVEYOR'S REPORT.

"Samples cut from the centre or near the centre of the plates were then flanged under different circumstances, and the results of these tests seem to indicate that the material is liable to crack, and is becoming very brittle when heated and hammered, even when this heating only reaches the temperature called forth in the plates by the hot rivets.

"As regards the nature of the cracking, I beg to inform you that I never believed that steel could break so badly; a single blow with a hammer of about 6 lb. weight was sufficient in most cases to crack the material between the holes or between the holes and the edges. A strong blow broke whole pieces from the edges, and even we have beaten a hole of about 6 in. in diameter in one blow with a light sledge-hammer. Before riveting, these plates could be punched, bent and hammered, but as soon as the plates had been riveted the steel was spoiled altogether . . . I may still add that in my opinion the shipbuilders are not at all to blame. The workmanship seems to be first class, and every precaution seems to have been taken to treat the material well."

That material such as has been described in this paper is manufactured and afterwards tested and passed by the various classification societies as an everyday occurrence, the author does not for one moment insinuate, nor, further, that the utmost has not been done by the societies as far as the recognised tests would allow; but the accompanying photographs (Figs. 8 and 9), taken from another and larger-classed cargo vessel which the author's firm repaired, show that the recognised "utmost" is still insufficient. This vessel, although built for traffic in the Baltic in winter, got severely squeezed in pack-ice. Fig. 8 shows the indented side, although not giving a good idea of it. Inside, the cargo-hold's frames had been sheered as if cut by a knife; stringers and knee-plates connecting them to bulkheads were bent and twisted as if made of lead. These facts give some idea of the terrible pressure boats built for winter traffic have to withstand, and, therefore, of the necessity of using only the very finest material. Fig. 9 is from the same boat. Here the material was entirely of the same character as dealt with in this paper. With regard to the other vessel, the author feels certain that had not the first cracks been observed, the vessel would have been launched, fitted out, and classed 100 A 1, and that the first attempt at ice-breaking would doubtless have ended disastrously.

At the instance of a friend, the case of the plates dealt with in this paper was submitted to Professor J. O. Arnold, of the University, Sheffield, to whom the author is very deeply indebted for the most interesting and exhaustive tests which he made of this steel in the interest of science. Extracts from his report, which shed further light on the subject, are given below.

Department of Applied Science,
St. George's-square, Sheffield.

Dear Sir,—With reference to our examination of the broken ship-plate from Finland, we have obtained the following results :—

Chemical Analysis.

	Per Cent.
CC	0.05
Gr	Trace
Si	0.08
Mn	0.86
S	0.08
P	0.06
As	Trace

The material is a dead-mild steel which, from a chemica point of view, is not of very good quality. A micrographic examination of the material showed the structure reproduced in the accompanying micrograph (Fig. 10). The very small carbon contents are centred into dark etching areas, best described as the fourth phase of pearlite—namely, when it is passing into ferrite and massive cementite. When such high sulphur as 0.08 per cent. is present, dove-grey areas of sulphide of manganese are scattered through the steel in very appreciable numbers. The crystals have sharp angular boundaries; indeed, the material appears to have been overheated in the manufacture, and gravely injured by the operation,

A number of alternating stress tests were made, giving extremely unsatisfactory results. The conditions of testing were the standard method adopted here—viz. : the bars were $\frac{5}{8}$ in. in diameter, and the distance from the zero of stress to the plan of maximum stress 3 in. ; the deflection each way on the zero plane was $\frac{5}{8}$ in., and the rate of alternation 650 per minute.

Good mild steel should endure a minimum of 300 alternations of stress. The faulty steel, however, in eight tests averaged only about one-third of this, or 100 alternations. This is the worst steel of its class I have ever examined under alternating stress.

I have not had the tensile tests made, as in such cases these would be of very little use, usually giving very fair results. As regards the bends, I send also three of the bars used in the alternating-stress tests. As you will see, they have bent double without any sign of a flaw. This also is quite usual.

I am a little puzzled as to the origin of this steel, since the high silicon, 0.08 per cent., suggests an acid steel. It may, however, be a basic steel, over-treated with ore, to which manganese and silicon have been added in the ladle. If the carbon were, say, 0.2 per cent. instead of 0.05 per cent., I should with some confidence class it as Bessemer steel; as it is I find it difficult to suggest its method of manufacture with any degree of certainty.

The overheating to which I referred would take place in manufacturing the plates from the slab ingots. When such ingots are heated to too high an initial temperature and rolled, they leave the rolls at too high a temperature, cool too slowly and crystallise; and if such plates are stacked in heaps to cool, it is obvious that the cooling is still slower, and the crystallisation more perfect, and hence more dangerous. . . .

I remain, dear Sir, yours faithfully,
J. O. ARNOLD.

That the ordinary methods of testing were in this case insufficient to detect this bad material certainly seems to place shipbuilders and others in a position in which they run grave risks. It is certainly worth considering whether the tests, in connection with which a mixture of snow and salt was used, described above, should be adopted or not, as they decidedly detected the fault in this steel.

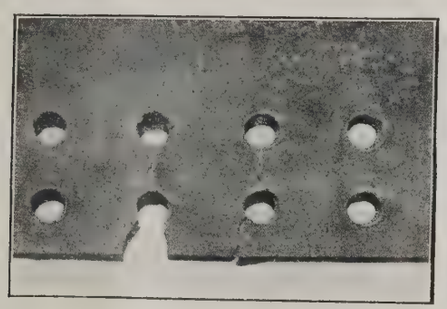
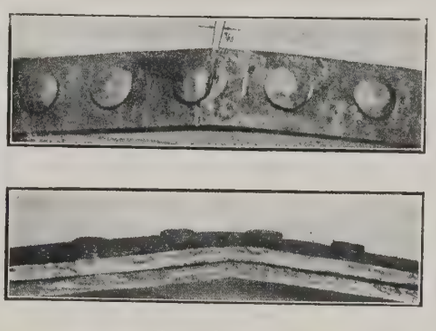


FIG. 5.



FIGS. 6 AND 7.

FIG. 8.

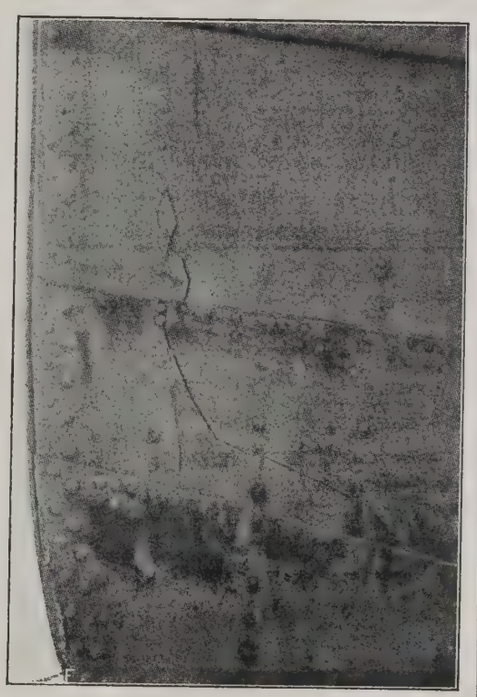


FIG. 9.

FIG. 10. FRACTURED SHIP-PLATE. TRANSVERSE SECTION. MAGNIFIED 184 DIAMETERS.

SURFACE-GRINDING MACHINE: ADDENDUM. — With reference to the "Linisher" surface-grinding machine, illustrated and described on page 667 of our last week's issue, we are now informed by Mr. R. H. Lash that he is not the designer of the machine. The machine was patented by Mr. R. Townsend, and Mr. Lash, whose address is 31, Carburton-street, London, W., has special manufacturing arrangements with the inventor.

REINFORCED CONCRETE, CONCRETE-CASED STEELWORK, AND THE EFFECT OF FROST ON CONCRETE.

THE following are abstracts of papers read at the ordinary meeting of the Institution of Civil Engineers on Tuesday, December 1:—

Tests of Reinforced-Concrete Structures on the Great Central Railway.

By JAMES BENJAMIN BALL, M. Inst. C.E.

THE Great Central Railway Company have completed within the last six years several considerable works in reinforced concrete, the more important of which include a bridge carrying a public road over their main lines at Ashton-under-Lyne, believed to be one of the heaviest reinforced-concrete bridges of its type yet constructed in England; a bridge carrying a new road and tramway over the Grimsby District Light Railway at Immingham Dock; and several reinforced-concrete bridges in the dock area at Immingham, as well as a large engine-shed at Immingham Dock, the foundations and pits of which are constructed in reinforced concrete throughout.

Reinforced-Concrete Over-Bridge, Ashton-under-Lyne.—This bridge consists of parallel girders of three spans. The main girders also form the parapets of the bridge. On a level with the bottom booms are formed the main deck-beams or cross-girders, and between these again are the smaller deck-beams parallel to the main girders, supporting the reinforced-concrete decking. The entire superstructure is reinforced with round bars on the Hennebique system.

The abutments at each end are of mass concrete, but the piers are braced and reinforced. The main girders only rest on the abutments, and are not anchored down in any way; moreover, they are not continuous, there being a space of 1½ in. between the girders over each of the intermediate supports for expansion; thus each span is independent, and consequently any slight settlement which may take place in the abutments or piers will not affect the stresses on the reinforcement, and in each case the full bending-moment effects due to both dead and live loads were taken into account. Both tensile and compressive reinforcements were used in all the beams, the percentage of reinforcement in the main girders being exceptionally high, on account of the small area available in the compression flange.

The bridge was tested with a dead-load of 1 cwt. per sq. ft., and a rolling-load of two 16-ton traction-engines, each drawing a lorry loaded with pig-iron to a weight of 32 tons, or a total moving load of 96 tons. In all cases the recovery was complete after the load was removed. The working stresses were limited to 700 lb. per sq. in. maximum compressive stress on the concrete, and 16,000 lb. per sq. in. tensile stress on the reinforcement. The actual cost of the work, as carried out in reinforced concrete, amounted to 5917*l.* The estimated cost of a similar structure in steel and masonry was 8390*l.*

Reinforced-Concrete Bridge Carrying New Road and Tramway over the Grimsby District Light Railway.—This bridge, also designed on the Hennebique system, consists of a roadway 40 ft. wide, extending over two spans of 37 ft. 2 in. and 31 ft. 2 in. respectively. There are five main longitudinal beams, the two outer of which also carry a reinforced parapet. The parapets, however, are not designed to take any portion of the load stresses. Between these main beams cross-beams are arranged, which support reinforced decking. The percentage of reinforcement ranges from 0.60 per cent. in the cross-beams to 4.67 per cent. in the outer main beams of the longer span. The bridge was tested with two moving tram-cars, and no appreciable deflection was recorded on any of the beams. It was designed to allow for the passage of two 40-ton boiler-trolleys drawn by a 15-ton traction-engine, that portion of the bridge not covered by the moving loads being loaded with 1 cwt. per sq. ft. In computing the stresses, the various members were taken as being freely supported, and no allowance was made for the continuity of the beams or for the fixity of the ends, the allowable working stresses being the same as in the case of the previous bridge. The actual cost of this bridge, carried out in reinforced concrete, was 2939*l.* The estimated cost of a similar structure in steel-work and masonry was 3500*l.*

Four High-Level Railway Bridges, Immingham Dock.—These are all skew spans of the same construction. Each bridge carrying four tracks over a siding for empty wagons, and forming practically a tunnel 86 ft. long. The square span between the abutments is 15 ft. Both the wing-walls and abutments are reinforced, and there are in addition reinforced tie-beams at the bottom of the abutments, at the same spacing as the cross-girders, embedded in a concrete raft. The bridges were designed to carry axle-loads of 18 tons, spaced 6 ft. 6 in. apart, or 72 tons on the single-line span. The average cost of these bridges in reinforced concrete was 3024*l.* each. The estimated cost of a similar structure in steel-work and masonry was 3800*l.* each.

Reinforced-Concrete Foundations and Pits for Engine-Shed at Immingham Dock.—This work consists of a reinforced-concrete raft, so spread that the load on the ground nowhere exceeds 10 cwt. per sq. ft., and the engine-pits form part of the raft. The floor of the shed is carried on the pit-walls; it consists of a reinforced-concrete deck between each of the pits, and is not in any way dependent on the earth filling underneath. There are, in addition, fourteen independent reinforced-concrete engine-pits outside the shed, of a similar design to those in the shed, but without any flooring between. Reinforced tie-beams are provided every 60 ft. apart between the pits. Kahn bars were used throughout in the reinforcement of this work. The actual cost of the work as carried out in reinforced concrete (engine-pits and foundations only) was 8850*l.* The amount of an actual tender received for brick pits on a reinforced-concrete slab was 12,920*l.* An estimate for brick pits on concrete carried on timber piling was 15,150*l.*

Corrosion of Steel Wharves at Kowloon.

By SOMERS HOWE ELLIS, M. Inst. C.E.

The wharves to which this paper refers were constructed in 1907-9, and are situated on the mainland side of Hong Kong Harbour, at the south-eastern corner of the Kowloon promontory. They belong to Messrs. Alfred Holt and Co., of Liverpool, the ships of whose Blue Funnel line, of a capacity of 6000 to 10,000 tons, use No. 1 wharf for discharging and loading. Wharves Nos. 2 and 3 serve for lighters, native craft, and an occasional small coasting steamer.

In 1906, in connection with the construction of a wharf, an examination was made of some steel-joist piles which had been placed for about four years, and they were found to be corroded in a curious and rather alarming manner. Any steel immersed in sea-water at Hong Kong becomes quickly coated with barnacles and other shell-fish, and with a dense vegetable growth, particularly from near the surface of the water to 15 ft. or so below it. It had been an accepted theory that this growth protected the metal and prevented rusting. On scraping away the growth from a pile of the wharf examined, however, it was found that a large number of pits had formed in the surface of the steel, varying in size up to 1¼ in. in diameter and ⅜ in. deep. They were full of a black carbonaceous powder, which was also found in a thin layer on the surface of the unpitted steel (though no rust or scale could be observed there), and which, on exposure to the air, turned to a dark-red colour. This powder was found to be sulphide of iron (FeS), and its change of colour to be due to oxidation. Apparently, some particular shell-fish or other marine growth attached to the piles produces large quantities of sulphuretted hydrogen when dead and decaying. This sulphuretted hydrogen attacks the metal, with an accentuated action in certain spots, producing the pits described; and it is evident that when once the process is started, the deposit of sulphide favours more rapid erosion beneath it.

The author examined at that time some steel piles of an H-iron pattern, which had been in place only three or four years, and estimated that 10 per cent. of the metal was eaten away in some sections, chiefly in the form of pitting. The destructive effects of the marine growth appear to be confined to the part between low-water level and 15 ft. below it, the zone of worst corrosion extending from 5 ft. to 10 ft. below low-water level. As a result of this inspection the author recommended that the piles and lower bracing of the main (No. 1) wharf should be encased in cement concrete; and it was eventually decided to encase the whole of this structure, leaving the other wharves—Nos. 2, 3, and that fronting the Praya Wharf—with bare steel, which was painted with anti-corrosive composition on erection.

The work of constructing these latter wharves was completed in 1908. Since then the superstructure and the piles above low-water level have been scraped and painted annually, and the steel has been kept in fair condition, with no marked deterioration, except in one year when a longer period than twelve months was allowed to elapse between the re-coatings. The yearly cost of maintenance is about 100*l.*, for a total deck area of 34,000 sq. ft.

Two years after completion, pitting had commenced on the under-water surface of the piles, the construction coating of paint having then almost disappeared, and a thick layer of shells and marine growth having become attached to the metal. In April, 1913, a European diver found that this corrosion had developed throughout to a serious extent.

The method adopted in encasing the piles of No. 1 wharf was the following:—The piles—12-in. by 12-in. 80-lb. joists in single unspliced lengths up to 78 ft.—were first driven with an ordinary pile-driver. Welded-steel cylinders, 20 in. in diameter inside, with metal ¼ in. thick, were then dropped over the piles and tapped down into the mud with an 8-cwt. wooden hammer. The face row of piles, being driven in close pairs, were enclosed in cylinders 3 ft. in diameter, built up of ¼-in. steel plates with riveted joints. A depth of 4 ft. to 15 ft. of the bottom of each cylinder (according to its depth) was then filled with 1 : 2 : 4 Portland-cement concrete, lowered down through the water in metal hopper-boxes, and when this had set the cylinders were pumped dry at low water and filled with concrete thrown in and rammed in place. The wharf superstructure was coated with concrete by encasing each member in temporary wooden moulds. A minimum cover of 2½ in. was provided throughout, the concrete being of Portland cement of standard quality, sand, and granite broken to pass a ¾-in. ring, in the proportion of 1 : 2 : 4 by measure, mixed by hand.

In July, 1910, when the whole of the work had been completed about a year, and the bulk of it for two years, the author made an inspection of the wharf and was unable to detect any sign of deterioration of the surface, but he did not cut into the concrete. Three years later, obvious indications of corrosion within were apparent on the surface of the concrete. Most of the diagonal members had developed longitudinal cracks in their upper lengths, above high-water mark, and the under surface of the casing to the deck-beams showed similar defects in a few places—all the cracks having formed in line with the outer edges of the channels of which the various members are built up. Rust stains were also visible on the concrete above high-water level.

Thorough examination of the whole structure revealed that above high-water level corrosion appeared to have gone on almost unchecked by the presence of the concrete covering, and a thickness of about $\frac{1}{16}$ in. of rust-scale was found on all the steel members in this zone on their under and outer sides. The upper sides of the top horizontals could not be examined without removing the timber deck, which at the time it was not convenient to do. The vertical posts were in slightly better condition, apparently owing to the concrete which encased them being of a denser quality, as their position allowed of more thorough ramming into place.

Although the workmanship was not everywhere good, the author was forced to the conclusion that even when perfectly encased in a 2½-in. covering of sound, homogeneous concrete, the steel was not protected against the effect of excessively damp, salt air in that climate. The limit of serious rusting may be taken as high water of neap tides; below that level the corrosion diminished rapidly down to mean-tide level, and there it practically disappeared. The lower bracing members of the wharf in question were all found to be entirely unaffected by corrosion.

The author concludes that while steel protected by concrete has little or no tendency to corrode if it becomes thoroughly wet twice in the 24 hours, yet when it is exposed to air rendered constantly damp by the evaporation of sea-water, especially in a tropical climate, some other external coating must be sought for, either as an addition to the concrete or in place of it. The corrosive effects of salt, damp air appear, however, even in such a climate as that of Hong Kong, to be limited to a zone immediately above the surface of the water. Steel-work, both exposed and embedded in concrete, in warehouses on the same property, is not thus affected. Neither, in the author's experience, does the evaporation from fresh water affect steel embedded in good concrete.

Concreting in Freezing Weather, and the Effect of Frost upon Concrete.

By JOHN HAMMERSLEY-HEENAN, Assoc. M. Inst. C.E.

The engineer who is called upon to carry out work in Canada during the winter finds that the methods of construction which were satisfactory in the summer will need considerable modification to suit winter conditions.

Concrete work, especially the lighter forms of reinforced concrete used in building construction, needs greater care and supervision. As a result of considerable experience gained during the last few years, it can be said that the freezing of concrete will not damage it if it has first had a chance to set under favourable conditions for about two days. The effect of the freezing is simply to delay the process of hardening, which will again proceed under suitable conditions, and will eventually attain its full strength. If concrete is frozen before it has commenced to set, it will not be injured if precautions are taken to prevent it from freezing again after it thaws until it is sufficiently hardened to withstand the effects of subsequent freezings. It is alternate freezing and thawing during the process of setting that causes the damage.

To meet the foregoing conditions, when carrying out concrete work in winter, it is necessary to devise means of mixing the concrete with materials freed of frost, placing it in the forms before it has commenced to freeze, and then protecting it and keeping it warm for about two days. After that it may be allowed to freeze without fear of its being damaged. In the case of concrete-in-mass of large bulk it is unnecessary to apply external heat, as the large body of concrete will generate sufficient heat during the process of hardening to enable the mass to set; all that will be necessary is to protect the outside of the concrete so as to keep the heat in. This can best be done by covering the concrete with clean straw.

For light sections of concrete, such as reinforced concrete, poured at a temperature not below 22 deg. Fahr., some engineers allow salt to be used in a proportion not exceeding 10 per cent. There are many arguments for and against its use. The author prefers not to use it, except in marine works when the concrete is mixed with sea-water and the salt is admitted in that form. He has found that, instead of using salt, good results will be obtained for temperatures that do not fall below 22 deg. Fahr. by heating the water with a steam hose taken from the mixer boiler, and when necessary placing a few coke or wood fires on the heaps of sand and crushed stone, the usual precautions being taken to protect the concrete when in the forms, as described later.

For lower temperatures than those referred to above, greater precautions must be taken to heat the ingredients by means of steam coils or radiators.

The concrete having been mixed, and the portion of the work to be carried out decided upon, the floor immediately below it should be partitioned off with tarpaulins, and coke stoves arranged under the floor-slab, allowing about one stove to every 800 sq. ft. of floor-space. All loose dirt and snow must be removed from the forms with brooms, and a steam-hose should be applied to remove all ice and frost, the steam playing continuously over the forms in advance of the concrete, thus warming them in readiness for the concrete. The concrete should be poured quickly and continuously, and as each section is completed a tarpaulin may be drawn over it, supported on wooden strips about 6 in. above the surface of the concrete. In most cases this protection will be sufficient, but during very cold weather it will sometimes be found necessary to form a sort of tent over the floor, in which extra stoves are placed to protect the workmen and the upper surfaces of the concrete. Great care must be taken to have the fires kept burning continuously for two days, after which the concrete may be allowed to freeze without fear. The work must be examined from time to time until it is found to be hardened sufficiently. During summer working the author has allowed the supports from the under side of

slabs to be removed in four days, but on other occasions four weeks have not been found to be too long. There are many examples of concrete works which have stood the test of time without showing any signs of being affected by frost; but, on the other hand, a few cases have been reported of very serious corrosion due to the action of frost, such as bridge piers and reinforced-concrete piles.

Judging from the information available at present, concrete exposed in air in a dry locality need not be affected by frost any more than good building stone, and probably it will stand much better. Concrete always submerged under water is protected and need cause no anxiety. But concrete alternately wetted and frozen must be protected from frost. On work which is being carried out at Halifax, Mr. John Kennedy, M. Inst. C.E., is protecting the concrete piles between high and low water with a covering of wood about 2 in. in thickness, which it is hoped will prevent the action of frost.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Australia: The Imperial Trade Correspondent at Adelaide reports that that city is threatened with a water famine, and bores and wells are being put down by manufacturers and others as an insurance against the stoppage of their businesses. One result of this situation is that there will probably be a brisk demand for filters of all descriptions, but principally for a cheap and simple type. Well-casing, chiefly 6 in., will also be required.

New Zealand: H.M. Trade Commissioner for New Zealand reports that tenders are invited in the local Press for heating and ventilating plant for the new Parliament Buildings at Wellington. Tenders on the proper forms will be received up to noon on January 8, 1915, at the Public Works Office, Wellington, New Zealand. The time for the receipt of tenders being limited, this intimation will be of use only to firms having agents in New Zealand who can be instructed by cable.

France (Algeria): The following information was prepared, prior to the outbreak of the war, by the British Vice-Consul at Constantine. The Biskra-Touggourth Railway opens up the Sahara Desert in a very great measure, and considerably facilitates communication with the many tribes, whether nomadic or living in the numerous and ever-increasing oases. It is possible that there may be here a market for red and printed cottons and calicoes, such as are sold to the natives of India. There is still a market for all kinds of mining machinery, light portable railways, and all tools and equipment required by prospectors and for mines in their initial stages of exploitation. In a general way the services of a good agent are necessary to push the sale of these articles, as the market is not sufficiently important to justify the opening of branches or the sending out from the United Kinghom of special agents. In all cases prudence is recommended in credit dealings with Algerian firms.

Spain: The *Gaceta de Madrid* publishes a Royal Decree authorising the Ministry of Finance to present to the Cortes a Bill for the approval of certain extraordinary and supplementary credits, including, *inter alia*, the following items in respect of the Ministerio de Fomento:—Construction, repair, and upkeep of roads, 10,800,000 pesetas; surveys and material, &c., for hydraulic works, 140,300 pesetas; dredging and other port and river improvement works, 1,000,000 pesetas; construction and working of the Avila-Peñaranda Railway, 500,000 pesetas; railway from Estella, through Vitoria, to link up with the Durango-Zumárraga line, 400,000 pesetas; strategic railway from Puertollano to La Carolina, 300,000 pesetas.

Colombia: The *Diario Oficial*, Bogotá, contains a decree authorising a Technical Commission to make surveys and to present to the Ministerio de Obras Públicas plans and estimates for the completion of the Girardot-Ibagué section of the Pacific Railway. After these studies have been concluded, the Commission will proceed to make surveys for the section between Ibagué and Calarcá, and finally for the continuation of the railway to Palmira.

RAILWAY CONSTRUCTION IN NORWAY.—The Norwegian Storthing passed in the year 1908 a complete plan for railway construction for the ensuing twelve years, till 1920. It was intended that a new plan for continuing the development should be ready in good time. As the original plan has been abandoned in some respects, as for instance, in the building of the Rauma Railway and the Thelemark Railway, the drawing up of a new plan has now become a necessity. The preparatory work in this connection is progressing, and the railway authorities expect that they can get the new programme ready to be laid before the legislature in the year 1918.

MOTOR-CARS IN DENMARK.—The number of motor-cars in Denmark is rapidly increasing. On September 1 last there were registered in Denmark 3430 motor-cars, with an aggregate capacity of 28,122 horse-power. Two years previously the number only amounted to 1587. The imports of American-made motor-cars are increasing, the figures being, respectively, 40, 32, 61, and 106 for the years 1910 to 1913, and 225 for the first seven months of 1914. The American cars are somewhat lighter—about 5 per cent.—than the all-round average. The demand is for motor-cars of the smaller sizes. There are, further, in Denmark 5248 motor-cycles, averaging in capacity 2½ horse-power.

CATALOGUES.

Revolving Shutters, Shop-Fronts, &c.—We have received from Messrs. S. W. Francis and Co., Limited, 64 to 70, Gray's Inn-road, W.C., a copy of their latest catalogue of steel rolling shutters, wood revolving shutters, shop-fronts, collapsible gates, sun-blinds, plate-glass facias, &c. Numerous examples of the firm's productions are illustrated.

Refuse-Destructors.—A copy of their new catalogue of refuse-destructors on the "Horsfall" system has been issued by the New Destructor Company, Limited, Welsbach House, Gray's Inn-road, W.C. Several installations are illustrated and described, and working results are given. Clinker-crushing and screening plant, tin-baling machines, mortar-mills, and other accessories are also dealt with.

Iron Castings.—Messrs. Head, Wrightson and Co., Limited, of Stockton Forge, Norton-road, Stockton-on-Tees, have sent us a little booklet illustrating examples of iron castings manufactured by them. The examples include segments for large sewers and tube railways, bollards, tanks, rolling-mill housings, blast-furnace parts, ingot moulds, railway-chairs, gear-wheels, plummer-blocks, &c. The firm's foundries have an annual capacity of 100,000 tons, and single castings can be supplied up to 40 tons in weight.

Hobs and Broaches.—From Sir W. G. Armstrong, Whitworth and Co., Limited, of Ashton-road, Openshaw, Manchester, we have received a copy of a booklet entitled "Hobs and Hobbing," recently issued by them. The booklet contains much useful information on the subject, and illustrates examples of hobs which the firm manufacture in their well-known "A.W." and "A.W. Premier" high-speed steels for hobbing spur, worm, and spiral gears, and for cutting sprocket-wheels, castellated shafts, &c. Examples of broaches, also made of "A.W." high-speed steel, are also illustrated. These tools are made in any size up to 48 in. long and 4½ in. in diameter. Prices are stated for hobs for cutting spur-gears.

Double-Speed Bottom Block for Cranes, &c.—Messrs. Herbert Morris, Limited, of Empress Works, Loughborough, have sent us some particulars of the Morris patent double-speed bottom block for cranes and other lifting appliances. The object of this device is to enable light loads to be lifted at twice the normal speed, and it can be applied to any crane, pulley-block, or travelling gear in which the lifting chain passes round a pulley attached to the hook. For this purpose the block is provided with an attachment for linking on to the "live" side of the chain, so that the load is supported and lifted by one chain only, and thus travels up at twice the normal speed. Obviously the load lifted in this way should not exceed half the total capacity of the crane, but, as many of the loads lifted are usually quite light for the crane, much time may be saved by means of the device. At the same time, the normal lifting arrangement for heavy loads can be used by merely detaching the link from the chain. The blocks are made in ten sizes, for maximum loads ranging from 1 to 15 tons.

Coating Objects with Metals.—A four-page pamphlet, briefly describing the Schoop process of depositing metals, and mentioning some of its many applications, has come to hand from the British Metal Spray Company, Limited, of Queen Anne's Chambers, Tothill-street, Westminster, S.W. The process was described in a paper submitted to the Institute of Metals by Mr. R. K. Morcom, and reprinted in our issue of September 25 last, on page 382, where full particulars of it will be found. Briefly the process consists of melting and pulverising the metal by means of a oxy-hydrogen blow-pipe, and spraying it on to the surface to be coated by a jet of compressed air. In this way adherent or non-adherent deposits can be produced. Adherent deposits may be used for protecting surfaces against physical, chemical, or mechanical influences, as well as for strengthening materials and rendering them electrically conductive. They may also be used for the ornamentation of the surfaces of metals, wood, plaster, pottery, glass, fabrics, and other materials. Non-adherent deposits can be used for the production of seamless metal tubes, dental-plates, printing-blocks, dies for striking medals, and for reproducing objects in metals. The company have a laboratory at Wolverhampton, where they demonstrate the process to intending purchasers.

Lubricating Grease, &c.—The Keystone Lubricating Company have sent us from their English dépôt at Whittle's Croft, Ducie-street (City), Manchester, a quantity of printed matter relating to their products. Among it is a catalogue giving full particulars of "Keystone" grease. This substance is a purely mineral grease, produced by the treatment of petroleum, and contains no resin, graphite, soapstone, or other added ingredients. It will keep indefinitely, and is claimed to be quite unaffected by fresh or salt water or steam. In order to meet all requirements, "Keystone" grease is supplied in eleven different densities, and full particulars of the properties of each grade are given in the catalogue. Greases for manilla ropes and wire-cables are also dealt with. The catalogue also illustrates screw and spring grease-cups, suitable for use with "Keystone" grease, and gives some useful notes on the lubrication of shafting. Another booklet deals with the use of "Keystone" greases and oils on motor-cars, and claims that the cost of upkeep is greatly reduced by their use. A binding case containing a set of bulletins issued by the firm at frequent intervals since May, 1911, has also been received. These bulletins contain articles on the lubrication of different classes of machinery, give full particulars of all the company's products, and also include the results of chemical and mechanical tests.

Steam-Engines.—From Messrs. Robey and Co., Limited, of Globe Works, Lincoln, we have received a very attractive catalogue of "Uniflow" steam-engines. These engines have drop-valves for steam admission, and exhaust takes place through ports in the centre part of the cylinder, the ports being uncovered by the piston near the end of each stroke. The steam thus travels always in the same direction, and the exhaust leaves the cylinder as far as possible from the inlet. Initial condensation is thus greatly reduced, and a much greater ratio of expansion can be used in a single cylinder than would be practicable in an engine of the usual design. It is claimed that a single-cylinder "Uniflow" engine is as economical as a high-class triple-expansion engine. Simplicity of construction and economy of floor space are other important advantages claimed for "Uniflow" engines, and these claims are obviously just ones. The construction of the firm's class "ES" horizontal, single-cylinder condensing "Uniflow" engines is illustrated and described in detail, and weights, dimensions, and other data are given of engines of this type, varying from 100 to 850 indicated horse-power. Several examples of these engines used for driving factories, mine-fans, and electric generators are illustrated in the catalogue. Particulars are also given of under-type "Uniflow" engines, which are listed in six sizes, both condensing and non-condensing. The former range from 20 to 200 horse-power, and the latter from 24 to 160 horse-power. A few other of the firm's productions, including large air-compressors and winding-engines, are illustrated in the catalogue, and some useful tables and notes on belt-driving and rope-driving are also included.

Transformer Oil-Dryers and Filters.—The British Thomson-Houston Company, Limited, of Rugby, have sent us a very interesting descriptive price-list dealing with their dryers and filters for transformer oil. The presence of a very small percentage of water in transformer oil greatly reduces its insulating properties, and in order to obtain a dielectric strength of 40,000 volts in the standard test (*i.e.*, between discs 1 in. in diameter 0.1 in. apart), as is required for all high-tension work, the quantity of water present in the oil must not exceed 0.001 per cent. Fine dust, especially if metallic, is almost as deleterious as water, so that drying of the oil alone is not sufficient. It is also necessary to remove any sediment which may result from long-continued heating, in order to preserve the normal viscosity of the oil, and to prevent incrustation of the interior parts of the transformer and the clogging of the oil-channels. The British Thomson-Houston Company therefore supply a compact set of apparatus, which comprises an electrically-driven pump and filter-press, for drying and cleaning the oil while the transformer is in service. The oil is drawn from the bottom of the transformer tank by the pump, which is either of the rotary or centrifugal type, and forced at a pressure of from 25 lb. per sq. in. to 100 lb. per sq. in. through layers of dry white blotting-paper suitably supported in the filter-press; from the filter the oil flows back to the top of the transformer tank. Most of the solid matter is caught by the first layer of paper, while the water is retained in the paper by capillary action. The capillary attraction between the paper and the water is greater than that between the paper and the oil, and the drying effect depends entirely on this fact. That this is really the case can easily be demonstrated by soaking a strip of blotting-paper in oil and another in water. If the oily strip is immersed in water the oil will be driven out and replaced by water, whereas if the wet strip is placed in oil it will be quite unaffected. The list contains a detailed and fully illustrated description of the apparatus, which is made in both stationary and portable forms. It also describes an electrically-heated oven for drying the filter-papers so that they can be used again and again. The outfits are also in use for purifying crude petroleum for oil-fired furnaces, insulating varnish and japan, benzine used for cleaning purposes, and viscous insulating compounds, as well as for treating transformer oil. Particulars are also given of apparatus for drying out the windings of transformers before they are filled up with oil. The apparatus comprises an electrically-driven fan, the discharge from which passes through an electric air-heater and thence into the transformer. The list is a very interesting and useful publication, and well worthy of the attention of central-station engineers and others.

THE MERRYWEATHER "HATFIELD" MOTOR FIRE-ENGINE.—At Workington, an engine of this type, which has done good work since it was placed in commission a little over a year ago, had, we are informed, a somewhat novel experience recently, on the occasion of a fire which occurred at the Lowca Coke-Ovens. The Workington Brigade received the summons at 10.15 a.m., and reached the scene of operations, 4½ miles away, at 10.30 a.m. Four tanks, containing about 3000 gallons of naphthaline and 2500 gallons of creosote oil, were found to be burning fiercely, and were a menace to seven large cylindrical tanks, which were stationed only 4 ft. away from the burning tanks, and which contained 38,000 gallons of benzol and naphtha. The motor-engine, which is of the 400-gallon size, commenced pumping water on to the flames, but subsequently, as there was so much at stake, it was decided to use ammoniacal liquor, of which there was a good stock at the works. The change from one supply to the other was quickly made, and with two jets operating, the fire was extinguished at 12.10. The fire was prevented from spreading to the large cylindrical tanks; the magnitude of the flames may be realised by the fact that 60 tons of ammoniacal liquor were pumped by the motor-engine before the fire was subdued.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

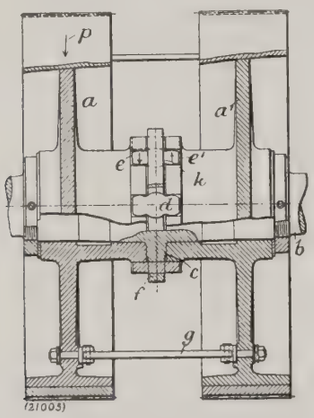
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

MACHINE AND OTHER TOOLS, SHAFTING, &c.

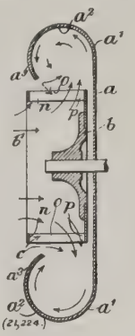
21,005/13. C. Marsden, Harlington, and the Power-Plant Company, Limited, West Drayton. Toothed Gearing. [1 *Fig.*] September 17, 1913.—In toothed gearing for very large powers, particularly in connection with steam-turbines, it is necessary to use pinions of comparatively small diameters in order to keep the tooth-velocities within admissible limits. Such pinions are of great face-width on account of the comparatively small tooth-pressure which must be used at high tooth-velocities. Up to a certain face-width, two bearings, one at each end of the pinion, are used. Above such face-widths, the pinion must be supported by at least three bearings, two at the ends, and one in the centre of the face-width, in order to prevent the pinion from bending excessively under pressure of the teeth. The invention consists in the employment of wheels divided into two or more parts, loosely mounted on the shaft, but connected thereto and to each other by means of compensating links, the distance between the parts of the wheel being sufficient to allow the pinion gearing therewith to have an intermediate bearing or bearings. The wheel shown is divided into halves a and a^1. b is the wheel-shaft with a flange c in the centre, arranged between the two half-wheels. The two half-wheels are spaced apart as shown, sufficiently to enable a pinion having a third bearing at the centre to be employed, and are loosely mounted on the shaft, making a good fit, being prevented from lateral movement in the centre by



bearing against flange c, and at the ends by nuts and washers. In flange c a suitable number of circular slots k are provided for carrying the compensating links or keys d. The wheel bosses are provided on their sides adjacent the flange c with a number of square slots e^1 corresponding in number to the slots k, and with which the compensating links or keys d also engage, said links being conveniently held in the slots k by means of shrink-rings f. If the teeth of the wheels are of the helical type it is desirable to provide means to prevent the half-wheels from deflecting under the stress, and for this purpose the linked distance-bolts g are provided, connecting the half-wheels as shown. The action of the above-described compensating, or balancing, arrangement is as follows:—As the half-wheels a, a^1 are mounted loosely on the shaft and are only connected thereto by means of the links d and the flange c, an excess of pressure on half-wheel a, for example, may have a tendency to displace it against half-wheel a^1 in the direction of the arrow p. Such excess pressure will be transmitted from the rim to the boss, from the boss to the compensating links d, and will tend to move said compensating links in the directions indicated by the arrows. The portions of the links engaging with the wheel bosses will act like the levers of a balance, and will move until equilibrium between the pressures on the two half-wheels is re-established. If the excess pressure should be on the half-wheel a^1 instead of on a with the same direction of rotation, the action would be the reverse of that just described. (*Accepted September* 23, 1914.)

PUMPS.

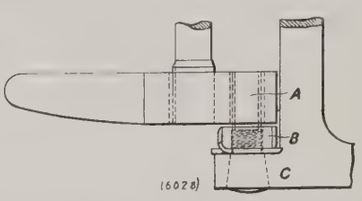
21,224/13. S. C. Davidson, Belfast. Centrifugal Pumps. [4 *Figs.*] September 19, 1913.—This invention relates to centrifugal pumps of the encased type, and relates to an improved construction of the casing, more particularly for further utilising in practical operation when large volumetric discharge is required against comparatively low or medium resistances. According to this invention, the casing on the suction side is turned inward over the periphery of the negative or intake end of the fan-blades and extends towards the positive end of the fan-wheel, the terminal end of said turned-in portion forming a circle of greater diameter than that of the intake end of the fan-wheel, and constituting the inlet or eye to the casing. The casing a is of such cross-section that the part a^1 thereof, which is contiguous to the positive end of the fan-wheel, and is parallel therewith, or to the back of the fan in the case of a single intake fan, gradually curves outwardly towards the central part of the casing, and then inwardly as at a^2 over towards, and as far as (or about) the plane of the negative or intake ends n of the blades, and, in its further extension, a^3 curves inwards and back towards the positive end p of the fan-wheel, the terminal edge of this curvature forming a circle of greater diameter than that of the intake end b^1 of the fan-wheel b, and the extension a^3 extending more or less over the intake end of the fan-wheel, but not further than the neutral part o of the blades, which is about midway of their axial length. An annular space c is thus left between the terminal edge and the periphery of the wheel b, through which space c an induced current of fresh air can pass, as indicated by the arrows, into the casing from the suction side, and a part of which current can enter centripetally into the spaces or ports between the negative ends of the blades, while the remainder of the induced current flows axially along the outer surface of the negative end, and joins in or combines with the air which is whirling round and along the concave interior circumference of the casing, as well as with the fresh air which is being directly discharged from the positive end p of the fan-wheel, and the



induced air thus admitted adds to the volume being discharged out of the casing, without the said induced air having to pass through the fan-wheel b at all. By this improved construction of the enclosing casing round the fan-wheel, the additional volume of air admitted by induction so increases the total volume dealt with that a much smaller diameter of fan-wheel can be employed for the required duty than if all the air had to pass through the wheel itself, but of course the velocity of discharge or the pressure set up thereby will only be a resultant between that of the direct discharge from the fan-wheel and the volume of induced air which is being admitted at atmospheric pressure. (*Accepted September* 23, 1914.)

SHIPS AND NAUTICAL APPLIANCES.

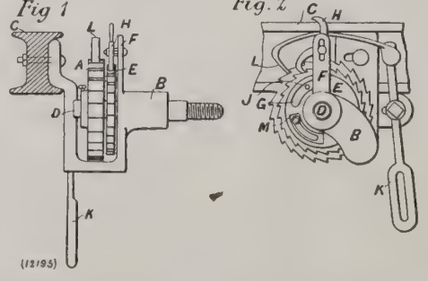
6028/14. J. M. Ramsay, Kilmarnock. Rudder Pintles. [3 *Figs.*] March 10, 1914.—This invention relates to rudder pintles, and has for its objects to improve the methods of fastening them, so as to make certain classes of uppermost pintles more easily tightened when they became slack, and more easily taken out for repair or replacement; also to remove in an inexpensive way the obstruction which a certain type of lowermost pintle presents to ropes rubbing along the keel of a ship, by the use of a nut placed upon the upper side of the sternpost gudgeon and the shaping of the rudder pintle, so that it can be withdrawn downwards. According to this invention, the nut fastening the pintle is placed upon the upper side of the sternpost gudgeon,



and the pintle is so shaped that it can be withdrawn downwards, the position of the rudder gudgeon being above the fastening nut. The drawing illustrates the application of the invention to the lowermost rudder pintle A, which is fastened to the sternpost with a nut B placed on the upper side of the sternpost gudgeon C. The pintle A is so shaped that it can be withdrawn downwards. This intermediate position of nut B and the shape of the pintle A permits of the tightening of this pintle and also of its withdrawal for repair or renewal whilst the rudder is in place, and dispenses with any nut or other projection on the underside of sternpost gudgeon C which would be liable to foul ropes rubbing along the keel of the ship. (*Accepted September* 30, 1914.)

TEXTILE MACHINERY.

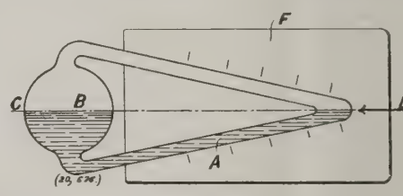
12,195/14. R. E. Starkie, Burnley. Looms. [3 *Figs.*] May 18, 1914.—This invention relates to a device for letting-back in the take-up motions of looms, and consists of an extended catch-wheel bracket bearing the catch-wheel stud, which has fixed at its inner extremity a catch-wheel with a projecting pin, the said pin engaging with a slot in a loosely-mounted ratchet-wheel, the parts being so arranged that when the catches are released, the pin engaged in the slot of the ratchet-wheel falls to the other



end of the slot, giving the amount of let-back required. Fixed to the loom-side C is the catch-wheel bracket B, which is enlarged in its capacity sufficiently to receive the ratchet-wheel E in addition to the usual catch-wheel A, both being mounted on the catch-wheel stud D. The bracket B is also provided with a slotted projection F to carry the holding-catch H. The peg J is carried by the catch-wheel A. Fig. 1 shows the catch-wheel stud D, with the usual catch-wheel A firmly fixed on the end thereof, allowing the ratchet-wheel E to work freely, being loosely mounted upon the catch-wheel stud D. Fig. 2 shows a detailed drawing of the ratchet-wheel E, with a slot G and adjustable cover M, provided with adjusting-screw to regulate the size of the opening of slot G. The hold-catch H is fixed loosely on the projection F to hold the ratchet-wheel E in position whilst the let-back is taking place. When the loom is in motion, the actuating-lever K pulls the catch-wheel A, while the holding-catch H retains the wheel E from slipping back, the pin J dragging the ratchet-wheel E. When the weft is broken, and the weaver desires to let-back, he releases the catch L on the catch-wheel A and the usual detent for the said catch-wheel, whilst the pin J falls back to the opposite end of the slot G, and so performs a let-back, and prevents thick and thin places in the cloth. If the loom weaves without weft, and the weaver desires to pull back, he can do so by releasing the catch L on the catch-wheel A and the holding-catch H. (*Accepted September* 23, 1914.)

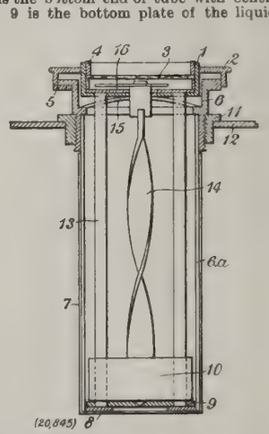
MISCELLANEOUS.

20,676/13. J. S. Drewry, Letchworth. Accelerometers. [12 *Figs.*] September 13, 1913.—This invention relates to apparatus designed to measure, by means of the displacement of a liquid with respect to its container, quantities directly derivable therefrom, such as the force producing the acceleration, resistance to motion, power developed, and other quantities such as gradients or inclination, the graduation of the scale being determined in each case in accordance with the quantity to be measured. Apparatus for the purposes referred to, and in accordance with the invention, comprises a reservoir containing liquid, a small-bore tube communicating with the lower part of the reservoir, and a return connection to the upper part of the reservoir, the whole forming a closed circuit partly filled with the said liquid. A represents the liquid column contained in a tube connected with the lower end of a reservoir B of comparatively large capacity, the diameter of the tube being sufficiently small to maintain a capillary surface at the end of the column, this surface constituting the index of the apparatus. The tube A is doubled on itself and connected with the upper end of the reservoir. If the instrument is attached to a movable body in such manner that the centre line C D is parallel to the horizontal line or motion, any change of velocity or of its relation to the horizontal will cause the liquid to move with respect to its



envelope, and the meniscus of the liquid column to be displaced to an extent dependent upon the rate of change of movement or of the change of inclination and upon the relative areas of the tube and the reservoir. This displacement of the meniscus is read on a suitable scale F, the zero of which may, as shown, be at the bend of the tube A, in which case the quantity of the liquid in the reservoir is adjusted so as to bring the meniscus of the liquid column to the zero point on the scale when the centre line C, D is horizontal. Since the movement of the indicating meniscus is due to the moment of inertia of the fluid in the horizontal or slightly inclined tube, and the resistance to such movement is consequent on the change of level of the fluid in the reservoir, it follows that a variation in the shape of this reservoir either above or below the neutral or zero level of the fluid will afford varying degrees of resistance. For example, if the cross sectional area of the reservoir be decreased above the neutral level, the fluid flowing into the reservoir, due to its displacement in the horizontal tube, will cause a higher level in the reservoir than if the cross-section of the same were constant, and consequently a different value is given to the scale reading. The shape of the reservoir may therefore be varied in order to give different values at different parts of the scale, or to give a uniform or substantially uniform value to each division of the scale, or alternatively an adjustable plug or displacer may be provided whereby the effective shape of the reservoir can be varied so as to effect the same objects. (*Accepted September* 23, 1914.)

20,845/13. K. Rotherham, Coventry. Liquid-Depth Gauge. [1 *Fig.*] September 16, 1913.—The object of this invention is to provide a combination of tank-filler, strainer, and liquid-depth gauge, and all fitting together into one hole in the tank. 1 is a dial and index-box. 2 is a bayonet locking-cap. 3 is a glass cover. 4 is a screwed glass locking-ring. 5 shows one of the bayonet lugs. 6 is a head-piece attached to a perforated tube 6a. 7 is a piece of gauze fitting over the perforated tube 6a. 8 is the bottom end of tube with centre hole covered with gauze. 9 is the bottom plate of the liquid-depth gauge.



10 is a float. 11 is a screwed ring which is soldered in the tank-top 12. 13 are float guide-rods. 14 is a twisted spiral centre for indicator. 15 is the spring disc for locking the bayonet joint on cover. 16 is the dial. The strainer consists of a perforated tube 6a, covered with fine-wire gauze 7. The top of the head-piece 6 may be formed for a bayonetted or a screw-down attachment in order to fasten the liquid-level gauge into the strainer. The centre of the cap 2 is bored out, and the dial and index-box 1 is soldered into the cap, so that the locking-cap and liquid-depth gauge are as one piece. (*Accepted September* 30, 1914.)

STRESSES IN ROTOR BINDINGS.

By ARTHUR MORLEY.

IN high-speed machinery, an important element of a rotating piece is some form of binding having a considerable initial tension, and at high speeds resisting centrifugal forces exerted by material which it binds. Probably the best known example is the binding-wire on the rotor of an electric generator. In the design of such bindings a question arises as to what total stress is induced in the wires. On reference to ext-books of design of electrical machinery it is found that in some cases the initial tension only is taken into account, and in others the only stress allowed for is that resulting from the centrifugal force of the whole rotating mass, including that of the wire itself. What actually happens, of course, is that the centrifugal forces induce in part an increase of tension in the binding, and in part a diminution in the compression of the rotor, which compression initially balances the tension of the binding. The proportion of centrifugal force which is effective in increasing the tension of the binding depends upon the relative elasticities of the binding in tension, and the rotor in radial compression. The calculation is analogous to that for a statically indeterminate structure. The estimation of the elasticity of the rotor under radial compression may or may not be practicable, depending upon the form of construction. In the case of a number of radial segments of metal in contact, the estimation would not be difficult, and in some others an experimental determination during binding would probably offer no great difficulty, and might provide useful data for similar cases; it would, of course, be important to eliminate any non-elastic strains.

The principles of the stress determination may be illustrated by the simple case, of which there are occasionally practical examples, for easy removal, of a thin, hollow bronze hub, containing uniformly-distributed loose, free masses, the hub being bound with a layer of thin steel wire and rotated at high speed (see diagram annexed).

Let A be the area (viz., length inside flanges × thickness + end flange sections) of a half section of the hub, in square inches, and let there be n turns of wire each of cross-section a square inches. Let f_0 be the unit stress in the steel wire, and $f^1{}_0$ the unit compressive stress in the bronze hub, and let f and f^1 be the corresponding unit stresses when the angular velocity of the rotor is ω radians per second, all unit stresses being in pounds per square inch.

Let E_s and E_b be the values of Young's modulus for steel and bronze respectively in pounds per square inch. Let R be the radius of the hub (assumed to be large in comparison with the thickness of the hub and binding), and let r be the distance of the centre of gravity of the inner rotating mass of W pounds in a half hub cut off by a plane through the axis. Then the centrifugal force exerted on the hub by the loose masses is $\frac{W}{g}\omega^2 r$ pounds, where $g = 32.2 \times 12$ in. per second per second. The centrifugal forces exerted per inch of arc by the wire and hub respectively are $\frac{n a w}{g}\omega^2 R$ and $\frac{A w^1}{g}\omega^2 R$, where w and w^1 are the respective weights of steel and bronze per cubic inch in pounds.

Equating the initial forces (at rest) across a diametral plane—

$$2 n a f_0 = 2 A f_0{}^1, \text{ or } f_0{}^1 = \frac{n a}{A} f_0 \quad . \quad (1)$$

Equating the forces across a diametral plane at a speed ω—

$$\left.\begin{aligned} 2 n a f &= 2 A f^1 + \frac{W}{g}\omega^2 r + \frac{2 n a w}{g}\omega^2 R^2 + \\ \frac{2 A w^1}{g}\omega^2 R^2 &= 2 A f^1 + K, \text{ or } f^1 = \frac{n a}{A} f - \frac{K}{2A} \end{aligned}\right\} (2)$$

where K = the resultant centrifugal force of the mass of the half rotor

$$= \frac{W}{g}\omega^2 r + \frac{2 n a w}{g}\omega^2 R^2 + \frac{2 A w^1}{g}\omega^2 R^2 \quad . \quad (3)$$

Due to the centrifugal tension, the wire stretches and the hub compression is relaxed; for small radial depths in comparison to diameters the essential fact is, that so long as contact is maintained between the binding and the hub, the changes in their circumferential strains are equal. Hence,

$$\frac{f - f_0}{E_s} = \frac{f^1{}_0 - f^1}{E_b} \quad . \quad . \quad . \quad (4)$$

and substituting the values of $f^1{}_0$ from (1) and f^1 from (2),

$$f = f_0 + \frac{K/2 n a}{1 + \frac{E_b}{E} \cdot \frac{A}{n a}} \quad . \quad . \quad . \quad . \quad (5)$$

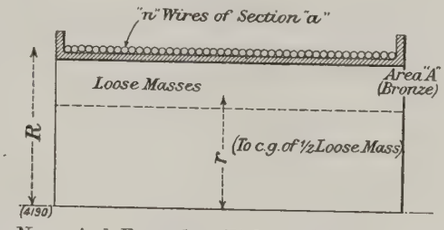
The extreme cases are (*a*) that of a very thin hub, in which A is very small compared to $n a$, and (5) approaches

$$f = f_0 + \frac{K}{2 n a} \quad . \quad . \quad . \quad (6)$$

i.e., the initial tension, plus that arising from all the centrifugal force, but the initial stress itself is also small. (*b*) That of a very rigid hub, in which A is large compared to $n a$ (or the Young's modulus of the hub is large compared to that of the wire) when (5) approaches

$$f = f_0 \quad . \quad . \quad . \quad . \quad (7)$$

i.e., the initial stress only.



Numerical Example.—Hub, say 3 in. long, 0.1 in. thick, bound by 500 turns of No. 18 S.W.G. wire. $a = 0.0018096$ sq. in.; $n = 500$; $n a = 0.9048$ sq. in.; $n a/A = 3.016 = 3$ approximately; $E_s/E_b =$ say 2. Then from (5):—

$$f = f_0 + \frac{K/2 n a}{1 + \frac{1}{2} \times \frac{1}{3}} = f_0 + \frac{6}{7} \times \frac{K}{2 n a},$$

i.e., the initial tension plus $\frac{6}{7}$ of the tension arising from the centrifugal force of the total mass of the half rotor.

In the more general case, if it is found by experiment or estimation that the hoop or circumferential tension required per inch of purely elastic reduction of the rotor diameter is e pounds, then equation (5) becomes

$$f = f_0 + \frac{K/2 n a}{1 + \frac{2 e R}{n a E_s}} \quad . \quad . \quad . \quad (8)$$

Stresses will, of course, also arise (with change of temperature) due to unequal coefficients of expansion of the materials of the hub and the binding. These may conveniently be estimated separately.

LITERATURE.

History and Romance of the Petroleum Industry. By J. D. HENRY. Illustrated by P. PIMLOTT and ERIC SWINSTEAD. Vol. I. London: Published by the Author, 4, London Wall Buildings. [Price 10s. net.]

UNQUESTIONABLY the author is in an admirable position to write the history of the petroleum industry. He has seen it in operation in many parts of the world, giving employment to all sorts and conditions of men; he has known those who have guided its growth from small beginnings to full maturity, creating one of the mammoth factors of the world's trade and commerce; he has had opportunities of noting how its hopes and promises have swayed and unsettled men's judgments, leading to those panics and share gambles whose remembrance is neither pleasant nor edifying. Provided with information of the influence of petroleum on transport and engineering, he is well qualified to tell the tale of marvellous enterprise that has profoundly affected the recent development of both. But he lacks one important qualification—that of a sense of proportion. He has no well-developed scheme, and whether this first volume will expand into three or a dozen, he is unable to decide. Little episodes are magnified into important events obscuring real issues, repetitions are frequent and annoying, the progress of the tale is irregular and involved. If the work is made long enough, all the facts may appear, but they will be covered by such a mass of detail that it will need a second historian to dig them out and exhibit them in a coherent and effective manner. This is the more to be regretted, because the history should be intensely attractive, being the history of an industrial revolution. Within the last sixty years—within the lifetime of many who must have been present at its birth—the industry has wrought a radical change in established procedure, enlarging the possibilities of engineering and mechanical science. The existence of the aeroplane and the submarine is traceable to the products of petroleum; it has furnished an effective and economic substitute for coal; the ever-increasing demand for the crude product has called forth the pipe-line and the tank-steamer, leading to important new developments in old industries.

The author has not only to explain this rapid progress, but to correct some errors that time and circumstance have combined to create and spread. Perhaps one might say that his main and laudable purpose is to render justice where it is due, and to resuscitate reputations that have been wrongly besmirched, either by accident or design, and to enable later comers to see the development of the petroleum industry in its proper perspective. In this endeavour the author will have cordial support, for an impartial inquiry is necessary, and well timed. The commanding position that the United States now occupy, when huge fleets are required to carry its oil product in bulk on both the Pacific and Atlantic Oceans, makes it difficult to realise that America was not always supreme in oil. The American people are apt to overstate their case, and to claim that it is to some peculiar merit in the American character that the world owes the birth and development of this industry in every feature from inception to consummation. No one could be more loyal and appreciative of American enterprise than is Mr. Henry, who fully admits the effect of the revolutionary impulse given to oil production by the successful drilling of the first oil-well at Titusville, and pays ample tribute to the engineering skill and resource which has ever characterised the progressive movement. He recognises the financial enterprise "that has created a trade of its own, opened the markets of the world for itself, and developed its own systems." He is not, however, carried away by the urgency of the American claims, and in strict justice he asks us to remember that Galicia was the scene of the commercial beginning of the petroleum world; that Dr. Young was at work in Scotland on paraffin products before oil was procured in commercial quantities at Oil Creek; that oil-carrying vessels were owned by Russians on the Caspian Sea, pioneers of the large tank-ships built later on the Tyne for the American trade. It may well be that, coming later in the field, all the more credit is due to the American character in overtaking and passing other nations, who had had the opportunity of working oil in commercial quantities. Mr. Henry says, and we think he is justified, that the two factors that have contributed to the foremost position that America now undoubtedly holds are the successful achievements in rock-boring for oil-wells, and the business aptitude displayed by Rockefeller and his colleagues. If these two factors are viewed aright, "we find that the pioneering honours of oil production and commerce must go to Russia, that British oilmen led the way in oil-refining experiments, that an ocean-borne business was first made possible by those few Tyneside firms which "converted" and built oil-carrying sailers and tank-steamers to the order of London oilmen."

These are large issues, affecting the welfare of nations and the social and industrial progress of the world. They command ready attention, and are worthy of careful analysis. The discussion of the merits and achievements of individuals is on a different plane, and however much we may admire the author's devotion and loyalty to the memory of Colonel Drake, his lengthy defence of that worthy pioneer, involving an excursion into dreary polemics, occasions weariness and makes his tale of intelligent and scientific organisation appear small by comparison. The whole dispute arises over the share Colonel Drake had in drilling and pumping the first oil-well that gave birth to this gigantic industry, and contributed so materially to the comfort and happiness of mankind. There is little doubt but that Drake's determined perseverance and rooted conviction of ultimate success overcame many obstacles, and probably by some months anticipated the inevitable development. Whether he was an employed agent by a commercial company or an independent prospector seems to us of as little consequence as whether the idea of pumping oil from subterranean sources was his original notion or derived from others. He appears to be entitled to the credit of perceiving more clearly than most that oil in quantity was to be found beneath a

rock formation that could only be penetrated by power-moved tools. Whenever a new thought dawns, opening up a wider arena for progress and exertion, or some new departure is made from old grooves offering a more favourable standpoint for further conquest of the unknown, it will be found that though one man attain the height, he is not alone in the race for pre-eminence. New ideas are the product of the time rather than of the individual, the experience of generations has prepared the way for the final illumination. Newton and Hooke raced for the discovery of the theory of gravitation, Darwin and Wallace for that of evolutionary processes, Lockyer and Janssen to unriddle the secret of solar prominences. Drake and Bissell and Fletcher, with others, strove for the prize of discovering petroleum in large quantities; accident and character gave it to Drake. He is entitled to the greatest credit in sticking to his task of drilling for oil, and oil only, in face of obstacles which would have discouraged weaker or ordinary men. But did Drake know what he was doing; had he that penetrating genius which prompted him to see in these subterranean oil stores a source of energy that would minister to the world's needs, or even prove the cheapest and most widely used illuminant science has discovered? If Drake realised the future, however dimly, he is entitled to all the monuments that those who have admired his genius or profited by its results can erect to his memory. But Mr. Henry is not able to make us see in the hero of this dramatic incident of tapping the first oil-well more than indomitable constancy rewarded by rare good fortune.

There is no evidence that Drake appreciated the value of this new mineral to commerce. His sole aim was to produce a larger and cheaper supply of oil for medicinal and, possibly, illuminating purposes; and having accomplished this task, he withdrew. He was in the position of a general who, having won a great victory, fails to follow it up, and permits others to gather the fruits of the harvest that might have been his. We yield to Drake our sympathy, to others the admiration that success always brings. Drake's subsequent career was sad; he suffered from actual poverty and want. While others reaped enormous fortunes, this pioneer was forgotten and unhonoured. His fate was as undeserved as it was melancholy, but genius of another order was required to achieve that material success which the world alone prizes. However unmerited and tragic his fate, it was shared by many other pioneers who laboured, not wisely but too well, in the unworked oil-fields of Pennsylvania.

The life of such a man illustrates both the history and the romance of the petroleum trade. It offers an epitome of what happened on a large scale in towns where obscurity suddenly gave way to meteoric fame and a brief notoriety, followed by quick decline and absolute decay and silence. A reference to the history of Pithole may serve to emphasise this surprising tale of marvellous development and as complete an abandonment which overtook many a less-known spot. But who now even remembers Pithole, which once boasted a string of palatial hotels to accommodate the rush of strangers, speculators, and adventurers of all kinds who sought its hospitality? Its streets adorned with imposing buildings, its banks, its churches, its schools, and its music-halls, saloons, gambling-hells, and dens of vice and infamy have all gone as completely as if they obeyed the genius of Aladdin's lamp. From a barren state it rose within one year to a city having a population of, perhaps, 20,000 inhabitants; its post-office boasted a volume of business surpassed by only two others in the State. Five brief years saw a decline to less than a score of ruined residents, and a few years later not a human being lived on the spot, and nothing could indicate to a stranger where the city had once stood. "It would require the acumen and active scrutiny of the traveller to form a probable conjecture as to the actual site of the most wonderful town the oil regions of Pennsylvania have produced." It goes without saying that the recital of tales of such contrasts of prosperity and decay prevents Mr. Henry's book from being dull. There are chapters of absorbing interest, and if the author had understood the value of compression, his volume would have been of the most fascinating character.

The outbreak of the war has induced the author to add a postscript on the geographical position and extent of the oil-fields and oil-fuel and petrol resources of Germany and the countries engaged in the life and death struggle. This is an important and valuable contribution, and, we may say, of a reassuring character. For with us petrol is an exotic product, and the maintenance of an abundant supply is imperative for our well being. It is therefore eminently satisfactory to read that, in the opinion of this expert, "our country, France, and Russia, and, indeed, every country with which we are allied in this war, are in an infinitely better position than Germany in relation to the world's chief oil-fuel and petrol-exporting centres." This, of course, was written before Russia had advanced so far into Galicia, threatening the rupture of transport connections between Germany and the Galician fields, a main source for Central Europe.

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FOUNDRY CRANES AND POWER AGENCIES.—No. III.

By Joseph Horner.

The system of overhead tram-rails, also termed mono-rail, and originally telpher system, has been extensively developed in those foundries where light work is handled. For convenience, for general utility, and for economy of installation combined, this system occupies an unassailable position. Its rivals are the floor-tracks, the overhead travelling-cranes, and the swinging jib-cranes. Yet the rivalry of these cannot be taken very seriously in foundries where the loads that are regularly handled do not exceed 1 or 2 tons. As the overhead trolleys can be operated by hand, or by air or electricity, this adaptability to power supplies is much in their favour. By far the larger

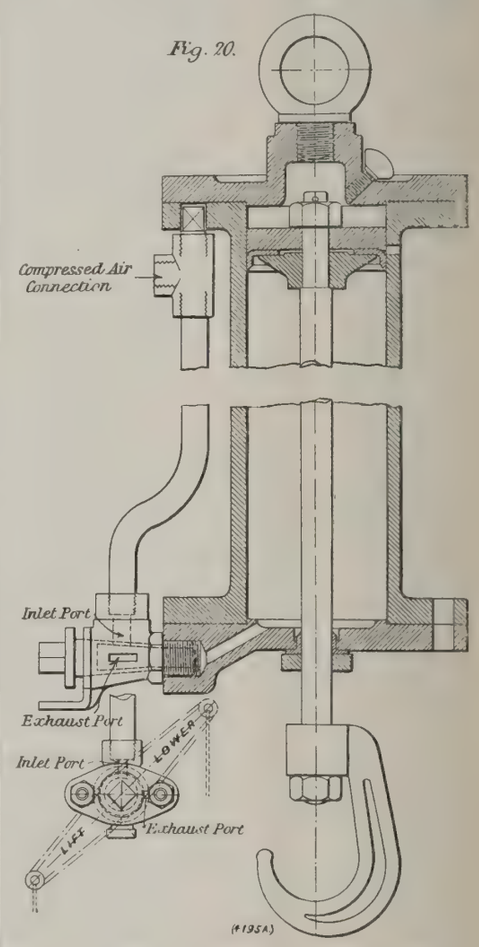


Fig. 20. Pneumatic Hoist, by Messrs. Reavell and Co., Limited, Ipswich.

number are hand-operated by the men on the floor, but the higher-powered electric trolleys frequently provide a seat for the attendant in a cage.

The utilities of floor-tracks are limited to transport. Overhead tracks combine provisions for both transport and hoisting. The floor-tracks came first because they were a natural development from the flat plates of cast iron that were laid in many foundries in order to lessen the labour of pushing wheel-barrows laden with pig, sand, boxes, and castings on sand floors. Where these were not laid a common practice was to make a temporary smooth track with 3-in. deals laid on the sand. From these crude methods the admirable system of floor-tracks has been elaborated with rails, switches, curves, and turntables. These occupy some of the floor space, but this is hardly objectionable, because a clear central gangway must generally be maintained in any foundry. But overhead tracks do not encroach on the floor at all, and as they permit of the combination of hoisting with transport, they are employed in many foundries where light castings are handled. Even in the economies of traction the saving is very great, the loads handled being probably from fifteen to twenty times as great as those which can be dealt

with by labourers pushing barrows on the sand floors.

In connection with these overhead lines the hoisting question assumes another character, that of the choice between the hoisting-tackle which can be carried on overhead tracks, and the light overhead travellers, or the fixed jib-cranes. The proper spheres of each of these two latter alternatives have already been stated. The first covers the entire foundry area ; but several travellers would be required to supply the demands of a large foundry, and they are expensive. A number of light hoists can be installed for the cost of one traveller, and by a well-arranged disposition of tracks the whole floor practically can be covered. A medium course can often be adopted with advantage—a combination of overhead tracks with overhead travellers and with jib-cranes. The tracks may be localised or may be feeders to the other hoisting-machines. They may be located next the cupolas or about the core-stoves, or over light moulding-machines or sand-bins, as may seem desirable to the management.

Overhead tracks should not be situated at more than 8 ft. or 9 ft. above the floor. It has been demonstrated that this is the most economical height for operation. A man can propel a load of 1 ton at this height with ease, though he cannot do it if the height is much increased.

A powerful argument for the overhead tracks is that they take charge of a large volume of light tasks, outside of those which are thrown on the hoisting tackle, tasks which are otherwise performed by the labourers, either carrying or transporting by the aid of barrows. The expenses for unskilled labour, which always bear an undue proportion to the cost of moulding in the foundries that are unprovided with floor-tracks or overhead trolleys, are thus reduced. Light castings, weighing a few pounds each, are transported in boxes thus, and bins of sand, cores, lifters, the smaller ladles of metal, all this light transportation, as distinguished from hoisting, is taken away from an army of labourers and transferred to the smooth tracks.

In this duty, the rivalry between floor-tracks and overhead runways becomes nearly a dead-heat. Yet, on the whole, the advantage lies with the latter, not in respect of the expense of installation, but in its higher flexibility. It is not easy to keep floor-tracks clear of sand and of other obstructions. There is no trouble of this kind with overhead tracks. The fact that floor-space is permanently occupied with narrow-gauge tram-lines, while runways do not take up space, is an objection to the former which is more apparent than real, because space below runways must be left clear enough for the men to walk about in order to pull the trolleys along. In favour, however, of overhead runways is the fact that they are much less liable to get out of alignment than floor-tracks are, and even running is essential to easy working.

Almost all runway-tracks are formed of I-beams, on the lower flanges of which the trolleys run. The supports are attached usually to roof principals or to brackets attached to principals or to walls or columns. Switches, cross-overs, and turn-tables are fitted as required. The trolley runs on four flanged wheels, with treads which are bevelled to fit the bevelled edges of the lower flanges of the joists. The axles in good designs run in ball-bearings. Such trolleys may carry a plain hook for mere traversing, or chain-blocks of differential or duplex or triplex types, or air hoists or electric hoists run on them, so that all possible requirements can be met.

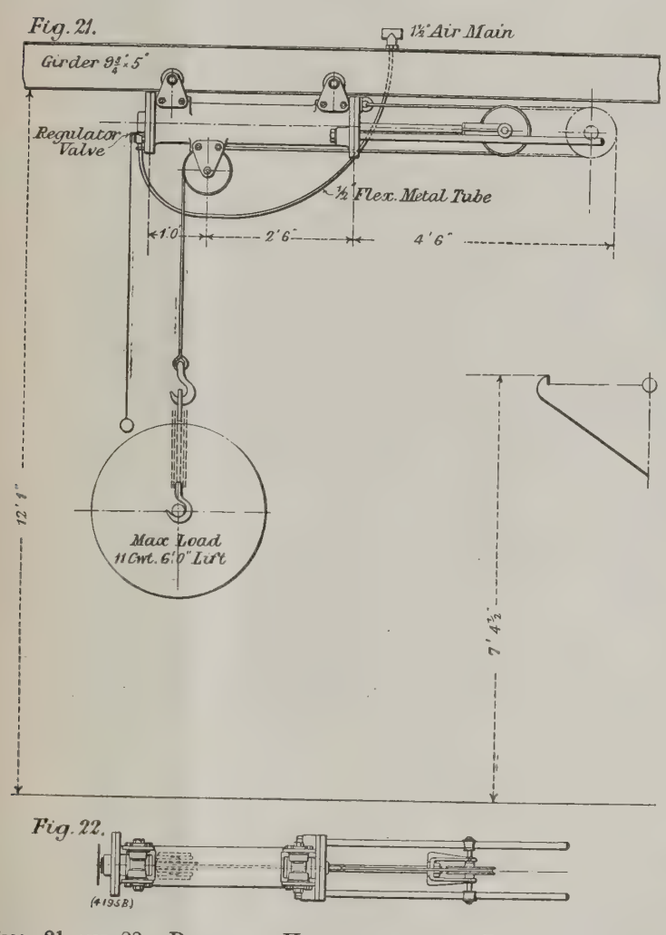
In the absence of a power plant, the hand chain-blocks are serviceable for light loads for which the regular crane service would be wasteful of time. The proper sphere of these blocks lies in the handling of loads not exceeding a ton, and preferably of those below half a ton. The higher-powered blocks are slow in action. But loads of a few hundredweights cover the range of work handled in many foundries. In most of the larger foundries now either compressed air or electricity, or both, are installed, and in these the hand-hoists may profitably be supplemented with air or electric hoists, or may be superseded entirely by these. Air-hoists are open to objection when the distances to be traversed from the air supply are great. The direct-acting vertical hoist is also often in the way ; it shortens, too, the height of lift, since the tracks are rarely more than 8 ft. to 10 ft. above the floor. To avoid this defect, many air-hoists are disposed with the axis horizontal.

The electric trolley-hoists are employed with increasing frequency. They are free from the drawbacks to which the compressed-air hoists are subject. With the general introduction of electricity into foundries, its advantages are readily extended to the hoists. These occur in various designs, ranging from the simple pulley-blocks, motor-driven, to the geared hoists driven through spur or worm-gears, and usually being self-sustaining. Two types are available : those which are controlled from the floor by dependent chains or wire ropes, and those in which the attendant is provided with a seat in a cage attached to the hoist. A dependent-rope type is also made in which the handles are brought away to some distance from the hoist, so that the operator is not subject to discomfort by the metal in the ladle, as he would be if seated above it.

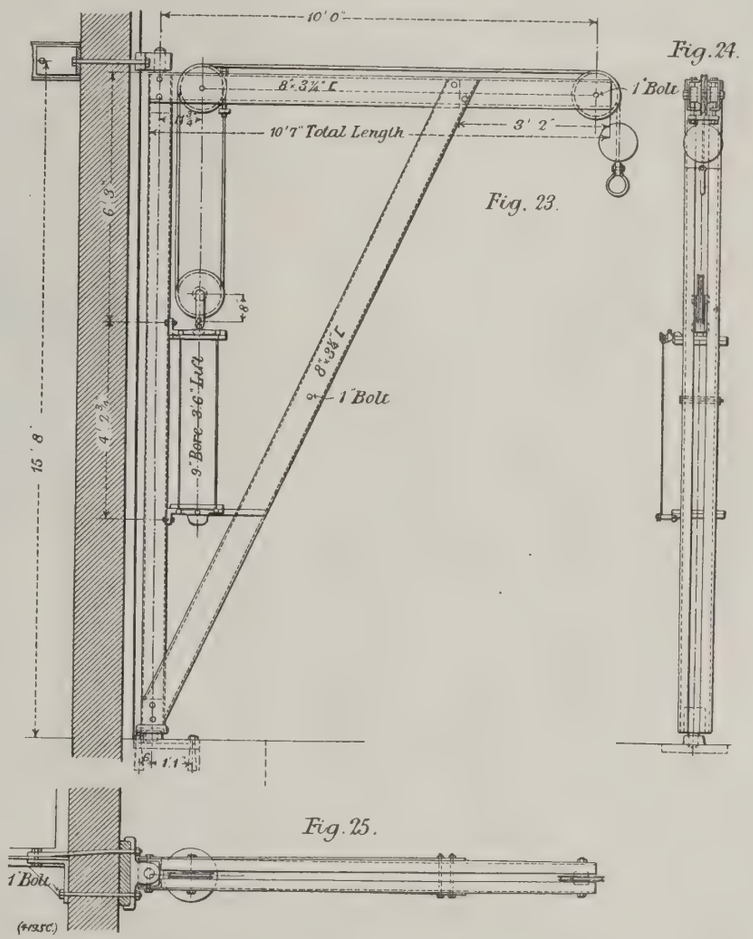
The plainest trolleys are those having sides carried by the wheels, with a hook from which the hoisting-tackle is hung. Properly, the two sides should be separate castings or plates, united with a pin connection, rather than in a solid piece, in order to compensate for any slight irregularity in the track or in the loading, which would throw more weight on some wheels than on others. The wheels, as in travellers, should be turned on the treads, or else chilled, and preferably be ground.

The Curtis trolleys for single I-beams have equalising steel frames carried on a pin, which permits the trolley-wheels to adjust themselves to inequalities in the flanges. The wheels are angled to suit the bevels of the flanges. The bosses are bushed with a steel shell, and contain Hyatt flexible roller-bearings, the bushing being adopted to prevent the rollers from cutting into the cast iron. Trolleys for double I-beams have the wheels bushed similarly for Hyatt bearings.

The lightest trolleys for carrying loads of from



FIGS. 21 AND 22. PNEUMATIC HOIST ARRANGED TO RUN ON OVERHEAD TRACKS, BY MESSRS. REAVELL AND CO., LIMITED, IPSWICH.



FIGS. 23 TO 25. DOUBLE-PURCHASE PNEUMATIC HOIST ATTACHED TO A JIB-CRANE, BY MESSRS. REAVELL AND CO., LIMITED, IPSWICH.

a ton to 30 cwt. have nothing but the smooth wheels for traction. A man can pull or push them along without unusual exertion. But beyond this load other methods of propulsion are adopted. The simplest is the hand spur-geared trolley, in which power is gained through pinion and gear, operated by a dependent chain on a sheave on the pinion-shaft. This is much better, even for the smallest trolleys, than the mere pull on the hook, because the load has to be drawn to a considerable distance out of perpendicular before the trolley moves. For the same reason it cannot be stopped so precisely and accurately as a spur-gear-driven one can be. So for this reason many of the lightest trolleys are fitted with geared drives. The electric trolley, combining trolley and hoist, is either a motor-driven chain block, or a motor-driven trolley and hoist. The speed of travel varies, an average being from 250 ft. to 350 ft. per minute.

Air-hoists are a class of manufacture seldom handled by the general crane-builders. The firms who make these combine the construction of pneumatic appliances with the air-compressors for actuating them. The standard pressure adopted is 80 lb. per sq. in. The early hoists were frequently jerky, and uncertain in action, consequent on the high elasticity of the air and on the presence of leakages. They were heavy, adding excessive dead-load to be moved. For these reasons they were less suitable for foundry work than for the original services for which they were designed, as ice plants, provision stores, and general industrial purposes. Any suspicion of jerkiness is fatal to the employment of hoists that have to draw patterns, set cores, close moulds, or pour metal. Methods of governing have been devised to ensure smoothness of movement, as oil-governing and air-balancing, with numerous variations in details, until now the hoists of the best firms leave nothing to be desired. Lightness is secured by the employment of steel tube for the cylinders of the larger hoists. They are also arranged in different ways to accommodate head-room, being pendent, or horizontal, independent, or forming portions of horizontal jib-cranes.

Fig. 20, page 720, shows one of the hoists by Messrs. Reavell and Co., Limited, of Ipswich. The barrel is of cast iron. The rate of lifting is governed by a three-way cock at the bottom in connection with the air supply. The hoist is suspended from the trolley, and the cock is operated by dependent chains. Very fine adjustments can be obtained as required for foundry service. The cylinder connections are modified to suit the horizontal disposition on tracks and on jib-cranes. Figs. 21 and 22, page 721, show the horizontal arrangement. They illustrate the proper way to design a hoist when head-room is limited. In this instance a 6-ft. lift is obtained, with head-room of 12 ft. 1 in., using a double purchase. The cylinder has cast on it lugs, to which plate brackets are bolted to carry the pins for the running-wheels above, and for the hoisting-sheave below. The movements of the piston are transmitted to the sheave at the end of the piston-rod, so that the outward movement lifts the load, and the inward one lowers it. The rope is anchored to the cylinder-cover. The regulator valve is actuated by a dependent chain. Flexible metallic tube makes the connection between the air-main and the hoist.

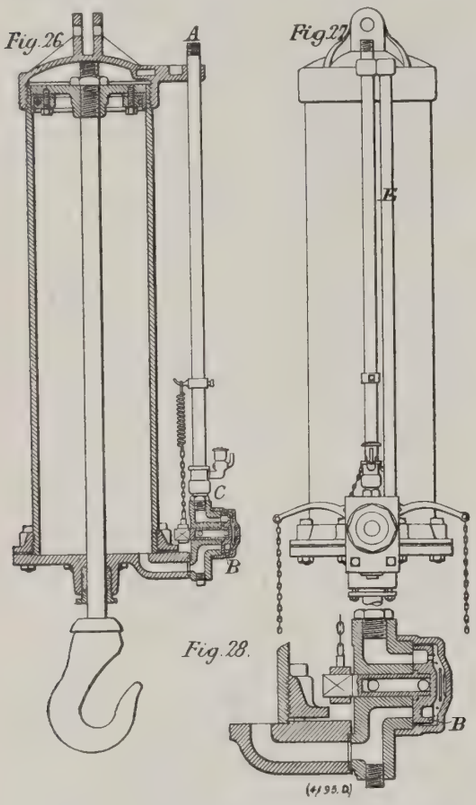
The design of a double-purchase hoist is shown by Figs. 23 to 25, page 721, attached to a jib crane for foundry service, this being made for serving a pickling-bath. The cylinder is attached vertically to brackets bolted to the post. The rope is anchored to the jib above, and, passing over the guide-pulleys seen, lifts and lowers the load by the inward and outward movement of the piston. The crane swings in a footstep bolted to the foundation and in a bracket bolted to the wall above. The framing, built of channels, is clearly shown.

The pneumatic hoist shown by Figs. 26 to 28, annexed, is by the Globe Pneumatic Engineering Company, Limited, of 1, Victoria-street, Westminster, S.W. It is of the air-balanced type, and is particularly adapted to foundry work where a good speed-control is necessary, as in the case of a ladle being emptied, or in pattern-drawing, and where a varying load has to be considered. The speed of hoisting and lowering is largely independent of the operator or of the load to be lifted, and these machines will sustain a varying load with practically no change in the position of the piston, while the full load may be disconnected from the rod when the valve is closed with but a small movement of the piston. This type of hoist is not quite as economical as the simple-pressure design, in which one side of the piston is open to the atmosphere, and the other to pressure, but the latter would only be of use in loading wagons and where delicate control is not necessary.

Air enters at A, and the lower side of the piston is under constant full pressure. Assuming that the piston is in its upper position, with the full pressure beneath, then, upon the left-hand ("lower") chain being pulled, air is admitted to the top side through the pipe E, so that the piston travels downward, due to the difference in area caused by the piston-rod. Upon the chain being released, the valve B automatically returns to its central position, and the load is sustained at the desired height. If the right-hand ("hoist") chain be pulled, the space on the upper side of the piston is put in communication with the exhaust, so that the piston rises with a slow, regular movement and without jerking. The disc-valve B is kept upon its seat by a spring when the air is off, while it is kept tight with pressure of air when the latter is admitted at A. A drain-plug is fitted at the lower end of the valve-box to release any accumulated moisture from the cylinder, and an oil-cup is provided at the inlet to the valve-box. This oil-cup admits two drops of oil every time the load is raised. A plug in the upper cylinder-head is provided to supply about ½ pint of cylinder-oil once a month. To prevent any accident, on account of failure of air supply during lifting or lowering, a check-valve C is fitted in the supply-pipe. These hoists are made in various types for horizontal positions, the usual lift being 4 ft., and the diameter of the cylinders varying from 4 in. to 19 in., with a lifting capacity of from 860 lb. to about 9½ tons when supplied with air at a pressure of 80 lb. per sq. in.

The hoists constructed by the Curtis and Co. Manufacturing Company, of St. Louis, U.S.A., lift loads which range from about 800 lb. to 20,000 lb., and have bores from 4 in. to 19 in. respectively. The tube of the first size is of brass, all others are of steel tube, ground on the inside. The upper head, whence the hoist is suspended, is of steel, screwed to the cylinder; the lower head is of cast iron, bolted to a steel ring, which is screwed outside the cylinder, thus avoiding long side-bolts. The piston leather is is of cup form, with spring pressure to keep it in contact with the cylinder. The valve, of bronze, is of the disc type, actuated by pendent chains to hoist and lower. It moves through an arc of 120 deg. A spring centring device returns the valve automatically to its central position, covering the ports immediately the operating chains are released, thus holding the load at any point.

Given the central unit, the cylinder, the different requirements which occur in foundries are provided for with modifications in the arrangements of detail. The pendent cylinder is the simpler design, most generally perhaps preferred because of its sim-



Figs. 26 to 28. Pneumatic Hoist, by the Globe Pneumatic Engineering Company, Limited, London.

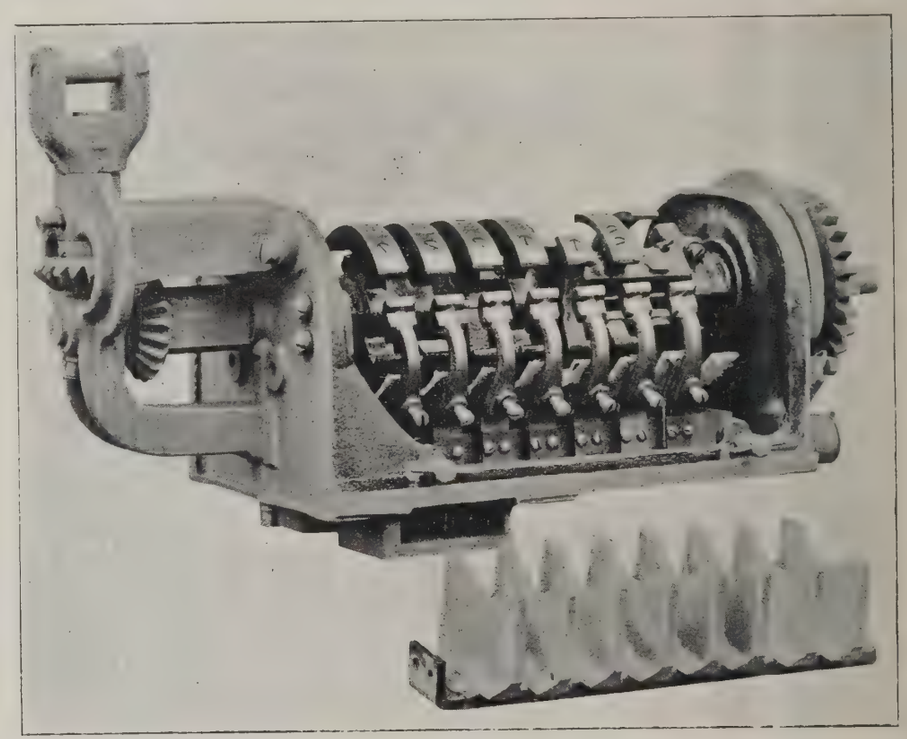


Fig. 29. Controller for Foundry Service, by the Sprague Electric Works of the General Electric Company, New York, U.S.A.

plicity and lower cost when head-room is sufficient, and when the presence of the cylinder always hanging vertically is not objectionable. It is then simply suspended from the trolley, usually by means of a hook inserted in the head or on trunnions lower down on the body. But other arrangements are often desirable. One is a horizontal disposition, with the cylinder suspended in a horizontal position from two trolleys running on the tracks. In another it runs upon the horizontal jib of a foundry crane. In both these cases the cylinder is attached to end-brackets, which, in turn, are bolted to the rolled joists, which form a self-contained framework for the cylinder and its necessary fittings. The unit can be suspended from trolleys running on rolled joists, I-beams, or to a crane-jib. Or it can be bolted to the jib of a crane or to a ceiling or to a wall.

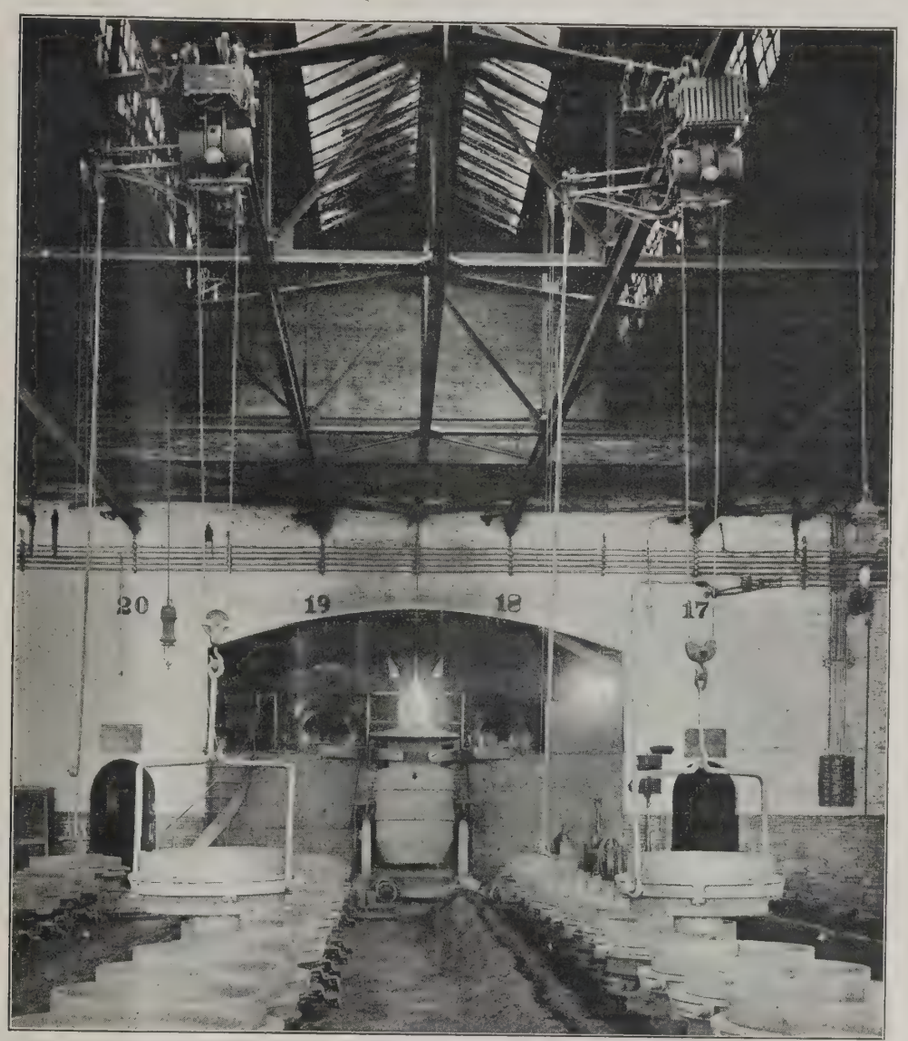


Fig. 30. Installation of Sprague Electric Hoists.

Among the variations made by the Curtis firm is the air-balanced type with a quick-power return to the stroke, which is suitable for foundry service. The lift is not direct, but is similar to that of hydraulic cylinders, but instead of the chains of the latter, ropes are used passing over sheave-pulleys and geared either 2 to 1, 4 to 1, or 6 to 1. That is, the rope travels twice, four times, or six times the piston stroke respectively. The power capacity is, of course, much less in the long-travel hoists than in the shorter-travel ones. In the 2 to 1 class it ranges from 800 lb. to 9000 lb. In the 6 to 1 class from 250 lb. to 2900 lb. on the rope, less friction. The power-return stroke to the piston is effected by the difference in the area of the piston under pressure, and is produced by an enlarged piston-rod. Cylinders are also made double-acting, with air-cushions at each end. Speeds may be governed by fitting a speed-control box patented by the firm. These boxes, placed in the port-pipes, automatically provide regulation independently of the operating-valve, both for the admission and exhaust of air to or from each end of the cylinder, independently of the other end. The effect is that the loads, whether light or heavy, will be lifted at practically constant speed, irrespectively of any speed-control by the operating valve. Pneumatic cushions can be provided to the cylinders in connection with the speed-boxes to stop the motion of the piston gently at each end independently of the operator.

These cylinders are fitted to trolleys for overhead tracks, as stated. Other methods of utilisation are to jib-cranes and to overhead travelling cranes and gantries, each being suitable for foundry service. The jib-cranes are either plain bracket cranes comprising a jib and ties only attached to a wall, and swivelling around their pintles ; or they comprise post, jib, and ties; or post, jib, and strut. In the bracketed cranes the jib is a single-rolled joist I-beam, a form which is well suited to the trunnioned hoist. This swings on the trolley, which is moved along the beam by hand. The post-crane with single I-beam and tie carries a pendent hoist hung from the trolley which runs on the lower flanges. In a more powerful design two channels are used, set back to back, with a clear space, between which a trunnioned hoist is suspended on a trolley which runs along the top flanges. An endless racking-chain is generally used for propulsion. In the third design, that of the post, jib, and strut, the cylinder is located between the channels which form the post, and a trolley-carriage only runs along the jib. The load is lifted by the movement of the piston-rod, the end of which carries a sheave, whence the rope passes over a guide-sheave to the sheaves on the trolley, and around the snatch or pendent sheave to which the hook is attached.

The overhead travelling cranes using air-hoists have the main beams of rolled joists and the end beams of steel castings. The main beams are single or double for the heavier types. In the first the trolleys run on the lower flange, the hoist being dependent. In the second the trolley runs on the top flanges of the beams, and the trolley is pendent therefrom, or, preferably, is hung on trunnions. In the heavier cranes the travelling is done by a long shaft geared to the running wheels, and actuated by hand by an endless dependent chain.

In the gantry design, which is suitable for yard use, for handling materials and boxes, two alternatives are given. In one the cylinder hangs between the gantry beams, being suspended on trunnions in the trolley. In the other the cylinder is carried horizontally on brackets bolted down on the beams. A sheave at the end of the piston-rod, with guide-pulleys, moves the hoisting-rope. The trolley is racked by power.

Another application of these hoists is the breaking of scrap with a falling ball. A steel framework with spreading legs encloses a space to receive the scrap. The ball is drawn up and suspended near the top of the framing, being controlled centrally by means of a guiding-bell. The hoist-cylinder is attached to the outside of the framing, with its piston and rope-sheave located downwards. Moving down it draws up the weight, which is released automatically.

Electric hoists are characterised by numerous variations to suit different powers and kinds of service. The general construction of the Sprague hoists is as follows :—The motor, controller, and drum are enclosed in a cylinder composed of two castings bolted together and suspended from the trolley. The gears also are enclosed separately. A brake-pulley is mounted on the armature shaft, which is gripped with pivoted levers that are automatically applied when the motor is stopped, and released by the starting of the motor. A special type of foundry controller is fitted (see Fig. 29, page 722), constructed similarly to the ordinary drum type of street railway controller. It is of cylinder type with stationary spring fingers, and with a central cylinder, bearing contact-plates which pass under and make contact with the stationary fingers. The fingers and contacts are of copper. The controller has a bevel-gear arrangement at the end, operated by a rod with a spade handle at the end. It has been found that the operator can feel the various steps with this arrangement better than with the ordinary rope-and-wheel method.

A mechanical load brake is provided which controls the lowering speed. It is of the screw-and-disc (Weston) type, having three discs geared to the intermediate shaft. During lowering the load tends to operate a coarsely pitched screw through the gears, pinching the middle disc, which is prevented from turning by a roller pawl. The resulting friction arrests the downward motion of the load, which is only continued by driving the screw with the hoist-motor. These hoists are suspended from plain trolleys or from geared carriages, the gears being operated by a dependent endless chain, or to motor-driven carriages with single-speed controllers. When loads exceed 2 tons, motor-propelled trolleys are made, and two, three, or four ropes are reeved. They are operated from below or from a cage. In the first case, the ropes are kept clear of the hoist by means of an outrigger, as shown in Fig. 30, annexed, so that the operator on the floor can stand at some distance away from the load. When a cage is fitted, it is brought to one side. Separate motors are used for hoisting and travelling, each with rheostat speed-control.

Our Locomotive Exports. — The exports of locomotives from the United Kingdom showed further progress in November, the engines shipped for the month being valued at 356,798*l.*, as compared with 267,560*l.* in November, 1913, and 230,644*l.* in November, 1912.

The Tees.—On Friday, December 11, Sir Hugh Bell presided at a meeting of the Tees Conservancy Commission at Middlesbrough. In reviewing the trading of the Tees for the past twelve months, Sir Hugh said the year commenced inauspiciously, but now the trade of the ports was improving, and, he thought, was likely to improve. With regard to the finances of the Commission, the net revenue showed a decrease of 13,264*l.*, an increase in expenditure of 29,567*l.*, and a deficit for the year of 19,544*l.* The gross receipts for the year amounted to 130,142*l.*, being a decrease of 15,286*l.* on 1912-13. This decrease was mainly in the receipts from river dues owing to the war. There had been a decrease in the number of ships cleared of 652, and a decrease in the net registered tonnage of 451,569 tons. During the year 25,730*l.* had been expended on dredging. The debt of the Commissioners at the close of October was 624,539*l.*, showing a reduction in five years of 103,161*l.*, notwithstanding expenditure for new plant and dredging, widening, and improvements.

INDUSTRIAL NOTES.

From the *Board of Trade Labour Gazette* of the 16th inst. we learn that employment in November showed a further marked improvement; indeed, some shortage of male labour was reported, owing partly to war contracts and partly to enlistments. The engineering, shipbuilding, cutlery, woollen, worsted, hosiery, leather, boot and shoe, and the wholesale clothing trades showed even greater activity than in October, and much overtime was worked. Carpenters and woodworkers were busy with the erection of military huts. The cotton trade, though still bad, showed a considerable recovery, and there was a great reduction in the amount of short time reported, especially in the spinning branch. There was also an improvement in the tin-plate, iron and steel trades, printing, furnishing, and glass trades. Employment at coal-mines and pig-iron blast-furnaces continued fairly good, but there was a slight falling-off in the linen and jute trades, and a further seasonal decline in the brickmaking industry. In the lace trade there was again an upward movement in the curtain branch, but the other sections of the trade continued very depressed. The bespoke tailoring and the dressmaking, millinery, hat, and collar trades were also adversely affected. Compared with the high level of November, 1913, there was an improvement in the industries affected by war contracts, but in the other trades there was a decline. This decline, which was apparent before the war, was most marked in the tin-plate, pig-iron, cotton, lace, pottery, and brick trades.

The changes in rates of wages taking effect in November affected 179,000 workpeople, and resulted in a net decrease of 1900*l.* per week. This decrease was mainly due to a reduction affecting 140,000 coal-miners in Durham, but there were also reductions affecting 2500 ironstone miners and blast-furnace men in Lincolnshire, and 3130 steel-melters, &c., in various parts of England and Scotland. The largest increase affected workpeople in engineering works in the London district.

The number of trade disputes beginning in November was 25, and the total number of workpeople involved in all disputes in progress during the month was 8061, as compared with 20,677 in October, 1914, and 55,094 in November, 1913. The estimated total aggregate duration of all disputes in progress during the month was 84,500 working days, as compared with 192,500 in October, 1914, and 857,200 in November, 1913.

The average weekly number of vacancies notified to all Labour Exchanges for the four weeks ending November 13, 1914. was 31,932, as compared with 31,981 in the previous five weeks, and with 22,580 in the four weeks ending November 14, 1913. The average weekly numbers of vacancies filled for the same periods were 24,220, 24,729, and 17,310 respectively.

The general level of the retail prices of food in Berlin in October rose to 16.4 per cent. above the July level; the corresponding figures for August and September were 13.3 per cent. and 10.5 per cent. respectively. As compared with September, there was an increase in the price of all the principal articles of food except beef and mutton, which fell slightly, and wheat bread, sugar, coffee, and milk, which showed no change. The most marked advances occurred in peas, haricot beans, lentils, rice, potatoes, and eggs. Compared with July, there were substantial increases in October in the prices of all articles except sugar and milk (which were unchanged), and wheaten flour, beef, pork, and coffee, the advances in which were relatively moderate. Mutton, which is not generally eaten in Germany, and also veal, showed a slight fall in price. The articles in which a change in price has the greatest influence on the cost of housekeeping in Berlin are rye bread, pork, beef, butter, potatoes, peas, beans, and lentils, and the prices of these foodstuffs for October were 14.3, 8, 4.7, 11.5, 12 5, 110, 64, and 75 per cent. greater than their prices in July last.

As regards the wholesale prices of wheat, rye, oats, and barley in Berlin, all four cereals showed increases over July, which grew in magnitude in each of the successive months of August, September, and October. For the latter month, compared with July, the increases were 26.5 per cent. for wheat, 30.5 per cent. for rye, 26.1 per cent. for oats, and 48.4 per cent. for barley.

In this country the average change in retail food prices during November was an advance of between 2 and 3 per cent. Some increase in price was recorded for most articles, but the only cases of an average increase exceeding 3 per cent. were eggs, tea, and fish, for which the advances averaged about 13, 12 and 6 per cent. respectively. Following the increased duty, the prices paid for tea advanced usually by 2d. or 3d. per pound, the average increase being about 2¼d. in both large and small towns. There were further reductions in the price of sugar, the decline averaging between 2 and 3 per cent., and bacon and margarine showed a decrease of about 1 per cent. As compared with July, sugar and eggs show the greatest advances; the prices of both average about two-thirds above the level of July, but it should be remembered that the increase in the price of eggs is partly due to seasonal causes. Fish and imported meat are also much dearer. Potatoes alone among the articles considered are cheaper than in July. Combining the figures for all the articles dealt with, and allowing for their comparative importance in working-class household expenditure, the average level of prices at December 1 was higher than that in July by about 17 per cent. in the large towns and 15 per cent. in the small towns and villages.

The Board of Trade are informed by the Advisory Committee of the National Federation of Meat-Traders' Associations that the retail prices of home-killed beef need not be more than 1d. per pound higher than a year ago, coarser joints being advanced somewhat more than prime joints. Home-killed mutton has advanced less on the prices of a year ago than home-killed beef. Pork and veal are also somewhat dearer than a year ago. On account of the restricted supplies of imported chilled and frozen beef, the committee consider that an advance, compared with the prices ruling in the middle of July, of 1d. to 2d. per pound for prime joints, and 2d. to 3d. per pound for coarser parts, may still reasonably be charged. For imported frozen mutton the advance need not exceed 2d. per pound.

Materials for tracing the manner in which the course of employment in Germany has been affected by the war are furnished by the returns made each month by the German trade unions to the Imperial Statistical Office, and summarised in the *Reichsarbeitsblatt*, the journal of the German Department of Labour Statistics. The latest available statistics of this kind relate to the month of October, when the total membership of all unions making returns was 1,347,222, exclusive, as far as possible, of members called up for military service. The percentage out of work at the end of July was 2.9, and the proportion at the end of August, the first month of the war, was 22.4 per cent. Since that time the position has considerably improved, mainly owing to large orders placed by the military authorities, so that by the end of September the percentage reported unemployed had fallen to 15.7, and by the end of October to 10.9.

As regards the month of October, the *Reichsarbeitsblatt* states that: "The improvement in the state of the labour market, which set in during September in nearly all branches of industry, was maintained during October. This was particularly the case in trades engaged either directly or indirectly in supplying military needs. The improved conditions extended to almost all trades, even to those concerned with articles of luxury, such as working in gold and silver. The building trades formed the only industrial group which did not, on the whole, exhibit an improvement, and this exception was, to some extent, due to bad weather."

The hearing concluded in the Chancery Division, on the 9th inst., of two actions against trade unions. The first action was brought by nineteen members of the Amalgamated Society of Carpenters and Joiners against the society as a whole, and the second by five members of the General Union of Operative Carpenters and Joiners against the General Union as a whole. In both cases the plantiffs asked for a declaration that a resolution fining them 2*l.* and expelling them from their unions was invalid. Plaintiffs stated that they refused to come out on strike at the Ford Motor Works, Manchester, in support of the tin-plate workers. They alleged that the tribunal which passed the resolutions was not properly constituted. Defendants contended that there were *bonâ fide* disputes between the unions and the Ford Motor Company. They pleaded that both unions were illegal societies and could not be sued in this case. His Lordship, giving judgment, said on pure merits it was impossible to justify the defendants' conduct towards the plaintiffs, but as regarded the legal question, the unions had been held to be illegal societies. Both actions therefore failed, and must be dismissed.

It will be remembered that shortly after the outbreak of the war Liverpool seamen demanded 1*l.* per month increase in wages to cover extra risks in navigation. The Board of Trade intervened, and the dispute was referred to arbitration, the result being that an extra 10s. per month will be paid to sailors, firemen, and stewards. This allowance is retrospective, and will take place from November 28 last.

At a meeting of the Durham Coal Trade Conciliation Board, held in Newcastle on the 15th inst., the Durham miners' representatives asked the colliery-owners to forego the 3¾ per cent. reduction in wages made on the 26th ult. The men put forward the circumstances due to the war as their reason for the request, but at the close of the meeting, which lasted an hour, the owners intimated that they were unable to comply.

According to the December report of the United Society of Boiler-Makers and Iron and Steel Shipbuilders there has been a remarkable improvement in the employment of its members during the month of November. When the report was issued, only 1788 members (2 8 per cent.) were unemployed, whereas the figures for the previous month were 4296 members unemployed, which is 6.4 per cent. of the total membership. Unemployment is now, in fact, very little greater than it was at this time last year, when 1654 members (2.7 per cent.) were unemployed. The union is taking up the question of steady employment and good time-keeping with the employers, and the report also deals with a scheme for making up riveting squads. It is recommended that members failing to accept employment, either in or out of their own district, under the proposed conditions, should not be allowed to come on to the Society's funds. The union has invested a sum of 30,000*l.* in the War Loan.

The Society of Amalgamated Tool-Makers also reports a satisfactory state of affairs with regard to unemployment. The recently-issued report for November states that only 39 members out of a total of 15,121 are out of employment, whereas in November of last year, when the membership was only 11,365, the number of members unemployed amounted to 156. We also learn from the report that negotiations, resulting in an advance of 2s. a week, have been carried on at Birmingham and Leicester, a two years' agreement having been secured in each case. It is also stated that the executive committee of the Society has withdrawn its opposition to the employment of Belgian refugees in this country, since fresh assurances have been given that trade-union rates and conditions will be observed in all cases.

The Industrial Commission of Wisconsin made an award directing the Nekoosa-Edwards Paper Company to pay the widow of Pat Smith the sum of 2040 dols. on account of his death. The company brought action in the Circuit Court of Dane County to set aside this award. The Circuit Court of Dane County set aside the award of the Commission on the ground that it had acted in excess of its powers in making the award. The Supreme Court of the State, three judges dissenting, reversed the judgment of the court below, and directed that the award of the Industrial Commission be affirmed. Judge Timlin, who delivered the opinion of the court, said, in part:—"It is quite possible for a person to be in an intoxicated condition, which condition proximately caused the accident which proximately caused the death, and yet not be guilty of wilful misconduct. The drinking of intoxicating liquor is wilful in the sense of intentional, but the mere fact of drinking is not misconduct. By Section 1561, any person found in any public place in such a state of intoxication as to be unable by reason of his condition to care for his own safety, is guilty of a misdemeanour. This is misconduct, and if one intentionally puts himself in this condition he might be said to be guilty of wilful misconduct. But there are many cases where, although the drinking is intentional, the intoxication is not, as, for instance, where one by reason of fatigue, hunger, sickness, or some abnormal condition becomes intoxicated in consequence of imbibing a quantity of liquor which ordinarily would not so affect him. While intoxication in such case to the degree specified might be a misdemeanour under the statute quoted, it is not necessarily wilful misconduct within the Compensation Act.

"There was evidence in the instant case that deceased was slightly intoxicated, that he drove out of a clay pit standing up on his load, that he was perfectly able to take care of himself and drive his team when last seen alive. There was, therefore, room to find upon the evidence not only with respect to the degree of intoxication, but that there was no intention or purpose to put himself in a dangerous or helpless condition of intoxication. The Industrial Commission finds that Smith was in an intoxicated condition, which proximately caused the accident, but that the accident was not caused by wilful misconduct. This means that he did not wilfully bring upon himself such degree of intoxication.

"There is no claim that the award was procured by fraud, and the findings of fact support the award. Hence, we reverse the judgment of the Circuit Court, and direct that the award of the Industrial Commission be affirmed."

Personal.—Messrs. William Jacks and Co., metal merchants, inform us that they have now opened a branch of their business in Birmingham, at The White House, 111, New-street, under the management of Mr. Claude A. Parson.—Messrs. Scholey and Co., Limited, electrical and mechanical engineers, announce the change of their address, which, on and after December 24, will be 56, Victoria-street, Westminster, S.W.

GERMAN IRON AND MINING INDUSTRIES AND THE WAR.

At several general meetings of large German iron, steel, and mining undertakings interesting statements have been made regarding the general effect of the war on the industries concerned. At the annual meeting of the Hasper Iron and Steel Works the chairman said that the war had taken the German industry entirely by surprise. Owing to the failure of the railways, of the telephone, and so many employees being called to take up arms, great confusion was caused, and it was not to be wondered at that many works had to close for a time. Thanks, however, to reawakened energy, and to the care of the authorities, it had been possible to start work again and to find employment for the hands left. The quantity of goods despatched during August was only small at most works; September and October brought an improvement, and at the end of November the average rate of employment was about 60 per cent. For this percentage there was work, and thus they had attained the goal which had been set before them at the beginning of the war—viz., that enough should be earned to cover costs, interest, and writings-off, so that the war might be concluded without suffering any loss of capital. Increased employment could not be looked for at present. Germany had of late years become a great exporting country, and export trade failed during the war, excepting to the neutral countries. Exports amounted to about 30 per cent., and of this from 7 to 8 per cent. went to Holland, the Scandinavian countries, Austria, and Italy. Consequently there was a big gap, added to which there was the decreased activity in the building trade at home and in other branches. On the other hand, the war had given increased employment in all war requisites, and in the coal and iron centres there was a strong demand for skilled labour.

As regards iron ore the industry had supplies for some time to come. The magnetic ore hitherto imported from Sweden would mostly be replaced by Minette ore from German and French Lorraine. These ores were at present poor in iron, because the present labour conditions did not allow of careful screening. They therefore could not stand the high rates of carriage. The Government might here help materially by introducing the promised reduced tariff for Minette coal and cokes on the Rhine-Herne Canal.

The principal thing for German industry, the chairman said, now that the influence of England was annihilated, was that the war should be carried on with all possible energy, even if it should last longer than had at first been reckoned. As far as the Hasper Iron and Steel Works were concerned, the Siemens-Martin works and another branch were entirely idle, because it had not been possible to find the necessary hands. As far as the other branches were concerned the employment had now reached about 60 per cent. of the normal. The months of August and September brought losses, but this had now been overcome. The Jarny mines in French Lorraine, which this company owned jointly with the Phœnix Company and the Hœsch Company, had so far been spared from the terrors of the war. The water, however, entailed daily expenditure there, but it was hoped that the mines, by the aid of the German administration there, could soon be worked again. The old complaint, made for many years, that the Rhenish-Westphalian Coal Syndicate fixed their coke at too high a price, was again brought forward. As others seemed to hold the same view, a reduction might be looked for, in anticipation of which they had again started their third blast-furnace towards the end of October, although they had no sale for all this pig iron; but they were anxious to help the Coal Syndicate in the matter of a larger manufacture of by-products, benzol, and ammonia.

The Lorraine combine of iron works, the Aumetz-Friede, lately decided to extend work and especially to increase the output of the blast-furnaces now in operation. The demand for rolled material was comparatively satisfactory, and the supply of coke had become more abundant. Shortage of labour was making itself felt in the mines and in the matter of transport. This might somewhat interfere with continuous working and extension. The supply of ore will, however, soon be replenished by arrivals from stocks at the Murville mines.

Several concerns in the iron industry have announced materially reduced dividends. Thus the Augsburg-Nürnberg Machinery Company is only declaring 8 per cent. for the last financial year, against 16 per cent. for the preceding year, an extra sum of 2,000,000 marks having been written off on account of the war, in addition to statutory writings-off of 2,343,627 marks. The large Bochumer combine in the mining and cast-steel industries had, shortly before the war broke out, proposed a dividend of 14 per cent.; the general meeting was postponed, and the board has now decided to reduce the dividend to 10 per cent. and to write off 1,500,000 marks on finished products, outstanding accounts, &c. Other writings-off amount to about 4,000,000 marks; the share capital is 36,000,000 marks.

On the other hand, the Bismarckhütte has declared the same dividend as last year—viz., 9 per cent.—the profits being almost exactly the same (1,969,000 marks). Prospects for the current year were stated to be satisfactory both as regards articles for peace and for war. The share capital is 16,000,000 marks.

The Westphalian Copper and Brass Company has reduced its dividend for the last financial year from 8 to 4 per cent. Employment at present is satisfactory, but uncertainty naturally prevails as regards the future.

We learn from the report presented at the recent annual meeting of the large Phœnix Company that the net profits for the last financial year will allow of the same dividend as for the preceding year (15 per cent.), but having regard to the present position a dividend of 10 per cent. was declared. The accounts owing to the company by hostile countries are not heavy (only about 3,000,000 marks), and against that sum the company owes about 1,000,000 marks. Even if this money should be forthcoming at the end of the war, it is not available at present. In addition, the Phœnix Company possesses extensive mines in foreign countries, especially in France; those in French Lorraine are still undamaged, the German troops being in the district, but they have not been worked for some time now, and keeping them in working order means a continuous expense. The fate of the mines in districts still in French possession is uncertain; it is not known whether they have been damaged, and, if so, what compensation can be reckoned upon, but it has been deemed advisable to increase the writings-off under this head. The effect of, and losses arising from, the war cannot be overlooked at present. Owing to the large extensions now in progress, which will be proceeded with, the bank deposits are only about half of what they were a year ago—viz., respectively 17,500,000 marks and 33,500,000 marks. During the first four months of the current year the shipments of iron products amounted to 273,710 tons, against 408,430 tons for the same period last year. This represents about 65 per cent. of the normal working of the mines, and for the immediate future an employment of 50 to 60 per cent. is reckoned upon. The output of coal during the first four months of the current year was 1,220,510 tons, against 1,776,026 tons for the same period last year. Orders in hand on November 1, those from hostile countries having been deducted, amounted to 266,000 tons, against 430,000 tons at the same date last year. The net profits for the first quarter of the current year were 4,380,000 marks, against 11,081,000 marks for the same period last year. Matters would have looked still worse had not the company, owing to the large stocks at the works, been able to work a couple of months without fresh supplies of any moment.

As regards the present position, some departments, busy with war requisites, compensate for the lack of employment in other branches, based mostly upon export; for instance, the wire works. For the next few months there is not likely to be any change in this respect; what may happen after that, no one can foretell. The value of the company's iron works and mines stand in the book at 89,000,000 marks, and the coal mines at 55,000,000 marks. The company's sales last year amounted to the substantial figure of 182,000,000 marks.

At the annual meeting of the Hoesch Steel Works, Dortmund (dividend 15 per cent.), the employment was said to amount to about 65 per cent. of the average, and orders in hand were enough to keep up this degree of employment for some three to four months. An increase of the production can hardly be looked for at present, partly on account of the shortage of skilled labour. Nor is it possible to increase the supply of iron ore, as there is a marked shortage of labour at the mines in which the company is interested. This again means that the present output of pig-iron cannot be increased.

OUR COAL ABROAD.—The war is now reducing our coal exports to an appreciable extent, no shipments being made at present to Germany, Austria and Hungary, Roumania, and Turkey. The aggregate shipments in the eleven months ended November 30, this year, were 55,341,006 tons, as compared with 67,170,655 tons in the corresponding period of 1913, and 58,747,636 tons in the corresponding period of 1912. These totals were increased to 57,951,092 tons, 70,160,934 tons, and 61,070,280 tons by the addition of coke and patent fuel. Account should also be taken of coal shipped for the use of steamers engaged in foreign trade; these shipments amounted in the first eleven months of this year to 17,287,364 tons, as compared with 19,189,501 tons, and 16,734,586 tons. In one way or another coal accordingly left the shores of the United Kingdom in the eleven months ended November 30 to the extent of 75,238,456 tons, as compared with 89,350,435 tons in the corresponding eleven months of 1913, and 77,804,866 tons in the corresponding eleven months of 1912.

"THE INFLUENCE OF BANKS ON INDUSTRY."

TO THE EDITOR OF ENGINEERING.

SIR,—The interesting leading article in your issue of December 4, under the above heading, is inclined to overlook the fact that the first duty of bankers is towards their shareholders; and whilst shareholders prosper it is little wonder that bankers abstain from a class of business which must necessarily be more hazardous than their present lucrative and safe methods.

As pointed out in your article, the primary object of industrial banks would be to promote and foster trade with the most powerful of all weapons—namely, finance. But why should our Government be expected to assist in these directions when already this country provides capital for industry abroad on the largest possible scale, but without our Government considering it necessary to ensure that preference must be given to British material in the spending of this British money?

Without discouraging new methods of fostering trade, why not take advantage of the channels already available? Recognition on the part of the Government that industrial matters deserve ordinary common-sense treatment would seem the first necessity. That the Government are capable of action has been shown by their treatment of commercial matters during recent critical times.

I am, Sir, yours faithfully,

E. J. FOX.

32, Roland-gardens, S.W., December 15, 1914.

SIR W. G. ARMSTRONG, WHITWORTH AND CO.—The trustees for the debenture-holders of Argylls, Limited, have issued a circular intimating their approval of the sale of works at Alexandria, near Glasgow, to Sir W. G. Armstrong, Whitworth and Co., Limited, and acceptance of the offer of the liquidators, Argylls, Limited, to pay the debenture-holders out of the purchase price the amount of their respective holdings—viz., 142,964*l.*—with interest to the date of the liquidation. The trustees state that the price offered for the works and ground at Alexandria, including feu duties, and also including the movable plant, which is valued at 11,933*l.*, and which does not form part of the debenture-holders' security, is 153,800*l.* The only other security held by the trustees for the debenture-holders is the Bridgeton works, which are valued approximately at 6000*l.*

GERMAN TRADE WITH CANADA.—A special report on German trade with Canada has been prepared by His Majesty's Trade Commissioner for the Dominion (Mr. C. Hamilton Wickes). The value of the German goods imported during the fiscal year ended March 31, 1913, amounted to only about 2,900,000*l.*, as compared with 28,500,000*l.* from the United Kingdom, and 90,600,000*l.* from the United States. The most important branch of Germany's trade with Canada consists of low-priced imitations or reproductions of British manufactures. British manufactures, which are usually of higher price than the German goods, but of intrinsically greater value, require to be given greater publicity, as well as assistance by first-class selling methods, to enable them to compete with low-priced goods. It is well known that this side of trade is neglected, and in many cases the British manufacturer handicaps himself further by indifferent knowledge of the local market condition. Copies of the report, which also contains detailed statistics of Germany's trade with Canada during the years 1908-9, 1912-13, and 1913-14, may be obtained by United Kingdom manufacturers on application to the Commercial Intelligence Branch of the Board of Trade, 73, Basinghall-street, London, E.C.

ROYAL INSTITUTION LECTURES.—The following are the lecture arrangements at the Royal Institution, before Easter:—Professor C. V. Boys, a course of six experimentally illustrated lectures, adapted to a juvenile auditory, on "Science in the Home": "Mechanics in the Home," December 29; "Chemistry in the Home," December 31; "Fluids in the Home," January 2; "Heat in the Home," January 5; "Electricity in the Home," January 7; "Light in the Home," January 9. Professor William J. Pope, two lectures on "Colour Photography—Scientific Applications": 1. "Photographic Appreciation of Colour in Monochrome." 2. "Photography in Natural Colours." Professor Sir James G. Frazer, two lectures on "The Belief in Immortality among the Polynesians." Dr. Henry G. Plimmer, three lectures on "Modern Theories and Methods in Medicine": 1. "Medicine and Science." 2. "Immunity." 3. "Methods and Results." Dr. Chalmers Mitchell, three lectures on "Zoological Studies: War and Evolution": 1. "Nations as Species." 2. "Struggle of Species." 3. "Struggle of Nations." Sir Herbert Warren, two lectures on "Poetry and War." Dr. Aubrey Strahan, two lectures on "London Geology:" 1. "The Form and Structure of the London Basin." 2. "The Ground Beneath London." Dr. Richard T. Glazebrook, two lectures on "Aerial Navigation—Scientific Principles:" 1. "The Requirements of Theory." 2. "The Requirements of Practice." Dr. Walford Davies, two lectures on "Music:" 1. "To Untrained Listeners" (illustrations by lecturer); 2. "Emergency Music" (illustrations by a small choir). Professor Sir J. J. Thomson, six lectures on "Recent Researches on Atoms and Ions." The Friday evening meetings will commence on January 22, when Professor Sir James Dewar will deliver a discourse on "Problems of Hydrogen and the Rare Gases." Succeeding discourses will probably be given by Dr. Dugald Clerk, Professor A. W. Crossley, Dr. William S. Bruce, Professor E. B. Poulton, Rev. A. L. Cortie, Sir Rickman John Godlee, Professor G. H. Bryan, Professor Sir J. J. Thomson, and other gentlemen.

MICHELL THRUST-BLOCK FOR THE S.S. "CIUDAD DE BUENOS AIRES."

On this page and on page 727 we illustrate the Michell thrust-blocks fitted by Messrs. Cammell Laird and Co. to the 6000-ton turbine-driven liners Ciudad de Buenos Aires and Ciudad de Rio de Janeiro. These are twin-screw geared-turbine steamers developing about 2625 horse-power per shaft, the shaft diameter being 9 in., and the revolutions at full speed 260 per minute. As Mr. J. Hamilton Gibson has pointed out (Proceedings of the Institution of Civil Engineers, vol. excvi.) a geared-turbine drive proves particularly trying to a thrust-block of the ordinary type. With a reciprocating engine the torque is not absolutely uniform, and the thrust, of course, varies in corresponding degree. There is thus a little pulsation in the load on the rubbing surfaces of the thrust-block with a reciprocating-engine drive, which appears to favour the introduction of the lubricant between the rubbing surfaces. With geared turbines, on the other hand, the pressure between the thrust surfaces is almost absolutely steady, a condition which tends to check the flow of the lubricant between the rings and collars. Trouble has, therefore, been experienced when the ordinary type of thrust-block has been fitted to geared turbines, although the conditions were nominally identical with those of thrust-blocks working quite satisfactorily with reciprocating drives. The ordinary thrust-block is, moreover, costly to construct and cumbrous. A by-no-means negligible fraction of the power applied to it is wasted in friction, and that it still remains in use is, in view of our present knowledge, somewhat surprising.

The principle of the Michell bearing has been repeatedly described in these columns, so that it is unnecessary to do more now than recall that the thrust is transmitted from the running part of the bearing to the standing part through a series of sectors supported in such fashion that the resultant thrust on each passes through a point one-third the width of the block from its trailing edge. Under these conditions each block takes a slight tilt, the interspace between it and the face of the opposing collar being about twice as wide at the leading edge of the block as at the trailing edge. This condition has been shown by theory to be that most conducive to the flow of lubricant between the surfaces. The result is that extraordinary pressures can be carried, the limit of endurance being, in fact, fixed not by limits of lubrication, but by the resistance to pressure of the metal surfaces themselves. In some experimental work loads of over 5 tons per sq. in. have been carried without any lubrication difficulties, though under this pressure the white metal itself began to flow.

A general view of the bearing is represented in Fig. 1, annexed, whilst Figs. 2 to 6, page 727, show details of its construction. The shaft, which, as stated, is 9 in. in diameter, rests on ordinary bearings at each end of the thrust-block housing (see Figs. 2 and 3), and has but two collars, of which one is used in forward running, and the other when running astern. One of these collars is shown exposed in Fig. 4, the distance between the opposite faces of the two being 20 in.

A bridge-piece A, Figs. 2 and 4, embraces the shaft between the collars, being split in halves, as shown in Fig. 6, so that it can be placed in position. It is provided with lugs to take the 2¼-in. bolts shown in Fig. 4, by which the thrust is finally transmitted to the housing, and is clamped in place by the double nuts shown. Besides being split radially, the bridge-piece is also divided along a plane normal to the axis of the shaft, the components being held together by bolts passing through the 1½-in. flanges shown. This joint makes possible small adjustments in the total length of the bridge-piece, by using in the joint packings of different thicknesses. A set of eight pivoted blocks (see Fig. 5) at each end transmits the thrust from the corresponding collar to the bridge-piece. Keys let into the faces prevent the segmental blocks being carried round by the motion of the opposing collar, whilst they are held in place radially by half hoops B of steel, studded to the bridge-piece, as best seen in Fig. 5. To ensure an ample supply of lubricant, the collars dip into oil confined in the lower part of the housing, and by the serrations shown pick up oil, which they deliver to the guides C which feed the oil-cups, shown in the bridge-piece at D. These by appropriate channels deliver the oil to the annulus between the shaft and bridge-piece, best seen in Fig. 6. From this annulus the oil makes its way out, and back into the housing again, between the faces of the collars and segmental blocks. A light wrought-iron cover, best seen in Fig. 1, protects the block from the dust and dirt of the engine-room.

Provision is made for the cooling of the oil in the bottom of the housing by means of the cold-water circulation pipes, shown in Figs. 2 and 3. On trial, however, the blocks were found to run perfectly satisfactory when merely air-cooled. With the shafts running at 260 revolutions per minute, and transmitting 2600 horse-power, the oil temperature did not rise beyond 148 deg. Fahr., the engine-room temperature being 90 deg. Fahr. There was no discoloration of the oil at the end of an 18½-hours' run. The block in the present case is lightly loaded, the pressure being but 300 lb. per sq. in.; but this figure, though low for a Michell block, is about six times as much as is commonly permissible with the ordinary type of thrust-block.

Mr. H. T. Newbigin, of 3, St. Nicholas-buildings, Newcastle-on-Tyne, who is Mr. Michell's agent in this country, was responsible for the design.

The bearings were made at Birkenhead by Messrs. Cammell Laird and Co., Limited, under the patentee's license.

MICHELL THRUST-BLOCK FOR GEARED-TURBINE.

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LTD., BIRKENHEAD.

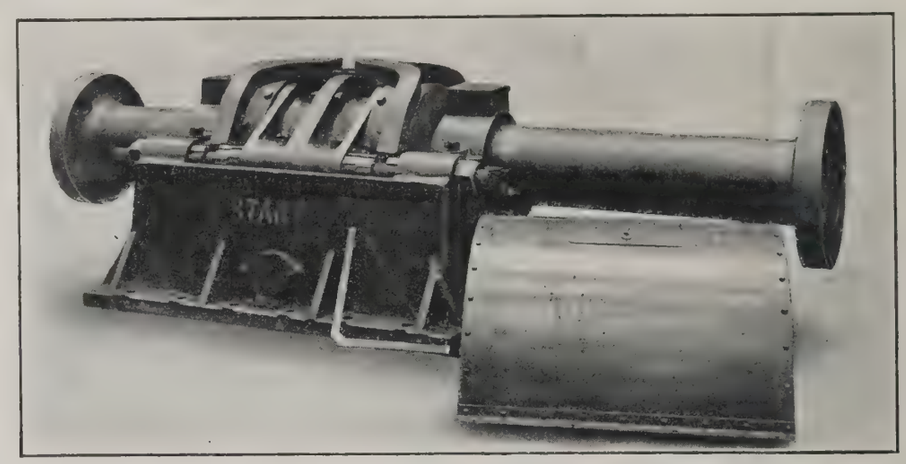


Fig. 1.

HORIZONTAL DRILLING, TAPPING, AND BORING-MACHINE.

On page 730 we illustrate a horizontal drilling, tapping, boring, and milling-machine, constructed by Messrs. William Asquith, Limited, of Halifax, for a British railway company.

This machine comprises a strong pillar, arranged to traverse by hand and power over a bed of heavy section, on which it can be securely locked when desired. The pillar is also arranged to swivel through an arc of 90 deg. by gearing operated from the saddle. An index arrangement is provided to ensure accurate adjustment.

The drilling-saddle is adjustable on the pillar by a screw actuated by a conveniently-placed hand-wheel, and can be quickly locked in any position. The saddle is accurately balanced to ensure easy adjustment on the pillar. The spindle, of hard steel, is 2½ in. in diameter; it is adjustable through a strong sleeve, which acts as a rigid support when the spindle is out at extreme traverse, and has feed traverse of 15 in., hand and self-acting. The self-acting feeds (four in number) are positive, through gearing, and can be instantly engaged or disengaged by a friction device. Double gear is provided on the saddle to give the necessary speeds for tapping, boring, and facing, &c. The reversing motion for tapping and studding is operated by a handle placed on the saddle. The spindle is driven by a variable-speed electric motor placed at the top of the pillar.

A strong base-plate, bolted to the bed, carries a special work-table, which is arranged to traverse to and from the pillar by hand and power motion. This special table has also a rotary motion through a complete circle, operated by hand and power motion, with indexing arrangement. The power motions of the work-table, and those of the pillar over the bed, are obtained by means of a variable-speed motor at the end of the bed. The power traverses enable the machine to be used advantageously for milling, &c.

The area covered by the drill-spindle is 5 ft. by 5 ft., 5 ft. traverse of the pillar on the bed, and 5-ft. adjustment of the saddle on the pillar. The work-table is 5 ft. square, with a traverse over the base-plate of 1 ft. 6 in.

The German Iron Industry.—The Bismarckhütte Company has declared a dividend of 9 per cent. for the last financial year, as in the preceding year. 2,750,000 marks have been written off, against 2,500,000 marks for the previous year. The board states that the company is most satisfactorily employed with orders both for war and peace purposes, and at present the prospects for the current year leave nothing to be desired.

NOTES FROM THE UNITED STATES.

Philadelphia, December 2.

There is a pronounced unwillingness among American makers of steel products for export to give specific information as to orders received, because of the possible danger of capture in transit of supplies ordered. It is known, however, that steel-rail export orders, closed or closing, foot up approximately 100,000 tons, 35,000 tons steel ties (for Greece), and close on to 100 locomotives, of which about one-third are of light weight. Pig-iron has suddenly improved, sales for the week aggregating over 275,000 tons, the bulk of the business being placed in the Buffalo district. Pig is regarded as at its lowest. Very few large consumers are protected by contracts. Conditions exist for a very heavy demand owing to very low stocks in makers' and consumers' hands. This applies to steel bars for agricultural uses, but buyers are trying hard to do with prices what the Germans are trying to do at Ypres. The steel-bar demand for 1915 will be exceptionally large, owing to the contemplated enlargement of the planted agricultural area to meet anticipated export demands. Outside of steel rails and pig-iron the improvement is not pronounced, though better than for a few weeks past. A recent European inquiry is for 2000 tons galvanised wire and 20,000 cast-steel car wheels. The St. Paul Railroad has ordered 12 electrical locomotives; the Canadian Trans-Continental, 450 steel freight cars and 40 sleepers. Norway wants 5000 tons of track supplies. The Standard Oil Company wants 4000 tons for a tanker. Greece wants 20 locomotives here. The Atchison Railroad has ordered 12,000 tons of rails and 6500 tons of tie-plates. The general outlook is more encouraging for an improved domestic and export demand. Financial conditions are expected to improve, and a steady enlargement of demand appears to be anticipated. Quotations are asked for several thousand tons of billets and slabs for export.

Metals in Germany.—The German industry, in spite of what the Press generally professes, must suffer terribly from the war, if for no other reasons than from short supply of raw materials, and correspondingly high prices. For instance, such a universally-used material as copper is now quoted in Germany at about twice the price of the current quotation in the open market, respectively 220 marks per 100 kg., and 55*l.* 5s. per ton. Aluminium has gone still higher in proportion, being now quoted at 450 to 500 marks per 100 kg., against 160 marks at the time of the war being declared. Antimony is still worse, now costing about four times the price when the war broke out, the figures being respectively 45 marks and 200 to 210 marks per 100 kg.

The "Mechanical World" Electrical Pocket-Book for 1915.—The 1915 edition of the *Mechanical World* Electrical Pocket-Book maintains tradition in giving extra and new matter as compared with previous issues. There are, for instance, new sections on electric circuits and switching, and synchronising and phasing-out. There is also a new section dealing with the troubles incidental to alternating-current generators and motors. The section on continuous-current dynamo and motor defects, which has appeared before, has been revised. It is arranged in a tabular form, rendering reference easy, and contains just the concise information which a user turning up the book might be likely to require. The pocket-book is published by Messrs. Emmott and Co., Limited, of 65, King-street, Manchester, and 20, Bedford-street, London, W.C., at the price of 6d., or 1s. 6d., depending on the binding.

MICHELL THRUST-BLOCK FOR THE S.SS. "CIUDAD DE BUENOS AIRES" AND "CIUDAD DE RIO DE JANEIRO."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, BIRKENHEAD, TO THE DESIGNS OF MR. H. T. NEWBIGIN, A.M. INST. C.E., NEWCASTLE-ON-TYNE.

(For Description, see opposite Page.)

Fig. 2.

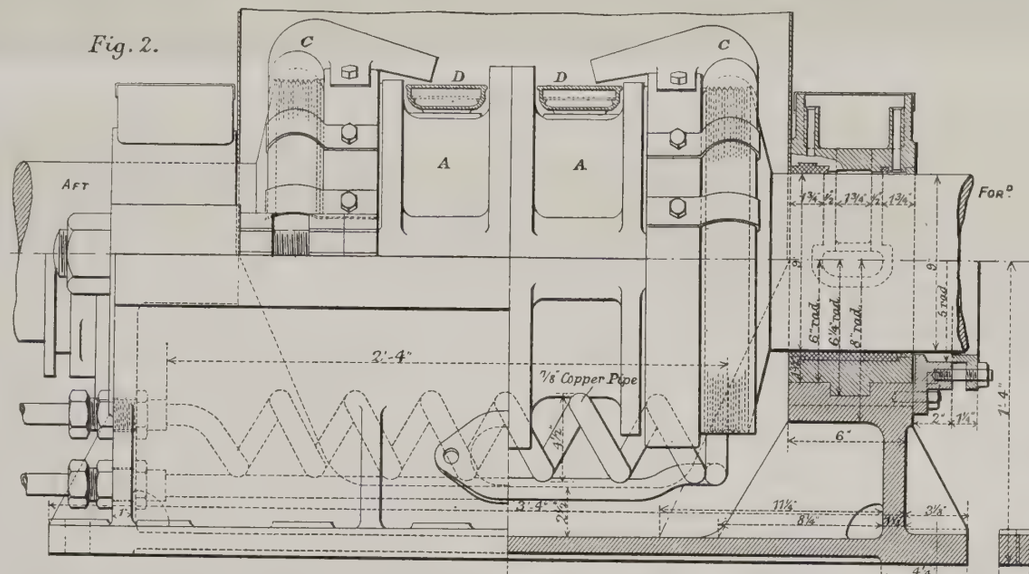


Fig. 3.
SECTION AT Z.Z.

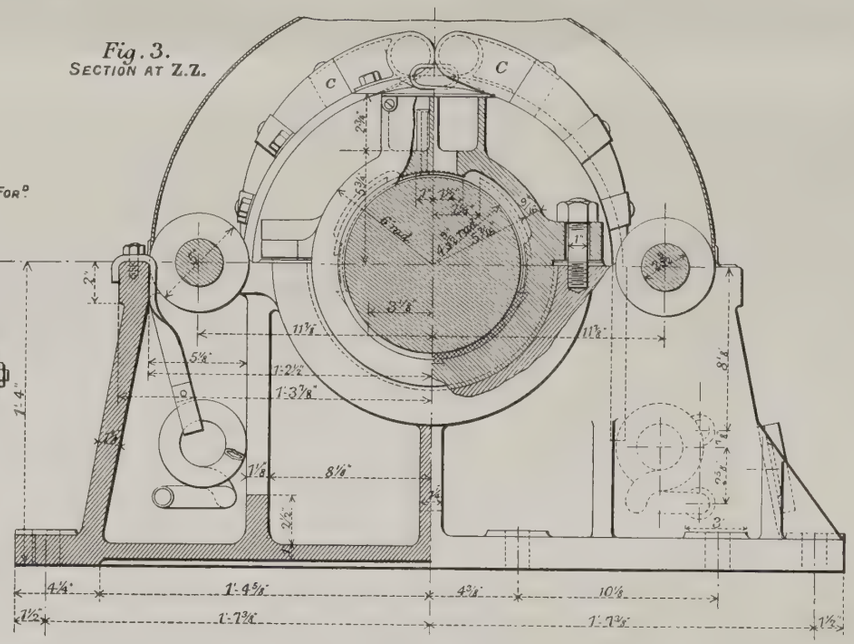


Fig. 4.

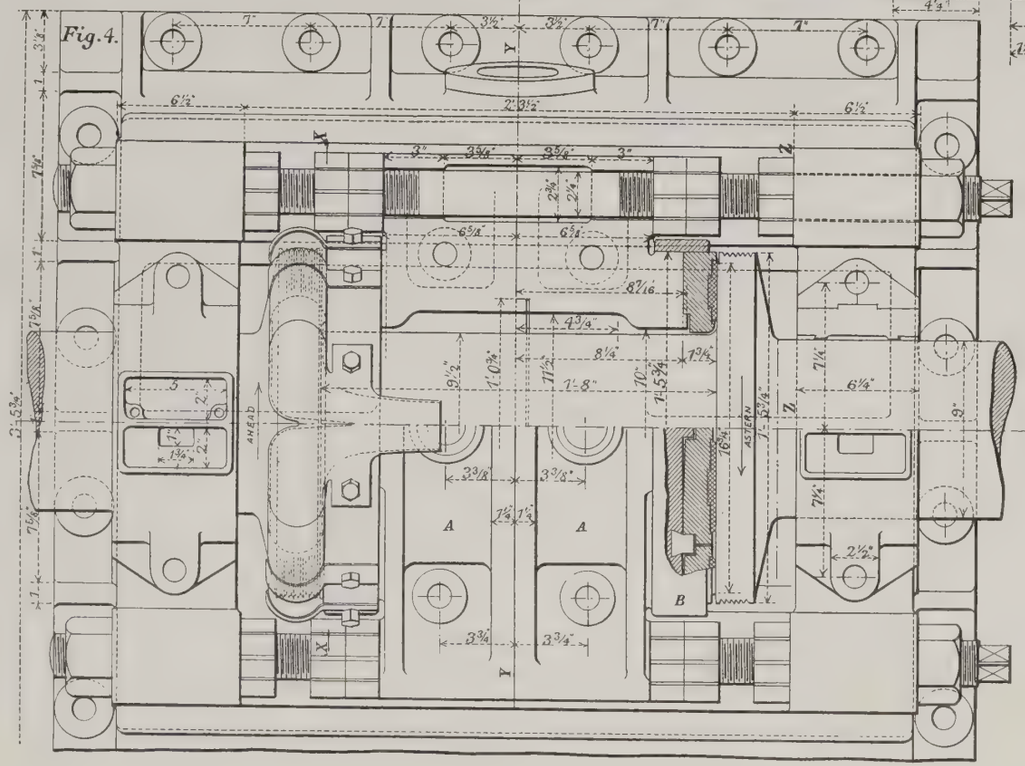


Fig. 5.
SECTION AT X.X.

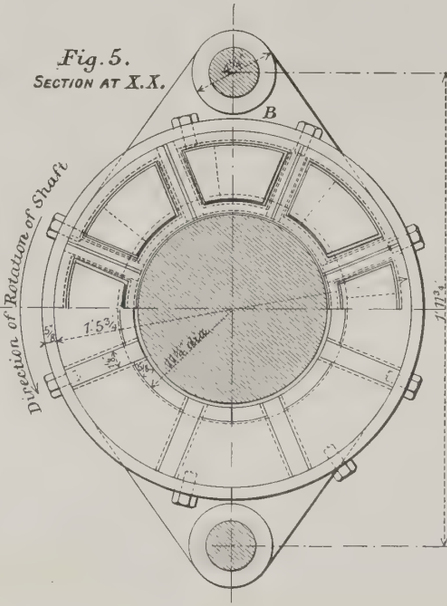
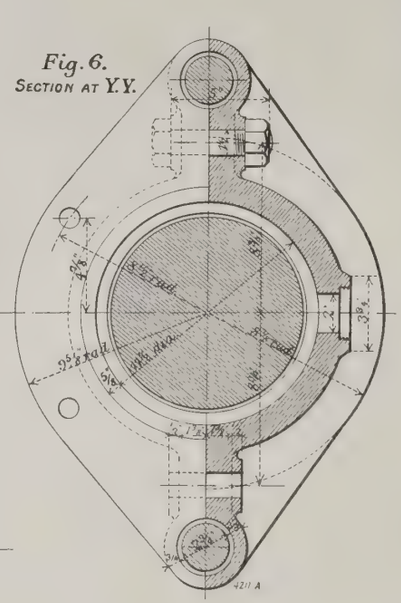


Fig. 6.
SECTION AT Y.Y.



AUTOMOBILE MANUFACTURING AND THE WAR.

A very important meeting was held in Birmingham on the 11th inst., under the auspices of the Institution of Automobile Engineers, to consider the question of finding new sources of supply of parts for motor-cars which have hitherto been obtained from the Continent, and to discuss generally the difficulties under which the industry now labours.

Captain J. S. Critchley, the President of the Institution, was in the chair, and over 120 members and visitors were present, including representatives of many of the big steel firms, such as Messrs. Frith's, Vickers', Kayser Ellison's, Flather's, &c.

Many of these gentlemen would not admit that the charges brought against the steel manufacturers of Great Britain by Mr. Pomeroy in his paper, which opened the meeting, applied to them, and thought that the fault lay rather with the automobile industry in not knowing what they really required. They also blamed the motor-car manufacturers for not giving better support to home productions. All the speakers did, however, agree with Mr. Pomeroy that it was desirable that the travellers of steel-makers, in fact, of all firms, should be more highly-trained men, who could discuss the technical problems with the heads of the firms upon whom they called, and that closer co-operation between the heads of the two parties would lead to much better results than now, when so much business was done between the traveller and buyer.

The stampers complained that their difficulties were enormously increased by the great number of specifications of steel which they had to work to, and this was a point which cropped up very frequently during the discussion. Another feature which Mr. Pomeroy laid stress upon in his paper, which was dealt with by several speakers, was the question as to whether heat treatment should be done by the stamper or by the automobile manufacturer after receipt of the stampings. There appeared to be no general agreement on the subject, one speaker going so far as to state that the practice of one big steel-maker was to insist upon having the stampings returned to him for heat treatment before being sent out as the production of his firm.

Mr. Pomeroy, in his reply, mentioned, among other things, that he had received quotations for a simple stamping from five different British firms which varied between 3s. 6d. and 14s. per piece, so that it was evident that there was a good deal of misunderstanding somewhere; it was possible that this was due to some extent to the point raised by the stampers that the quotations applied to quite different specifications of steel.

The President summed up the matter by suggesting that the first step to be taken should lie in the direction of a reduction in the number of steels used, and the fixing of a limited number of standards, with recommendations as to the parts or class of work for which each standard would be suitable. He proposed the election of a committee to discuss the question as a preliminary, which was unanimously agreed to, and Dr. Hatfield, Messrs. Brearley, Dickenson, Flather, and Kayser Ellison were elected to represent the steel-makers, to act with a committee of automobile manufacturers to be appointed by the Institution of Automobile Engineers.

It is to be hoped that the work of this committee will not be confined entirely to the limitation of the number of steels, but that their meetings will lead to closer co-operation between the heads of the steel-making and motor-car building firms in all branches of their work, which is bound to have an excellent effect throughout.

Fire-Tests with Doors.—Some interesting tests of the fire-resisting property of 1¾-in. deal doors treated by the "Oxylene" process are the subject of report just issued by the British Fire-Prevention Committee. The "Oxylene" process of impregnating timber, of the Timber Fire-Proofing Company, Limited, London, was fully described in Engineering, vol. xcvii., page 760. The tests recently conducted were made on two six-panel deal doors with flush panels, one door being placed inside a brick opening, and the other outside a similar opening. The test consisted of exposure for 60 minutes to fire, the temperature gradually rising to 1500 deg. Fahr., but not exceeding 1650 deg. Fahr., followed by the application of water from a hose for 2 minutes from the fire side. The test showed that though smoke issued through the joints, the doors were standing intact without any sign of burning on the outside at the end of the 60 minutes, when the gas was turned off. On the inside the wood was charred, but at the time the gas was turned off the charring did not exceed an average depth of ¾ in. On water being directed on the doors from the inside a panel of each fell out and water came through several joints. Paper placed on a terra-cotta block, 12 in. away from the outer face of each door, was not scorched. The value of these reports is considerably curtailed by the fact that the Committee does not venture to draw up any conclusions. The reports "are intended solely to state bare facts . . . and they are on no account to be read as expressions of opinion, criticisms, or comparisons." In spite of this some idea of the value of the process by which these doors had been treated may be gained by reference to an earlier report by the Committee on 2-in. oak and teak doors. Doors of this type subjected to a similar test collapsed so completely that practically nothing was left standing at the end of 60 minutes' exposure to fire, flame appearing on the inside at the end of 5 minutes. Two-inch doors of teak and oak are recognised as fire-resisting by the London County Council, but the "Oxylene"-treated deal doors would appear from these tests to afford vastly greater protection, their resistance really being extremely good.

THE ROYAL METEOROLOGICAL SOCIETY.

At the meeting of the Royal Meteorological Society, held on Wednesday evening, the 16th inst., at the Surveyors' Institution, Westminster, Mr. W. F. Stacey, of University College, Reading, read a paper on "*The Distribution of Relative Humidity in England and Wales.*" He had prepared mean monthly and annual maps of relative humidity, based on the 9-a.m. observations made at over ninety stations during the ten years 1901-10. An examination of these maps shows that in winter the air over the interior of the country is more moist than that over the coastal regions; that the minimum relative humidity occurs earlier in the year in the western parts of the country than in the eastern; that in summer the air over the interior of the country is drier than that over the coastal regions; and that the smallest range of humidity is found in the west and the greatest in the interior towards the east. The distribution of temperature is the chief determining factor in the distribution of relative humidity; while sea influence, the direction and character of prevailing winds, the configuration of the country, all have important effects on temperature and therefore on relative humidity.

A paper by Mr. A. E. M. Geddes, M.A., on "*Observations of the Upper Atmosphere at Aberdeen by Means of Pilot-Balloons*" was also read. These observations were made at the Observatory, King's College, during the years 1912 and 1913, and in every case two theodolites were used, thus securing an accurate determination of the flights to a level of 3000 metres. In clear weather the upward velocity of the balloon is shown to be fairly uniform, but to depend on more than the free lift. When clouds are present they influence considerably this velocity, the effect differing according to the nature of the cloud. The gradient, wind velocities and direction have been calculated and compared with those actually found by observation.

The Royal Agricultural Society.—At a meeting of the Royal Agricultural Society, held in London last week, Lord Northbrook in the chair, it was announced that it had been decided to proceed with the arrangements for holding the Royal Show at Nottingham next summer. The Society had built up a reserve fund, which would enable the Show to be held even if it were to result in some loss. In view of the activity throughout the country of manufacturers engaged on Government contracts, it had been decided to postpone the tests of agricultural tractors and ploughs, originally fixed for 1915, until 1916.

The Metropolitan Water Board.—During the past year a contract has been let for two storage reservoirs in the Thames Valley, near Laleham and Littleton, of an aggregate capacity of 7,000,000,000 gallons, together with an intake channel from the River Thames just below Penton Hook, inlet, outlet, and other incidental works. The water abstracted from the river will be gauged through three Venturi meters, each registering amounts between 10,000,000 and 100,000,000 gallons per day. Venturi meters will also be provided at the outlet for gauging the water supplied from the reservoirs. The outlet pipes from the reservoirs will be 7 ft. in diameter, and arrangements will be made for discharging water either into the existing Staines aqueduct, which runs along the northern side of the reservoirs, or into the 7-ft. diameter main conveying the water to Kempton Park, where it is intended to construct additional filter-beds, and from thence a pipe of smaller diameter will be laid to supply water to the Board's existing Hampton works. The contracts have been let for the construction of a service reservoir at Shooter's Hill to contain approximately 1,000,000 gallons, and at Westerham Hill and Betsoms Hill each to contain 300,000 gallons. These reservoirs will be constructed with side walls and floors of mass concrete, and the roofs of reinforced concrete. The reservoirs will be lined completely with asphalt. A tunnel, of 16 ft. internal diameter and lined with cast-iron segments, has been driven through the London clay under the Thames between Twickenham and Richmond, and the contractors are now proceeding with the laying of three lines of 36 in. and one line of 30-in. steel main. Tenders have been invited for the erection of pumping-station buildings at the new well recently completed at Shortlands, in Kent. The water-tower, containing an elevated steel tank, to contain 30,000 gallons, has been completed in the neighbourhood of Potter's Bar, Enfield, and is now in use. Additional pumping installations at Cricklewood and Fortis Green have been brought into use; each of these installations consist of three units, each comprising 160 brake-horse-power, three-cylinder Diesel oil-engines, driving helical gearing and horizontal three-throw ram-pumps. The Board is promoting a Bill in the coming session of Parliament seeking powers for the following:—The construction of service reservoirs at Bourne Hill, near Southgate, in their Northern District; and in the Kent District, Eltham, Grove Park, Bromley, Farnborough, Chelsfield, Sundridge Park, Bickley; the sinking of a well and the erection of pumping machinery and buildings at Eynsford; the construction of additional filter-beds at Walton-on-Thames; the laying of a main from Walton to their Brixton Works and thence to the Beachcroft Reservoirs at Honor Oak; the laying of a main from Nunhead Reservoir to connect to a main in Queen's-road, Dulwich, supplying water to the Kent district; the driving of a tunnel under Grove-lane and Dog Kennel-hill, Dulwich, to accommodate a large-size main. In the Kent district, during the coming year, a duplicate well at Southfleet is to be completed, and wells are to be sunk at Sundridge and Bexley; when these wells are completed pumping machinery and buildings will be erected.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with a strong tone, but business was limited to two lots of Cleveland warrants at 52s. 3d. January 20, and 53s. three months. The closing quotations were called 52s. 4½d. cash, 52s. 7d. one month, and 53s. three months sellers. In the afternoon Cleveland warrants were just a trifle easier, and other two lots—making 2000 tons for the day—were done at 52s. 2d. cash, with closing sellers at 52s. 2½d. cash, 52s. 5d. one month, and 52s. 11d. three months. On Friday morning the market was quite idle, but the quotations for Cleveland warrants were very firm, with sellers naming 52s. 9d. cash, 53s. one month, and 53s. 6d. three months, but buyers only offered 52s. 1½d., 52s. 4½d., and 52s. 10d. respectively. The afternoon session was also idle, but prices drew nearer. Cleveland warrants were quoted by sellers at 52s. 7d. cash, 52s. 10d. one month, and 53s. 4d. three months, with buyers at 52s. 4d., 52s. 7½d., and 53s. 1d. respectively. Monday morning saw little change in the conditions, but Cleveland warrants were stronger at 52s. 8d. cash, 52s. 11d. one month, and 53s. 5d. three months sellers. There were no transactions. In the afternoon the upward movement made further progress, and 1500 tons of Cleveland warrants were put through at 52s. 11d. cash, 52s. 9d. seven days, and 53s. 3d. one month. Closing sellers quoted 53s. 1d. cash and 53s. 4d. one month. On Tuesday morning there was a notable advance in the price of Cleveland warrants, when an increase of 11d. per ton was recorded. The turnover consisted of 3000 tons at 53s. 6d. fifteen days, and from 53s. 10½d. to 54s. 1½ l. one month, with buyers over at the latter figure, and sellers at 54s. cash and 54s. 3d. one month. In the afternoon the tone remained strong, but quotations were just a shade down from the morning. The business only amounted to 1500 tons of Cleveland warrants at 54s. one month, and at the close sellers quoted 53s. 10½d. cash, 54s. 1½d. one month, and 54s. 7½d. three months. When the market opened to-day (Wednesday) the tone was steady, but it eased off later. Cleveland warrants, 500 tons, changed hands at 54s. one month, with buyers over at 53s. 8d., and sellers at 53s. 11d., while for the other positions sellers named 53s. 7½d. cash and 54s. 3d. three months. In the afternoon the market was weak and idle, and sellers of Cleveland warrants quoted 53s. 4½d. cash and 53s. 7½d. one month.

Sulphate of Ammonia.—The sulphate of ammonia market has become somewhat stronger, and there seems more disposition to buy. Quite a good demand exists at present, and for prompt lots, and the price is from 11*l.* 7s 6d. to 11*l.* 10s. per ton, Glasgow or Leith. There is a fair inquiry for forward parcels.

Scotch Steel Trade.—After a spell of quietness the steel-makers in Scotland are now experiencing a kind of mild boom, which some consider to be largely due to the more hopeful conditions prevailing in the war zone. Business was much upset in the early days of the war, as we were not prepared for the gigantic task before us, but now that we have had four months to perfect our "war-machine," and to put our house in order, a quiet confidence in our ultimate success prevails, and business has once again begun to open out all round. The orders booked by steel-makers during the past week or two are some proof of this, as many schemes which were hung-up in the early days of August are again under consideration, and the carrying out of some of them has already been decided upon. Government orders amounting to a large tonnage have been responsible for much activity in some quarters, and no effort has been spared to push on with that work both by night and by day, all recognising that the quicker the work is turned out the sooner will hostilities be ended. Ship and boiler-plates continue in very good demand, and although firmer prices prevail, there is still a lot of buying going on, as all the recent orders have not yet been covered, and raw material and fuel have an upward tendency. In the case of black sheets the makers are fairly well employed, while for sections there is quite a lot of business passing. The home trade has picked up wonderfully of late, but the same cannot yet be said of the export trade. Inquiries are better, and now that most of the enemy's raiders have been accounted for, foreign orders are bound to improve, as the insurance of cargoes against war risks has been considerably reduced.

Malleable-Iron Trade.—The malleable-iron trade of the West of Scotland also exhibits signs of sharing in the general improvement which is current at present, and employment is better. Prices are firm, but without change as yet, although an early advance is very probable. "Crown" bars are quoted at 7*l.* 12s. 6d. per ton, less 5 per cent. for local delivery.

Scotch Pig-Iron Trade.—During the past week the demand for Scotch pig-iron has again improved, and a large business has been put through at enhanced prices. The better feeling which has been very noticeable in general commercial circles has led to increased bookings, especially on home account, but export trade is also rather stronger since the work of clearing the high seas of the German warships is being so successfully accomplished by our Navy. Hematite is still in good request round 77s. 6d. per ton, and deliveries are satisfactory. Prices are all up, and the following are the market quotations for makers' (No. 1) iron:—Clyde, 69s. 6d.; Calder, Gartsherrie, and Langloan, 70s.; and Summerlee, 70s. 6d. (all shipped at Glasgow); Eglinton, 64s., and Glengarnock, 71s. (both at Ardrossan); Shotts, 70s.; and Carron, 72s. 6d. (both at Leith).

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—Further substantial decreases are shown in the returns of coal traffic by way of Hull during November, but the actual position is not so bad as it appears at a glance, seeing that the figures relating to supplies to the British Admiralty and to the Governments of Allied Powers are excluded. The total received for the month, 339,266 tons, was only about half the tonnage dealt with in November, 1913; while the total for eleven months, 5,254,216 tons, was about two million tons less than for the corresponding period of last year. Exports for the month totalled 185,768 tons, and for the eleven months over 2¾ million tons, representing respective decreases of 100,000 tons and about 1¼ million tons compared with 1913. The great shrinkage of foreign trade is mainly accounted for by the cessation of business to Russia and Germany. In November, 1913, 94,000 tons went to Russia and 43,000 tons to Germany. Other countries, however, assisted to compensate in some measure for the loss. The month's export of 72,893 tons to France was 45,000 tons more than in 1913, while Sweden increased her requirements by 21,000 tons to 55,642 tons. The reduction was shared by all the collieries in South Yorkshire. Denaby and Cadeby Main sent 35,000 tons less, Wombwell Main 18,000 tons less, Bullcroft 12,000 tons less, Bentley 11,000 tons less, Dalton Main 10,000 tons less, Dinnington and Manvers Main 6000 tons less each. Elsecar and Wath Main 5000 tons less each, and Brodsworth 4000 tons less.

South Yorkshire Coal Trade.—Prices for all classes of fuel have hardened with the reduction of output brought about by the shortage of wagons. From this cause most pits are losing on an average one day a week. Derbyshire house sorts have been marked up 3d. to 6d. on top of the recent advance. Yorkshire household sorts are not quotably different, but the general tendency is for prices to appreciate. Trade in hard steams is active. There is a marked improvement in the demand for best sorts. Bigger tonnages are going to the Mersey and the Humber, and home consumption, particularly on local industrial account, is more than maintained. Slacks are a steadily improving market, and stocks are being cleared. Coke is the only weak feature. Quotations:—Best branch hand-picked, 16s. to 16s. 6d.; Barnsley best Silkstone, 13s. to 14s.; Derbyshire best brights, 13s. 6d. to 14s. 6d.; Derbyshire house, 11s. to 12s. 6d.; best large nuts, 11s. to 12s.; small nuts, 9s. to 10s.; Yorkshire hards, 10s. to 11s.; Derbyshire hards, 9s. 6d. to 10s. 6d.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.; smalls, 2s. to 3s.

Iron and Steel.—There is a firm feeling in pig-iron. The upward trend of values, and the difficulty of securing anything approaching prompt delivery, have directed greater attention to contract buying. Hematite is the strongest feature. West Coast hematites are quoted at 80s., East Coast at 71s., Lincolnshire No. 3 foundry at 54s. 8d., Lincolnshire forge at 53s. 8d., Derbyshire No. 3 foundry at 55s., and Derbyshire forge at 52s. Bar iron is improving, and the South Yorkshire Makers' Association has decided to continue its basis quotation of 8*l.* 5s. for crown bars. Sheets remain at 9*l.* 10s. The outstanding event of the week has been an important conference between the National Engineering Employers' Federation and the Amalgamated Society of Engineers. Output at the big engineering firms engaged on urgent work for the Government has been delayed owing to a shortage of men to work machines and bring material through the first stages of manufacture. The more advanced departments have been kept waiting, and if the maximum amount of work is to be done, it is essential that this defect should be remedied. The conference was private, but it is understood that the representatives of the Amalgamated Society of Engineers agreed to a relaxation of the Society's rules which will enable the simplest form of engineering work to be done by men who are not regarded by the Society as qualified for membership. Work is increasing at forges and foundries. No concern that can in any way participate in the execution of Government orders need be without orders. Such work embraces a wide variety of products, including guns, shells and armour, swords, gun-barrels, arrows for airmen, military tools of all descriptions, knives, spoons, forks, razors, drinking-cups, and surgical instruments. The improvement in the condition of general trade in steel goods is maintained, though there are weak patches in export business. Billets are firm at unchanged rates.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Encouraging accounts are given of the pig-iron trade. Producers have recently booked good orders, and there are still substantial inquiries in the market, though the naval engagements in the North Sea have become the all-absorbing topic, somewhat to the detriment of business. To some extent the improvement in Cleveland pig-iron is attributed to speculative deals in warrants, but undoubtedly the principal reason is the larger legitimate demand for home use. Much better reports are given of East Coast hematite pig-iron, and in this branch there is little facility for gambling; consequently hematite is not hampered by speculative operations to any extent. The make of pig-iron of all kinds is stated to be fully taken up, and as there is a marked shortage of labour, owing to so many workmen having joined the Colours, there is little likelihood of the output being increased. The already by no means unsatisfactory statistical situation should therefore further improve. No. 3 g.m.b. Cleveland pig has this week realised 54s. f.o.b., which is the highest price paid since the early part of October last year. The general market price has now settled to 53s. 9d., and it is rather more a seller's than a buyer's quotation. No. 1 is 55s. 9d. to 56s.; No. 4 foundry, 53s. 3d.; No. 4 forge, 52s. 9d.; and mottled and white iron, each 51s. 9d. Nos. 1, 2, and 3 East Coast hematite pig are now fully 70s. That price has been paid, and makers, as a rule, ask rather more, some of them quoting up to 75s. Foreign ore has been further advanced, sellers pointing out that higher freights and much difficulty in securing steamers has rendered the step essential. Market rates are now based on 23s. ex-ship Tees for Rubio of 50 per cent. quality; that is for early delivery. Contracts over six months next year have been arranged on the basis of 21s. Freights, Bilbao-Middlesbrough, are in the neighbourhood of 9s. Coke is steady and firm. Local consumers who are compelled to purchase have to pay high rates. Durham bee-hive blast-furnace coke of average quality is quoted 17s. 9d. to 18s., delivered at Tees-side works.

Stocks and Shipments.—Stocks of Cleveland pig-iron in the public warrant stores now stand at 102,950 tons. Since the beginning of the month the stock has been reduced by 2544 tons. Shipments of pig-iron from the Tees are on only a very moderate scale, and fall considerably below those of last month. To date this month they average 924 tons per working day, the total despatches being returned at 12,943 tons, 12,393 tons of which have gone from Middlesbrough and 550 tons from Skinningrove. To the same date last month the loadings were given at 33,896 tons, or a daily average of 2421 tons, and for the corresponding part of December a year ago the clearances reached 44,294 tons, or an average of 3163 tons per working day.

Manufactured Iron and Steel.—Very satisfactory accounts are given of all branches of the manufactured iron and steel trades. Producers have excellent orders, and many firms are being pressed for delivery. A substantial steel-rail order is expected to be placed locally by the North-Eastern Railway Company. The Cargo Fleet Iron and Steel Company have booked an order for 4000 tons of rails. Fairly good Colonial and Continental inquiries are in the market, including a 10,000-ton rail order for Denmark. Quotations all round are very strong, and advances are anticipated. Principal market quotations stand:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 5s.; iron shipplates, 7*l.* 5s.; iron ship-angles, 8*l.*; iron ship-rivets, 8*l.* 17s. 6d. to 9*l.*; iron girder-plates, 7*l.* 5s.; steel bars (basic), 7*l.* 10s.; steel bars (Siemens), 7*l.* 15s.; steel shipplates, 7*l.* 10s.; steel ship-angles, 7*l.* 5s.; steel boiler-plates, 8*l.* 5s.; steel strip, 7*l.* 5s.; steel hoops, 8*l.*; steel joists, 7*l.* 2s. 6d.; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 7s. 6d.; steel railway sleepers, 7*l.*—railway material net at works, and all other descriptions less 2½ per cent. discount; galvanised corrugated sheets, 24 gauge, in bundles, 14*l.* f.o.b.—less 4 per cent.

Northern Shipbuilding Orders.—Further orders for tonnage have been placed with North-East Coast shipbuilders. Messrs. A. F. Klareness and Co., of Lysaker, Norway, have contracted with Sir W. G. Armstrong, Whitworth and Co. for a steamer of about 12,000 tons, to be built on the Isherwood system.—Messrs. Ropner and Sons, of Stockton, are stated to have secured an order from Messrs. Steel, Young and Co., London, for an 8000-ton cargo-boat.—Messrs. Guthe Brothers and Co., West Hartlepool, have placed an order with Irvine's Shipbuilding and Dry Docks, Company, Hartlepool, for two shelter-deck steamers, with a dead-weight carrying capacity of about 7500 tons each.

DE DION CARS FOR 1915.—The cars which are being made by this firm for next year are practically the same as last year, with the addition of some improvements which are worth notice. The silent chain-gear is still retained, but has been considerably modified and improved. Formerly two chains were employed, and while means were provided for their adjustment, it was not so easy to do as is now the case. In the new model only one chain is employed; this passes round chain-wheels on the crank, cam, and magneto-shafts. The case containing the chain has a large detachable cover in front, and a smaller one, pivotally connected to the case by means of three studs and nuts, at the rear. This smaller cover forms a bearing for a short spindle, on the forward end of which is mounted the chain-wheel, and at the rear the magneto coupling. The magneto is mounted on a bracket forming part of this cover. The stud-holes in the cover are elongated, so that should the chain require tightening, all that is necessary is to loosen the nuts, when the whole cover, with magneto complete, can be rocked over the necessary amount, after which the nuts are tightened up. The rear suspension of the car has been modified by the substitution of semi-elliptic springs in place of the three-quarter pattern formerly used. A simple new device is seen in the means of lubricating the road-wheel bearings. Hitherto it has been usual to unscrew the hub-cap; in the new car it is only necessary to remove a small screw in the centre of the cap and inject the lubricant by means of a grease-pump. The new model should uphold the famous De Dion reputation as worthily as its predecessors; the more so in that, for the first time, Messrs. De Dion Bouton (1907), Limited, 10, Great Marlborough-street, London, W., are putting it on the market complete and ready for the road with a very full equipment at an inclusive price, either as a two or four-seater, both types being of smart design and of high-grade construction and finish.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade remains in much the same state. On Saturday it was reported that ample tonnage was in dock; that a number of steamers were waiting for loading berths; that many were due to arrive within the next few tides, and that colliery owners were looking forward to loading upon a large scale up to the holidays. Large steam coal has shown steadiness, and transactions for deliveries a few days hence have shown rather more firmness. Smalls, which have been scarce, have also shown strength. The best Admiralty large has made 20s. to 21s.; best secondary descriptions have brought 18s. to 19s.; other secondary qualities have made 17s. to 17s. 6d.; best bunker smalls, 11s. 3d. to 11s. 9d.; and cargo smalls, 8s. to 9s. per ton. Best household coal has been quoted at 19s. to 20s.; good households have made 17s. to 18s.; No. 2 Rhondda large has brought 13s. to 14s. 6d.; and No. 2 smalls have realised 7s. 6d. to 8s. 6d. per ton. Patent fuel has brought 17s. to 18s. per ton. Special foundry coke has been quoted at 27s. to 31s.; good foundry coke at 20s. to 26s.; and furnace coke at 17s. 6d. to 19s. 6d. per ton. As regards iron ore, Rubio has realised 19s. to 20s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Swansea.—The great undertaking carried on by Lord Swansea and other members of the Vivian family as smelters of copper ore, silver, zinc, and lead ores, rollers of copper and other metals, manufacturers of alkalis and super-phosphates, &c., has been registered as a private limited company, with a share capital of 650,000*l.*

Newport.—Steam coal has shown little change. Large steams have been steady, and smalls have exhibited firmness. Tonnage has also arrived satisfactorily. Best Newport Black Vein large has been quoted at 16s. 6d. to 16s. 9d.; Western Valleys have made 16s. to 16s. 3d.; and Eastern Valleys, 15s. 3d. to 15s. 9d. per ton.

Llantrisant.—In view of great mining developments which are expected to take place in the area of the Llantrisant and Llantwit Vardre Rural Council, a deputation from the local trades council waited upon the local authority to urge the adoption of town-planning schemes for the Ely and adjoining valleys. Mr. Idwal Williams, in introducing the deputation, said the population of the district was destined to increase from 18,000 to 100,000, and the Trades Council urged that building should be controlled in the public interest, and that the natural beauties should be preserved. The Council promised to consider the suggestions.

The Swansea Valley.—There has been a good demand for pig-iron at the blast-furnaces at Landore, and business has shown steadiness in pretty well all departments. The tinplate trade has been rather easier, but several mills are still idle. There has been a good supply of steel ingots and an average production of steel bar.

NEW SWEDISH IRONCLADS.—In response to invitation by the Swedish Naval Department, tenders for the building of four new ironclads of the Sverige type have been received from four Swedish yards—viz., the Kockum Yard, Malmö; the Bergsund Yard, Stockholm; and two Gothenburg yards. The first-named firm was lowest, with an offer at about 4,710,000 kr., the delivery of one vessel being promised in thirty-six months. The design is for quadruple-shaft turbine vessels and Bofors-Gullspang deck armour. The twin-screw system would increase both price and time of delivery slightly. The Bergsund Yard offer was 5,440,500 kr.; time, forty-two months. The Gothenburg New Yard quoted 4,949,000 kr. for one, and 10,000,000 kr. for two, the first to be delivered within thirty-six months, the second eighteen months later. The Lindhalmen Yard asked 5,337,000 kr.; time, 34½ months. These prices were for quadruple-shaft vessels; with the twin-screw system the cost would be somewhat dearer— from 1000*l.* to about 3000*l.*

FRIED. KRUPP AKTIEN-GESELLSCHAFT.—The fact that this company, under the existing circumstances, has increased its share capital by such a large amount as 3,500,000*l.* has naturally attracted much attention, and has been received with satisfaction in Germany. By raising its capital from 180,000,000 marks (9,000,000*l.*) to 250,000,000 marks (12,500,000*l.*) the Krupp Company is now the second largest German limited liability company as far as share capital is concerned, the first being the Deutsche Bank. Of other large German companies, the following have the largest share capital:—

	Marks.	£
Gelsenkirchen Bergwerks Gesellschaft	180,000,000	(9,000,000)
Hamburg-America Linie	180,000,000	(9,000,000)
Allgemeine Elektricitäts Gesellschaft	155,000,000	(7,750,000)
Deutsch - Luxemburg Bergwerks Gesellshaft	130,000,000	(6,500,000)
North German Lloyd	125,000,000	(6,250,000)
Deutsch - Uberseeische Elektricitäts Gesellschaft	120,000,000	(6,000,000)
Phönix	106,000,000	(5,300,000)
Great Berlin Tramway Company ..	100,000,000	(5,000,000)

The increase of the capital of the Fried. Krupp concern is stated to be due to the fact that the working capital has of late been largely tied up by extension of workshops, purchase of property and coal-mines, &c. The demand caused by the war have also necessitated an increase in the company's working capital. The Krupp family has taken over the entire new capital, of which half, or 1,750,000*l.*, has to be paid before the end of the present year. The company has paid the following dividends of late years:—In 1906-7, 19 per cent.; in 1907-8, 1908-9, and 1909-10, 8 per cent.; in 1910-11, 10 per cent.; in 1911-12, 12 per cent.; in 1912-13, 14 per cent.; and in 1913-14, 12 per cent.

HORIZONTAL DRILLING, TAPPING, AND BORING MACHINE.

CONSTRUCTED BY MESSRS. WILLIAM ASQUITH, LIMITED, ENGINEERS, HALIFAX.

(*For Description, see Page* 726)

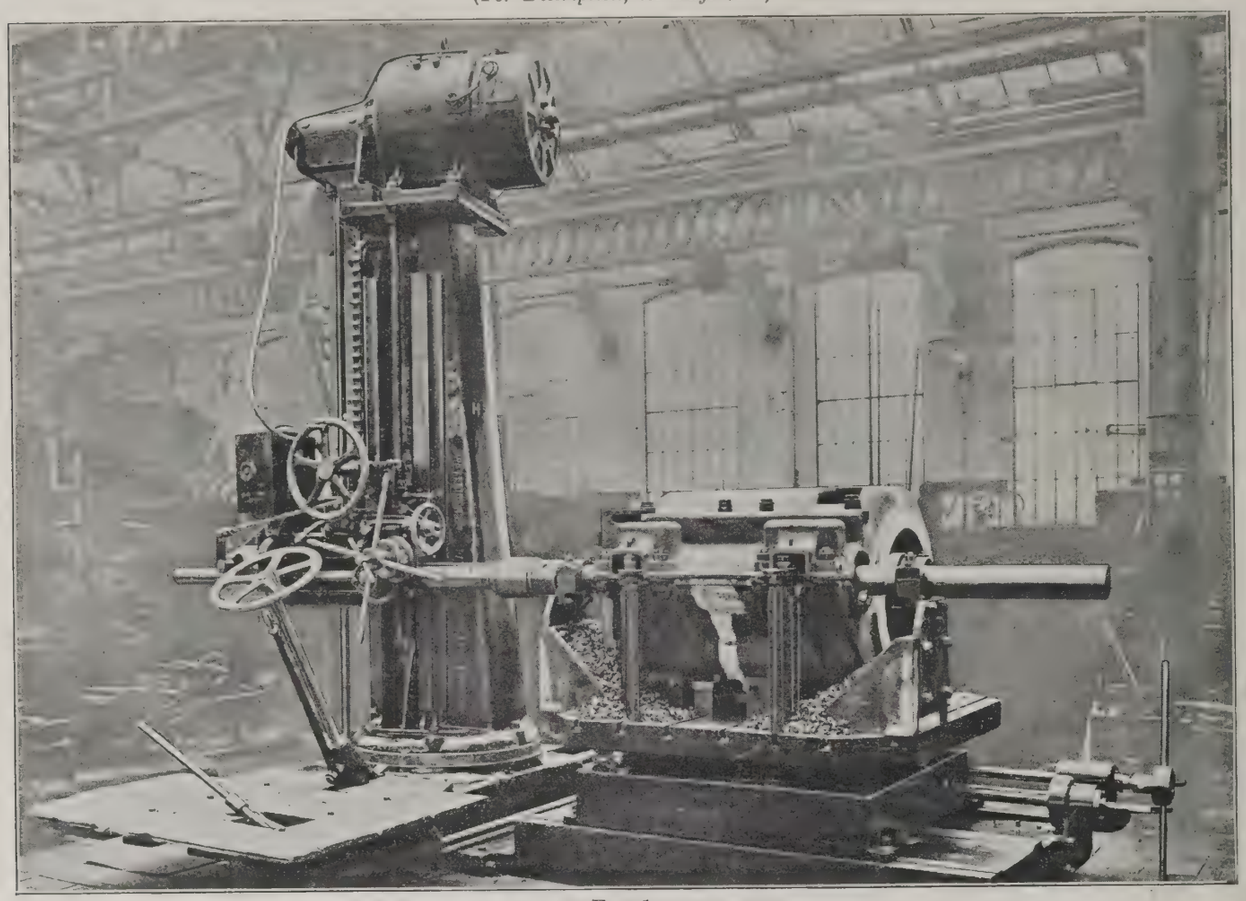


Fig. 1.

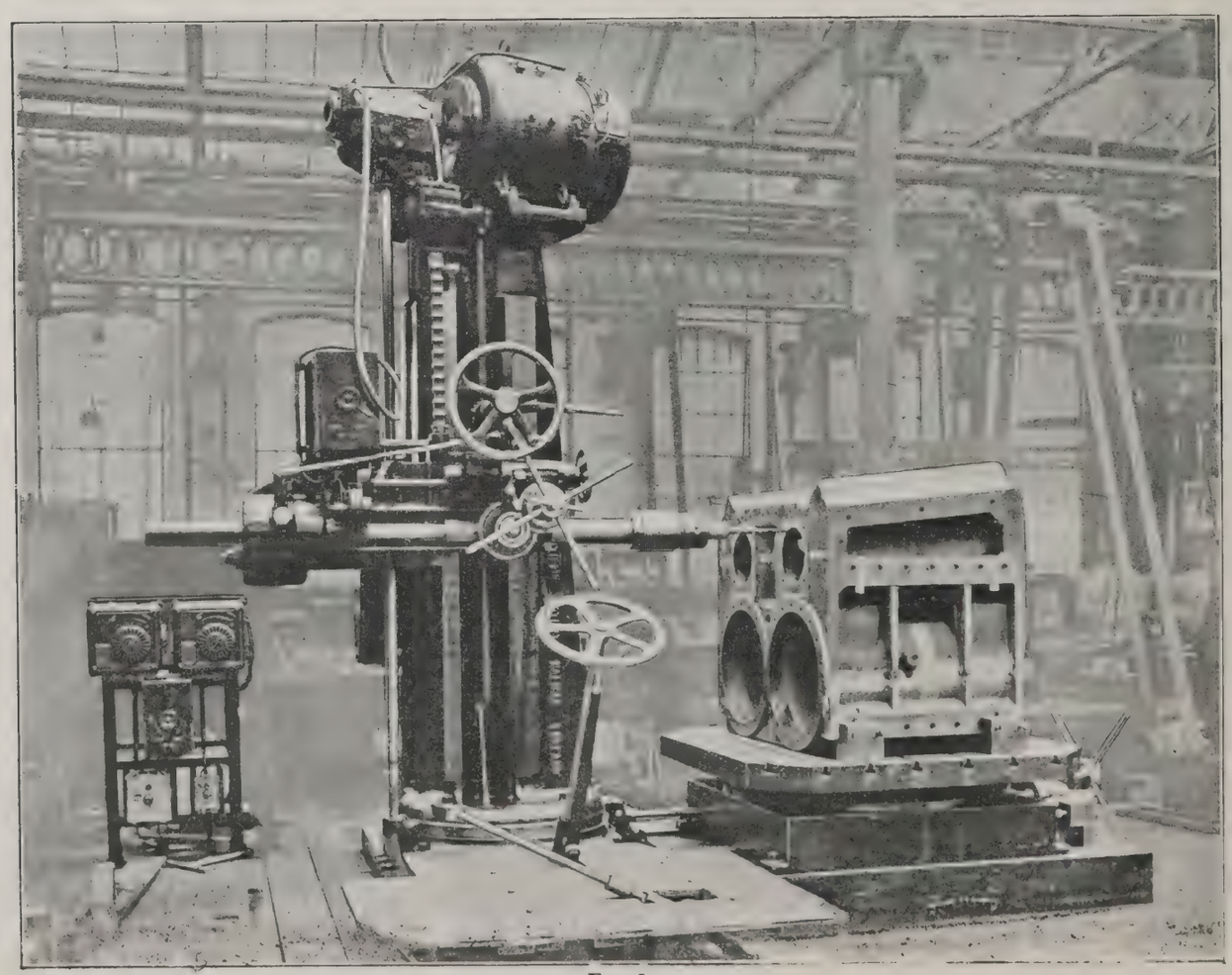


Fig. 2.

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Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

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NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 18, at 8 p.m. Five brief papers on "Audible and other Cab-Signals on British Railways," by Mr. W. C. Acfield, Member, Midland Railway; Mr. Leon P. Lewis, Caledonian Railway; Mr. Vincent L. Raven, Member, North-Eastern Railway; Mr. W. A. Stanier, Member, Great Western Railway; and Mr. W. Willox, Metropolitan Railway.

THE PHYSICAL SOCIETY OF LONDON.—Friday, December 18, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, S.W. Agenda: (1) "Exhibition and Description of Some Apparatus for Class Work in Practical Physics," by Dr. G. F. C. Searle, F.R.S. (2) "A Vacuum Guard-Ring and its Application to the Determination of the Thermal Conductivity of Mercury," by Mr. H. R. Nettleton, B.Sc. Dr. G. F. C. Searle, F.R.S., will show the following experiments:—1. Harmonic motion of a rigid body suspended by a torsion wire. 2. Determination of gravity by a rigid pendulum. 3. Determination of Poisson's ratio for india-rubber. 4. Two Methods of Measuring the surface tension of spherical soap films. 5. A simple viscometer for very viscous liquids. 6. Experiments with a prism of small angle. 7. Revolving-table method of determining the Curvature of Spherical Surfaces. 8. Experiments illustrating flare spots in photography. 9. Determination of the effective Aperture of a photographic lens. 10. The comparison of nearly equal electrical resistances.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, December 19, at 7.15 p.m., at the Institute, Wolverhampton-street, Dudley, a discussion on "Puddling Problems and the Roe Puddling Process," will be opened by the President.

THE INSTITUTION OF POST-OFFICE ELECTRICAL ENGINEERS: LONDON CENTRE.—Monday, December 21, at 6 p.m., at the Institution of Electrical Engineers, a paper will be read by Mr. S. C. Bartholomew on "Power Circuit Interference with Telegraphs and Telephones."

ENGINEERING.

FRIDAY, DECEMBER 18, 1914.

THE WAR AND ENGINEERING.

It has long been a commonplace that naval warfare is carried on by machinery. At every dinner of an engineering society the orator who replies for the older branch of the forces of the Crown acknowledges their debt to the engineer, and urges his hearers to greater effort, so that the national supremacy may be maintained. It is also admitted that the success of the Army depends upon its obtaining an ample supply of weapons, but the intimate connection between the gun made by the engineer and the victory won by the soldier is not so keenly felt in this case as in that of the Navy. Yet it is undoubtedly true that, other things being equal, success has been attained by the side that had the better weapons ever since warfare was waged. Primitive man fought, no doubt, with his teeth and his nails, and his first attempt at weapons did not go beyond sticks and stones. These cannot be claimed as engineering achievements; but the flint axe most certainly can, and it is quite conceivable that the first tribe which had a well-developed flint manufactory rapidly subdued its neighbours. When the enemy broke, the axe would complete the rout far more thoroughly than could be done by natural weapons. Probably the next step—and a very long one—was the production of missile weapons. This was, of course, preceded by stone-throwing, but the tough skins and hard heads of our early ancestors would not be easily damaged by these missiles. What was needed was some way of increasing the energy stored in the projectile beyond that which could be imparted to it by one effort of the arm, or, alternatively, its velocity must have been increased so as to ensure its penetration. The sling and the bow represent the efforts of the early engineers to fulfil these conditions. These with, later, the catapult were the only weapons for thousands of years which enabled a man to slay his enemy from a distance, but they were notable achievements, and were the source of many a victory. But the early engineers did not confine themselves to weapons of offence. The bowmaker was often foiled by the armourer even more effectually than to-day the gunmaker is countered by the armour-plate maker. But armour was expensive and heavy, and while the knight and the man-at-arms were fairly invulnerable to arrows, the horse was not, and his fall involved that of his rider. The battle of Poitiers was won in 1356 by the English archers shooting the horses of the French advance guard and those of German mercenaries who disdained to fight on foot.

The object of the engineer who applied his skill to the invention of weapons was ever to extend their range, so that a man could strike his adversary and yet remain himself outside the danger zone. The gun which followed the sling and the bow was not of much greater range, but it required less skill in management and produced a more serious wound, being able to penetrate armour. Slowly—very slowly, indeed—the range of the gun, both small arm and cannon, was extended, until 200 yards for the "Brown Bess" musket and 1200 yards for the 32-pounder naval gun represented the limits of effective fire for years. All civilised nations were then fairly on an equality as regards weapons, and none owed any special gratitude to its engineers; for it was no better armed than its neighbours. Even the actual combatants had not great cause for thankfulness, for the range of the guns was not sufficiently long to afford them much chance of orderly retreat when they found themselves beaten. In a hand-to-hand fight, a broken line is generally the prelude to a massacre, and in the Napoleonic wars the retreating army was always badly cut up by the cavalry.

Until the nineteenth century was well advanced the sword and the bayonet were the decisive factors in battle. The gun, both large and small, played its part, and no army could take the field without it, but it was not sufficiently powerful to crush the foe and hurl him into rout. Its function was, in military parlance, to "shake" the enemy, and render him more vulnerable to the charge, the really effective work being done with weapons not differing in principle from those by which the Romans conquered the world. There was a very long interval during which the engineer did very little for the soldier. The musket was introduced about 1446, and the flint-lock in 1520, and there was no other invention of outstanding importance until the rifle and the percussion-cap appeared in the nineteenth century. There is even less to chronicle in cannon, for once the art of founding was perfected, the only improvement consisted in boring them. The changes were so gradual that they were adopted practically simultaneously by all European combatants, and gave no advantage to any.

It was not until the termination of the Crimean War that the engineer entered enthusiastically into the construction of weapons; but the rapid diffusion of knowledge which characterises the present time has not often allowed him to give his clients any very great advantage. There have been, however, a few notable exceptions. The Prussian needle-gun swept the field in the Austrian War of 1866, and made every Government in Europe adopt breech-loaders in a hurry. The mitrailleuse, although it did not bring victory, saved many a French rear guard in the Franco-Prussian War. The Boers outranged our artillery by the device of putting big guns on wheels, although military experts declared that such artillery would be useless for want of mobility. In the present war the German howitzers of large size have come as a complete surprise, and have immensely reduced the menace of fortresses. In most of these instances the secret of the engineers was well kept, and the result has been an immense advantage to their clients; but, speaking generally, there is an equality in arms all over the Continent. An improvement introduced in one country is quickly imitated in another, with the result of greatly increased expenditure, but no particular military advantage.

Weapons mainly affect tactics, the chief effect of improvements being that battles are now commenced with the combatants at a greater distance apart than formerly, and that cover has become of immense importance. But the enthusiastic soldier is not content to watch his opponent through a telescope. We read to-day of trenches only fifty yards apart, and of hand-grenades being thrown from one to another, pending the bayonet charge, which finally settles the question of possession. If the engineer had done nothing but invent long-range weapons warfare would not have exhibited the startling features we see to-day. The first of these is the immense size of armies. As the Marquis of Graham pointed out in his able Presidential Address to the Junior Institution of Engineers last Monday night, the great armies of the past were all well below 100,000 in number, with the single exception of that of Attila, the "scourge of God for the chastisement of christians." The armies of those days were, of course, drawn from much smaller populations than at the present time, but, on the other hand, the proportion of potential combatants in a country was larger, and it is clear that the numbers were not so much limited by want of men, as by the difficulties of transport and commissariat. It is, indeed, related that Attila crossed the Rhine with 700,000 followers, and was eventually defeated at

Chalons in a pitched battle; but one naturally feels sceptical about the figures. The defeat is probably authentic, but is difficult to understand if we admit that Attila commanded forces so greatly exceeding the usual limits of the time, for his men had been almost uniformly victorious against the Greeks and the Romans, and at Chalons were mainly opposed to Franks and Burgundians. Whether we reject the figures, or whether we regard the case of the Huns as the one exception that proves the rule, it is clear from history that the size of armies was strictly limited by the difficulties of transport. Napoleon's maxim was "scatter to live, concentrate to fight," but the necessity of concentration in a reasonable time limited the possible area over which the army could disperse to live, and therefore the number that could be dealt with. To-day we see armies of a couple of millions standing steadily face to face without a single man detached for foraging, and it is quite possible that before the war ends there may be ten million soldiers crowded into a comparatively small area. The first step towards this condition of affairs was made when George Stephenson got his "Puffing Billy" to work in Northumberland, and the last—so far—was the introduction of the petrol motor. The intermediate stages are far too numerous to mention in detail, but prominent among them was the invention of mild steel by Bessemer. The locomotive, the steel rail, the steel steamer and the triple-expansion engine, are the all-important contributions of the engineer to this war, and it is by their means that it has been possible to bring all these millions of men face to face, and to feed them when there. It is idle to speculate what would happen if great countries had no railways, and could not maintain large armies in the field, because the countries are equally the product of the engineer as are their fighting forces, and the former would not have come into existence.

Strategy has been much lost sight of in this war, not for want of able exponents on both sides, but because it has been largely upset by the aeroplane. As already explained in the series of articles we are publishing on aircraft in warfare, the foundations of strategy lie in concealment and surprise, and there can be little of these when the modern cherub is sailing aloft all over the lines of communication. Nevertheless there have been several notable occasions on which the means provided by the engineer have been grasped by the respective generals, with more or less effect. The German retreat from Paris and the transference of large bodies of troops from the right flank to the centre of the line was a manœuvre which all the military manuals assert to be full of danger, and could scarcely have been effected without the aid of motor traction. Whether this movement was caused by the discovery of large French reserves behind Paris, or whether its purpose was to liberate divisions for use in East Prussia, it is certain that it was followed by the despatch of thousands of men against the Russians, and for the first time in history an army was seen fighting on two fronts, 600 miles apart. More than once men have been transferred from Poland to Belgium, and *vice versâ*, by the aid of engineering appliances, and each time with unpleasant results to one or other of the Allies. Railways crossing a great country are not built entirely for strategic reasons, although these are never absent from the minds of German engineers, but on the frontiers, however, military considerations are predominant, and we have recently seen the enormous advantage the railways on the borders of Poland have been to the Germans. These lines strike the frontier at numerous points not far apart, and it has been possible by their aid to launch an army at some place which could not be foreseen, and where there was not a corresponding force to meet it. This arrangement fulfils the American soldier's definition of strategy, "to get most men at a given spot," and it was so far successful as to oblige the Russians to retreat nearly to Warsaw.

Railways seldom end in defensive positions. They naturally follow valley bottoms, and hence they cannot deliver men and stores at the fighting line. Until this war the distance from railhead has always been covered by horse traction, but it is doubtful if this would have availed for the immense expenditure of ammunition and the vast requirements of food during the present war. Here, again, the engineer has come to the aid of the military man, and thousands of motor vehicles are at work ministering to the necessities of the armies on both sides. It is pleasant to find in Lord Graham's address a recognition of the fact that the engineer does not confine his energies to aiding in destruction. The motor ambulance has played a most beneficent part, not only by getting the wounded into the care of the surgeons before their lives had ebbed away, but also by abolishing the long-drawn horror of a jolting ride in a country cart. It has aided strategy also by carrying officers from head-quarters to vantage points and back again, and in its simpler form of the motor-cycle it has enormously facilitated the carrying of despatches, and has kept the commander informed of events, particularly during the serious retreat from Mons. Tactically the armoured motor-car has checked the Uhlan on many occasions, and has driven him from villages where his presence often meant death to peaceful inhabitants.

On a survey of the situation the British engineer has no cause to be dissatisfied. The work of our railways in transporting our expeditionary force was the greatest piece of transit work ever attempted in this country, and was splendidly successful. No less than 350 trains, averaging thirty vehicles each, were drawn to the port of embarcation and emptied within forty-eight hours, without a single mishap. The men and stores were taken across the Channel and landed in France equally successfully, and ever since there has been no break in the chain of communications. Only last week we learnt from the Postmaster-General that 30,000 parcels are despatched to the army every night by private senders, and that all but an insignificant proportion are duly delivered to the men, even if they are in the trenches. Our guns have held their own against those of Krupp, and often have established a distinct superiority over them; while if we have not had any giant howitzers, we have not needed them so far, as their only use is against fortifications. There is no doubt that British engineers could have produced them if the military authorities had encouraged the idea, and that to do so without official sanction would have been to invite disappointment. Our airships have done splendidly, and the number which have had to descend within the enemies' lines for mechanical defects has been strikingly small. When we contrast our ideas of a year ago on the dangers of aeroplaning with the experience of the past four months the change is remarkable, and we have to reconsider our views on the subject. Even bullets and shrapnel seem to make but little difference to the aviators. For railway facilities in France we have to depend on our allies, and have been well served, while there is nothing but praise for our automobiles. With the exception of the hundreds of motor-buses supplied by the General Omnibus Company, the rest of the fleet is a scratch lot, in the sense that it contains all sorts and makes of vehicles, and many of them not recent. The conditions of service have often been appalling, and there have been numerous breakdowns; but the net result has been most creditable to the solidity of British material and the accuracy of British workmanship.

We have already referred to the fact that superior equipment may turn the scale in warfare, and that it is most difficult to maintain any advance in this age of rapid communication. The best-guarded secrets leak out in time, and no nation has a monopoly either of material or workmanship. The only way in which superiority can be maintained is by constant advance. Contentment may be a virtue from the point of view of the philosopher, but when it is entertained in relation to the munitions of war it is the prelude of disastrous defeat. Unfortunately, progress is expensive, and the question arises as to who is to find the money. Evidently it cannot come out of an empty pocket, and the Marquis of Graham was well advised in calling attention to a speech of Sir William Beardmore, in which he insisted that manufacturers could not make progress if they had not the means to conduct research. They must pay for material and labour, and they cannot obtain the use of capital unless they can offer a reasonable interest. Governments often think that when these three requisites are attained—and they are not particularly interested in the last—they have no further responsibility. But an additional surplus is necessary if we are to keep in the front rank, and we trust that after the war the claims of our engineering manufacturers will be scrutinised in a less grudging spirit than they have often been in the past. Already the Admiralty has set a fine example by deputing Dr. Macnamara to go to the naval construction centres and convey to the workmen their thanks for the splendid efforts they have made in turning out ships and guns at an unprecedented rate since the war commenced. Last Monday he spoke in the Tyne Theatre, and since then he has visited various districts, and has not only referred in terms of high praise to the endurance of the men during long hours at high pressure, but has also put it on record that "the man in overalls is fighting his country's battles as truly as the man in uniform," and that "the bench is as important as the trench."

The engineer who does not wear overalls, but who advances the science he professes, fights his country's battles in times of peace as truly as do the soldiers who guard our fortresses. He may have nothing to do with guns and explosives; absolutely essential as they are in tactics, they must ever be subsidiary to strategy, and there is scarcely any advance in engineering which is not reflected in strategy or which does not affect the consultations fo statesmen preliminary to the declaration of war. The little Parsons steam-turbine, which many of us saw at South Kensington some thirty years ago, was the seed from which the high-speed battle-cruiser of to-day was developed; while the early crude-gasoline engine of America was the parent both of the motor-car and the aeroplane. No engineer is so far-seeing as to know what will be the ultimate effect of his experiments and his new designs, but of one thing he may be certain, that advance in many fields is absolutely essential to his country, both for purposes of peace and war, and that as long as improvements are eagerly sought and strenuously followed, we shall never suffer permanent eclipse either in commerce or on the stricken field.

BRASS-FURNACE PRACTICE IN THE UNITED STATES.

The United States Bureau of Mines is doing generally useful work by inquiring into the elimination of waste in mineral industries. The term "waste" is properly understood in its wider sense to include also the waste of human life and health and strength caused by obnoxious processes, bad ventilation, and dangerous machinery. When the waste in the melting of non-ferrous metals was being inquired into, big losses were at once recognised, and Dr. H. W. Gillett, alloy chemist of the Bureau, was entrusted with conducting a special investigation into brass-furnace practice and control. Bulletin 73 of the Bureau is the outcome of this investigation, and the 300 pages of this Bulletin constitute a very instructive treatise on the problem, based upon information supplied by the works and on personal studies.

We see from the Bulletin that, according to the Thirteenth Census of 1909, there were 1021 firms in the United States which mainly dealt in brass and bronze, including rolling-mills, but not including the non-ferrous departments of iron foundries nor the numerous brass-foundry departments of manufacturers of electrical fittings, cash-registers, &c. It is estimated that at present altogether 3600 plants are melting brass and bronze in the United States in bulks weighing from a fraction of an ounce up to 10-ton propellers. The net losses of metal vary very much, of course, but are averaged at 2.5 per cent., and the gross losses in bought raw material at 5 per cent. The waste in fuel (coke, oil, natural gas or producer gas) is much more serious; from 1½ to 16 per cent. of the fuel seems really to be utilised for melting, and the average efficiency hardly rises to more than 7 per cent. These figures mean that about 3,000,000 dols. are wasted every year in metal for brass foundries; by more judicious technical control that loss could certainly be reduced by one-half, and a couple of million dollars might be saved by the introduction of improvements of recognised advisability.

For the purpose of his investigation, Dr. Gillett sent inquiry-sheets to 2000 firms; the twenty-eight questions put concerned type of furnace, dimensions, linings and relinings, output, &c., of same; supply of fuel, waste-heat recovery, number and bulk of heats per day, handling of materials, loss of materials, ventilation, safety and hygienic regulations. About 350 sheets were returned unanswered, the firms no longer being in existence or not doing brass work; 280 firms replied—230 giving information, 50 saying that they did not keep records which would enable them to comply. Some of the replies covered several types of furnaces, so that some 300 sets of complete data were obtained. Dr. Gillett afterwards visited some 80 works; in three rolling-mills he was refused admittance, in

some others information was refused; usually information was given freely; but the number of firms which took no notice at all is very unsatisfactory. A lack of proper control and proper records was largely observed in the works inspected, and this want undoubtedly went together with serious losses.

The essence of a compilation of the kind we are discussing lies in its details. The Bulletin concludes that there is "no best furnace." But it expresses a desire for an efficient electric melting-furnace—they are not in ordinary use in America—and for a pyrometer that the workman can handle, and tells the brass-founder exactly how pit, tilting, reverberatory furnaces, &c., are worked, how they are heated and what the heating costs, how long they will live, and how the product should be treated. There are no illustrations of furnaces; but we find ample literature references and a good alphabetical index. Some manufacturers may, of course, have put their best foot foremost in answering questions as to output and economy; the practical man will be able to compare statements and to draw his own conclusions, however. The need of scientific methods in the foundry becomes very obvious. In most plants, the haziest notions prevailed as to the suitable draught. Progress is badly needed also in the United States, at any rate, as to the standardisation of brasses. People do not quite know what to order. Expensive alloys are frequently used where an ordinary brass would do; in other cases, a cheap alloy is expected to answer very special requirements, and the inquirer is bewildered by long lists of possible mixtures, which really may be supplied as stated, provided things—gates and scrap—do not get mixed up in the foundry. Dr. Gillett duly emphasises, also, that proper care should be taken of the men; he suggests conferences of the foremen on accidents, for instance. The laws are good in some of the United States, as they are elsewhere, and they may likewise be very loose and especially framed apparently for those who like to shirk responsibility. Dr. Gillett appears satisfied with the following law of the State of New York, which strikes us as deplorably vague: "There shall be in every foundry, available for immediate use, an ample supply of lime-water, olive oil, vaseline, bandages and absorbent cotton . . .; but any other equally efficacious remedy for burns may be substituted for those herein prescribed." A little lime-water and a little cotton would satisfy that law.

DELAYS TO WORKS OF CONSTRUCTION CAUSED BY THE WAR.

THERE are probably but few construction contracts of any magnitude now running in this country which are not more or less seriously affected by the great war. In most cases, probably, the effect will have been to cause delay. Delay may be caused in a variety of ways:—*e.g.* (*a*) many of the contractor's skilled workmen may have joined the Army; (*b*) a large part of the machinery indispensable to the work of construction, or of the specified materials, may have been due from Germany or Austria; (*c*) the sub-contractor, employed with the approval of the engineer to do a vital part of the work, may have been a German firm. In all these cases, delay in completion will necessarily follow. Who is to be responsible therefor?

To answer a question of this kind with reference to any particular case, one must have regard to the terms of the contract. But if the contract is silent as to war risk, or as to delays caused by this country being in a state of war, one has either to see if there is any clause which may accidentally meet the case, or else go back to first principles for a settlement of the question.

Owing, possibly, to the fact that most of the forms of construction contract were framed in the piping times of peace, there was no need to provide for the awful possibility of a European war, and even the leading text-books which have dealt with construction contracts in all their great variety are entirely silent on the matter. Although many of the customary forms make no actual provision for the "war risk," it is possible that some of those in existence may empower the engineer in charge to extend time where delay is caused by circumstances which could not be foreseen. Let us examine a few of them. The following clause is sometimes to be found in engineering contracts:—

"*Engineer may Delay or Suspend Work.*—The engineer shall have the power, by notice, to delay or suspend the whole or any part of the work during unsuitable weather, or for any other sufficient reason; but the works shall be recommenced after receiving due notice in writing from the engineer. Such delay shall in no way vitiate or invalidate the contract, and in no case shall any compensation for damage, injury, or loss of profit or otherwise be allowed the contractor for or on account of such delay or suspension of the work." It is difficult to see how a clause of this kind could be said to cover war risk, or to enable the engineer to grant an extension of time.

Indeed, the power of the engineer or architect, as the case may be, is generally so narrowly defined that it could not be extended to a case affected by the war. For instance, the well-known form of contract which has been approved by the Institute of Architects provides that:—

"If in the opinion of the architect the works be delayed by *force majeure* or by reason of any exceptionally inclement weather, or by reason of instructions from the architect in consequence of proceedings taken or threatened by, or disputes with, adjoining or neighbouring owners, or by the works or delay of other contractors or tradesmen engaged or nominated by the employer, or the architect, and not referred to in the specification, or by reason of authorised extras or additions, or in consequence of any notice reasonably given by the contractor in pursuance of Clause 1, or by reason of any local combination of workmen or strike or lock-out affecting any of the building trades, or in consequence of the contractor not having received in due time necessary instructions from the architect for which he shall have specifically applied in writing, the architect shall make a fair and reasonable extension of time for completion in respect thereof. In case of such strike or lock-out the contractor shall, as soon as may be, give to the architect written notice thereof. But the contractor shall, nevertheless, use his best endeavours to prevent delay, and shall do all that may reasonably be required to the satisfaction of the architect to proceed with the works."

It could not be argued that this clause gave power to the architect to extend the time on account of delay caused by war, inasmuch as that could not possibly be described as *force majeure*. Under the powers conferred upon him by such a clause he might extend the time if delay was due to an exceptionally violent storm; but a European war could not be regarded (for this purpose) as the act of God.

It remains to consider whether, the terms of the contract apart, a contractor who was held up through, say, half his skilled workmen having enlisted, could plead the war as an excuse for delay. It has been laid down that if, from any unforeseen cause, without fault on either side, the performance of the contract (where there is no mention of time for completion) is delayed, the loss must remain where it falls (Ford *v.* Cotesworth (1868), L.R. 4 Q.B. 127); but if the contractor has entered into any contract, express or implied, that there shall be no delay, as, for instance, by contracting to finish the work by a day named, he is bound to finish the work on the day named, or to pay damages to the employer for not doing so, unless he is prevented by the employer or by an act of God.

"We agree that whenever a party to a contract undertakes to do some particular act, the performance of which depends entirely upon himself, so that he may choose his own mode of fulfilling his undertaking, and the contract is silent as to time, the law implies a contract to do it within a reasonable time under the circumstances. And if some unforeseen cause, over which he has no control, prevents him from performing what he has undertaken within that time, he is responsible for the damage. But where the act to be done is one in which both parties to the contract are to concur, and both bind themselves to the performance of it, there is no principle on which, in the absence of a stipulation to that effect, either expressed by the parties or to be collected from what they have expressed, the damage arising from an unforeseen impediment is to be cast by law on the one party more than on the other, and consequently we think that what is implied by law in such a case is, not that either party contracts that it shall be done within either a fixed or reasonable time, but that each contracts that he shall use reasonable diligence in performing his part." (Per Blackburn, J., *loc. cit*, 1868, page 133.)

The actual facts in that case were that a merchant chartered a ship to take a cargo to Callao. She arrived in due time, but owing to war between Peru and Spain the local authorities stopped her unloading and caused a considerable delay. The shipowner sued for damages for delay in unloading beyond the usual lay days. It was held that he could not recover.

From this it would appear that if the contractor is bound to time, the loss caused by the war must fall upon him; on the other hand, if the contractor is *not* bound to time, the loss is upon the employer.

From amongst much that is obscure, one fact emerges quite clearly: no contract which involves illegal trading can be enforced.

It may be taken as established that if the delay is caused by something which would have involved the making or completion of a contract with an alien enemy, performance will be excused. So if the completion of a construction contract could not be carried out owing to the non-delivery of materials which were to have come from Germany or Austria, the head contractor could not be made responsible. In "Halsbury's Laws of England," vol. vii., page 431, the law is thus stated:—"Where performance of a contract has been rendered impossible by an Act of Parliament passed after the contract was made, the promissor is excused from performing his promise, unless it appears that he intended to bind himself with reference to the future state of the law, for the presumption is that the parties intend to contract with reference to the law as existing at the time when the contract is made. The same principle applies where the impossibility is created by an act of State, such as a declaration of war or an embargo imposed upon shipping by an Order in Council, but not where it arises from foreign law or the act of a foreign State, except where the obligations of the parties under the contract are mutually dependent, and both parties are prevented from performing them."

IMPURE AIR IN RAILWAY TUNNELS.

THE last account of investigations of the contaminated air of railway tunnels was, so far as we remember, published in 1900, when A. Mosso studied the air of the Rocco-Giovi Tunnel, in Italy, five miles in length, which had acquired a very bad reputation. Now the same subject is treated of in Bulletin No. 92 of the United States Health Service, which describes researches undertaken for the special purpose of determining the contamination of the air by sulphur dioxide, carbon monoxide and carbon dioxide, in tunnels through which coal-burning engines or electric locomotives pass exclusively. The tunnels selected were the Fulton or Baltimore-Potomac Tunnel, on the Pennsylvania Railroad (coal engines), and the Camden-Mount Royal Tunnel (electric propulsion), both located within the City of Baltimore. The investigations, which were made by Messrs. A. Seidel and P. W. Meserve, have not brought out any unexpected results. The air in the Fulton Tunnel was found to be disagreeable, but not positively dangerous, and the percentages of the three gases mentioned were about five times as large there as in the tunnel worked by electric traction. The authors of the report therefore urge better ventilation, although they do not disclose any alarming facts.

Air samples were taken in the following way:—Glass jars of 2.5 litres capacity were chemically cleaned, rinsed with alcohol and ether, charged with air, evacuated, and then sealed off, the jar being scratched in the drawn-out neck, so that it could be opened by pressure of the hand on that spot. In the railway-carriage a window was raised a little, and a glass tube was fixed in the gap to project into the tunnel; by rubber piping this tube was connected with the jar, and when the neck was broken the jar at once became filled with air from the tunnel. The determination of the sulphur dioxide was not an easy matter. To bubble the air through iodine solution would have taken far longer time than the whole journey through the tunnel occupied, and it was intended to collect air samples at different points of the tunnel. To produce an atmosphere somewhat resembling that of the tunnel, SO_2 was admitted into a room, the air of which was well agitated, until it smelled like tunnel air. Analyses of this air were then made, and it was found that direct

nitration of the air, as soon as possible after collection, with N/1000 normal iodine solution would answer for the weak concentrations. Unless the analysis were quickly performed, the SO_2 was converted into SO_3, which could not be determined in the same way. This direct oxidation, which is technically inapplicable unfortunately, takes place within an hour or so when the SO_2 is very diluted and moist and the content does not exceed 15 parts per million, as in the tunnel.

There were equal difficulties concerning the determination of the carbon monoxide; it was effected after long experimenting by means of iodine pentoxide. As much as 267 parts per million of CO were found; the corresponding figures for the electrified tunnel were 2.9 parts of SO_2 and 25 parts of CO. The determination of the carbon dioxide (CO_2) by means of barium hydrate and oxalic acid does not call for special remark. But something may be said on the action of the other gases on the animal system. Sulphur dioxide irritates the mucous membrane. According to K. B. Lehmann, who experimented near factories, up to 11.5 parts per million of SO_2 can easily be borne for 10 or 15 minutes; 15 parts produce irritation, and 30 parts cannot be endured for more than a quarter of an hour. But the system becomes accustomed to SO_2, and workers near roasting furnaces can bear occasional strong doses; yet the illnesses most to be dreaded for them are pneumonia and bronchitis. With carbon monoxide the case is different. Whether or not quite small percentages of CO will have deleterious effects, if inhaled for long periods, is a doubtful question. In a pure atmosphere the CO is given off again; but some physiologists believe that the continued breathing of an air containing as little as 0.04 per cent. of CO is injurious in the long run, and that miners' phthisis is really slow CO poisoning. There is apparently no getting accustomed to CO, and weak poisoning with it seems to render patients less able to resist other diseases. The CO combines with the hæmoglobin in the blood, and makes it unfit to take up oxygen. Fatal doses of CO, it is known, impart to the victim a healthy pink complexion; but the slow poisoning makes miners pale. It is noteworthy that an atmosphere containing 0.25 per cent. of CO would cause a 60 per cent. saturation of the hæmoglobin and may thus become fatal, all the more so as the gas does not betray itself by any smell or other characteristic.

THE LIMITS OF EFFICIENCY OF GAS-ENGINES.

By Thomas B. Morley, B.Sc., A.M.I. Mech. E.

The limit of thermal efficiency of an internal-combustion engine is the efficiency it would have if the conditions of working were ideal—that is, if there were no mechanical losses, and no transference of heat between the working substance and the walls of the combustion-chamber and cylinder.

It is well known that the "air standard" efficiency, which has been adopted as a standard of comparison for internal-combustion engines, is higher than this limit of efficiency.

The air standard cycle is supposed to be carried out with a working substance whose specific heat is constant, and for which the specific heat ratio γ is 1.4. The efficiency is then given by the expression:—

$$\eta = 1 - \left(\frac{1}{r}\right)^{0.4},$$

where r, the "compression ratio," is the ratio of the total cylinder and clearance volume to the clearance volume.

The chief merit of this standard is its simplicity. Actually the specific heat of the gases employed increases with the temperature, and this accounts for the difference between the air standard and the true limit of efficiency, which must be calculated with due regard to the actual properties of the working substance. The calculation of the true limit of efficiency is difficult, because the specific heats of gases at high temperatures are not yet known with certainty, and also the mathematical expressions which seem most nearly to give their values are inconvenient in form.

The writer has devised a chart, by the aid of which the calculation of efficiencies—and of any of the changes to which a gas may be subjected—is very greatly simplified, and has investigated and compared the limits of efficiency which correspond to specific-heat data published by different authorities.

The chart is an improved modification of that described by the writer in Engineering, vol. xcvi., page 445. The chief difference in its arrangement is that the lines of constant pressure are inclined back at 45 deg., so that the adiabatic curve takes a more convenient position. The inclination of the constant-volume lines is also affected. The chart is plotted from revised values of the specific-heat constants, and is adapted for rapid modification in order to suit different values of these constants.

The chart shown in Fig. 1 is based upon values of the specific heats given by Professor Stodola in the *Zeitschrift des Vereines Deutscher Ingenieure*, June 22, 1912.

The specific heat at constant volume is of the form $K_v = a + s\,T + u\,T^2$, where T is absolute temperature, and a, s, u are constants.

In calories per gramme-molecule, $a = 4.67$; various values for s and u are quoted, but for a typical example $s = 0.00174$ and $u = -0.000000203$.

The density of a gas-engine mixture is in all probable cases very nearly 14 referred to hydrogen—*i.e.*, its "mean molecular weight" is 28. Hence, in thermal units per pound $K_v = (4.67 + 0.00174\,T - 0.000000203\,T^2) \div 28$.

$$= 0.167 + 0.000062\,T - 0.725 \times 10^{-8}\,T^2.$$

K_p is of the form $b + s\,T + u\,T^2$, and $(b - a) = \frac{R}{J}$, where $R = \frac{P\,V}{T}$ and J is the mechanical equivalent of heat.

From the density, R is found to be 99 ft.-lb. per lb. of gas, J = 1400.

$$\therefore\ b - a = \frac{99}{1400} = 0.0707,$$

and

$$K_p = 0.2377 + 0.000062\,T - 0.725 \times 10^{-8}\,T^2.*$$

The chart has logarithmic scales of temperature, pressure, and volume, so that constant-pressure and constant-volume lines are straight. The abscissæ are really entropy values, but instead of plotting them from a straight axis of entropy, and obtaining curved lines of constant volume and constant pressure, these latter are made straight, so that a constant entropy line or adiabatic becomes curved.

The adiabatic is plotted from the equation for the change of entropy at constant pressure between temperatures T and T_0.

$$\phi - \phi_0 = \log_\epsilon \frac{T}{T_0} + S\,(T - T_0) + \frac{u}{2}\,(T^2 - T_0^2).$$

T_0 may be any convenient temperature, say 300 deg. Cent. absolute. Then $(\phi - \phi_0)$ is calculated for a series of values of T, and plotted horizontally from the sloping constant-pressure line. The resulting curve is thus an adiabatic, and all other adiabatics—corresponding to the same specific heats—could be obtained by displacing this curve horizontally. Only one adiabatic need be drawn on the chart.

The intercept between a pair of constant-pressure and constant-volume lines which intersect at T_0 is represented by

$$(b - a)\,\log_\epsilon \frac{T}{T_0}.$$

This determines the inclination of the constant-volume lines.

The change of entropy at constant temperature is

$$-(b - a)\log_\epsilon \frac{P}{P_0}$$

or

$$(b - a)\log_\epsilon \frac{V}{V_0},$$

from which the scales of pressure and volume—which are equal—are determined.

The internal energy of the gas, measured from T_0, is given by

$$I = a\,(T - T_0) + \frac{s}{2}\,(T^2 - T_0^2) + \frac{u}{3}\,(T^3 - T_0^3).$$

Values of I are plotted to a uniform scale, shown at the top of the chart, giving the temperature-internal-energy curve.

The total energy E is equal to $I + A\,R\,T$, where $A = \frac{1}{J}$, and can be found from the scales of I and A R T.

Except for the determination of I and E, the method of using the chart is similar to that described in the previous article referred to, which may be consulted for applications other than those now described.

So long as $(b - a)$ does not alter—*i.e.*, if the density at 0 deg. Cent. and 760 mm. is the same—the only change required to adapt the chart to new gases or new specific heat constants is the substitution of another internal-energy curve and another adiabatic.

The two dotted lines in Fig. 1 correspond to s = zero and u = zero, while $a = 0.167$. To allow for variations of s and u while a remains unaltered, the new curves may be readily obtained by plotting from the dotted lines $s\,(T - 300) + \frac{u}{2}$ $(T^2 - 300^2)$ and $\frac{s}{2}\,(T^2 - 300^2) + \frac{u}{3}\,(T^3 - 300^3)$ respectively to the scales indicated.

If a, as well as s and u, is changed, entirely new curves must be plotted. They should be drawn on tracing-cloth, and need only then be superposed on the original chart.

Even if $(b - a)$ also is changed, it is an easy matter to alter accordingly, on the tracing-cloth, the inclination of the constant-volume lines.

Fig. 2 illustrates the method of using the chart to find the changes of pressure, &c., for ideal constant-volume cycles.

The small figure at the right shows the ordinary pressure-volume diagram; two cases are represented.

Corresponding points on the chart and the diagram have the same letters. The volume lines V_1, V_2 correspond to the given compression ratio. The adiabatics A B, C_1 D_1, C_2 D_2 need not actually be drawn. For example, C_1 is determined by the intersection of the volume line V_2 with the line for, say, a given maximum pressure, or a given maximum temperature. A scale is laid horizontally on the chart, as shown, so that a point L on its edge coincides with C_1. K, the intersection with the adiabatic, is marked or noted. From the intersection with the internal-energy curve, the internal energy $I_{c\,1}$ is read as indicated. Now the scale is lowered, K is kept on the adiabatic, and the scale is kept horizontal (it may rest upon a parallel ruler and slide laterally along the edge of the ruler as required). Where L falls upon the volume line V_1, fixes the point D_1, $I_{z\,1}$ is read as indicated. If required, the pressure and temperature can be found by projecting in the proper directions to the corresponding scales. The original chart from which Fig. 1 is prepared is drawn upon squared paper, which facilitates its use, especially in the reading of the internal energy.

The thermal efficiency of the cycle A B C_1 D_1 =

$$\eta = 1 - \frac{\text{Heat rejected}}{\text{Heat supplied}} = 1 - \frac{I_{D\,1} - I_A}{I_{C\,1} - I_B}.$$

These values of I being read from the chart, the calculation of η is simple.

In this manner the efficiencies of a number of constant-volume cycles have been determined.

Fig. 3 shows the results obtained by the employment of the data adopted by Stodola. $T_{max.}$ denotes the maximum temperature attained in the ideal cycle.

In his Gustave Canet lecture to the Junior Institution of Engineers, delivered in June, 1913, Dr. Dugald Clerk republished a table of specific heats for temperatures up to 1500 deg. Cent., which was originally published by him in 1907. (Proceedings of the Institution of Civil Engineers, vol. clxix., page 136.)

The expression $K_v = 0.194 + 0.00005\,t$ has been given as an approximation to these results, but the writer finds that

$$K_v = 0.177 + 0.000104\,t - 3.88 \times 10^{-8}\,t^2$$

or, using absolute temperatures—

$$K_v = 0.145 + 0.000126\,T - 3.88 \times 10^{-8}\,T^2$$

is a much closer approximation, the difference being nowhere greater than 2 per cent.

From the density of the gases as given by Clerk $(b - a)$ is found to be 0.071, so that

$$K_p = 0.216 + 0.000126\,T - 3.88 \times 10^{-8}\,T^2.$$

Using these constants, new adiabatic and internal-energy curves have been plotted on tracing-cloth for superposition upon Fig. 1. Since $(b - a)$ is prac-

* The reason for the magnitude of the difference between the specific heats employed in the chart previously published and the above values is that in deducing the former from the internal-energy curve in the first report of the British Association Committee on Gaseous Explosions, it was not noticed that the zero of internal energy was taken as 100 deg. Cent.

tically the same as before, no further alteration of the chart is necessary. Fig. 4 shows the efficiencies derived from these constants, for $T_{max.} = 1000$ deg. Cent. absolute and 1600 deg. Cent. absolute.

The diagram gives values somewhat higher than those found by Clerk. He has calculated efficiencies for r ranging from 3 to 7, with $T_{max.} = 1273$ deg. Cent. absolute, and with $T_{max.} = 1873$ deg. Cent. absolute, which differ from those derived from the chart by 3 to 4 per cent. and 5 to 6 per cent. respectively.

The difference is probably due to the method of approximations adopted by Clerk for adiabatic changes; also he has taken γ as constant for the compression curve. Clerk's values for the specific heat are believed to be too high. The Gaseous Explosions Committee of the British Association has published a temperature-internal-energy curve, which, as Wimperis has pointed out, corresponds very nearly to $K_v = 0.172 + 0.000075\ t$, or $K_v = 0.1515 + 0.000075\ T$.

The chart has been adapted for these values of the constants, and the efficiencies worked out again, with the results shown in Fig. 5.

The limiting efficiencies, as shown by Figs. 3, 4, and 5, do not differ very widely, and for any given maximum temperature they are in a fairly constant ratio to the air standard efficiencies.

The following table shows the ratios as derived from the three sets of data :—

Ratio of Limit of Efficiency to Air Standard Efficiency.

Source of Data.	$r = 3$.			$r = 7$.			$r = 10$.		
	$T_{max.}$ in Deg. C. Abs.			$T_{max.}$ in Deg. C. Abs.			$T_{max.}$ in Deg. C. Abs.		
	1000	1600	2000	1000	1600	2000	1000	1600	2000
Stodola (Fig. 3) ..	.90	.86	.83	.91	.87	.85	.93	.89	.86
Clerk (Fig. 4)	.875	.83	—	.88	.85	—	89	.86	—
British Association Committee (Fig. 5)	.88	.84	.81	.90	.86	.83	.915	.88	.845

The data given by Stodola in 1912 are based upon the then most recent research, and it is interesting to notice that the efficiencies derived from them are the nearest to the air standard.

It would appear that the air standard efficiencies, instead of being about 20 per cent. too high, as stated by Clerk in 1907, are only from 10 to 15 per cent. too high in usual cases. If this be confirmed, it follows that the margin for possible improvement in the thermal efficiency of engines working on the constant-volume cycle is greater than has hitherto been supposed.

In the Diesel-engine cycle, with reception of heat at constant pressure and rejection of heat at constant volume, more variables are involved, and it is more difficult to state general conclusions. As an example of the results obtained, however, the case of a Diesel engine tested by Professor Dalby (Proceedings of the Institution of Naval Architects, 1914, or ENGINEERING, April 10, 1914) may be taken.

The compression ratio is 14.3; the ratio of the volume at "cut-off" to the clearance volume is 1.56. The air standard efficiency is 0.62; the efficiencies found from the chart using the constants based upon the data given by Stodola, Clerk, and the British Association Committee are 0.553, 0.551, and 0.558 respectively, or about 90 per cent. of the air standard in each case, although it must be remembered that the maximum temperatures differ somewhat.

In his Gustave Canet lecture, in 1913, Dr. Clerk made the statement that further specific heat experiments were in progress, by which he hoped to arrive at greater certainty. All interested in the possibilities of the internal-combustion engine will look forward with great expectation to the results of this research.

NEW DIESEL-ENGINED VESSELS.—A Norwegian owner has just placed an order with Messrs. Burmeister and Wain, Copenhagen, for two Diesel motor-vessels of 10,000 tons each, to be delivered, the one at the beginning, the other at the end, of 1916; and another Norwegian firm has ordered a similar boat, also to be delivered in the beginning of 1916.

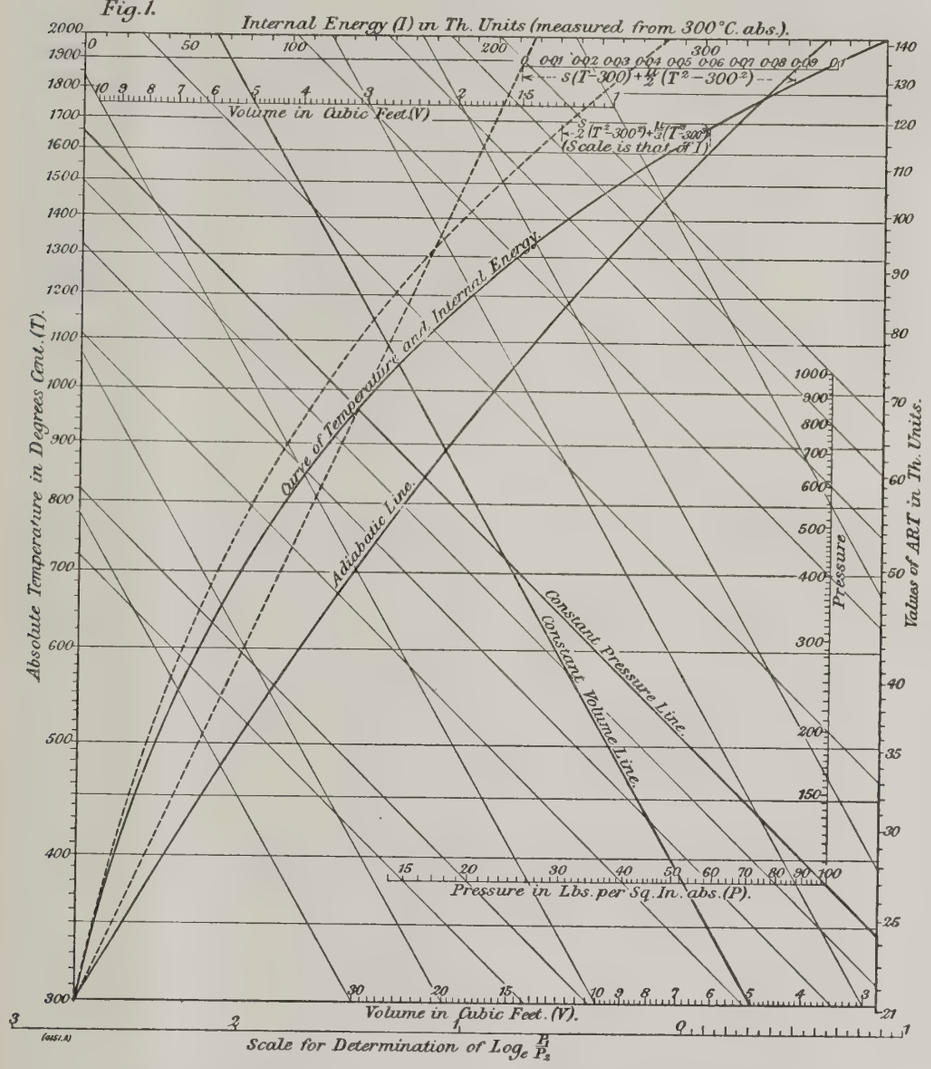
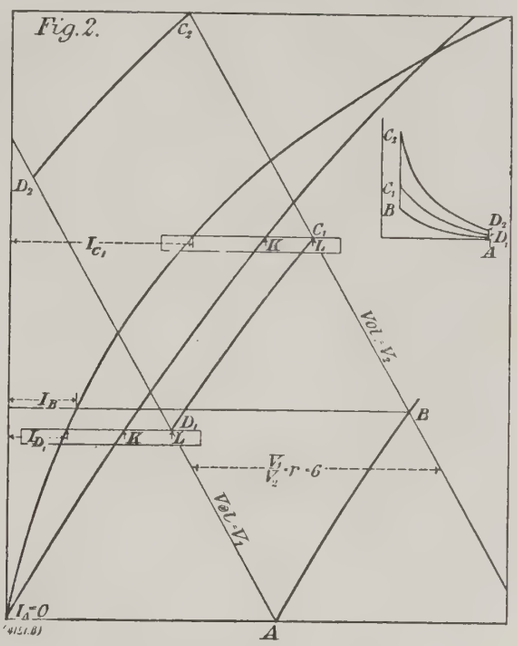
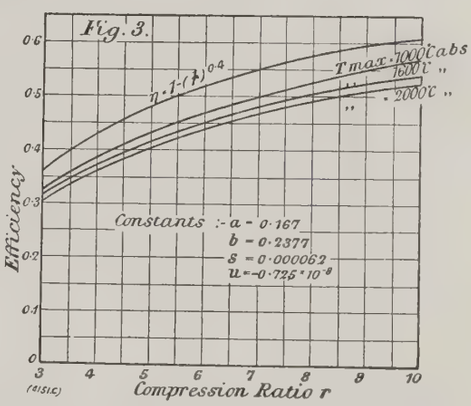
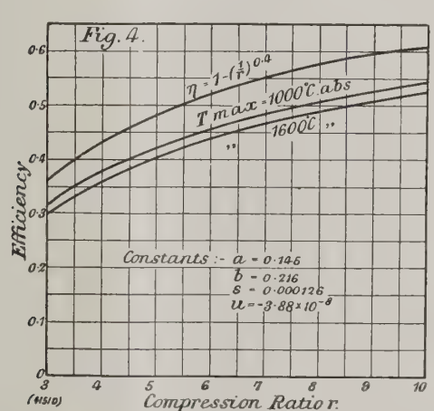
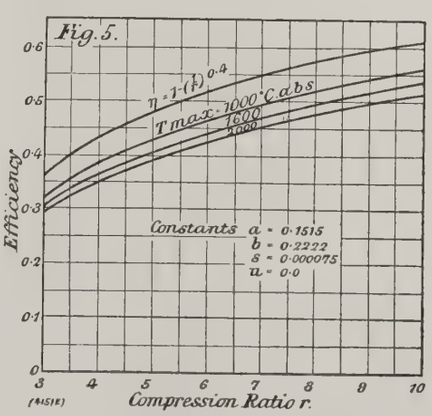


Fig. 1.
Internal Energy (I) in Th. Units (measured from 300°C. abs.).
Volume in Cubic Feet (V)
Curve of Temperature and Internal Energy.
Adiabatic Line.
Constant Pressure Line.
Constant Volume Line.
Pressure
Absolute Temperature in Degrees Cent. (T).
Values of ART in Th. Units.
Pressure in Lbs. per Sq. In. abs. (P).
Volume in Cubic Feet. (V).
Scale for Determination of Log$_e$ $\frac{P_1}{P_2}$









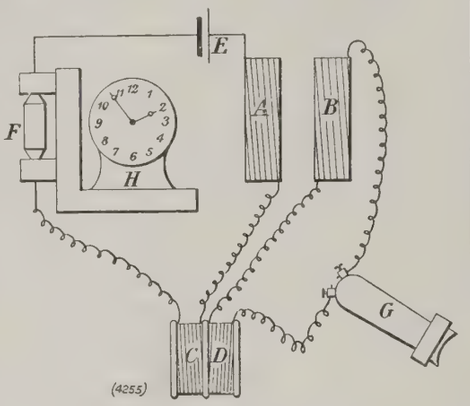
NOTES.

American Depression.

Reports from America still bear witness to great depression in many branches, and matters are generally pronounced to be much worse than they were in the panic year 1907. Although the great European war has benefited certain branches, others have suffered and tend towards a worse condition. The action against the trusts is by many considered a little too precipitate, with the result that the effect is felt by many whom it was not intended to harm. The net earnings of the railways in the United States for the year ended July, 1914, show a decrease of 102,000,000 dols., the Inter-State Commerce Commission not having granted the railways the asked-for advance in rates, although the existing rates are low—lower, in fact, than almost anywhere. The Gary Steel Works have been running very short hours for the last four months, and 5000 men have been discharged. The International Harvester Company has lost nearly all its European business, and having been declared for a trust, the company is debarred from doing business in several States; the McCormick Works have been partly closed, and many men paid off. The Western Electric Company, whose new plant in Antwerp is said to have suffered severely from the bombardment, is practically doing no European business at present, their cable department has been closed and most of their plant is only running reduced time, five days in the week; they have paid off several thousand hands. The American Can Company works only half time, and 1200 men have been paid off The works here referred to are Chicago concerns, but the same conditions prevail in Pittsburg, around New England and New Jersey. To show the general feeling of depression it may further be mentioned that the big Chicago firm of Marshall, Field and Co. has discharged a very large number of clerks and assistants. Altogether the estimate of persons at the present moment out of employment in the United States reaches the alarming aggregate of about 4,000,000, and now the winter is beginning. On the other hand, the war has, of course, benefited some special branches. Manufacturers of firearms, harness, saddlery, &c., are very busy, and the export of grain and feeding stuff goes on at a very high rate; but this is not enough to alleviate the general depression. And it should be remembered that the war has been the cause of a number of large engineering contracts being cancelled, or, in any case, left in abeyance for the time being, and both the number of hands and engineers of some of the largest contracting firms have been reduced to half or quarter of their average muster. In some cases a fair amount of consideration is extended to the employees, so that amongst the engineers the single men have to leave first, then the married men without children, those with a family being kept as long as possible, though often on a reduced salary.

The Hughes Induction-Balance.

The announcement that the Hughes induction-balance is being used to locate bullets in the wounded victims of the war recalls the fact that this instrument was first employed for this purpose when President Garfield was shot by Guiteau. The idea of using the instrument in this way seems to have originated with Professor Graham Bell, the inventor of the telephone, who, in view of the difficulty found by the doctors in determining where the assassin's bullet had lodged in the President's body, cabled to this country asking Hughes to cable back whether his balance could be used for the purpose of finding the situation of the bullet, and, if so, to add instructions for the assembling of a suitable instrument. This was done, and, with an induction-balance, improvised on Hughes's directions, the position was rapidly and accurately determined. In fact, the rapidity with which the observations can be made constitutes one of the greatest advantages of the balance for use in military hospitals. The general features of the Hughes induction balance are represented in the annexed figure. Here A and B denote two parallel equal coils of wire similarly wound and so arranged that the distance between them is adjustable at will. These coils are connected by flexible leads, as shown, with another pair of equal coils C and D, oppositely wound, mounted parallel to each other at a fixed distance. Into the circuit of A and C is interpolated a battery and a microphone F, whilst a telephone G forms part of the circuit which includes B and D. A clock H mounted on the frame of the microphone gives rise by its ticking to a succession of variations in the microphone current, and by induction a current corresponding to each tick of the clock is generated in the telephone circuit. Since, however, the coils D and C are oppositely wound, whilst A and B are similarly wound, the current induced in D tends to oppose that induced at B, and by adjusting the distance between A and B, the one can be caused absolutely to neutralise the other, in which case the ticking of the clock is inaudible in the telephone. If, however, after this balance is secured, the pair of coils C D are brought near a piece of metal, such as a bullet, currents are also induced in



this metal, and some of the energy which would otherwise produce current in D is dissipated in the bullet. The consequence is that the balance is upset, and a new adjustment of the distance between A and B must be made in order that the telephone may remain silent. The nearer the coils are brought to the bullet, and the more exactly their centre line intersects the bullet, the louder is the sound in the telephone. Hence, by bringing the coil over the body of a wounded man, the direction in which the bullet lies can be ascertained, whilst by noting what adjustment of A and B is necessary to reduce the telephone to silence, the depth below the surface can be found, since it is only necessary to find the distance from C D to which a similar bullet must be brought in order that the telephone shall be again reduced to silence, after the coils C D have been removed from the neighbourhood of the patient.

The London County Council Electricity Scheme.

Further particulars of the Bill for the constitution of an Electricity Authority for Greater London, which is to be promoted in the 1915 session by the London County Council, were furnished at the meeting of the Council on Tuesday last. In its general scope the Bill is to follow the lines with which we have already dealt more than once, but a few minor alterations have been determined on. The Authority is to consist of twenty-seven members, eighteen of which will represent the London County Council, two the Middlesex County Council, one each the County Councils of Essex, Hertfordshire, Kent and Surrey, and one each the county boroughs of East Ham, West Ham, and Croydon. Fourteen of the London County Council representatives must be members of the Council. Other representatives need not be members of the appointing authority. Existing powers of compulsory purchase possessed by the various councils concerned will pass to the new authority, which will have power to take or lease, or acquire by agreement, the undertakings of any company or local authority now supplying in the area. The new body will have authority to supply energy (*a*) to any authorised distributor in the area, or in areas contiguous to the area; (*b*) to any company or body working any railway, tramway, canal, water works, or system of docks; and (*c*) for general purposes; (i) in any area not forming part of the area of supply of any authorised distributor, or within any such part of an area if no supply is being given; (ii) in the district of an authorised distributor with the consent of that distributor. Obligation to supply is provided, subject to conditions, with a penalty for failure. The maximum price for bulk supply or for power supply to any railway, &c., is 3*l*. 10s. a kilowatt of the maximum power supplied plus 0.25d. a unit. Provision is made for revision of the maximum price after five years. The powers relating to supply, the execution of works, and the purchase or transfer of other undertakings are to be transferred to a company for a period not exceeding fifty years, and at the expiration of this period the company is to be paid a sum equal to its capital. The Authority will be empowered to make advances to the company for the purchase of any undertaking, and to the extent of two-thirds of any other capital expenditure. For these purposes the Authority will have power to issue stock to the present extent of 10,000,000*l*. Such stock will be based on the security of the new undertaking, and on the rates of the districts concerned. The net revenue is to be devoted to meeting the stock charges, providing sinking funds, &c., and the company may pay a dividend up to 8 per cent. Any further profits after these various charges have been met are to be expended in reducing prices and the relief of rates. As compared with the proposals in their earlier form, the functions of the Technical Committee have been considerably widened. This Committee, which is to consist of the Chairman of the Authority, its financial adviser and engineer, and an outside member appointed by the Board of Trade, and is to form a link between the Authority and the company, originally had its functions fairly definitely laid down and limited. It is now proposed that the Authority may delegate any of its powers to the Committee.

Reinforced-Concrete Sleepers for Tramways.—The newer lines of the Berlin tramways were from the end of 1912 to the middle of 1913 supplied with about 25,000 reinforced-concrete sleepers, and some 8000 sleepers of the same kind will be delivered to the tramways in the course of the present year.

Contracts.—Erith's patent automatic timber-dryer is being installed by H.M. War Office at Woolwich Arsenal. Erith's Engineering Company, Limited, 70, Gracechurch-street, London, are also furnishing a very large extension of their automatic timber-dryers to Messrs. Armstrong, Whitworth and Co., Limited, of Elswick.—The Edison and Swan United Electric Light Company, Limited, have received the lamp contract for the supply of "Royal Ediswan" lamps for next year's requirements for the Cunard Steamship Company.

The Northampton Polytechnic Institute.—Last Friday, the 11th inst., the annual prize-distribution took place at the Northampton Institute, St. John-street, London, E.C. The presentation was made by the Right Hon. Lord Moulton of Bank, M.A., LL.D., F.R.S. The laboratories and workshops were open to inspection, and revealed the wide range of most useful work which is undertaken at this flourishing institution. Among the more technical subjects dealt with we may note the following: Dynamo construction, die-sinking and chasing, clock and watch-making, cookery, dressmaking, embroidery, modelling, jewellery and diamond-mounting, copper-plate printing, bookbinding, carving, silversmithing, automobile and aerial locomotion, fuel and gas analysis, mechanical and electrical engineering, technical optics, including lens-grinding and microscope-making. In addition, there are classes and laboratories dealing with the principles of the various sciences involved in the arts and industries enumerated. The Institution is doing most useful work under the care of the Principal, Dr. R. Mullineux Walmsley, F.R.S.E.

The Government and Trade.—At a meeting of the British Engineers' Association held at Manchester on Tuesday, the 15th inst., Mr. Wilfrid Stokes, Chairman of the Executive Committee, referred to the necessity for reconstructing those Government departments which deal with foreign trade, by establishing a new Board of Industry. He said:—"A paid Council, composed of the best business men of the country and representatives of the High Commissioners of our Self-Governing Dependencies, the India Office, and the Agents-General of our Colonies, should be formed, and should meet at intervals to decide upon the general policy to be followed. It should be the duty of some of the members of Council to visit foreign countries and our Colonies to collect information at first hand. The head of this Council should be, *ipso facto*, a member of the Cabinet, and should be a permanent official, chosen for his ability and in receipt of a high salary. The Council should have a Parliamentary Secretary as its mouthpiece, appointed by the Government in office, and the department should be named the Board of Industry. Numerous qualified Trade Commissioners should be appointed in our Dependencies and Colonies, and in foreign countries, with adequate staffs and ample office accommodation. The function of these Commissioners would be to promote the foreign trade of the Empire, thus relieving the Consuls of that portion of their work. Our Ambassadors and Ministers should be provided with ample funds to further British trade interests by legitimate means. The Commercial Attaché service should offer a separate and distinct career, and should be made sufficiently attractive to secure the right men. Owing to the fundamental character of these reforms, there is only one way of attaining them, and that is by universal co-operation."

THE PHYSICAL SOCIETY OF LONDON.

AT the meeting held on November 27, 1914, at the Imperial College of Science, Dr. A. Russell, Vice-President, in the chair, a paper entitled "*Note on the Conduction of Electricity at Point Contacts*" was read by Mr. A. F. Hallimond.

The paper deals with the "characteristic" or volt-ampere curves given by various "point" contacts when the voltage is slowly varied. The curves were plotted by means of a form of rocking-mirror galvanometer, which projected the characteristic as the path of a spot of light on the screen, the co-ordinates being respectively proportional to the current and voltage.

The first part describes the behaviour of a typical contact, zincite-tellurium. The well-known unilateral curve is terminated by a sudden breakdown of resistance, after which the contact has a more symmetrical characteristic of lower resistance at the origin. By allowing the contact to stand under a certain voltage with zincite positive it may frequently be restored to the condition of high resistance, in which it again yields the unilateral curve.

The second part describes the results obtained on examining the characteristics for the forty-five contacts possible between ten chosen substances. The conclusion is reached that the results in all cases are similar to those given by zincite-tellurium. No line could be drawn separating "metallic" contacts from those in which one or both conductors were "crystals."

The results obtained are expressed in terms of a series in which the higher member behaves towards the lower as zincite to tellurium.

Series: zincite, brookite, molybdenite, chromium, galena, inserite, chalcocite, copper, chalcopyrite, tellurium.

In the third part the conclusion is drawn that in a contact yielding the unilateral (high resistance) curve, the resistance lies within the surface of the member standing higher in the series. Rough measurements showed that the weight required in these contacts diminished from about 1000 grammes for zincite to very light contact for the substances lying near tellurium, and it is suggested that this gradation in weight determines the relative positions arrived at for the respective substances.

Mr. Duddell thought the author's method of obtaining continuous curves much more satisfactory than the ordinary method, as it gave less chance of the point contacts altering during the experiment, and, further, the arrangement of the minerals in the table he gave appeared to have some correspondence with their order of sensibility when used as wireless detectors.

Mr. D. Owen attributed much of the success of the author's experiments to the attention paid to the preparation of polished surfaces of contact. It would be useful if the author would specify the curvatures employed. The two types of characteristic might be accounted for by the greater or less extent to which the electrostatic attraction between the contacts extend, type B occurring when that effect was large. Calculation proved that, assuming a potential difference of only one volt, and a distance apart of 10^{-7} cm. (ten times the molecular distance), the electrostatic pull was of the order of 1000 gm. wt./mm^2. It might in some cases be much greater than this.

Mr. P. R. Coursey thought the chief point of interest in the paper was the table in which the substances were arranged in the order of the effects obtained with them. It would be of considerable use if some connection could be found between this arrangement and some of their physical or chemical properties. He asked if the author had obtained any evidence of a hysteresis effect in the contacts. With reference to the jumping of the characteristic from the "A" to the "B" type of curve by the application of excessive voltage, it seemed evident that this must be what happened when a strong "X" was received, though he had noticed with a zincite-tellurium detector that the impact of a strong atmospheric often increased the sensitivity of the contact. On one occasion he had obtained a curve with a particular zincite-bornite contact which was concave to the volt axis on the side with zincite positive, but convex with zincite negative. He had failed to obtain this with other samples of the same minerals.

Professor Fortescue communicated the following: The curves given are very interesting. I have repeatedly noticed the same thing with the zincite and galena series of contacts. The breakdown is apparently due to increase of area of the contact, brought about by the increase of mechanical pressure, or by the softening, or even fusing, of one of the materials when high voltages are applied. The restoring effect of the reverse current is not so easy to explain: possibly it may be some electrolytic action. I have never found a point which had been rendered conductive by heavy mechanical pressure restored in this way. The tabulation of the substances can also be carried out from their thermo-electric properties with similar results. Carborundum, however, presents a difficulty, as it can be strongly positive or negative, and is, to a large extent, independent of the mechanical pressure.

The author, in reply, thought it likely that some connection would exist between the table and the behaviour of the contacts as detectors. He had not been able to connect this series with one derived from other physical properties. He had noticed hysteresis as described by Pierce, but assigned it to alteration and recovery. The action of an "X" on the detector could scarcely be predicted from the change in the characteristic alone. If the "X" were strongly damped, the first impulse might tend either to breakdown or recovery. The curvature of the surfaces appeared to be immaterial, and no special shape beyond that of a blunt point was attempted. He did not think the electrostatic attraction offered of itself any possibility of a unilateral effect, since the force on interchanging + and − signs would be the same. Some other unilateral property would still be required. The recovery of the contact was undoubtedly one of the most difficult features of these curves. It seemed impossible to conceive a mechanical change which would be reversible to such an extent. He felt that the published thermo-electric data which he had encountered were too sparse and too conflicting to permit a comparison with any degree of certainty.

A paper on "*The Thermal Conductivity of Badly-Conducting Solids*" was read by Mr. T. Barratt.

The thermal conductivities of several typical solids of low thermal conductivity have been determined by the same method, and, in the main, the same apparatus, as was recently employed by the author for pure metals and alloys. The substances tested include electrical insulators, such as glass, fused silica and ebonite, various kinds of wood, and some partial conductors of electricity —viz., carbon and graphite.

In a former paper it was shown that the thermal conductivity k is given by

$$k = \frac{H^2 \coth^2 a\, l}{p\, q\, h\, V^2},$$

or, where l is sufficiently great,

$$k = \frac{H^2}{p\, q\, h\, V^2},$$

where H is the heat given to one end of the specimen, of length l, perimeter p, and cross-sectional area q; V is the difference of temperature of the "hot" end of the specimen and the enclosure; h is the heat lost from 1 sq. cm. of the surface per second when its temperature is 1 deg. Cent. above that of the enclosure; and

$$a = \sqrt{\frac{h}{q}\frac{p}{k}}.$$

In nearly every case the simpler form of the equation could be used.

For the first time in the measurement of thermal conductivity a direct comparison of this quantity in the case of a non-metal has been made with that of a metal—viz., bismuth—whose conductivity is of the same order of magnitude as those of some of the non-metals.

The results agree well with those obtained by Professor Lees' "disc" method in cases where direct comparison is available.

Dr. Harker mentioned that the formula used by the author assumed that the isothermal surfaces in the specimen were plane. This would not be far wrong in the case of good conductors, but it might introduce serious error in the case of substances such as those now treated. He also doubted the validity of the assumption that h was proportional to V for any but very small differences of temperature. The results given in the paper for firebrick were about twenty times lower than those given by other observers, including recent determinations of his own.

Mr. F. E. Smith asked why the second platinum thermometer was not put inside the water-jacket. He was not sure that it was justifiable to assume that the end of the rod that fits in the copper cylinder is at the temperature given by the platinum thermometer Pt_1. Was the end of the copper plug blackened in the same way as the specimen rods? He did not like the symbols used by the author, which were not those generally employed.

Dr. Russell said that it was important to know how much of the heat was lost by radiation and how much by convection currents. The author's emissivity constant seemed to include both. With ordinary copper wires suspended in air it was known that about 90 per cent. of the total heat emitted was taken away by convection currents, and only about 10 per cent. was lost by radiation. Newton showed that the convected heat carried away was proportional to the difference of temperature between the cooling body and the surrounding medium, and hence, so far as the convection loss was concerned, the author's assumption was justified. Stefan's law applied to the radiation loss, and, strictly speaking, the assumption that this loss was proportional to the difference of temperature was only permissible for small differences of temperature. Luckily, however, this loss was small, and he did not think that the accuracy of the results obtained was appreciably affected by the assumption.

The author communicated the following reply:—The points raised by Dr. Harker are, I believe, in each case due either to misapprehension or to misprints in the advance proofs. In the first place, the diameters of the specimens were 5 mm. to 6 mm. (not centimetres, as given in one part of the paper). The ratio of the sectional area to the thermal conductivity thus remains approximately the same as in the experiments on metals. This part of the criticism applies to practically all recent determinations of the thermal conductivity of metals where the dimensions of specimens are of the same order as in the present experiments. As Dr. Russell remarks, Newton's law of cooling is applicable to that part of the heat lost by convection, and also very nearly to that lost by radiation, provided the excess of temperature of the rod is not great. In the present research this excess of temperature was no greater than 10.6 deg. Cent. Finally, the value of k in the case of firebrick is that given in the main table of results—viz., 0.0010. The value referred to by Dr. Harker is again a misprint. In reply to Mr. Smith, it is not safe to have a bare platinum thermometer in water or steam, and, in addition, the temperature to be measured ($P t_2$) is that of the actual enclosure. In answer to the next point, I consider it quite justifiable to assume that the temperature of the "hot" end of the cylinder was the same as that of the rest of the copper cylinder containing the thermometer $P t_1$, as the enclosing cylinder was of thermal capacity greatly in excess of that of the specimen rods. The end of the "copper plug" was blackened in precisely the same way as the rods. Dr. Russell's remarks as to the probable ratio of convection to radiation are interesting, and I hope shortly to determine this ratio in the case of my own arrangement of apparatus.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

New Zealand: H.M. Trade Commissioner reports that tenders are invited in the local Press for heating and ventilating plant for the new Parliament Buildings at Wellington. Tenders on the proper forms will be received, up to noon on January 8, 1915, at the Public Works Office, Wellington, N.Z. Drawings, specifications, and conditions of contract may be consulted by United Kingdom heating and ventilating engineers at the Commercial Intelligence Branch. It will be observed that the time for the receipt of tenders is limited, and this intimation therefore will be of use only to firms having agents in New Zealand who can be instructed by cable.

Russia: H.M. Embassy at Petrograd reports that, according to the official *Torgovo-Promyshlennaya Gazeta* (Petrograd) of October 19/November 1, the Minister of Ways of Communication has laid the following proposals before the Council of Ministers:—(1) The expenditure by the Ministry of Ways of Communication of 1,049,593 roubles (about 110,700*l.*) for the purchase abroad of thirty steam-engines (Mallet type) for the narrow-gauge railway between Vologda and Archangel; and (2) the expenditure of 12,062,430 roubles (about 1,273,000*l.*) for the construction of a broad-gauge line on the Vologda-Niandom section of the above-mentioned narrow-gauge railway.

Colombia: The *Diario Oficial*, Bogotá, publishes the text of a contract entered into between the Colombian Ministry of Public Works and Señor G. Porros Troconis, of Cartagena, for the construction on the Salmedina and Isla Fuerte, Department of Bolivar, of two lighthouses with steel towers, and of two light-buoys, at a total estimated cost of 50,000 pesos gold (about 10,000*l.*). Material required in connection with the work which it may be necesary to import will be exempt from import duty.

Brazil: The *Diario* publishes a decree approving the project of the Commissão Federal de Saneamento da Baixada Fluminense for the execution of dredging and other improvement works on the River Iguassú and its tributaries at a total estimated cost of 698,372 milreis (about 40,700*l.*).

Chili: The *Diario Oficial*, Santiago, publishes a decree granting to Don Florencio Rioja a concession for the installation of a telephone system between the towns of Tacna and Puerto Montt. The work is to be undertaken in two sections—viz., the Valparaiso-Puerto Montt section, which must be completed within a maximum period of five years from the date of the decree, and the Tacna-Valparaiso section, which must be completed within a period of nine years.

BRITISH TRADE IN BELGIUM.—The Belgian Chamber of Commerce in London, 24, St. Dunstan's-buildings, St. Dunstan's Hill, E.C., is at the disposal of manufacturers who wish to get into communication with Belgian refugees who formerly acted for German firms, and are wishful to replace these makers by English manufacturers of similar goods. These refugees are here unoccupied, and would be very pleased to spend their time in acquiring knowledge of the lines they will be called upon to introduce later on. The Chamber of Commerce can also supply foreign correspondents.

THE TRENT.—On Monday, the 14th inst., the Nottingham City Council further discussed a proposal for the expenditure of 150,000*l.* in improving the navigation of the Trent. It was decided, however, not to proceed further with the project, at any rate for the present. The idea had been that the proposal would give Nottingham the status of a port; on the other hand, it was contended that the project was brought forward mainly in the interest of the Trent Navigation Company, which, it was urged, would have itself carried out the improvement had it been certain that it could have derived some profit from it.

EXTERNAL TRADE OF THE UNITED KINGDOM.—The net tonnage of British and foreign vessels (sailing and steam) which arrived and cleared last year with cargo and in ballast from and to foreign countries and British possessions at the principal ports of the United Kingdom was as follows:—

Port.	Arrived. tons	Cleared. tons
Cardiff	7,617,450	10,447,151
Cork	3,760,365	3,693,833
Dover	2,416,943	2,407,818
Glasgow	3,573,945	4,331,003
Grimsby	2,498,883	2,755,332
Hull	4,704,865	4,350,700
Liverpool	12,054,056	11,209,415
London	13,725,156	11,403,908
Middlesbrough	2,374,801	2,117,832
Newcastle	7,218,833	8,496,747
Newport	2,229,101	2,874,683
Plymouth	3,809,341	3,778,427
Southampton	6,700,780	6,625,472
Swansea	2,119,551	2,782,414

DETAILS OF 2-8-8-8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD.

CONSTRUCTED BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA., U.S.A.

Fig. 182.

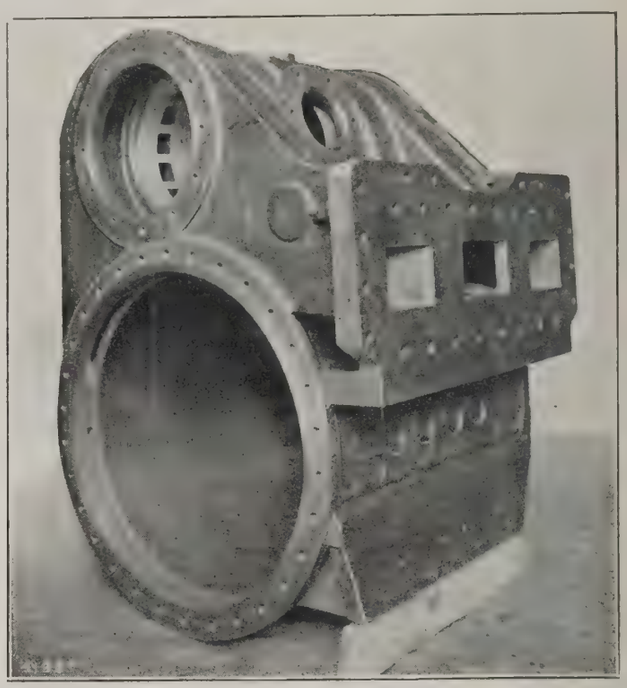
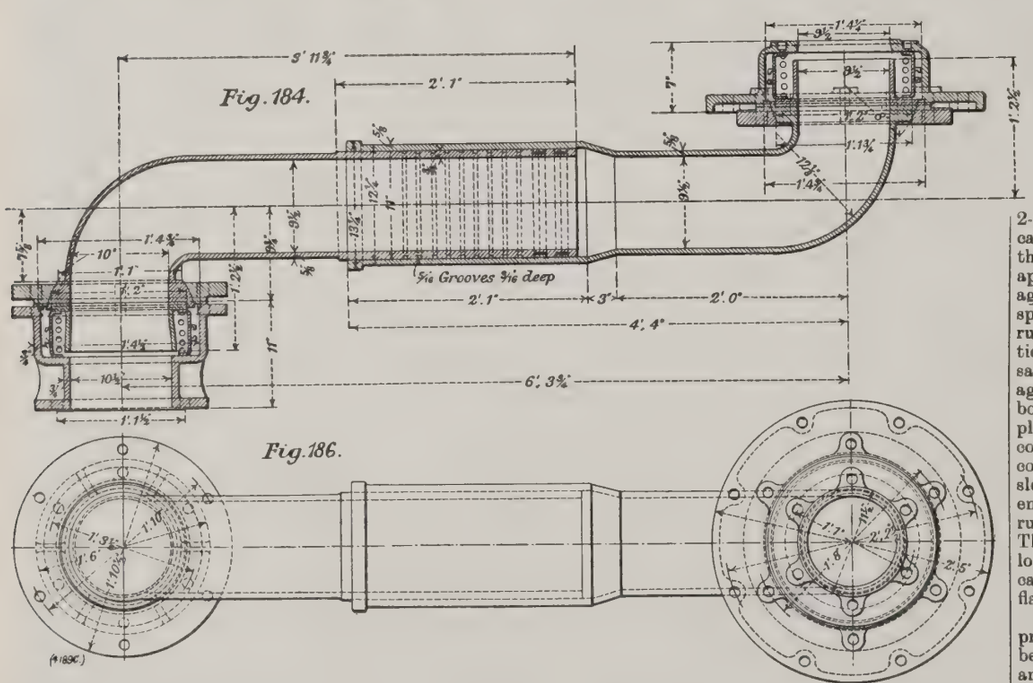
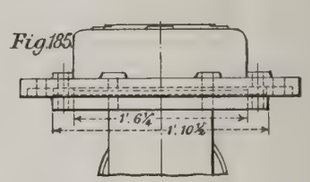


Fig. 183.





COMPOUND ARTICULATED 2-8-8-8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD.

(Concluded from page 684.)

In our issue of the 4th inst. we described the frames, saddles, and articulation system of the large 2-8-8-8-2 locomotive built for the Erie Railroad by the Baldwin Locomotive Works. We will now proceed to a description of the bearers fixed to the frames of the front section and carrying the weight of the boiler-barrel. These bearers have to allow for the radial movement of the front section under the barrel, which, of course, keeps the alignment of the second section, to which it is fixed. There are two sliding bearers under the barrel. They are illustrated in Figs. 131 to 147 on Plate XLV., with this week's issue of Engineering. The bearer illustrated in Figs. 131 to 139 is situated on the frames between the second and third pairs of drivers; that shown in Figs. 140 to 147 is placed between the third and fourth pairs. The former embodies a spring control for returning the front section to the central position when the locomotive leaves a curve and runs on to the straight.

From our engravings it will be seen that this bearer consists of a large cast-steel cross-tie fitted between the frames and clipping the top rail, with arms extending on either side. Fig. 131 gives a side elevation of this bearer, while Fig. 132 is a half elevation of the back side. A plan is shown in Fig. 138, and in Fig. 139 a horizontal section through the control. Fig. 137 shows the under side of the cross-tie casting and the fit for the frame top rail. The gear frame of the Baker valve-gear is attached to the front of the arms extending from this casting, the other end of the gear-frame being fastened to the yoke (see Fig. 2 *ante*). The top side of the cross-tie casting forms a table, on which a cast-steel saddle riveted to the boiler-barrel with 1¼-in. rivets moves to either side. Between the saddle and the table is a rubbing-block (Figs. 135 and 136), consisting of steel faced with a brass plate. This is held between flanges on the cross-tie. The under side of the saddle is provided with oil-grooves. A 1¾-in. to 2-in. rod passes right through the saddle, and is held in cast-steel brackets at the end of the cross-tie arms. Near the middle of this control-rod are placed, about 14½ in. apart, two large washers. Bearing on the inside end against these washers there are on this rod powerful springs, at the outer end of which are manganese-steel rubbing-plates, shown in Fig. 134. When the front section and boiler move relatively one of the springs in the saddle is compressed and its rubbing-plate bears hard against a cover-plate fixed on the end of the spring-box of the saddle, and shown also in Fig. 133. This plate has surfaces on the inside struck to a radius corresponding with that of the rubbing-plates on the control-rod. The cover-plates have each an oblong slot for the control-rod to pass through and large enough to allow of the requisite movement of the rubbing-plates, which approximately fit the slots. The rubbing-plates and springs are held in position by lock-nuts. At the back and front of the cross-tie casting there are large cast-steel clips passing over the flat bottom flange of the saddle.

The second bearer is of simple construction, and provides merely for sliding movement, the control being omitted. It is illustrated in Figs. 140 to 147, and consists of a cast-steel cross-tie casting across the frames clipping the top rails, and a cast-steel saddle fastened to the boiler by 1¼-in. rivets. Between the top of the cross-tie and the under side of the saddle casting is a brass-lined steel rubbing-plate (Figs. 144 and 145). A half elevation is shown in Fig. 141, and in section in Fig. 140. Fig. 142 shows a side elevation, and Fig. 143 the half plan of the saddle, Fig. 146 showing the setting out of the rivets on the flange of the latter, while Fig. 147 shows the oil-grooving on the lower side of the saddle casting.

The cylinders, of which two views are given in Figs. 182 and 183, above, are bolted to the saddle castings, described in our issue of the 4th inst. They are also keyed, but not bolted, to the frames. All six cylinders have an internal diameter of 36 in. and a stroke of 32 in. As already stated, the cylinders on the central section are for high-pressure steam. The front and rear pairs of cylinders are supplied with low-pressure steam from the high-pressure exhaust. The exhaust from the right-hand high-pressure cylinder is led forward to the cylinders on the front section; that from the left-hand high-pressure cylinder being taken to

Fig. 155.

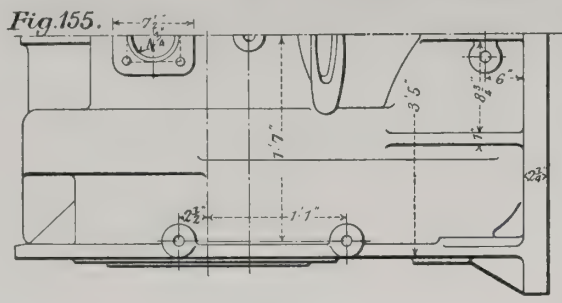


Fig. 156. SECTION ABCDE.

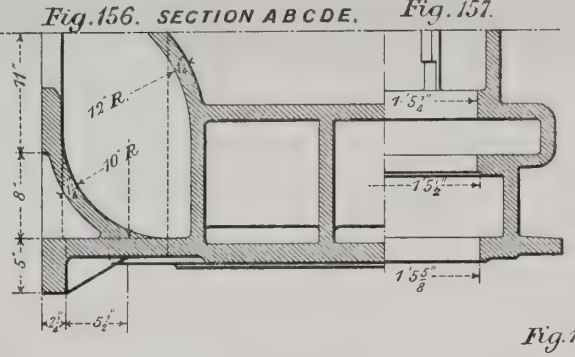


Fig. 157.

Fig. 158.

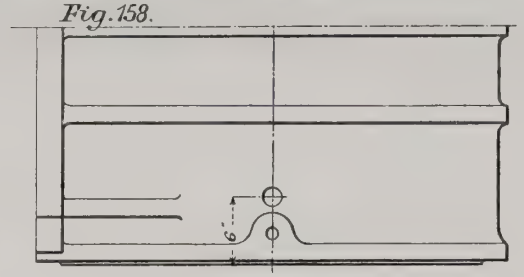


Fig. 159.

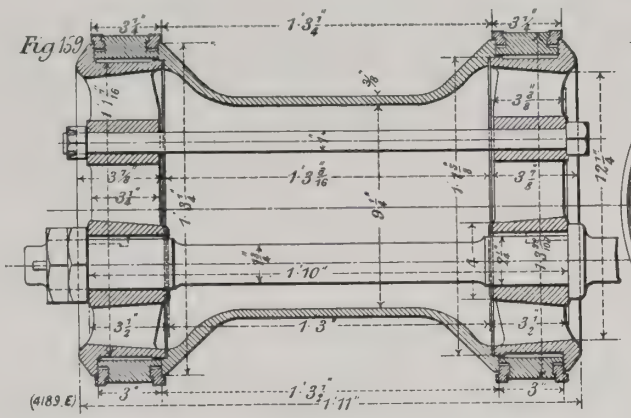


Fig. 160.

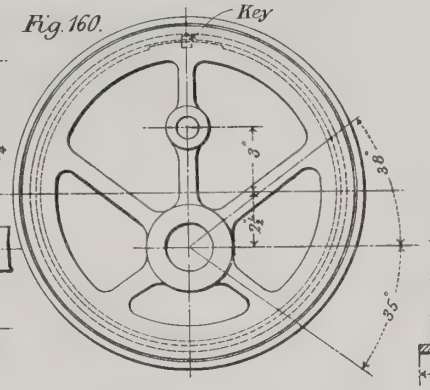


Fig. 161.

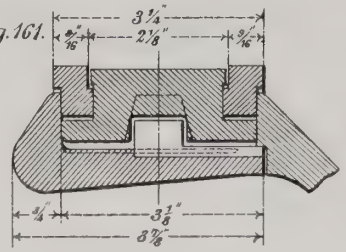


Fig. 162.

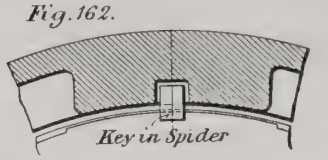


Fig. 163.

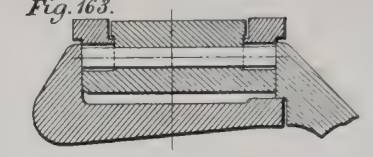


Fig. 164.

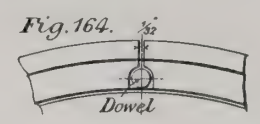


Fig. 165.

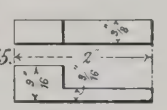


Fig. 166.

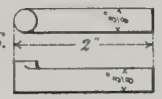


Fig. 167.

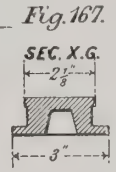


Fig. 168.

Fig. 169.

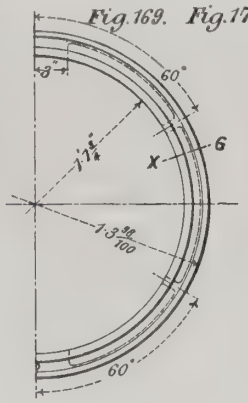


Fig. 170.

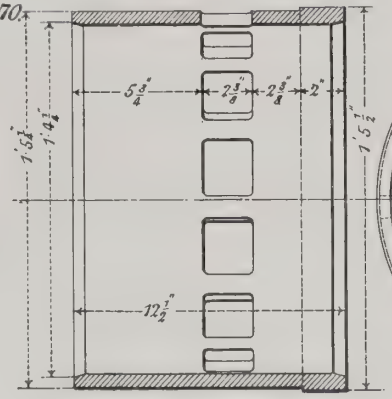


Fig. 171.

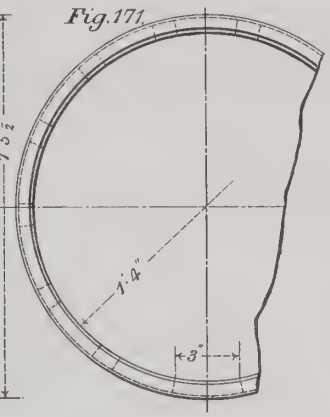


Fig. 172.

Fig. 173.

Fig. 174.

Rings cut at 45°

Fig. 175.

Fig. 176.

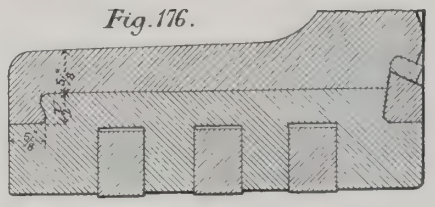


Fig. 177.

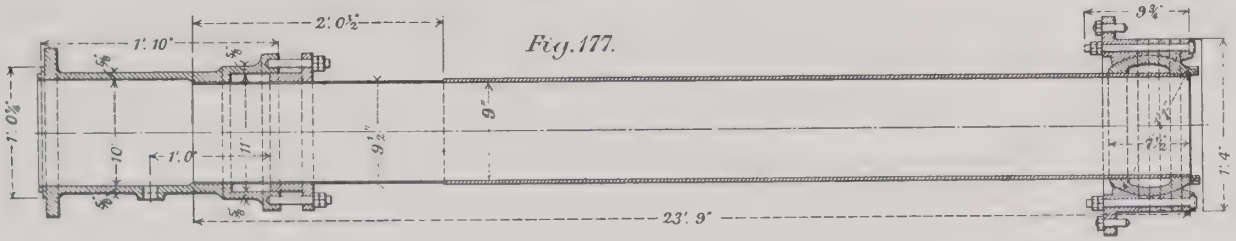


Fig. 178.

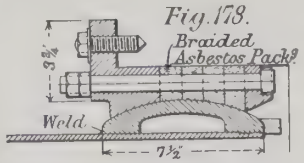


Fig. 179.

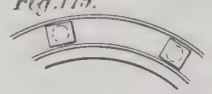


Fig. 180.

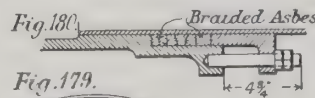
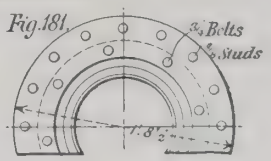


Fig. 181.



DETAILS OF COMPOUND ARTICULATED 2-8-8-8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD.

CONSTRUCTED BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA., U.S.A.

(*For Description, see Page* 738.)

Fig.131.

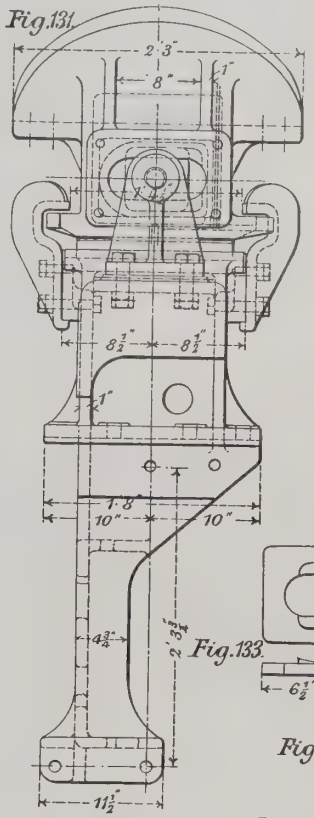


Fig.132.

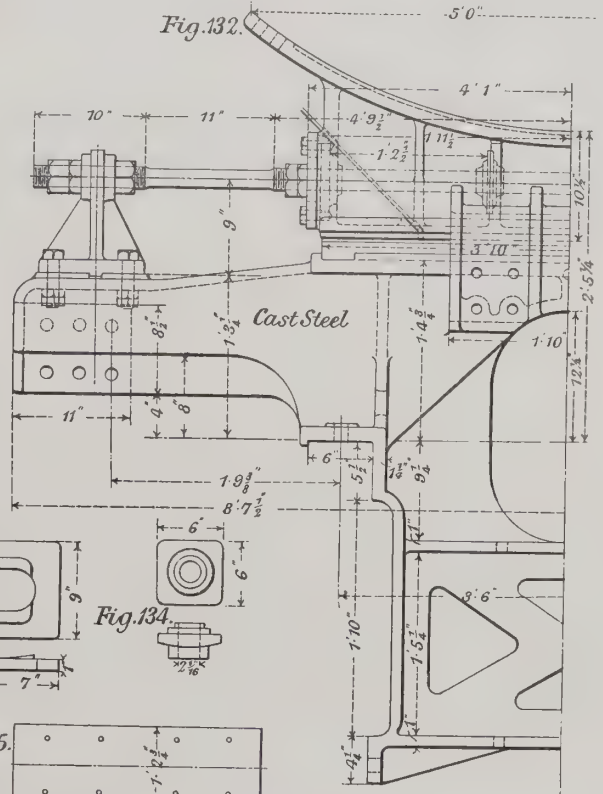


Fig.133.

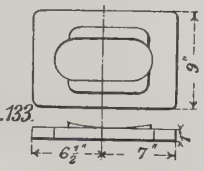


Fig.134.

Fig.135.

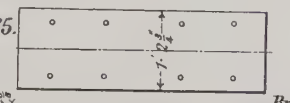


Fig.136.

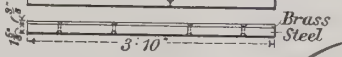


Fig.137.

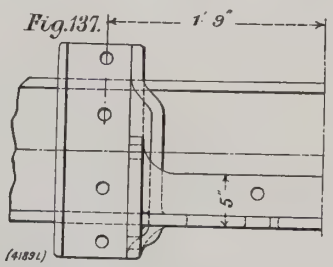


Fig.138.

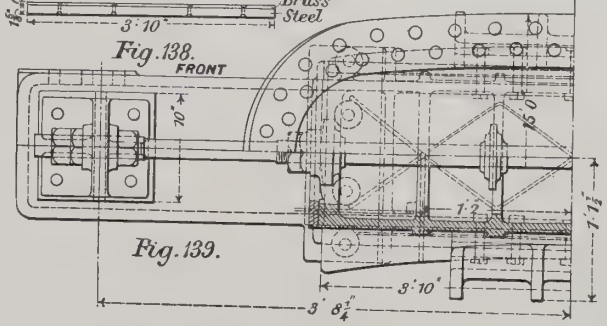


Fig.139.

Fig.140.

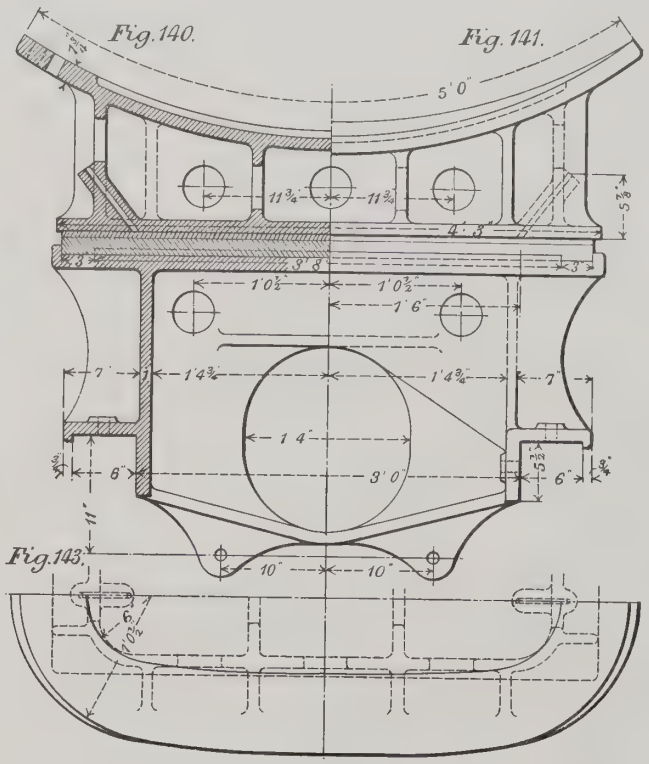


Fig.141.

Fig.142.

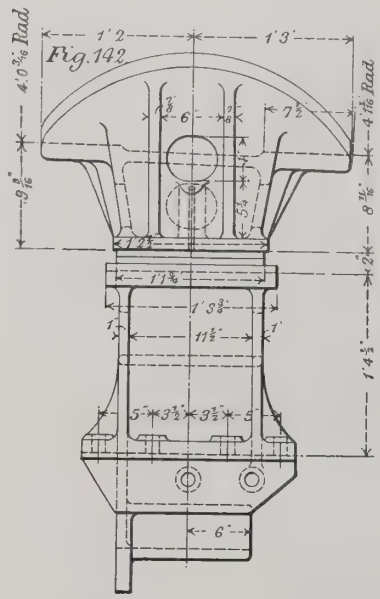


Fig.143.

Fig.144.

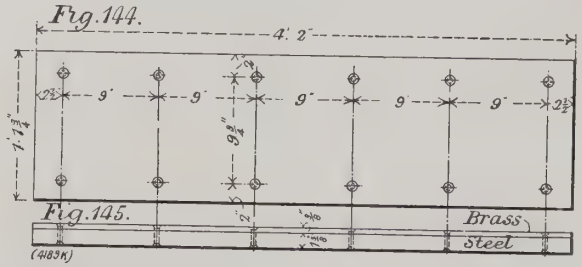


Fig.145.

(4183K)

Fig.146.

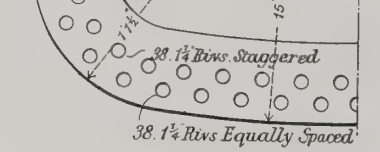


Fig.147.

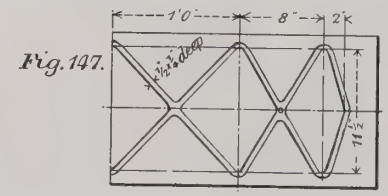


Fig.148.

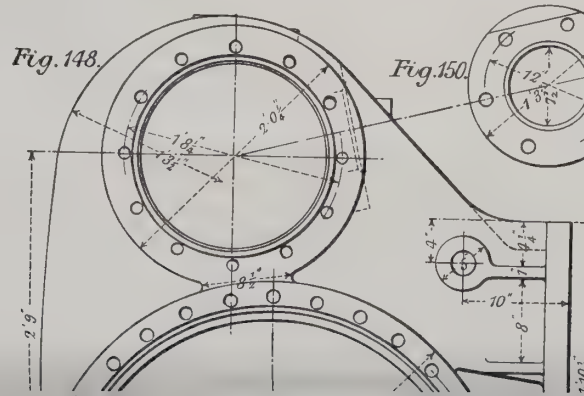


Fig.150.

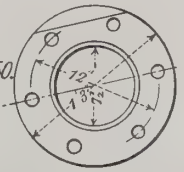


Fig.149.

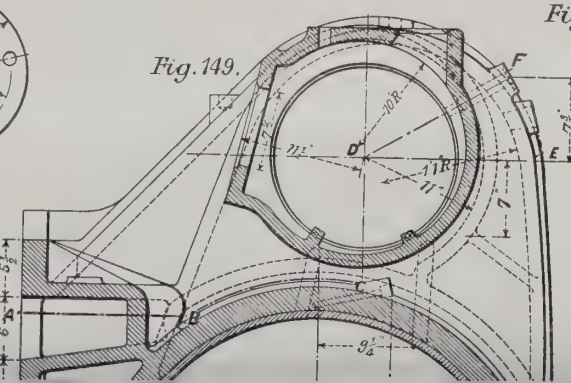


Fig.151.

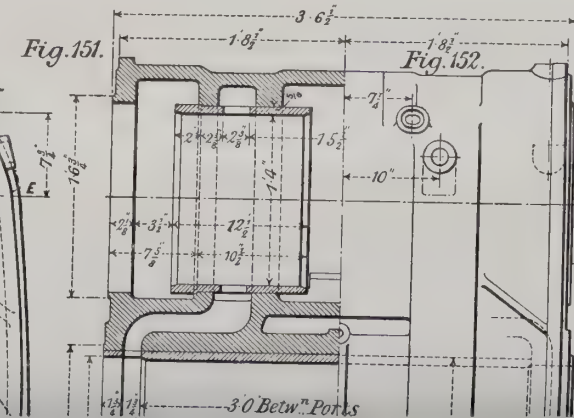


Fig.152.

Fig.153.
SECTION D.F

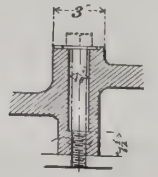
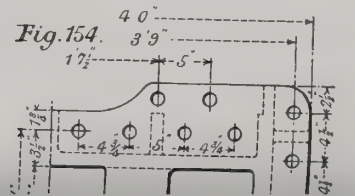
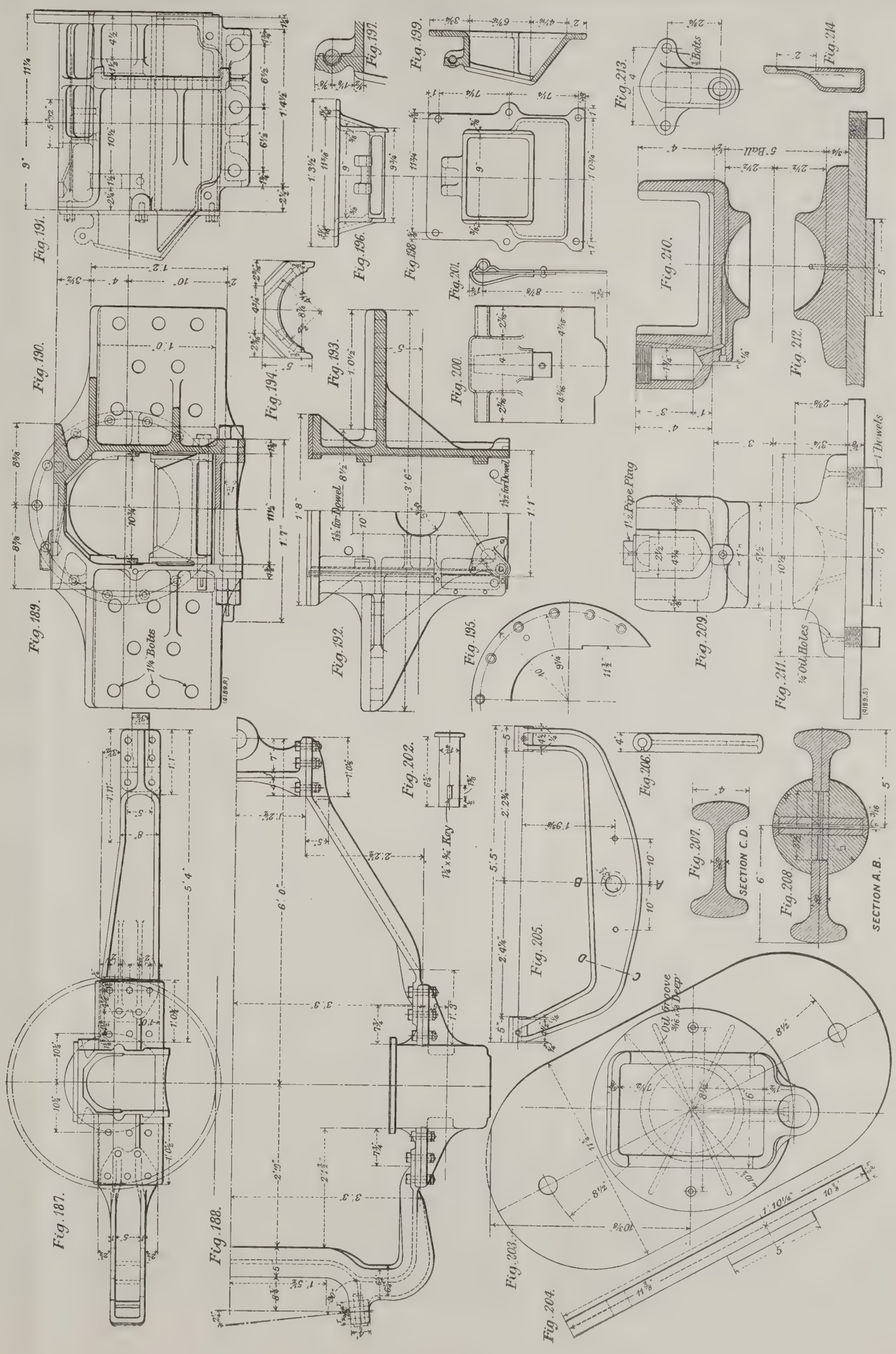


Fig.154.



DETAILS OF 2-8-8-8-2 TYPE LOCOMOTIVE FOR THE ERIE RAILROAD; DETAILS OF TRAILING TRUCK.

CONSTRUCTED BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA., U.S.A.



the rear pair on the tender section. All the cylinders are cast to the same pattern. They are bored out to 37½ in., and are fitted with ⅜-in. bushings of Hunt-Spiller iron. They are illustrated in Figs. 148 to 158, Plate XLV. Of these, Fig. 148 is an end elevation, and Fig. 149 a vertical cross-section at the middle of the casting. Fig. 151 is a half cross-section taken vertically on the longitudinal axis of the piston and valve. Fig. 152 is a half side elevation. Fig. 154 gives details of the flanges by which the cylinder is bolted to the saddle. A half plan is shown in Fig. 155, while in Figs. 156 and 157 are given sections along the line A B C and D F (Fig. 149). A drawing of the under side is shown in Fig. 158. There are no live-steam joints between the cylinders and the saddles or the frames. In the case of the high-pressure cylinders the steam supply is brought to the steam-chests by outside steam-pipes from the smoke-box, one on each side of the engine. Connection is made with the cylinder casting by an elbow on the inner side at the steam-chest level. Admission to the steam-chest is through a 7½-in. opening set 14 deg. above the centre line of the valve. This is shown in Figs. 148 to 150 and 155. In the case of the low-pressure cylinders this opening is connected, by elbow-pipes passing above the flanges of both castings, with a corresponding supply opening on the top of the saddles. The exhaust is in all cases taken through a rectangular opening, 10 in. by 6 in., direct into the saddle casting, with which a steam joint is made at this point with a varnished paper gasket. These joints, of course, are only subjected to low-pressure steam.

The steam-chests are bored to 17¼ in. diameter. Each is bushed to 16 in. with two short liners of Hunt-Spiller iron. The ports are 2⅜ in. wide. The circumference is divided into thirteen equal ports, between which are one 3-in. and eleven 1-in. bridges. These bushings are shown in Figs. 170 and 171, and in position in Fig. 151. The piston-valves, which are all 16 in. in diameter, are illustrated in Figs. 159 to 169. They are arranged for inside admission. The valve-spindle is eccentric, and a 1-in. retaining-bolt is provided to assist in holding the parts firmly together. The valve is composed of a hollow body of cast iron and two cast-steel ends or spiders. These are drawn up together by nuts on the spindle and by the retaining-bolt. At each end they hold in place a bull-ring of Hunt-Spiller iron and two packing-rings, also of Hunt-Spiller iron. Figs. 159 and 160 show the complete valve, and Figs. 167, 168, and 169 the bull-ring. Fig. 161 is a section through the spider and bull-ring at the key shown in the valve on the vertical diameter in Fig. 160, and also in Fig. 163. The key itself is shown in Fig. 165. The packing-rings are prevented from slipping round by a steel pin driven through the bull-ring at the bottom, the rings being parted at this point. This arrangement is shown in Figs. 162 and 164. Fig. 166 illustrates the keys used at the fit of the spiders on the valve-rod. As previously stated, the valves are worked by Baker gears, the mechanism of which is shown in Figs. 2, 3, and 4 *ante*. This is a constant-lead type of gear, deriving its motion from two points—viz., the crosshead and a return crank on the driving-wheel crank-pin. Reversing is accomplished by one power reverse-gear. The gear adopted is on the Ragonnet system. In this reversing-gear a piston working in an air-cylinder is coupled to the reach or reversing-rod. The movement of this piston is controlled by what amounts to a floating-valve, of which the spindle is attached to a combining lever. This lever is connected at one end to a small reversing-lever by means of a rod, and at the other to an arm fixed to the piston-rod. On the small lever being moved the combining lever swings on the piston-rod arm and the valve is moved, admitting air to one side or other of the piston, and thus causing the piston and reversing-gear to move. This movement in turn moves the piston-rod arm and the combining lever, which now pivots round the end connected to the small reversing-lever. This movement causes the valve to cut off, and the gear is held stationary. For each movement of the small lever there is a movement of the piston, and the valve is always brought back to the central position. This reversing-gear is coupled with the reversing-shafts on all three sections by rods and rocking-levers, flexible joints, &c.

The pistons are illustrated in Figs. 172 to 176. The piston-head is of forged steel, with a cast-iron bull-ring shrunk on, the shrinkage allowance being $\frac{1}{64}$ in. At the front end the bull-ring fits against a shoulder on the rim of the piston-head. At the back end, a wedge-shape retaining-ring is held in place by a keeper, ¼ in. thick, welded in place after the retaining ring has been inserted in place. These details are shown in Fig. 176. There are three snap-rings, cut as shown in Fig 174. The piston-rod is 4½ in. in diameter, the fits at both ends being 4⅜ in. at the largest diameter, with a taper of ⅜ in. in 12 in. The collar on the rod at the piston is shown at Fig. 175.

Steam is conveyed from the high-pressure to the low-pressure cylinders through two 9-in. steel pipes, details of which are given in Figs. 177 to 181. At the leading end in each case these pipes are provided with slip-expansion joints; at the back end they have ball-and-socket gland joints. At the leading end of these pipes a cast-steel socket-pipe, 22 in. long, is attached by a flange joint to the back of the high-pressure and low-pressure saddles. The pipe proper fits into this socket, and the gland is packed with three cone-shaped brass rings, on either side of which are rings of braided asbestos (see Fig. 179). At the back end of the pipe there is a ball of cast steel screwed and acetylene-welded to the pipe. This ball is held between two brass-neck rings, between which are four thick rings of braided asbestos packing. The neck rings and packing, details of which are shown in Figs. 178, 180, and 181, are held by studs and nuts in large circular cavities, 16 in. in diameter, in the front of the high-pressure cylinder-saddle (see Figs. 96, 98, 101, and 125 *ante*), and in front of the rear low-pressure cylinder-saddle (see Figs. 115, 118, 120, and 128 *ante*).

The exhaust connection from the rear low-pressure cylinder-saddle to the feed-water heater was illustrated in Figs. 63 to 66 *ante*. The exhaust from the front low-pressure cylinder-saddle is carried to the blast-pipe through the 9½-in. pipe shown in Figs. 184 to 186, page 738. This exhaust-pipe has a ball-joint struck to 8-in. radius at each end. At the front end a cast-iron spring-box is fixed to the top of the saddle. The pipe is held down into this box against the pressure of a powerful spring by means of a flange and bolts. A somewhat similar arrangement inverted is provided in the bottom of the smoke-box. In both cases the springs are arranged in collapsable cages, the parts of which clip together when the pressure of the flange-ring is removed. The pipe proper is of cast iron, and is composed of two portions, each of which has a right-angle bend at one end. At the other end the two parts fit one inside the other to form an expansion joint. The sliding joint is made by nine $\frac{5}{16}$-in. oil-grooves, and four rings ⅝ in. wide by $\frac{5}{16}$ in. thick, sprung into two grooves on the outside of the inner pipe.

Details of the trailing truck are given in Figs. 187 to 214, page 739. This truck is of the Cole pattern. It was shown in the general arrangement, Fig. 4 *ante*. It is built up of three cast-steel frame pieces and two steel outside axle-box castings. The frame is shown in elevation and plan in Figs. 187 and 188. It allows 4½ in. swing on either side of the centre line, and is spring-controlled at the back end. Details of the axle-box casting, brass, keeps and covers, are given in Figs. 189 to 201, Fig. 195 showing the brass liner next to the boss of the wheels. Above each axle-box is a bearing-plate (Figs. 203, 204, 211, and 212), which supports a moving cup. In this cup rides a ball fixed to a spring yoke (Figs. 205 to 208). Above this again is an inverted cup (Figs. 203, 209, and 210), which forms a spring-shoe, the load on the axle being thus transferred to the axle-box through this sliding cup and ball. In the top of the axle-box are oil-pockets covered by a plate and with the malleable-iron cover shown in Figs. 213 and 214. From these pockets oil is fed to the face of the hub liner and the top of the brass.

ELECTRICITY IN THE PRINTING OFFICE.*

By Frank Broadbent, M.I.E.E.

[The complete paper deals with electricity for two main purposes in the printing office—for illumination and driving. Both are treated very fully, but want of space prevents us from reproducing the former, and we have therefore confined our abstract to the latter alone. Illumination is a very important matter in a printing works, both as regards comfort and efficiency, but we must refer those who are interested in that aspect of the case to the paper itself.]

Power.—Owing to the special character of the work—speaking now more particularly of the general printing office—electric driving offers exceptional advantages, for not only is it far more economical than mechanical driving, but it is cleaner, it produces better work, and also increases the output per machine. Generally speaking, there are a number of machines, each taking a small power per square foot of space occupied. The space occupied includes not only the actual ground space covered by the machine frame, but also the necessary gangways all round it. Take, for instance, a machine-room such as is represented in Fig. 1. We have here 28 machines in a room having a superficial area of about 16,000 sq. ft. The maximum power-demand of the machines, exclusive of any shafting, would not exceed 100 horse-power, or 1 horse-power per 160 sq. ft. of area, whilst the average horse-power would be about 50. If mechanical driving were adopted, we should require about 450 ft. of shafting, with its bearings, pulleys, and main belting; also 28 countershafts, It is a little difficult actually to estimate the power which would be required to drive all the shafting and belting. A figure which is frequently assumed is 1 horse-power per 10 ft. of 2½-in. shafting, running at 150 revolutions per minute. This would give us about 45 horse-power for the main shafting alone. We should have, however, in addition to the main shafting, the cone-pulleys and belts, which would take about as much power as the main shafting. Taking the maximum demand of the machines as 100, we should require an engine of not less than 150 horse-power, the average load being 100 horse-power, made up of the 50 horse-power line-shaft losses and 50 horse-power usefully employed in the machines. This gives us a transmission loss of 50 per cent. Assuming the cost per horse-power generated on site to be ½d. per hour, and the working hours 2500 per annum, there would be a loss of 125,000 horse-power-hours per annum, representing approximately 260*l*. per annum, which, at 5 per cent., represents the interest on a capital outlay of 5200*l*.

Lest these figures should be thought to be purely theoretical, the author may be permitted to refer to savings in the cost of power which have been effected in printing offices electrified under his own supervision. Lighting is included in the comparison; but as the advocates of gas generally argue that electric lighting is dearer than gas lighting, this makes the economy all the more striking.

In case (1) the cost of gas both for power and lighting was 1400*l*. per annum. After electrification, notwithstanding the addition of several new machines, the cost for electricity was 800*l*. The horse-power installed was about 200.

In case (2) the combined cost of gas lighting and coal for steam-power was 1500*l*. per annum, whereas the cost of electricity is now less than 900*l*. per annum, although very considerable extensions have been made to the machinery. The horse-power installed is about the same as above.

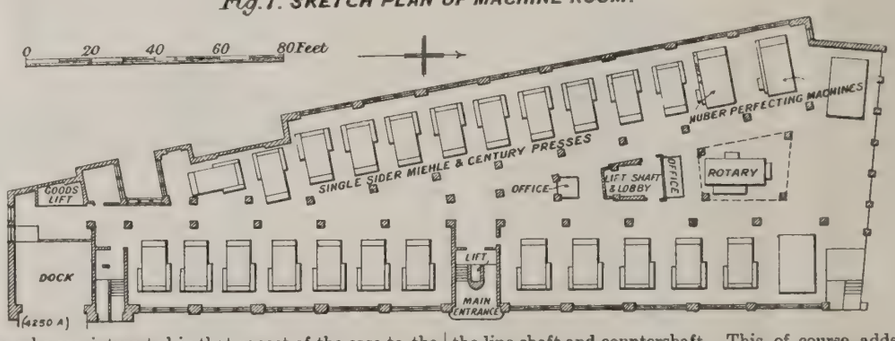
In case (3) the figures are almost the same as in case (2), the average cost of electricity in all cases being about 1¼d. per unit. If we could buy electricity at the rate of ½d. per horse-power per hour, the economy would be proportionately greater. These figures simply represent the saving in fuel costs alone, and would show to much greater advantage if we included the saving in belting, oil, repairs, and maintenance of shafting and bearings, and saving in cleaning and painting, and added the value of the increased output per machine. One does not wish, however, to labour this point, because the saving in fuel alone is quite sufficient generally to justify the change from mechanical to electrical driving, and the advantages apply to the small as well as to the large works.

Individual or Group Driving.—One is frequently asked what is the smallest machine which can be economically individually driven. A great deal depends upon the method of working, and each case must be considered individually somewhat on the following lines:—

Let us suppose that we have half a dozen small machines, none of which would take more than 1 horse-power to drive. To drive them mechanically takes 30 ft. of line shafting, which alone with its belts would absorb, say, 2 horse-power continually, or 1d. per hour, reckoning ½d. per horse-power per hour. The annual cost would therefore be a little over 10*l*., representing 5 per cent. interest on a capital of 200*l*. If variable speeds are required, as is very common in printing works, each machine must have its countershaft with cone pulleys, fast and loose pulleys, and two belts—namely, one between the countershaft and machine and one between the line-shaft and countershaft. This, of course, adds to the power required, and increases very considerably the cost of upkeep, so that we can probably afford to spend 300*l*. now in order to eliminate these standing losses and other charges. This is only the preliminary consideration; we have to consider the comparative costs of depreciation, and also the cost of electrical energy, but it will serve as an indication of the often-unsuspected losses in mechanical group driving.

Bearing upon this point, there may be given figures of a small installation which incidentally will serve to show that it is not only in the large works that economies are

Fig. 1. SKETCH PLAN OF MACHINE ROOM.



* Abstract of paper read before the Association of Engineers-in-Charge on December 15.

possible. In these works there were a dozen machines of comparatively small size, including four platens. These were all driven by a single motor rated at 5 horse-power, but which must occasionally have worked up to about 10 horse-power. The annual consumption was approximately 6500 units. The machines are now all driven individually by separate motors, the aggregate power amounting to 20 horse-power, which includes an additional machine of comparatively large size. The annual consumption now is reduced from about 6500 to less than 4500 units per annum, a reduction of over 30 per cent. in consumption, notwithstanding the increase in horse-power.

Another important factor to be considered is the improvement in the quality of the work, due to the steadiness of the drive. When a machine is driven through various stages of shafting and belting the variation in speed of the machine is very much greater than that of the prime mover, and this variation has a marked effect on the quality of the work produced.

The left-hand diagram in Figs. 2 and 3 shows that the

Fig. 2.

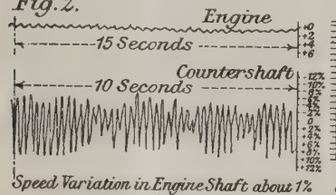
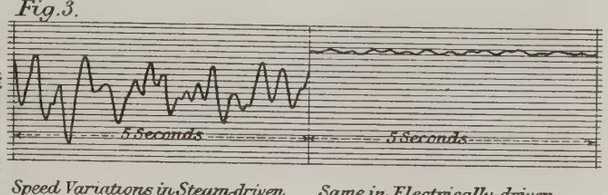


Fig. 3.

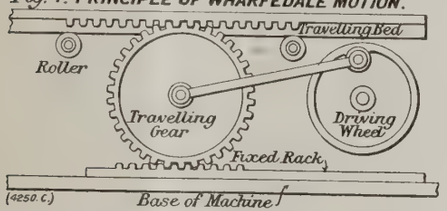


speed of a countershaft may vary 15 per cent. though the engine speed does not vary more than 2 per cent. This is due in part to the various stages of transmission through which the power passes. By driving a similar countershaft by means of a motor, as shown in the right-hand diagram, the speed variation may be reduced from about 15 per cent. to about 2 per cent.

Still another and most important consideration, one which in some offices far outweighs even the cost of power, is the increased output which follows the change from mechanical to individual motor-driving. This advantage is not a theoretical one; it is borne out by the experience of practically every printing-office in which individual electrical driving has been adopted, and printers who smile the smile of the sceptical when this advantage is pointed out to them as an inducement to electrify their works, and who persist that they do not want more than three or four speeds, as these have always been sufficient for them in the past, are generally forced to admit afterwards that the fine speed control which is possible by electric driving has proved of inestimable advantage to them. The increased output may be anything between 10 per cent. and 25 per cent., depending on the class of work done.

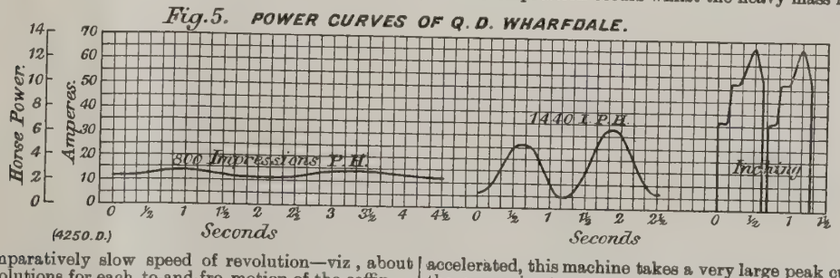
Flat-Bed Machines.—The power curve of a flat-bed printing-machine depends upon the make and type of the driving-gear. In some machines, such as the Wharfedale, the principle of the driving-gear is that shown in Fig. 4. Here the main driving-shaft gears with

Fig. 4. PRINCIPLE OF WHARFEDALE MOTION.



a large spur-wheel carrying a crank-pin, to which one end of a connecting-rod is attached. The other end of the rod is attached to the axle of a spur-wheel, which travels along a fixed rack and engages at the top with a rack fixed to the underside of the bed or coffin of the machine. The coffin therefore travels further and accelerates quicker than the spur-wheel, as it is driven backwards and forwards both by the horizontal motion of the spur-wheel and also by its rotary motion. At each end of the travel, whilst the coffin is momentarily stationary, the power is very low, but rises rapidly as the machine accelerates, and then falls rapidly after the centre has been passed, the stored energy of the fly-wheel helping the motor somewhat during the second half of the stroke. In this type of machine, however, the stored energy is very small, owing to the small mass of the fly-wheel and its comparatively slow speed of revolution—viz., about six revolutions for each to-and-fro motion of the coffin.

Fig. 5. POWER CURVES OF Q. D. WHARFDALE.



Power curves of a Wharfedale letterpress machine are shown in Fig. 5. The first set of curves were taken on a very slow speed—namely, 800 impressions per hour—whilst the second set are at a speed of about 1440 impressions per hour. It will be noticed that in the second set the current fluctuates much more than in the first, although the average current is very little higher. This is due to the quicker acceleration on the first part of the forward stroke, which means increased power, and to the regenerative effect of the fly-wheel during the completion of the stroke, which causes the current to fall to a very low value. The peak of one curve, it will be noticed, is higher than the other, this being due to the impression, the lower curve being that of the return stroke when the impression is lifted.

The third pair of curves on the same diagram shows the excessive currents thrown on the motor during "inching" operations. When an ordinary hand-starter is used for this purpose, the operator pushes the starting-handle over quickly, and returns it again as soon as the machine moves; he repeats this process until he has moved the forme to the required position. It will be seen that the peak current here is about four or five times the average current required for printing. This operation is obviously bad from every point of view—namely, from the point of view of the wear and tear on the starter, the overload on the motor, and the racking strains on the printing-machine itself.

The power curve of an old drop-bar perfecting machine—that is, a machine which prints both sides of the paper—is shown in Fig. 6. The driving mechanism is different from that used in the Wharfedale machine, being a modification of the old box-mangle driving-gear, of which the principle is shown in Fig. 7. This principle, first used, it is believed, by Cowper about a hundred years ago, is now found in various forms in many makes of machine, including the Miehle, the Babcock, &c. The pinion drives the coffin forward by engaging with one side of the rack, and at the end of the travel is transferred by suitable mechanism to the other side, the coffin being brought to rest and reversed by spring or air buffers. The coffin is not slowly accelerated as in the Wharfedale type of machine, but travels at almost the same speed throughout the stroke. In modern machines, such as the Miehle, the speed of revolution of the driving-shaft is at least double that of the old type of Wharfedale, and the speed of printing is also much faster; the fly-wheel effect is consequently very much greater. The result of this is that the power curves at slow and fast speeds are practically the reverse of those shown in Fig. 5, the greater fluctuations being shown on the slow speeds, when the fly-wheel effect is not so great, the current on the top speeds being fairly steady.

Fig. 6. H.P. CURVE OF A Q.D. BAR PERFECTOR RUNNING AT 1,200 IMPRESSIONS P. H.

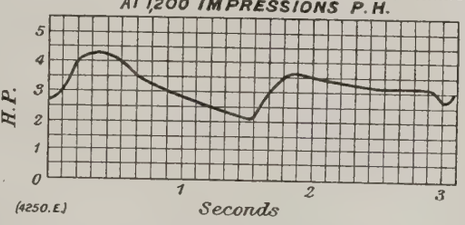
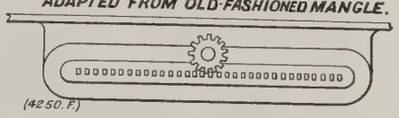
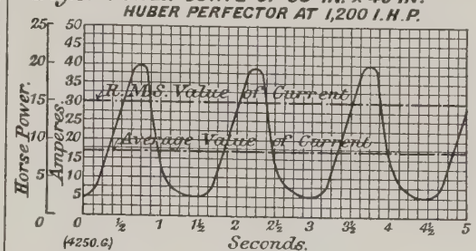


Fig. 7. DROP BAR PRINCIPLE OF DRIVING ADAPTED FROM OLD-FASHIONED MANGLE.



Some modern machines, such as the Huber perfecter, have a very heavy coffin, which is started slowly at the beginning of the travel, speeded up towards the middle, and slowed down towards the end, like the Wharfedale. As the impression occurs whilst the heavy mass is being accelerated, this machine takes a very large peak current, the approximate power curve being shown in Fig. 8. From this it will be seen that the current fluctuates in the particular machine tested from 5 to 40 amperes, corresponding in this case to about 2½ to 20 horse-power. The average current, calculated from the units taken during an hour, is about 16 amperes, or only 40 per cent. of the peak current. This is shown in the horizontal thick line of the diagram. It is, however, very important to remember that this average current is not the current for which the motor must be designed. The heating effect is proportional to the square of the current, so that the motor must be designed to stand what we call the R.M.S. value of the current, that is, the square root of the mean value of the square of the currents given by the curve. In the particular case shown in Fig. 8 this R.M.S. value is 30 amperes, and it is this current for which the motor must be designed from the heating point of view, and not for the average value of 16 amperes. From the sparking point of view, the motor must be designed for neither of these values, but for the peak or maximum current; so it is fairly obvious that the ordinary motor suitable for a steady load would be quite unsuitable for driving printing-machines, unless the motor has a very considerable margin of power above the average required.

Fig. 8. POWER CURVE OF 60 IN. X 40 IN. HUBER PERFECTOR AT 1,200 I.H.P.



Best Type of Motor to Use.—For variable loads, such as are taken by printing-machines, a compound-wound motor is the best type to use, and the curves shown in Figs. 5, 6, and 8 all refer to compound-wound motors. If shunt-motors had been used, the peak currents would have been much greater.

The torque exerted by any motor depends on the armature current and field strength, and a compound-wound motor automatically strengthens its field as the current increases; hence, when the impression takes place, the field becomes stronger instead of weaker, as is the case with a shunt-wound motor. It is claimed that the use of interpoles with a shunt-wound motor gives a compounding effect. This is true under some conditions, but for printing-machines better results are obtained with compound interpole motors than with shunt-wound interpole motors, as the currents, both whilst starting-up and on the impression, are lower.

In Fig. 9 there are two curves taken with the same motor when driving the same machine to which Fig. 8 refers—namely, a 60-in. by 40-in. Huber, the one curve showing the peak currents at various speeds with the motor running as an interpole shunt motor, and the other when running as an interpole compound motor. It will be seen that for the same number of impressions per hour the current is lower when running compound and the differences become greater as the speed rises. Both these curves were taken without paper, and it is interesting to compare these with Fig. 10, which shows the currents for the same motor and machine when running compound, and printing with automatic feeder. This curve shows a somewhat unexpected result—namely, that the peak current reaches a maximum at about 1080 impressions per hour, after which it falls, the peak current at 1250 i.p.h. being practically the same as at 1000 i.p.h. This fall is attributed to the increasing effect of the fly-wheel, which on these motor-driven Hubers is very heavy. It must not be assumed that the power taken at 1250 is the same as at 1000 i.p.h.; but that the peak current is lower and the minimum current higher.

Fig. 9. 60"x40" HUBER PERFECTOR. RUNNING LIGHT WITHOUT PAPER.

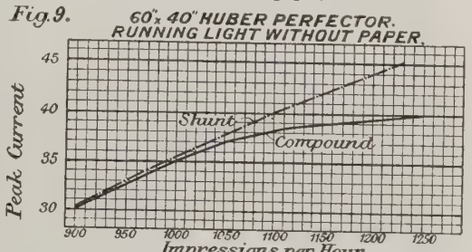
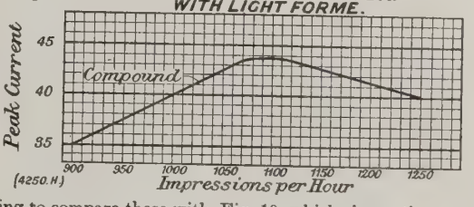


Fig. 10. 60"x40" HUBER PERFECTOR. WITH LIGHT FORME.



Not only is there a difference between the peak currents of the compound and shunt-wound motor, but there is a difference also in the energy consumption. When running as a compound-wound machine, the motor in question took 7 units per hour at 1200 i.p.h., or approximately 6 units per 1000 copies. When running as a shunt-wound machine the consumption was from 6½ to 6¾ units per 1000 copies when running at the same speed, or approxi-

mately 10 per cent. more energy than when running as a compound-wound machine. The starting effort is also considerably improved by the compound winding; when shunt-motors are used it is essential to employ very heavy fuses to prevent them blowing each time the motor is started up.

The figures just given are useful in emphasising another very important advantage of motor-driving—namely, that a printer is in a position to know exactly the cost of energy per 1000 copies on any machine in his works. He is also in a position to measure the energy used in making-ready, and by this means is able to estimate, with a fair degree of exactitude, his power costs for any job for which he is quoting. This is quite impossible when driving in the old-fashioned way.

Method of Driving.—The method of driving depends upon the class of machine to be driven. The old types of Wharfedale machine, in which the driving-shaft is fixed on the end of the frame immediately under the delivery board, lends itself best to driving by spur-gearing. If driven by belt it means that in order to get sufficient length of drive the motor must be placed at the opposite end of the machine to the driving-shaft, and the belt must run alongside the machine, interfering very much with access to the forme and to certain parts of the gearing; this arrangement also reduces the available passage space. Moreover, the speed of the driving-shaft, which is generally between four and six revolutions per impression, is so slow that to drive by belt necessitates a very slow-speed motor. Spur-gearing, when properly designed, gives very satisfactory results. Fig. 11 shows a typical spur-gear drive of a Wharfedale machine.

For short drives where spur-gear is not convenient, we may use either a silent chain, of which there are several now on the market, or a short belt drive with a jockey or

Fig. 11. TYPICAL GEAR DRIVE ON FLAT BED MACHINE.

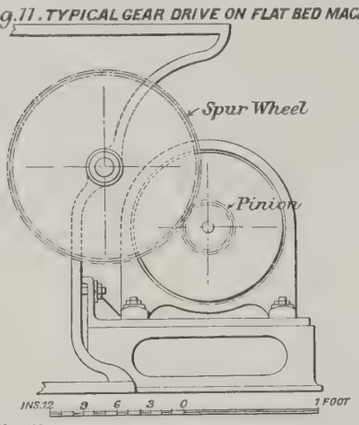
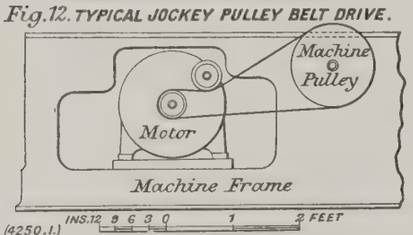


Fig. 12. TYPICAL JOCKEY PULLEY BELT DRIVE.



idler-pulley. With a chain drive the important thing to remember is that a wider chain must be used on a printing-machine than for any other machine taking the same power but whose turning moment is uniform. Suitable provision must also be made for taking up the slack of the chain.

Machines of the two-revolution type, which generally have the shaft placed about the middle of the machine, are most conveniently driven by belt from the motor fixed either at the delivery or feeder end, as found most convenient. The American practice is to fit the motor in the aperture of the side frame. This gives a very short drive, and necessitates the use of a jockey-pulley, a typical case being shown in Fig. 12, where the driving centres are only 2 ft. 6 in. apart. This is a very convenient arrangement from the point of view of the printer, as the motor does not take up any space outside the machine frame. It is, however, not at all convenient from the point of view of the engineer-in-charge, nor of the inspecting engineer, as the motor is very awkward to get at, particularly when, as is commonly the case, the commutator is turned inwards under the machine. In my recent practice, I have generally had the pulley put on the commutator end, but even this is not very convenient, because there is the obstruction caused by the belt itself and by the belt-guard and steps when one wishes to get at the commutator or brushes.

Switch-Gear.—One of the extraordinary things about printing-work is that a type of switch-gear which may give very good results in country works is practically useless in London printing-offices. The fact remains that whilst a robust form of hand-operated starter with special inching contacts may give good results in country works, such starters deteriorate very quickly indeed in London offices, and practically the only satisfactory form of starter to use in these cases is the push-button automatic type, which minimises the power of the operator to ill-use the switch. This type of switch-gear gives a much more perfect degree of control than the hand-starter, and effects considerable saving in time.

Speed Control.—As already mentioned, speed control is one of the most important advantages of electric driving, and the range of control depends very largely upon the class of machine. For most purposes an increase of about 50 per cent. above the lowest speed is sufficient, a range corresponding to, say, 1000 to 1500 impressions per hour, or 1200 to 1800, or anything in that ratio. Some machines, particularly those which are used for a very great variety of work, require a wider range, but the tendency in large printing offices is towards specialisation, and certain machines are kept, as far as possible, on a similar class of work, so that they may work at their maximum speeds as much as possible. The use of interpoles on machines has made it possible to get a very wide speed range by means of shunt control—that is to say, by varying the current in the shunt windings, and so varying the strength of the magnetic field, the maximum speed being obtained with the weakest field. Without interpoles there is a danger of motors flashing over when working on weak fields, particularly when subjected to overloads. When it is desired to fix the motor in an aperture in the side frame of the machine, the size of the motor is limited by the space available, and this practically settles what we call the normal speed of the motor—that is, the speed without any resistance in the field or in the armature circuit. This speed may be too high to obtain a satisfactory drive for the lowest speed of the press, and it then becomes necessary to obtain the speeds below the normal by the use of a regulating resistance in the armature circuit. This is a wasteful method, inasmuch as the main current has to pass through the resistance for the purpose of reducing the voltage on the armature, and this loss of voltage represents so much waste. When this method is adopted, drum or tramway-type controllers are sometimes used, the full-speed range being obtained partly by regulating resistance in the armature circuit, and partly by resistance in the field circuit. The series resistance acts both for starting and regulating. It is not a very convenient method of regulation when automatic control is used, owing to the large dimensions necessary for the series resistance. In order to get over this disadvantage of large dimensions, the resistance is frequently separated from the switch and placed underneath the machine, involving a large number of connecting cables between the two pieces of apparatus.

For very small motors, such as those used for stitchers, sewers, and the like, a combined starting-switch and series-regulator forms a satisfactory arrangement, as the amount of power is so small that the waste in the regulating resistance is almost neglible. There is, however, no difficulty in regulating these small machines by shunt-field control, if desired, but it involves a larger and more expensive motor.

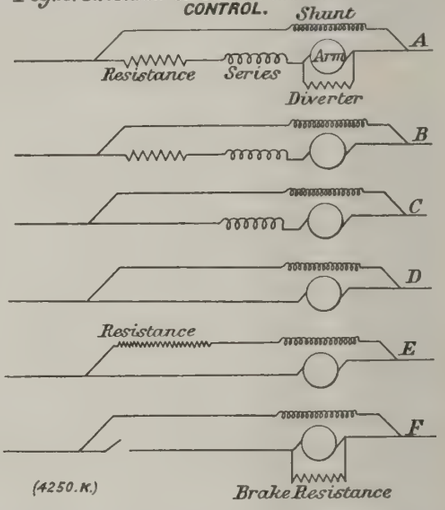
When a very wide range of shunt regulation is used, it is desirable to provide a means of short-circuiting or cutting out the resistance during periods of starting up, for the purpose of ensuring that the motor will start up with a strong field.

Rotary Newspaper Machines.—There are few, if any, industries in which the element of speed is of such great importance as in the publication of a great City newspaper. As a few seconds are of importance, considerable ingenuity has been exercised in the development of the method of rotary-press driving and control. In a large rotary press there are hundreds of moving parts, scores of bearings, multitudinous gears, amounting in the aggregate to tons of moving machinery which must be started gently and run at a very slow rate to permit of the paper strip or web from the five-mile reel being threaded between the various rollers. Very smooth and gradual acceleration is necessary also to prevent breakage of the web, as this would mean considerable loss of time in leading it in again. When once fairly started the machinery must be quickly run up to speed, without jerk or jar of any kind, until the machine is travelling at a rate sufficient to turn out from each deck from 24,000 to 34,000 copies of the paper per hour. A large machine consists of a number of decks placed, generally, one above the other, all interconnected by gearing so that they may be either run separately or together, as required. Complete machines, consisting of several decks, are also placed end on to each other, so arranged that they may be coupled together if desired to work as one complete unit. As each press has its own driving and control equipments, arrangements have also to be made to couple these together so that they shall start up and accelerate simultaneously from any one of the many push-button control-stations located at different points on the press.

Except in very small size, rotary presses cannot be satisfactorily driven by the ordinary methods adopted for driving other kinds of machinery. The reason for this will be apparent if we only consider what takes place in starting up. If we gear up a plain motor to a printing-press and then switch current on to it through a starting resistance, the press would not start until a considerable amount of resistance had been cut out, giving the motor a current very much in excess of that necessary to run it slowly. This is due to the fact that the starting torque of the machine is very much in excess of the running torque, owing to the heavy masses of machinery to be set in motion, and the stiction or suction of the multitudinous rollers, static bearing friction, &c. Assuming now that we have given the motor sufficient current to enable it to start the press, the torque falls off very quickly when the machinery is in motion, with the result that the speed would quickly accelerate and probably snap the paper. Or, if the paper had not yet been threaded through, the speed at which the motor would run after once starting would be much too fast to permit of this operation being carried out. It would then be necessary to insert resistance to slow the machine down, and under these conditions the running would be very unstable or irregular. In practice this method of control has been found to be quite impracticable. Very many and ingenious methods have been devised from time to time to get over this difficulty; and had this paper been read a few years ago, it might have been desirable to describe a number of them. Owing to the fact, however, that certain patents have recently expired in connection with what we may call the double-motor drive, there is really no need to describe more than two of the methods. These are the single motor, with diverter control for the slow speeds, and the double-motor system.

Single-Motor Diverter Control.—In this system a very heavily compounded motor is generally used. To start up, current is supplied to the motor through a resistance, which is gradually cut out until the motor starts. As soon as it has acquired, say, 5 per cent. of its full speed, the voltage across the armatures excites an automatic switch which connects the diverter resistance across the armature terminals. The position of affairs then is that shown in diagram A in Fig. 13, from which it will be seen that there is a complete circuit through the diverter resistance, the series windings and regulating resistance, the armature being across a portion of resistance, the shunt field being connected in parallel with the whole thing right across the lines. The details of the controller connections are not here shown, as they are somewhat

Fig. 13. DIAGRAM OF SINGLE MOTOR DIVERTER CONTROL.



complicated. In this condition the armature cannot accelerate, as any tendency to do so would increase its back electromotive force and divert more current into the diverter resistance. We can only increase the speed by increasing the diverter resistance, so allowing the armature to take more current. The next movement of the controller gradually increases the diverter resistance, the speed increasing until what we call creeping speeds are passed, when the diverter circuit is broken and the machine runs as a plain compound-wound motor with armature resistance in circuit, as shown in the second diagram, B. The armature resistance is then gradually cut out (C), and after that the compound winding is cut out or diverted (D), the motor then running as a plain shunt motor. Further increases of speed are obtained by plain shunt regulation, the state of the connections being shown in diagram E. The whole of these operations may be carried out by means of a controller worked by a single handle. When push-button control is required, a small motor is geared up to the controller spindle, this motor being controlled by means of push-buttons fixed on the press. As the push-button boxes are practically similar to both methods of control, these will be referred to after describing the double-motor method. In the event of the paper breaking, or any other circumstance arising to necessitate the press being stopped, this is done by means of a press-button which brings down an electro-magnetic circuit-breaker. Besides breaking the circuit, the switch connects a diverter resistance across the armature which, acting as a dynamic brake, brings the press very quickly to rest. This resistance can be adjusted to bring the press to rest practically instantaneously or to occupy a few seconds, as desired. Diagram F in Fig. 13 shows the connections after the stop-push is pressed.

A curve of currrent and speed of a single-motor diverter equipment is shown in Fig. 14. This refers to a 40-horse-power Laurence-Scott equipment, driving a three-reel Hoe press having an output of 24,000 copies an hour of a twelve-page paper. It will be seen from this that the press takes about 10 horse-power to start from rest, the power falling slightly as soon as the press is in motion. The speed then increases almost proportionately with the current. In this equipment the series-starting field is very powerful, the speed increasing by 50 per cent. as this is cut out. After this a further increase of 100 per cent. is obtained by shunt-field control. Hence, assuming the normal speed of the motor to be 200 revolutions per minute with the compound-winding in, it is 300 revolutions per minute when cut out, and 600 with all shunt resistance in — a total range of 300 per cent. on field variation alone. This accounts for the low starting current.

Two-Motor Equipment.—It is well known that a great mass can be moved through a small distance by the exertion of a comparatively small force acting through a long dis

tance. This, in short, is the principle of the lever, by means of which a large weight on the short end can be lifted by means of a much smaller weight at the long end. The same principle is applied in lifting or hoisting-tackle. In rotary motions the lever takes the form of gearing, which may be spur-gearing, worm-gearing, or any other kind of multiplying gear. In the two-motor drive the principle is made use of by gearing a small or auxiliary motor to the larger or main driving-motor, which, in turn, is geared or coupled to the printing-machine shaft in the most suitable way. If we assume that the auxiliary motor is geared to the main motor by means of a worm-gear having a ratio of 25 to 1, we could, assuming there was no loss of efficiency, exert on the machine-shaft a torque or turning effort of about twenty-five times the torque exerted by the auxiliary motor. Obviously, therefore, it will take very little effort on the part of the auxiliary

Fig. 14. 3-REEL PRESS. 12 P.P. SINGLE MOTOR EQUIPMENT.

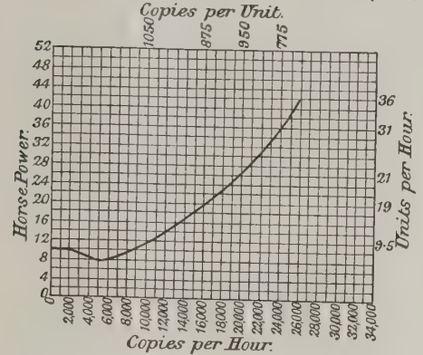


Fig. 15. 2-REEL PRESS, 1 REEL ONLY IN USE. 4 P.P. 2 MOTOR EQUIPMT.

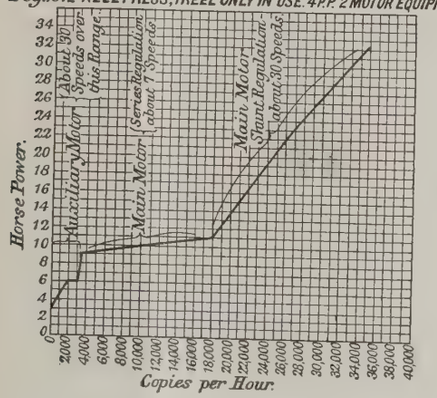
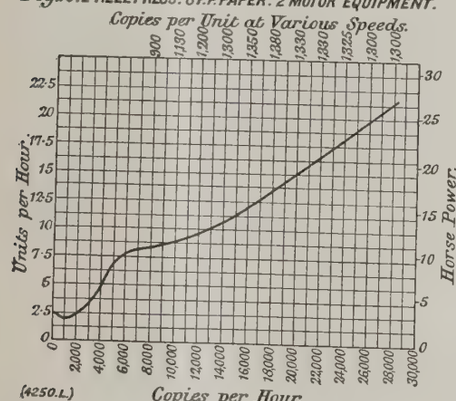

Auxiliary Motor (about 30 Speeds over this Range)
Main Motor (Series Regulation about 7 Speeds)
Main Motor (Shunt Regulation about 30 Speeds)
Horse Power.
Copies per Hour.

Fig. 16. 2-REEL PRESS. 8 P.P. PAPER. 2 MOTOR EQUIPMENT.



(4250.L.)

motor to move the press, and owing to the large gear reduction, a considerable movement of the armature results in a very small movement of the printing-press shaft. The same principle has been previously applied in engineering work, and is used in textile factories and on board ship, where a small barring-engine is used to turn the main-engine shaft. In these cases, however, the object is merely to move the main engine round a little, and not to start and accelerate it before the steam is turned on to it.

The sequence of operations in the two-motor control is briefly the following :—Assuming the main switches to be already closed, the controller first closes the circuit of the auxiliary motor through a resistance. This motor therefore starts up slowly, driving the main motor through the intermediate gearing. The motor, if suitably designed, runs quite steadily at a speed which drives the press at about 5 per cent. of its maximum speed. This is slow enough for leading in the web from the reel. Further movements of the controller gradually speed up the small motor, first by cutting out resistance in the armature circuit, and afterwards, if desirable, by weakening the shunt field until it has attained its maximum speed. Before this point is quite reached, the controller closes the circuit of the main driving-motor—which immediately exerts a certain torque, but probably not sufficient to drive the press alone—further movements of the controller cut-out portions of the main starting resistance still maintaining the circuit of the small motor, until a point is reached when the main motor takes charge of the press and begins to accelerate on its own account. If it were rigidly geared to the worm-wheel shaft it could not accelerate, as it would tend to jamb the worm-gear ; but, to prevent this, an automatic clutch is provided between the worm-gear and the main motor-shaft. This sometimes takes the form of a free-wheel clutch, and sometimes the form of a self-releasing claw-clutch, the effect of which is mechanically to disconnect the two motors as soon as the main motor runs at a speed faster than that of the worm-wheel shaft. The auxiliary motor is then automatically switched off by the controller, which continues to accelerate the main driving-motor in the ordinary way by cutting out resistance and subsequently weakening the field. When the automatic clutch is controlled by a solenoid, this is energised by the first motion of the controller so as mechanically to couple the motors together again. It is not the purpose to go into the details of the actual controllers, as these and their connections are of a complicated nature, and are only interesting to those who have them actually under their charge.

The controllers are sometimes operated by hand, sometimes by a complete push button system, or a combination of hand and push-button control may be used. In the latter, which may be called semi-automatic control, push-buttons are provided on the press for giving inching or slow motions. These buttons control an electro-magnetic switch, which closes the circuit of the auxiliary motor only, all accelerating being done by means of the hand-controller. In the full-automatic system one or more push-button boxes, each containing five or six pushes, are provided. One push controls the inching operations. On pressing this the small motor starts, and runs at a slow or creeping speed until the stop-button is pressed. When the "up" push is pressed the controller is set in motion and continues in motion, accelerating the motor so long as the pressure is maintained. When the push is released, the controller remains in the position last reached, the press continuing to run steadily at the corresponding speed. Similarly, whilst the "down" push-button is pressed the controller runs backwards, reducing the speed of the motor, which continues to run at the speed last reached when the push is released. Generally speaking, it is not necessary to continue the slowing down right down to the creeping speeds, and in some cases this would not be be possible, as it is necessary to bring the controller back to its first position in order to excite the automatic clutch and mechanically couple the motors. The "stop" push releases the main solenoid switch, which cuts off the main current and applies the automatic brake, the controller itself returning automatically to its first, or starting, position. "Lock" and "free" pushes are generally provided when more than one control-box is used. When the "lock" or safety-push is pressed, it breaks all the control-circuits and remains in until released by pressing the "free" push. This safety-push is used by any man who may be working in a position in which he would be liable to injury if the press moved. This is a very essential requirement, because, as already mentioned, the noise of a rotary-press room is such that it is practically impossible for anyone to hear a shout of warning before the press is started up, and even hooters and loud-ringing bells cannot always be heard.

The speed-current curve, shown in Fig. 15, is based on figures taken from a two-motor equipment driving a new two-reel press, but with only one reel in operation, printing a four-page paper (owing to scarcity of paper, due to the war). This curve, whilst interesting, must not be taken as a quite typical one, as the machine was absolutely new and had not really settled down to its normal running conditions.

Fig. 16 also refers to a two-reel press driven by a two-motor Holmes Clatworthy equipment.

From any of these three speed-current curves it is possible to calculate the number of copies delivered per unit of consumption when running at various speeds, and I have given these figures for several speeds at the top of Figs 14 and 16. Hence from Fig. 14 we deduce that when running at 10,000 copies per hour one unit produces 1050 copies, at 16,000 copies one unit produces 875, and at 24,000 copies one unit produces about 775 copies of a 12 page paper.

From Fig. 15 we deduce the following results : at 12,000 copies per hour one unit produces 1500, at 18,000 the output is 2000, at 24,000 it is 1600, and at 32,000 it is 1400 copies of a 4-page paper per unit. In this case there is not the same amount of shunt-field control as in the first case, and it will be noticed that the power falls off very slowly between 18,000 and 9000 copies, due to the fact that on this range there is regulating resistance in the main armature circuit. From Fig. 16 it is seen that one unit produces 1325 copies of 8-page papers at a speed of 24,000 per hour, 1380 at 18,000, and so on.

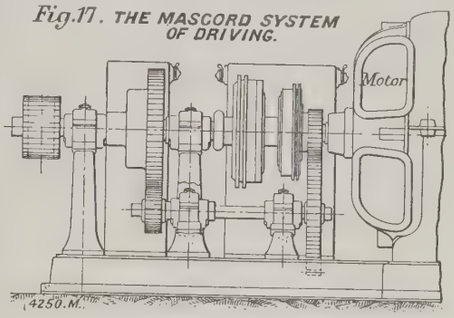
The foregoing are the two principal systems in use, although many others have been used to a lesser extent.

Variable Voltage Control.—Among the other systems which have been used are several modifications of what is known as the Ward-Leonard system. In this system the main driving motor is supplied from a motor-driven dynamo, the whole of the control being obtained by varying the voltage of the dynamo by means of a shunt-field regulator, the dynamo being driven at a constant speed. This is almost an ideal system, but is expensive and involves the use of three commutators.

Electric Slipping-Clutch System.—A system which the author has not yet seen in operation, known as the "M.E." system, depends for its action on what might be called an electric slipping-clutch. This slipping-clutch consists of a motor-driven armature revolving in a magnetic field which is free to rotate, and is geared up to the press shaft. When the revolving magnets are unexcited there is no torque, and therefore no motion. When, however, a current is switched on to the magnets a torque is produced, which gradually increases as the magnet current is increased, and in this way a slow start and gradual acceleration are produced. It is understood that this principle has been applied to motor-cars ; and, in fact, the author took out a provisional patent for it in this connection a few years ago, only to find that he had been anticipated by several years by Jenatzy. It is a very simple form of control, a simple shunt regulator only being necessary, and the motor can be run in either direction with equal facility by reversing the field excitation.

The Mascord System.—This system of driving, which can be seen at Messrs. Lloyd's printing works, is interesting, in that it has been developed from the mechanical rather than the electrical side. It is a single-motor system in conjunction with an electro-

Fig. 17. THE MASCORD SYSTEM OF DRIVING.



magnetic slipping-clutch and back reducing gear. The general arrangement will be gathered from the elevation in Fig. 17. The motor, which has a speed range of 300 to 750 by field control, is coupled through a main electro-magnetic clutch to the printing-machine shaft. On the motor-shaft is also keyed one member of a smaller magnetic clutch, the other member of which runs freely on ball-bearings on the shaft, and carries a pinion which gears with a spur-gear and side shaft, which in turn gears with the main shaft on the other side of the main driving-clutch. This gear has a ratio of about 10 to 1, and when in operation forms a mechanical by-pass to the main clutch. The motor is first started up light, and a little armature resistance is kept in circuit. To move the press slowly the inching push is pressed, which energises the small magnetic clutch and puts the back gear in motion, driving the press at about 7 revolutions per minute of the printing cylinder, whether one or all eight decks are in operation. In order to accelerate the press the controller is moved, which first energises the main clutch, and as this takes up the load the motor drops its speed, due to the armature resistance referred to, so producing a soft or velvety acceleration. The main shaft frees itself from the back gear by a free-wheel device. Further movement of the controller cuts out armature resistance, and then introduces field resistance, the speed control being spread over about forty steps. The "stop" push drops the main circuit-breaker, and also breaks the circuit of the main clutch, so disconnecting the press from the motor. Incidentally, the clutch acts as an over-load safeguard by slipping.

Although this paper is already unduly lengthy, the author has endeavoured, as far as possible, to steer clear of special technical details, and to deal mainly with the general features of electrical applications in printing offices.

AUSTRALIA.—We take the following notes from a communication recently issued by the High Commissioner for Australia :—It has been stated unofficially that Australia's total population has reached five millions. The United Kingdom has 376 people per square mile ; the German Empire, 310 ; Belgium, 650 ; Australasia, less than 2. Australia has a wider range of climate than any of these countries, and can produce successfully a greater variety of products than the three others. Over 900,000 square miles of the Commonwealth enjoy a rainfall of over 20 in. per annum. The number of factories in the Commonwealth increased from 11,000 in 1903 to 15,000 in 1913. In four years the value of the raw material used in Australian factories annually increased from 60,000,000*l.* to over 88,000,000*l.*, and the total value of the output from 99,000,000*l.* to 148,000,000*l.* Australia's coal production is worth over 4,000,000*l.* per annum. In 1912 11,700,000 tons were produced. The mining industry in Australia gives direct employment to 91,000 persons. The Australian Government pays a bounty of 12s. per ton on pig-iron made in Australia from Australian ore, puddled bar-iron and steel made from Australian pig-iron, and 10 per cent. on the value of galvanised sheet or plate-iron or steel, wire netting, wire and iron and steel pipes made in Australia. Australia's total mineral production has reached a value of over 850,000,000*l.* ; of that total gold represents over 600,000,000*l.* The great Australian artesian basin, from which many millions of gallons of water are obtained daily in areas where the natural rainfall is light, includes considerably more than one-half of Queensland, a considerable strip of New South Wales, and the north-eastern part of South Australia proper, together with the extreme south-eastern corner of the Northern Territory. There are other artesian areas in South Australia, Western Australia, and Queensland.

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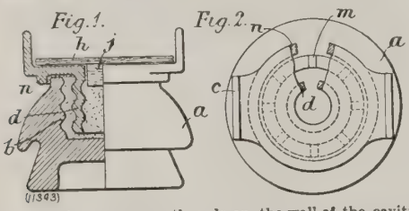
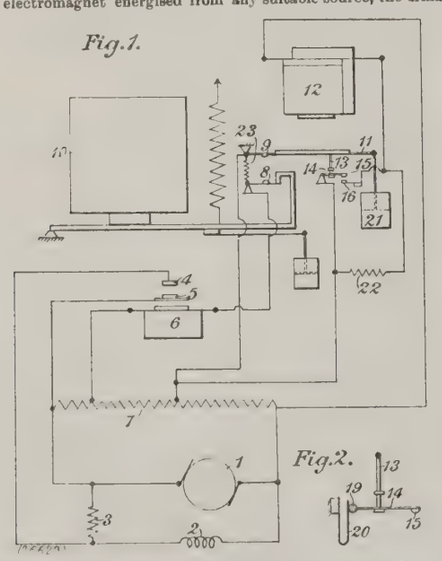
ELECTRICAL APPARATUS.

11,343/14. E. P. B. Estler, London. Insulators. [2 *Figs.*] May 8, 1914.—The conductor rails of electric railways have to be held securely in position, and insulated. For this purpose, the practice is to employ a chair for holding the rail and interposing an insulator between it and the cross-tie or "sleeper" connecting the traffic rails. Various devices are employed for attaching the insulator to the cross-tie. This invention relates more particularly to the means of securing the chair to the insulator. The insulator consists of a pedestal *a* of pottery, glass or other suitable material, the outer shape assuming such form and configuration as circumstances may require. An inner cavity is formed in the insulator, the sides *b* of which are corrugated or screw-threaded, and large enough to receive a cylindrical projection *d* depending from the base of the chair *c*, this cylindrical projection, which must be hollow, having its inner and outer walls corrugated or screw-threaded to correspond with



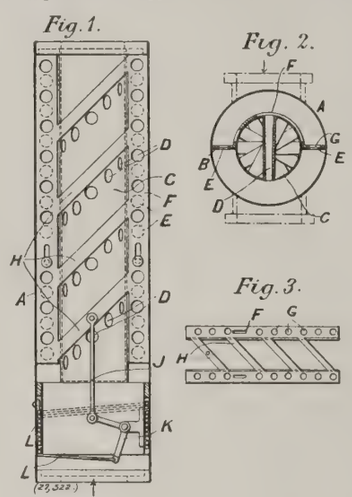
the corrugations or screw-threads on the wall of the cavity in the insulator. To secure the chair to the insulator, the cavity is first filled with cement or other suitable material, in a liquid or viscous state. The cylindrical portion *d* of the chair is then pressed in, the cement filling the interspace between the corrugated walls of the chair-cylinder and the insulator, and the corrugations formed on the inner walls of the cylinder *d*. The cement also overflows the head of the insulator, forming a bed whereon the base of the chair *c* can rest. A cylindrical flange *n* is also formed on the underside of the chair and surrounding the edge of the insulator, the interspace being also filled with cement. The top of the insulator may have radial or other grooves *m* formed in it for the better outward flow of the cement when the chair cylinder *d* is being pressed into position. A block of wood *h* (or other suitable material) having a circular boss *j* on its base which enters the open top of the cylinder, is interposed between the chair and the rail. (*Sealed December* 3, 1914.)

26,623/13. A. H. Olmsted, Altrincham. Voltage-Regulators. [2 *Figs.*] November 19, 1913.—This invention relates to voltage-regulators of the kind adapted to vary the excitation of an electric generator or of its exciter so as to maintain a constant voltage on the generator terminals. In a voltage-regulator for electric generators, according to this invention, two contacts control the insertion of a resistance which governs the field strength of the generator, one of the said contacts being actuated by means of an electromagnet connected to the circuit of the generator, and the other of which is vibrated by means of an electromagnet energised from any suitable source, the armature of the said magnet being connected by a lost-motion connection with a pivoted lever carrying a contact which makes and breaks the circuit of the said magnet. 1 is the exciter, 2 the field winding thereof, and 3 the resistance which is cut into and out of the field circuit by means of the relay contacts 4, 5 governed by the relay magnet 6. The relay magnet is energised from tappings from a resistance marked 7 in circuit with the exciter in the usual way, and its circuit is opened and closed through two contacts 8 and 9. Of these, the contact 8 is adjusted in position by means of the electromagnet 10, which is energised from the circuit the potential of which is to be regulated, while the contact 9 is carried by an arm 11 which is caused to vibrate by means of an electromagnet 12. The vibrating arm 11 does not in the present instance directly carry the contact governing the circuit of the electromagnet 12, but is connected through a link 13 to a lever 14 carrying a contact 15 which co-operates with a resiliently-supported contact 16. The link 13 has a lost-motion connection with the lever 14 by means of two stops spaced a short distance apart, and the lever 14 is further arranged so as to move stiffly on its pivot. One means for ensuring this stiffness of movement is illustrated in Fig. 2, in which 19 is a cylindrical shaft, on which the lever 14 is mounted, the shaft being suitably supported at each end, and 20 is a flat spring adapted to press against the shaft so that the friction will hold the shaft and lever in any position to which the latter is moved. By this arrangement the lever 14 will only be moved by reason of a positive engagement of the stops 17 and 18 therewith. The arm 11 is also provided with a dashpot 21 which serves to damp its vibration. 22 and 23 are resistances connected across the contacts 15, 16 and 8, 9 respectively in order to reduce the sparking. (*Accepted September* 30, 1914.)



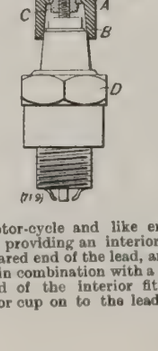
GAS-ENGINES, PRODUCERS, HOLDERS, &c.

27,522/13. T. E. Halliday, Bishopstoke. Internal-Combustion Engines. [5 *Figs.*] November 29, 1913.—This invention relates to vaporisers for use with internal-combustion engines of the type in which the vapour-pipe, where it passes through the heating-chamber, is fitted with cross-tubes conducting the hot gases across the pipe. Under certain conditions, as when the engine is running under full load, the contents of the vapour-pipe may become excessively hot, and it is the object of the present invention to provide simple means for preventing this. It is customary for the vaporising chamber to be provided with partitions, so that the gases in passing from one side of the chamber to the other must travel through the cross-tubes, and, according to the present invention, there is provided one or more slides, or the equivalent, which are adapted to close the cross tubes and at the same time open up passages which put the two parts of the vaporiser into communication with one another. The type of vaporiser to which this invention is applied, shown most clearly in Fig. 2, comprises a heating-chamber A, through which exhaust gases or other heated fluid pass in the direction of the arrow. A partition B supports the vapour-pipe C, which is



provided with cross-tubes D, which may be spirally arranged as shown. In the partitions B are holes E which are normally closed by the edges of the slide F. Thus the exhaust gases pass through the tubes D, as will be clear from Fig. 2. In the edges of the slide F are holes G, and the slide carries covering strips H so arranged that when the slide is moved end-wise the covering strips H close some or all of the tubes D and bring the holes G into register with the holes E, as shown in Fig. 2. Consequently, the passage through the tubes D is blocked and the apertures E opened up, so that the heating fluid passes round the vapour-tube and the vapour passing along it is less heated. The slide may be connected with the throttle or governor, or it may be coupled to a thermostat. In the case illustrated, it is connected by a link J and bell-crank lever K to a copper wire L, the other end of which is fixed. As the wire heats up it expands, causing the bell-crank lever K to move and the slide to be operated if necessary with the assistance of a spring. Similarly, as the vaporiser cools, the wire L contracts in length, exerting a pull on the bell-crank lever K and uncovering the ends of the tubes D. The construction of thermostat described is, of course, not essential, and may be varied. (*Sealed December* 13, 1914.)

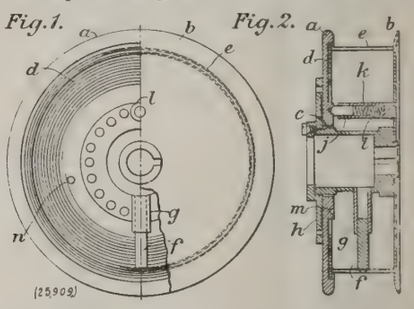
719/14. F. H. Bluemel, and Bluemel Brothers, Limited, Wolston. Sparking-Plugs. [2 *Figs.*] January 10, 1914.—This invention relates to sparking-plugs for internal-combustion engines, and more especially to sparking-plugs which are liable to be exposed to shock, rain and damp, as in the case



of those used in motor-cycle and like engines. The present invention consists in providing an interior metal fitting having a hole to receive the bared end of the lead, and means for guiding the end into the hole in combination with a ring or a cup adapted to pass over the end of the interior fitting, and means for forcing the said ring or cup on to the lead to secure the latter firmly in place and ensure its good contact with the interior fitting. The interior metal fitting A is embedded in a shell B of vulcanite or other insulating material, and bored out at its lower end to receive the split tubular portion of the adapter C which screws on the central electrode of the sparking-plug D. In a cylindrical part A^1 of the interior fitting a hole A^2 is drilled to receive the bared end E of the lead F, which is passed through a tubular portion B^1 of the shell B of the inner end of the tubular portion, being shaped to guide the lead into the hole. The lead extends right through the hole and is held in place by means of a ring or cup G which passes over the cylindrical part A^1 of the fitting A and is forced down on to the lead by means of a nut H which screws on a screw-threaded extension of the metal fitting A. The nut H is embedded in a shell of insulating material, which, when in position, overhangs the top of the insulation B, and the latter insulation extends considerably over the porcelain portion of the plug. If desired, a short spiral spring may be introduced between the nut and cup G. (*Accepted September* 30, 1914.)

MOTOR ROAD-VEHICLES.

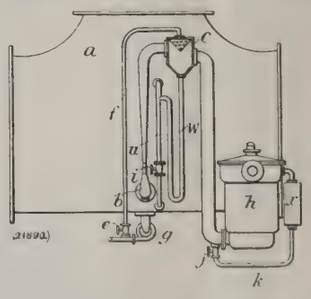
25,909/13. W. O. Smith, Lewisham. Speed-Indicators. [3 *Figs.*] November 12, 1913.—This invention relates to an expanding pulley particularly intended for driving speed-indicators on motor-cars where it is required to adjust the pulley from time to time in order that the speed shown on the indicator may be the exact speed of travel of the car. According to this invention, one of the flanges of the pulley has a grooved spiral, a flexible band being held between the flanges so as to be adjustable in the spiral. *a* and *b* are two flanges, *c* is a bush fixed to *b*, *a* being free to turn on *c*. *d* is a spiral groove on *a*, stopped at a short distance from the edge, which is raised above *d*, and left with a flat surface to prevent the driving-belt rubbing against the grooved surface. *e* is a spring band of suitable strength and material, one edge of which presses against the surface of *b*, whilst the other drops into the spiral groove *d*. *f* is a plunger fixed to



one end of *e*. *g* is a tube fixed to *c*, in which *f* is free to move backwards and forwards only, the object being to retain one end of *e*, so that whilst turning *a* the diameter of *e* can be increased or diminished. *h* is a lock-nut engaging with *c* for clamping *a* when the correct expansion or contraction has been given to *e*, and thereby the correct diameter of the pulley has been obtained. *j* is a plunger, *k* is a spring, both of which work in the receptacle *l*, which is fixed to *b*. A circle of blind holes *m* is provided, spaced at a convenient distance apart on the surface of *a*, into which the end of *j* projects; this enables the adjustment of *e* to be made in definite stages if it is required to do so. In Fig. 1 is shown a stop *n*, which prevents *e* from leaving the groove *d* when the minimum amount of contraction has been obtained. The spring-band *e* cannot leave the groove *d* by being expanded too far, as the plain part on *a* effectually stops it. (*Accepted September* 30, 1914.)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

21,890/13. D. B. Morison, Hartlepool. Condensers [5 *Figs.*] September 29, 1913.—This invention relates to steam-condensing apparatus working under vacuum, wherein aerated vapour is withdrawn from a main condenser by a steam jet, and is discharged into a heater in which the steam from the jet and vapour withdrawn from the condenser is condensed by water from the condenser, the air being discharged from the heater by any suitable type of pump. According to this invention, the temperature of the condensing water delivered to the heater can be regulated by being delivered into the condenser above and/or below the condensing surface, whereby a variable or large air-withdrawing capacity may be obtained with small thermal loss. The aerated vapour is discharged from the condenser *a* by a steam-jet device *b* into a heater *c* in which the steam is condensed by direct contact with condensate withdrawn from the condenser by the pump *g* which discharges a controllable quantity through the valve *e* and pipe *f* into the heater *c* from which aerated vapour is withdrawn by the pump *h* that is supplied with a



continuous and regulated quantity of cooled water by way of the valve *j* and pipe *k* from the cooler *x* in a known manner. The heated condensate is delivered from the heater *c* through a water-sealed looped pipe *w* into a vertical pipe *u* connected with the upper and lower portions of the condenser, a valve *i* being inserted in the pipe. Under normal conditions, when the condenser is under full load, a portion of the condensate sufficient to condense the steam from the steam-jet is delivered through the pipe *f* into the heater *c* wherein it is heated, and from whence it flows through the pipes *w* and *u* into the lower portion of the condenser, where it mixes with the condensate which is beneficially raised in temperature. When the condensate produced in the condenser is reduced to such an extent that the water circulating through the heater becomes too hot to condense the steam therein, then the valve *i* is partly or wholly closed so that water from the heater is delivered into the upper portion of the condenser over the cooling surface, whereby a reduction in the temperature of the water is effected. (*Accepted October* 7, 1914.)

T.-S.S.S. "CIUDAD DE BUENOS AIRES" AND "CIUDAD DE MONTE VIDEO."

In some respects there has been greater progress in the design of Channel steamers than in other productions of the marine constructor. The limitations imposed in the matter of length of hull and in draught, owing to harbour dimensions, have resulted in the tackling, by tank experiments, of the problem of resistance, and a form of hull with special reference to the lengthening of the load-line without increasing the over-all dimensions of the ship has yielded favourable results. In regard to machinery also satisfactory conditions have been got, alike in reduction of weight per unit of power and in efficiency. In no class of ship has the advance been so rapid from paddle-wheel engines to high-speed reciprocating machinery, later to turbines directly driving triple screws, and now to turbines working twin propellers through gearing. But it is doubtful if there has been equal progress in the arrangement on decks. On most services there is a day and a night passage, and most owners seem to wish that all the vessels built should be utilisable by day or by night. The requirements are altogether different; and since so many of the services are conducted by railway companies, it seems the more surprising that the management has not applied the same reasoning as dictates a difference between the day train, with its dining-car and corridor coaches, and the night train with many sleeping-carriages. A night steamer with compactly arranged series of Pullman outer berths and interior promenades, with large supper or breakfast-rooms, would be greatly appreciated, and for this reason we commend to the attention of the owners of Channel steamers the drawings of two vessels just completed by Messrs. Cammell Laird and Co., Limited, at their Birkenhead works, for service between Buenos Aires and Monte Video, accompanying this article.

The distance to be traversed nightly, and the degree of exposure to elemental forces by these steamers, are comparable with those prevailing in the English Channel, the North Sea, and the Irish Sea; and yet there is much in the design evolved by the builders and the owners—the Argentine Navigation Company (Nicolas Mihanovich), Limited—which differs materially. In the first place, state-rooms, many of them of the Pullman type, have been arranged for 494 first-class passengers, while for 258 second-class passengers berths, mostly in large compartments, are provided for what we would regard as steerage passengers. There are no berths along seats or shelves in the supper, smoking, or public rooms, and yet these latter are of great size, admirable in arrangement, and placed on the superstructural decks, where supper or breakfast is served. These upper decks, too, enable all the first-class state-rooms to be above the water-line, so that natural ventilation is also possible. The length of the deck-houses is a noteworthy feature, the capstan and windlass and other gear forward being more compactly arranged than in our Channel steamers, while the steering-gear is also on a low level. Nor are these upper decks pierced by great wells for the shipment of baggage or cargo into holds. Passengers' luggage, &c., is taken in through openings on the side of the ship by a crane with a special form of jib. Another feature is the lightening of the scantlings, and yet the vessel takes the highest class at Lloyd's. Thus the vessel has a draught of only 10 ft., while the total height from keel to the awning-deck is 23 ft. 3 in., and the beam is 44 ft. The length over all is 364 ft., and between perpendiculars 350 ft. The G.M. is 4 ft. On the official measured-mile trial the speed was 19 knots for 5800 shaft horse-power. The high-pressure turbines made a mean of 2320 revolutions per minute, the low-pressure 1630 revolutions, while the propellers were run at 267 revolutions. The steam consumption for all purposes was about 14 lbs. per shaft horse-power per hour. These results are in themselves indicative of the fact that the Cammell Laird organisation under the managing directorship of Mr. G. J. Carter is advancing the traditions of the old firm.

In describing the ships in detail, first reference may be made to the general appearance and scantlings. Fig. 1, on Plate XLVI., is a longitudinal section of the vessel. There are five decks, two of them above the moulded structure, and two high pole-masts fitted for wireless telegraphy. Three funnels contribute to the suggestion of power and speed, although only two are needed for the four cylindrical single-ended boilers fitted, the third serving for the ventilation of the turbine-room, &c. The deck plans are also given on Plate XLVI., Fig. 2 being a half plan of the boat-deck; Fig. 3 shows the wheel-house; Fig. 4 is a half plan of the promenade-deck; Fig. 5 illustrates the arrangement of the awning-deck, Fig. 6 the upper deck, and Fig. 7 the lower deck. Fig. 8, on Plate XLVII., is a view of one of the steamers on trial.

The scantlings are given fully in the cross-sections, Figs. 9 and 10, Plate XLVII.; the former shows the construction before and abaft the machinery spaces in way of the single bottom, and the latter the mid-ship portion with cellular double bottom. There is no need to enter here into details. The vessels are classed A 1 at Lloyd's for Channel service, with extra stiffening of the floors, stern frame and bottom plating. Siemens steel has been used throughout, and the cellular double bottom extends well over half the length of the vessel. The fore peak is arranged as a tank for trimming purposes. Forward of the foremost boiler-room, as shown in the longitudinal section, Fig. 1, is a large hold, extending the full width of the vessel, with trunk hatchways on the upper deck. Two smaller holds arranged aft of the engine-room are also fitted with trunk hatchways. The hull is well divided by transverse and longitudinal steel bulkheads, and access to the various compartments is gained by means of sliding water-tight doors, operated from the level of the upper deck. The steel water-tight lower deck, which forms a safety deck, extends from the stern of the vessel to the engine-room and from the boiler-room right forward. Access below is provided for by means of water-tight manholes.

The deck plans illustrating the arrangement of the passenger accommodation are reproduced on Plate XLVI., and on Plates XLVIII. and XLIX., in Figs. 11 to 18, are perspective views by Messrs. Bedford, Lemere and Co., London, of some of the principal saloons and state-rooms.

The boat-deck (Fig. 2) is interesting, first in respect that it is of Canadian pine covered with stout, heavily-painted cotton canvas. This is light and water-tight. Situated at the fore end of this deck is a large house, containing chart-room, pilots', officers', and captain's sleeping and sitting-rooms, first-class hospital, barber's shop, and captain's and officers' bath-rooms. On this deck also is placed amidships a large Marconi operator's house, containing office and cabin. On the same deck are six steel life-boats, with one decked life-boat under each. In addition there are two steel motor-boats and a dinghy, made of teak, for the use of the captain. Suitable davits are provided for serving these, and a hoisting-winch has also been fitted for raising and lowering the boats as necessary. On this deck also are wood deck-seats fitted with buoyancy tanks to render them serviceable as life-saving rafts. Flax canvas awnings are fitted over the boat-deck, and a special fitting, with a galvanised-steel hood, is placed at the centre to receive the awning when furled; the awnings are arranged to slide up and down on tube rafters. Cotton curtains are fitted around the sides of the saloons between the rail and the deck above.

On the chart-house forward is a large wheel-house (Fig. 3), containing the necessary steering, pedestal, compass, telegraphs, voice-pipes, &c. Above this wheel-house is a large revolving top, of ornamental design, seen better in Fig. 1. The name of the vessel is cut out in this top, and it can be illuminated at night. Operated by means of gear inside the house, the top revolves through 180 deg. Above is a large polished-glass globe, fitted with circular red-glass faces, on which is engraved the letter M, for Mihanovich. The globe, which is illuminated from the inside, is surmounted by another glass globe containing a powerful incandescent light.

The arrangements of the promenade and awning-decks are somewhat similar. On the former (Fig. 4) there are eighteen two-berth cabins, and twenty-six with two sofa-berths. There are in addition four special *cabins de luxe*, decorated in Louis XVI. period, all beautifully finished, as suggested by the view, Fig. 18. The main stairway forward, leading from the awning-deck to the promenade-deck, is shown in Fig. 13. Aft of it, and extending from side to side of this deck, is a dining-saloon, with accommodation for 168 persons. As shown in Figs. 11 and 12, it is in ivory-white flat enamel relieved with gold. The large open well in the centre, seen in Fig. 11, with its balustrade, admits light to the awning-deck saloon below (Fig. 13). Suitable sideboards are fitted at the forward end in close proximity to the first-class pantry, which latter is in direct communication by lifts with the kitchen on the upper deck. The veranda café, situated aft of the dining-saloon, is strikingly ornamented in Chinese style, the colour scheme in one vessel being a bright red, and in the other a rich green. The tables and chairs harmonise in design with the general scheme of decoration. A special feature in this café is its originality, as will be seen by the views, Figs. 15 and 16. Specially-designed French windows of large size, oval in shape and draped with curtains, admit light to this, as to the dining-saloon. Handsome beaten-copper vases, containing earthenware pots with large ferns, are placed between the easy-chairs outside the veranda café, the impression being of a Viennese garden. Overhead, and extending the full length of these several rooms, is a raised coach-roof (Fig. 11), with rectangular coloured-glass windows in the sides, and three handsome coloured-glass skylights in the dome. The ceiling in the dining-saloon is of fibrous plaster, ornamented. Completely covering the promenade-deck is a layer of stout, heavily-painted canvas, which has the appearance of linoleum, while along the corridors are fitted jute-matting runners (Figs. 13 and 14).

The awning-deck (Fig. 5) is partly of steel, and is covered with teak outside the steel deck-house and with Canadian pine inside. This deck, which is fitted with a continuous waterway with teak grating covers all round, is devoted entirely to the accommodation of first-class passengers in twenty-six double-berth cabins, and twenty-eight which can be arranged to accommodate either two or four persons. Each cabin is fitted with a mahogany folding lavatory, specially designed to form either a seat or to serve as a step to the upper berth. The interior is finished in white enamel, and all sofa seats and backs are covered with dark floral Moquetterie. In addition to the above state-rooms, there are special *cabins de luxe*, finished to conform with different periods of architecture. Forward are four cabins, decorated to conform to the Louis XVI. period, and provided with two single bedsteads in electro gilt, similar to those shown in Fig. 18. The panels are adorned with silk tapestry, the furniture, comprising easy chairs, tables, and table chairs, being of mahogany, and upholstered with silk tapestry. The electric-light brackets are also of the Louis period, of Parisian manufacture, in electro gold, fitted on the panels. Port curtains are of silk tapestry, supported on electro-gilt rods. The rectangular sliding windows are fitted with Venetian shutters and opaque glass. The ceilings are decorated with Louis XVI. Tynecastle tapestry, and finished in flat white enamel. Aft are four cabins of the Queen Anne period, two of which are finished in ivory-white enamel and two in highly-polished hardwood. Each room is furnished with two bedsteads, two lacquered ivory-white and two silver finish. Immediately forward of the above rooms are four large special cabins, decorated in the Georgian period, two of which are finished in ivory-white and two in polished mahogany. Between each pair of rooms there is a communicating door, so that they can be let singly or as a *suite de luxe*. The walls of the room are panelled with silk tapestry. The fronts of the first-class state-rooms, of polished Hungarian ash, face on to the saloons.

Aft on this, the awning, deck is a large social hall, which, in the case of one of the vessels, is designed and decorated in the Louis XVI. period, with furniture of Spanish mahogany, and silk tapestry panels. At one end of the hall is an open marble fireplace. in Breche de Rose marble. The ceiling is panelled with mouldings. This room is illustrated in the perspective view in Fig 17. In the case of the second vessel the social hall is decorated and panelled in the Jacobean period (in dark oak), with oak fire-place and suitable furniture. The general ticket and purser's office, which is finished in polished mahogany, is situated at the after-end of the engine-casing on the awning-deck.

The forward and after ends of the ship on the upper deck are almost entirely taken up by first-class four-berth cabins—exactly similar to those described for the top decks—and large central saloons, in which are arranged handsome staircases, leading to the deck above. Amidships are large cabins for petty officers, second-class

GEARED TURBINES OF THE T.-S.S. "CIUDAD DE BUENOS AIRES."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, BIRKENHEAD.

Fig. 22.

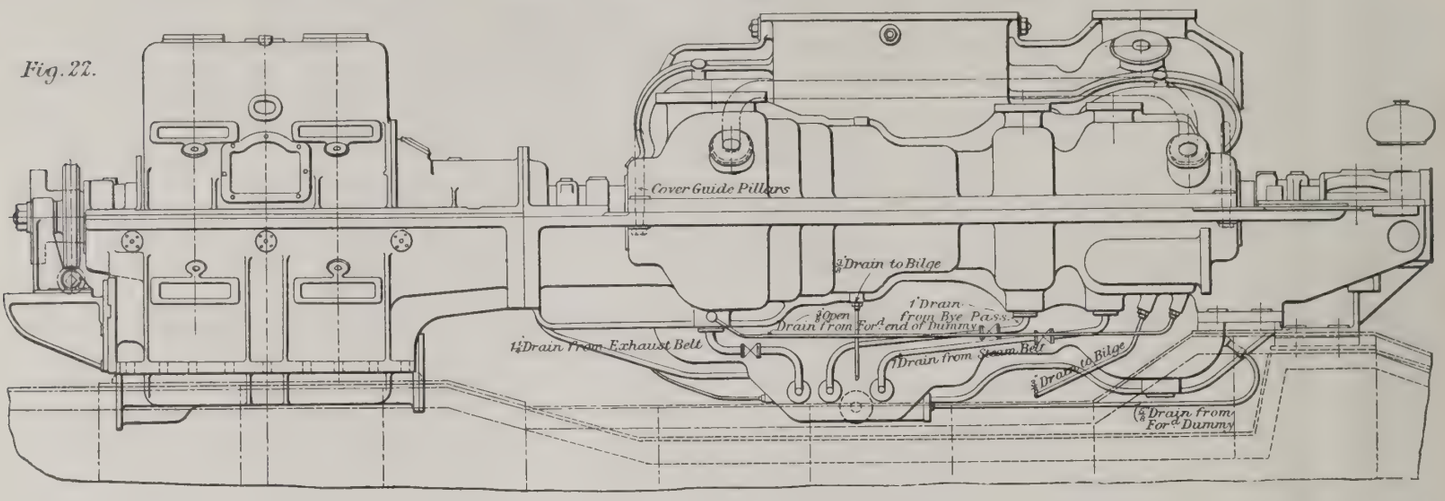
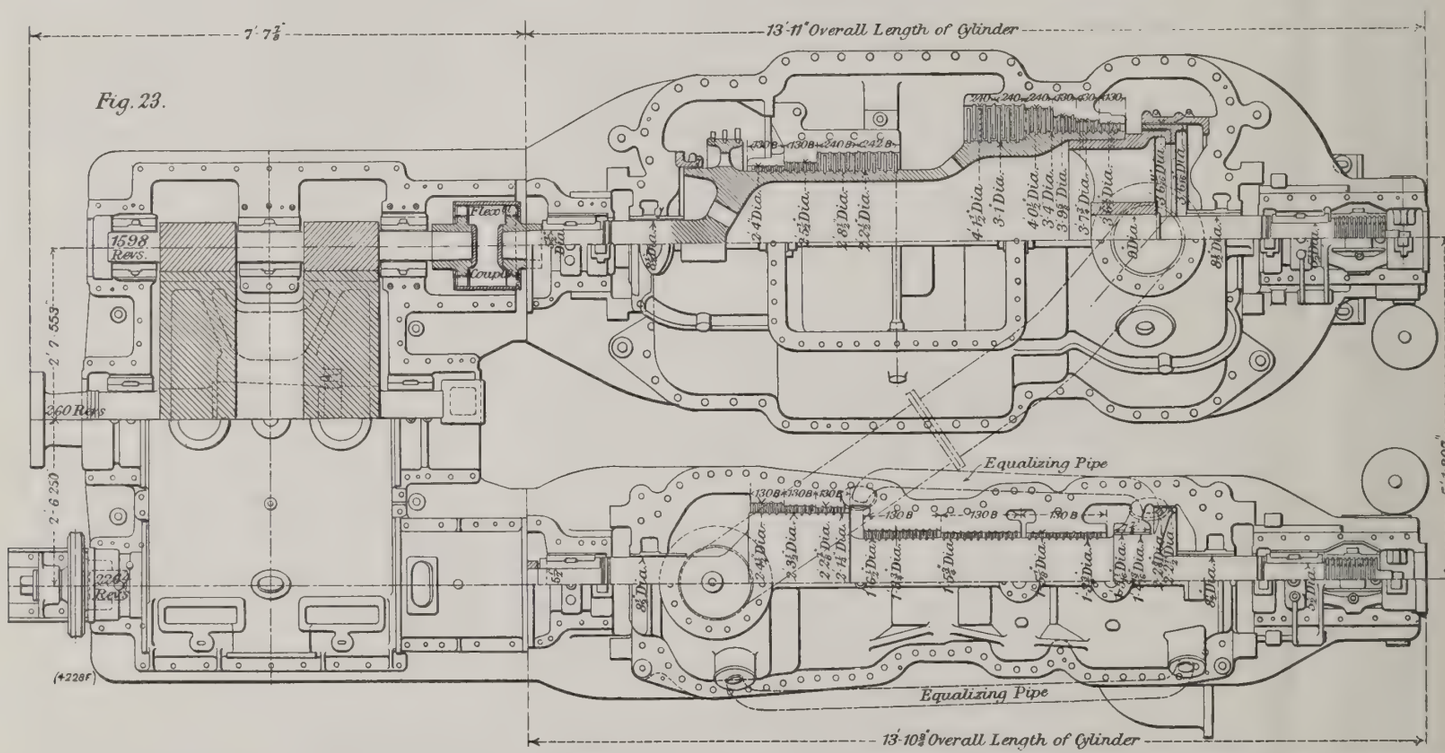

Cover Guide Pillars
¾ Drain to Bilge
1 Drain from Bye Pass
¾ Open Drain From For.d end of Dummy
1½ Drain From Exhaust Belt
Drain from Steam Belt
Drain to Bilge
¾ Drain from For.d Dummy

Fig. 23.



lavatories, and crew's wash-houses and lavatories. At the ship's side, and on each side of the engine-casing, are the engineers' cabins and second-class lavatory accommodation for ladies. Cold stores for provisions and the pastry-shop are situated on the starboard side, while immediately abaft the engine-casing is a galley sufficiently large for the full complement of passengers and crew, and fitted with a lift to the first-class pantry on the promenade-deck. Accommodation for seamen is provided forward.

On the lower deck (Fig. 7) accommodation is arranged forward for trimmers, second-class passengers, and petty officers. Second-class accommodation is provided aft, in four-berth state-rooms, leading off a general saloon, as well as in a special ladies' saloon. All the wood-work, inside and out, is finished in white enamel, the steel-work being cork-dusted. Sofas, seats, and cushions are stuffed with horse-hair and covered with leather. The saloons and corridors are covered with dark self-coloured linoleum. Luxurious and tastefully-upholstered lounges give an air of comfort and cosiness to the corridors; while marble statues supporting electric-light candelabra embellish the casing sides. Between the casings are fitted first-class lavatories for ladies and gentlemen, comprising w.c.'s and baths, non-absorbent tiling being used for the floors.

The steering-gear is placed on the awning-deck (Fig. 5). It is of the hydraulic type controlled from the wheel-house forward. Hand-gear is also fitted. Cargo and heavy luggage is handled by four powerful hydraulic cranes, placed between decks at the sides of the vessel on the upper deck (Fig. 6). Hydraulic power is supplied by means of a complete installation of pumps, accumulator, &c., fitted in the engine-room. Aft and forward on the awning-deck are fitted a steam warping-capstan and a steam-windlass, with large warping ends and cable whelps of steel, suitable for lifting anchors and cables quickly.

The lighting throughout is on an extensive scale. Corridors and passage-ways are notably well lighted. To assist navigation at night, a searchlight is fitted on the bows of the vessel. Current is supplied for the whole installation by two powerful dynamos situated in the engine-casing at the level of the upper deck (Fig. 20). As regards ventilation, the state-rooms on the lower and upper decks are fitted with sidelights, and those on the promenade and awning-decks with sliding windows. Ventilating-fans are also fitted to the lower-deck compartments and the public rooms. An elaborate fire-extinguishing system is provided, consisting of water-pipes fitted on the under side of decks and hydrants above. Boxes containing hose, couplings, and directors are in all cases stowed near at hand. In addition to the water supply, steam-pipes are led to the coal-bunkers and holds, and are controlled from the upper deck.

On Plate L. we give, in Figs. 19 to 21, a plan and cross-sections showing the general arrangement of the machinery of the ships. The engines are of the Parsons geared-turbine type. These are the first vessels of the company to have turbines; but the success achieved with such machinery in other vessels naturally appealed strongly to a progressive firm like MM. Mihanovich. There are two sets of turbines, each operating a propeller-shaft through a gear-wheel. The high-pressure turbine in each set is placed inboard, and the low-pressure turbine in the wings. The astern turbines are incorporated in the same casing as the low-pressure ahead turbine. The designed ratio of speed reduction in the case of the high-pressure turbines is 8.7 to 1 of the propellers, and in the case of the low-pressure turbines 6.1 to 1. Fig. 25, page 747, is a diagram of rotation. A by-pass is fitted to the high-pressure turbines, and otherwise the turbines are in accordance with Parsons' latest practice; elevations and sectional views are given in Figs. 22 to 24, on the present and opposite pages. Each of the rotors for the high-pressure turbines is of steel, and was forged in one piece. The low-pressure rotors are built up with a forged-steel drum, a cast-steel wheel, and forged-steel spindles; the whole of the

DETAILS OF GEARED TURBINES OF T.-S.S. "CIUDAD DE BUENOS AIRES."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, BIRKENHEAD.

Fig. 24. END ELEVATION—LOOKING AFT.

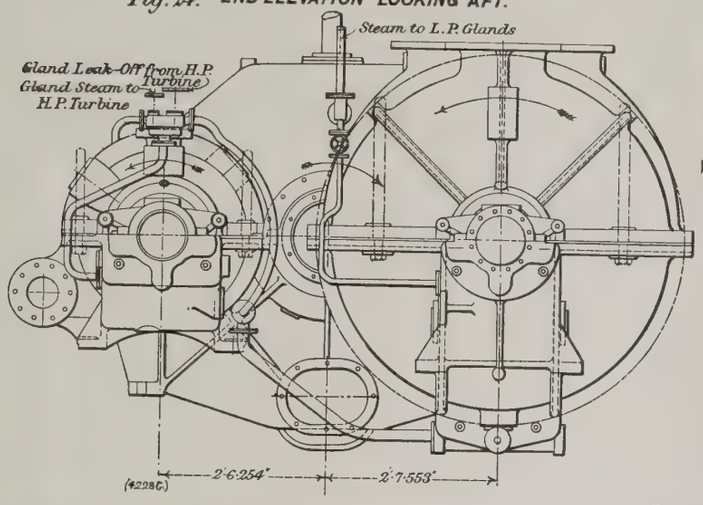
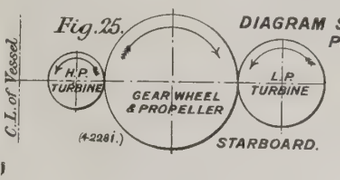


Fig. 25. DIAGRAM SHOWING DIRECTION OF ROTATION OF PROPELLERS WHEN GOING AHEAD. LOOKING FORWARD.



Revolutions per Minute.
H.P. 2264. } Propeller 260.
L.P. 1598. }

Fig. 26. SECTION THRO' ASTERN TURBINE IMPULSE WHEEL

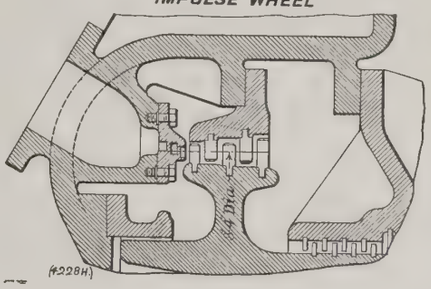


Fig. 27. ½ FULL SIZE SECTION OF GLAND STRIPS

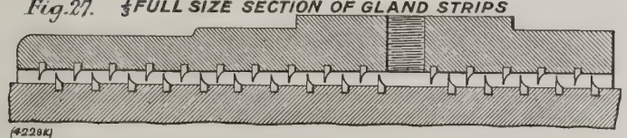


Fig. 28. ASTERN DUMMY

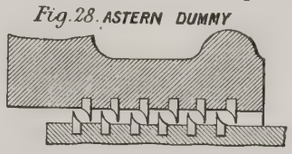
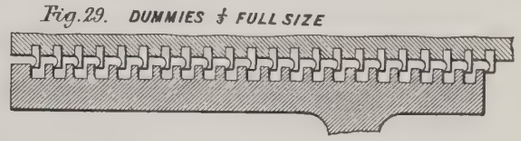


Fig. 29. DUMMIES ½ FULL SIZE



forgings were made at the builders' steel works at Sheffield. The details of the impulse and reaction turbines are given in Figs. 26 to 29. The gearing was cut at the builders' works by the latest type of gear-cutting machine, and as every effort was made to eliminate inaccuracies, the gear is practically noiseless. The gearing is, of course, placed at the after end of the turbines, the spindle of the high-pressure turbine working on the inboard, and the spindle of the low-pressure on the outboard, side of the wheel. The propellers are of solid bronze. The machinery of these vessels is fitted with the Michell type of thrust, which was decided upon on account of the advantages gained in reduction of weight and space, and the extremely satisfactory nature of its working on previous vessels built in this country. This application was illustrated and described on pages 726 and 727 *ante*.

The starting-gear is placed so that the engineer faces the turbines when manœuvring (Fig. 19). A large steam-separator is fitted in the main steam supply. The manœuvring-valves are of the flexible disc type, and the usual steam-strainers are so fitted as to exclude the possibility of foreign bodies entering the turbine-casings. A throttle-valve, operated by Proell's governors, has been fitted in the main steam-pipe.

Steam is supplied by four single-ended boilers of the cylindrical multi-tubular type, fitted with Howden's system of forced draught, the air for combustion being supplied by two steam-driven fans, 72 in. in diameter (Fig. 19). Three furnaces of the Morrison suspension type are fitted to each boiler, which are designed for a steam pressure of 170 lb. per sq. in. As circumstances may permit the use of oil fuel in the future, one of the boilers in the first vessel is fitted with an oil as well as a coal-burning installation. The oil will be carried in the cellular double bottom; the coal is stowed in water-tight side-bunkers.

The condensers are of large surface, with steel bodies and cast-iron doors. The following auxiliaries, which are all of Weir's standard type, are installed:—Two dual air-pumps, to maintain a vacuum of 28 in.; a pair of independent direct-acting feed-pumps of the vertical type; two independent oil-pumps for lubricating purposes; a general-service pump and an evaporator capable of producing 25 tons of water in twenty-four hours. In addition, there are a feed-water filter and heater; two independent centrifugal circulating-pumps; bilge-pumps; sanitary-pump; an oil-cooler for cooling the lubricating oil after it has passed through the bearings; two small pumps for fresh water and sanitary purposes; and two "Sentinel" ash-hoists.

The builders have been greatly assisted in the design of the vessels and machinery by the first-hand knowledge of the requirements possessed by Baron Mihanovich. The whole of the work is in accordance with Lloyd's requirements and survey, and no efforts have been spared to make the ships the finest vessels afloat of their class.

THE INSTITUTION OF MECHANICAL ENGINEERS.

An ordinary general meeting of the Institution of Mechanical Engineers was held on Friday last, the 18th inst., the chair being occupied by Mr. Michael Longridge, Vice-President.

Cab-Signalling on British Railways.

The formal business having been concluded, papers down for reading on the above subject were taken. There were five papers, the authors being as follows:—Mr. W. C. Acfield (Midland Railway), Mr. Leon P. Lewis (Caledonian Railway), Mr. Vincent L. Raven (North-Eastern Railway), Mr. W. A. Stanier (Great Western Railway), and Mr. W. Willox (Metropolitan Railway). All these papers we publish in full in our present issue.

Mr. Acfield summarised his paper, which dealt with "Audible Signalling on Railway Trains in Motion." The paper entitled "Automatic Signals on Trains," by Mr. Lewis, was, owing to the absence of the author, summarised by the Chairman. Mr. Raven's paper, "Electrical System of Cab-Signalling," was summarised by Mr. J. Pigg. The paper entitled "Combined Automatic Train-Control and Audible Signal System in Use on the Great Western Railway of England," was summarised by its author, Mr. Stanier. Finally, Mr. Willox read his paper on "Signalling on Railway Trains in Motion."

The Chairman remarked that the importance of the papers lay in the fact that the safety of a great many people depended on the efficiency and reliability of the signalling system controlling and directing railway traffic. Experience had shown, and it was generally admitted, that the present system in use was not entirely reliable. Signals, semaphores, and lamps, even in fine weather, did not overcome the risk of overrunning and mistakes; in fogs they were useless, and it then became necessary to substitute bombs and shouting. He thought signals which appealed to the ear were more reliable than those appealing to the eye, and the efforts of engineers would have to be directed towards perfecting the system of audible signals. The papers had set forth some of the difficulties of the problem, and also some of the solutions which had survived the ordeal of every-day work. In addition, however, he was sure that there were other schemes for systems of audible signalling which might prove successful, while again others might not prove successful, but might, nevertheless, contain the ideas which other engineers could utilise in a practical manner. Members of the Institution were rightly impatient of those who took the opportunity of puffing their own inventions at meetings, but that was wholly different to explaining the construction of apparatus which members thought they had been able to scheme out or invent. He would therefore ask members to give the benefit of their experience without undue modesty or fear of misconstruction. The aim of discussion was to elicit information.

Mr. A. T. Blackall, of the Great Western Railway, observed that he would like to record his opinion of the importance of the latest development of the system described by Mr. Stanier—namely, the application of the brake at the distant signal when that signal was at "danger." He thought there was no doubt that such an application would have prevented a good many of the accidents which had occurred in past years. He referred to the accidents caused by the overruning of the signals. Some were attributed to the signals being missed owing to atmospheric conditions; others to absence of mind, or something less excusable, on the part of the driver. The automatic application of the brake at the distant signal in the class of accident referred to would inevitably have prevented them, as the train would have been pulled up at the "home" signal, the real danger point. With the addition of the automatic application of the brake the need for visual signals in the cab of the engine seemed to disappear, at any rate in those systems in which, like the Great Western, only the distant signal was provided for.

It was very important that the systems adopted by various railways should conform to some standards, so that the engines of one line passing over the system of another would pick up the signals which that line would ordinarily give to their own engines, and *vice versâ*. All cab-signalling devices should be considered from that point of view. Systems in which the engine on one line could not pick up the signals on another line were useless. Mr. Acfield and Mr. Stanier both insisted that there should be no movable parts upon the line. In the case of "tube" and other similar railways, where comparatively low speed obtained, and where movable train-stops were already in use with good results, some people might tbink that it was not necessary to insist on this point. But in the case of fast-running lines it was most important. To rely upon stopping a train by impact of the engine with a movable apparatus, brought into position by the action of a signalman, approximately, with dis-

tant signalling half a mile away, was, to say the least, a risky thing. He did not doubt that if cab-signalling, combined with automatic-brake control, were generally adopted upon railways, it would prove a very great factor in the safe working of trains. He thought a very great extension of cab-signalling might confidently be expected in the near future.

Mr. S. L. Gibson stated that the system in which he was interested was really a Swiss one. It was now largely used in Canada and the United States. Over 130 miles were in operation with extensions amounting to about 250 miles. The first installation, made in 1902, was on a steam road, and others installed since were on electric roads. It was more than a signalling system, because it included control of the trains from a central office. In the United States and Canada signalling was worked on what was called "the normal clear" position, the signals being all at the "clear" until something happened on the track or a train entered the block to put them at "danger." Here the system used was what was called the "normal danger," all the signals being at "danger" until the train approached, when the "clear" was given if everything was all right. In the system he was describing a fixed ramp and a shoe were used, together with visible and audible signals. The visual signal consisted of a green light for safety practically all the time, but between a "distant" and a "home" signal, when trains caused a stoppage, a red light was given.

In addition to the signalling system was the "despatch" system, the ramps being connected up to central stations. In that central station was a moving record-sheet divided horizontally into time, and vertically into the number of blocks into which the line was divided. The trains automatically registered their position on that sheet, so that the man who controlled the signals had, at the same time, an accurate record of the position of each and every train at that instant on his line. Further, an automatic speed-control was used. They did not aim at stopping the train, though that could be done if desired, but at controlling the speed. The apparatus was not in any way under the control of the driver. If it were under the driver's control, he might, if he so chose—and experience showed that he would—reset the apparatus, and, unless some elaborate system of registering the movements of the mechanism were also adopted, no one else would be any wiser.

The apparatus was set in motion, say, at a "distant" signal. If the "distant" signal were at "danger," and the driver did not obey the signal and begin to take charge of and stop his train, the apparatus would within a certain time—registered according to the distance required for braking the train between the "distant" and "home" signal—take charge, and put on the brake, cutting off the steam or electric power. The driver could, all the time, keep his control of the train just below that point, and if performing his duty properly the arrangement would never come into operation until the "home" signal was reached. When the "home" signal was reached, and if the driver received a "clear" signal to go ahead, the apparatus was automatically released, and the driver was allowed to proceed at any speed up to the maximum. The apparatus could be so arranged that the speed of the train could be brought down to a predetermined maximum, allowing the driver to proceed at, say, 5 miles an hour until the "clear" signal was given. It was also found practicable to control the speed, if necessary, at any special parts of the line, say on a curve, by placing extra ramps, one at the entrance to the curve, and one further along. The speed could be reduced to that necessary to allow the train to pass the curve safely. The value of the system would be perhaps more completely realised when he stated that the Railway Signal Company, of Rochester, N.Y., had taken up a licence for it in connection with the resignalling of the subways of New York, while the Pennsylvania Railroad, in the United States, had given a provisional order for twenty miles of their four-track way. [The Chairman here suggested that Mr. Gibson might furnish the Institution with a drawing or sketch of the ramp* used in the system referred to. Mr. Gibson expressed his readiness to do so.]

Mr. H. Raynor Wilson said that he had always been a cab-signal man, as he recognised the great assistance which some sort of duplication of the fixed signals would be to drivers. He recognised that there was another side to the question. Had he been in the position of a general manager, and a proposition had been laid before him for the installation of cab-signalling apparatus, there were certain arguments he could have used against such work being done. First, there was the fact that great improvements had been made in recent years in the location of signals. No expense was spared with regard to putting signals on gantries across the line and bracketing them out, to provide 10-ft. spaces, and so on. Another argument which might be used was the large decrease in the number of accidents due to overrunning signals. Mr. Pigg, in summarising Mr. Raven's paper, had referred to tables appearing in the *Railway Gazette* on the last ten years' railway accidents. An index was to be published of the causes that had been assigned by the Board of Trade inspectors. He had found that during the five years ending on December 31 last, 24 accidents were alleged to have been due to drivers overrunning signals. The records for the five-year period from January, 1899, to December, 1903, showed 47 accidents, so that in the ten years there had been a reduction of practically 50 per cent.

Further, cab-signals had never been recommended by the Board of Trade. A quotation had been given of a statement Sir Arthur Yorke made at a meeting of the Institution of Civil Engineers, but Colonel Yorke had never encouraged cab-signals in any of his official reports. Colonel Yorke had pointed out very serious difficulties in the way of providing cab-signals, and none of his colleagues had recommended them. In some cases, in his opinion, cab-signals might have prevented accidents, but in no case had they been recommended by the Board of Trade inspectors. Cab-signalling had made wonderful progress. It appeared that there were ninety engines fitted on the Great Western Railway with cab-signals, thirty-six on the North-Eastern, and two on the Midland. At the Paris meeting of the Institution, Mr. Aspinall stated that his company was experimenting with cab-signalling, and other companies were moving in the same direction. He would, however, urge that the movement should be slow. He thought it would be wise to move slowly; at first, the "distant" signal should be repeated efficiently, then add later "stop" signals, if necessary, and route-indicators.

Mr. J. Sayers, of the Midland Railway, thought no one would challenge the opinion that for high-speed railways train-stops were of no value. They were useful, to a certain extent, on moderately low-speed railways, and they had proved useful in urban and inter-urban electric railways. About a year ago he had read in America a wonderful account of the train-stops in use on the New York subways. Two accidents subsequently occurred in one night, owing to two trains doing what was called a side swipe; that was to say, two trains running from two lines on to one came into collision. In both cases, the general manager of the line ended their accounts of the accident by saying that the train stops were invulnerable. In the *Electrical Railway Journal*, of about four weeks ago, there also appeared a small paragraph recording four accidents in one night on the Third Avenue and another line, whereby a quarter of a million people were held up between midnight and four o'clock in the morning. He believed that two of the accidents should have been prevented by train-stops. With regard to the question of cab signalling, he confessed to have seen until recently only one system worth looking at—namely, that in use on the Great Western Railway. They had tried it for years, and had never found it giving a false indication. It had been employed on a single line, and had to be fitted with the polarised-relay system of preventing trains coming on to the ramp and picking up a signal which did not apply to them. There had been no trouble at all. Now that electric traction was coming so much to the fore it seemed to him that there was no room on the track for anything but traction. Even with the simplest form of overhead collection it was necessary to have something to take away the current at present entirely removed by rails. If regulations with regard to the return current, &c., became more stringent, the various systems of ramp-signalling would have to find some other method of communicating with the engine.

It was that fact that had driven them to consider inductive or wireless signalling, and an experiment had been made, on a short piece of the Midland Railway, with a system based on the railophone. It was a simple matter to run a piece of wire along a track either under or overhead. If an alternating current were passed through this, then a coil near by would pick up a certain amount of induced current. That could be made to operate a relay which would only respond to a certain frequency. They had used that device to control the brake and an audible indicator on a cab. The system of ordinary semaphores and of lights at night was really very efficacious, depending, as it did, entirely upon ether waves. The usual signals gave an indication to the driver solely by means of the vibrations of the ether, which were continuous, and received by him continuously from the time he saw the signal to the time he got by. It was, he considered, the simplest possible arrangement, and the most scientific. It was the first thing ever devised, and the best. If the visual system could be perfected, so that by night as well as by day the ordinary signal was always visible, that would be far better than any method of cab-signalling.

Mr. A. D. Jones, of the South-Eastern Railway, remarked that it appeared, from the system in use on the North-Eastern Railway, that the normal position of the indicating-arm was at the "clear" or "off" position. He considered that was open to objection. He noticed also that the driver seemed able to cut off the simple indicating battery with a switch-key, and if he did so the arm remained at "off;" that appeared to him rather like the use of a Sykes key, which was sometimes a cause of accident. It further appeared that the driver could stop the bell by releasing a switch. When running slowly in a fog, and creeping up to the signal, the driver would be too liable to use the switch. One of the papers suggested that the most critical period was between the commencement of a fog and the calling out of the fogmen. Doubtless that was true, but the difficulty could easily be got over if the signalmen were able to place mechanical fog-signals on the line until the fogmen arrived. Had cab-signalling improved running in a fog? Personally, he considered that cab-signalling in the form of visual signalling was liable to distract the driver's attention from the road. He felt that all the attention of the driver should be given to the road. There were sometimes things on the line of which the driver was ignorant; such, for instance, as plate-layers' trolleys, loads that had fallen off in transit, cattle, slips from banks, &c.

Moreover, cab-signalling did not seem to get over the difficulty of irregular signalling on the part of the signalman. The Board of Trade records would, he thought, indicate that a large number of accidents were caused by irregular signalling. The Great Western system appealed to him because of the train-control, without which he did not regard any system of cab-signalling as of practical value. He was interested in Mr. Sayers' remarks about high speed. He had been on the foot-plate of an engine which, when travelling at fifty miles an hour, was brought up very quickly with the control. Trains, of course, ran much faster than that, and it became a question whether the gear would stand it. In the case of goods trains running down a bank at a fairly high speed, if it met a control there would be a risk of

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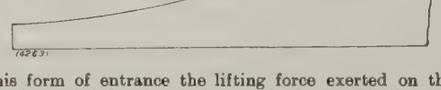
* [In connection with ramps, it is worth noting that neither in the papers read at this meeting, nor in the course of the discussion, was any question raised as to the effect of the form of ramp on the shock imposed on the part of the apparatus by which it is struck. So far as we know, ramps have generally been made with plain inclined ends, a form which means that the detail by which a ramp is struck has at once its full vertical velocity imparted to it. A great reduction in the shock of striking would be secured by shaping the ends of the ramp to Scott-Russell's well-known "wave-line," consisting of a pair of sine-curves, as shown in the annexed sketch. With



this form of entrance the lifting force exerted on the detail carried by the engine would be practically constant throughout the length of the lifting portion of the curve, the part lifted receiving a gradually accelerated vertical motion while passing over the first half of the curve, and being then gradually brought to rest in its raised position. The same form should, of course, be adopted for the leaving end of the ramp.—Ed. E.]

wagons going over the tender. Was it not a fact that in the old days, when there were not many signals, certainly no train-controls, &c., there were far fewer accidents than at present; that the men had to depend entirely upon their good look-out? That might, perhaps, be a reason for not having expensive systems installed.

He was rather surprised to find, from Mr. Willox's paper, that the Metropolitan Railway had so many cases of running past signals. But it was interesting to find that carelessness or failure of apparatus was so completely corrected by the train-stop. Mr. Acfield had referred to the sealing up of the train-stop, so that if it acted it could be observed, and had to be corrected; and it had been suggested by Mr. Lewis that a glass tube should be placed in the brake-pipe. He would not advise such a course. There were quite enough troubles as it was. Mr. Blackall had referred to the adoption of universal standards. That he regarded as on all fours with the question of electric traction by third rail or overhead.

Mr. Garner Smith remarked that at this period of the year railway engineers had opportunities for realising that visual signals were not all that could be desired, with the result that hundreds of inventions were worked out. If only one system had been devised, it was possible that it would have been adopted some time ago. The various signal superintendents each considered his own apparatus the best. He thought when first he had received the papers that the different engineers had arrived at a solution of the problem by sinking their individual instruments in favour of one good machine. Matters, however, had not yet reached that point. With regard to Mr. Raven's system, if it did not fail, it certainly seemed rather complicated. Mr. Stainer's apparatus, on the other hand, was simple, and simplicity should bring reliability. He would like to indicate one or two points where it might fail. He would therefore refer to Fig. 8. The apparatus shown appeared to hold the signal at "line clear" by means of the local battery situated on the engine. When the engine passed over the unelectrified ramp the local battery circuit was broken, and the arm fell to "danger;" when the ramp was electrified it took up another current, giving "line clear" again. It would therefore be seen that the cab electromagnet armature must be rather light, or else a very big battery would be required, otherwise the shaking would cause the armature to drop off, or the armature arm might stick on the pivot, either through corrosion, or oil, or something of the sort. Again, residual magnetism might give trouble. Another thing: the current might leak across the local circuit connections, and the "danger" signal would not be given. The apparatus, to be effective, should give the driver a mechanical, as well as an electrical, "danger" signal.

Mr. R. G. Berry, of the Lancashire and Yorkshire Railway, observed that cab-signalling was a very absorbing subject. They had been experimenting with a cab-signal on the Lancashire and Yorkshire Railway. They had introduced a feature which, he believed, had not been found in any other cab-signal giving both "all-right" and "danger" indications. An audible indication was given for both "all-right" and "danger" signals, but no battery or accumulator was used on the engine, and there were no delicate contacts. It seemed to them that the apparatus should be such as the driver not only understood, but was able to repair in the event of anything going wrong with it. A driver was not an electrician, and they had therefore done away, as he had said, with batteries, accumulators, and contacts.

Mr. A. E. Roberts, of the London and South-Western Railway, stated that it had occurred to him that high-speed steam engineers were rather severe on electrical slow speeds. By way of criticism he would say that he did not consider it a sound mechanical job to hang collector-shoes upon the frames of a truck. The North-Eastern Railway Company's device showed the brush upon the framework of the locomotive where the vertical movement was pronounced.

Mr. Insell, of the Great Western Railway, said the North-Eastern Railway system gave a "danger" signal in every case of approach to a signal. On the Great Western Railway a signal was also given to the driver when approaching a signal, but that signal coincided with the semaphore, which was worked by the signalman, and the driver was not continuously told that the signal was at "danger" if it were "all right." He considered that system better than that of the North-Eastern Railway. With regard to route-indicators, the Great Western Railway Company did not attempt to give route-indications to drivers approaching diverging junctions unless the speed were such as would enable them to run on. Any train approaching a diverging junction where speed had to be reduced received a distant signal at "danger." That was carried out through the whole system, and only where the speed might exceed 40 miles an hour was it necessary to give the driver a clear indication at the distant signal. Referring to the train-stops on the Metropolitan, before the stops came into operation drivers had to pass the signals. Such a practice would not be possible on steam lines, as the "stop" signal always indicated the "danger" position, and if a driver passed it any distance, trouble would probably result. With regard to Board of Trade inspectors not requiring cab-signals, he could refer to more than one report of an accident in which the inspectors had recommended some form of cab-signal. They had, however, very little choice, as there were only one or two systems possible. He thought some form of cab-signal was bound to be brought into general use sooner or later by law.

Mr. W. C. Acfield was first called upon to reply to the discussion. He said that Mr. Blackall had referred to the undesirability of movable ramps on railways. It was difficult to see how a movable ramp could be worked satisfactorily by mechanical means. It seemed to him that it was impossible to get the necessary adjustment, especially when, as in the case of his own line, the maximum distance of the "distant" signal was 2200 yards from the signal-box. In regard to train-stops, as the result of some unfortunate accidents, the Midland Railway had decided to make tests of train-stops at high speeds. Accordingly, trip-valves and train-stops had been devised, and the trains were run at a speed of 70 miles an hour. No train-stop would stand such speeds. Mr. Gibson had spoken of an apparatus for recording the position of trains on the line; that, however, was quite different from the apparatus referred to in his paper for recording running past signals. The French railways had in use a year or two ago an invention, by M. Van Braun, according to which the apparatus was sealed up, and whenever the driver ran past a signal the guard had to come and replace the signal and reset the apparatus before the train could start. It would be quite impossible to work present-day traffic with such a rigid regulation; wherefore, he thought, means should be given to the driver to release his brake as soon as he became aware that his brake had been applied by an audible train-control apparatus. Some had suggested that it was undesirable to give an engine-driver such power, because he might not have time to collect his thoughts. He thought, however, that the application of his brake would bring the driver to his senses. Mr. Blackall suggested that visual signals were not necessary where the distant signal only was indicated to the driver by audible means. But there were "home" signals also to be dealt with, and it appeared to him that some visual indication would be preferable.

Mr. J. Pigg agreed with Mr. Blackall that the latest development of cab-signalling was connected with the operation of the brakes. If he had been subjected to an examination on the point, he was not sure whether he would have considered the application of the brakes essential or not. The business of drivers was to operate the engines, and, so far as he could judge from the causes of railway accidents, the reason drivers had not managed their engines as they should was because they had not seen the signals exhibited to them. He agreed as to the necessity for visual signals. He considered that far too much had been made by the opponents of these signals of what was termed "the withdrawal of the driver's attention from the line." Mr. Raven employed a visual signal which had the advantage that it remained, and always showed the last signal until the next one was received. It was therefore in a position to be seen by any man otherwise engaged at the moment. A visual indication got over the difficulty of the driver's memory; with an audible indication the driver had to remember the actual signal he had obtained.

He also agreed that there should be a considerable degree of uniformity, and that engines belonging to one railway should be able to get such indications as they required when passing over another. Mr. Gibson's remarks, although very interesting, scarcely bore upon the question of cab-signalling as understood in this country. With regard to Mr. Jones's remarks that in Mr. Raven's system the normal position was "clear," he might explain that the normal position of the indicating-arm was "danger," but the normal running position was "clear." That "clear" position was only obtained and maintained by a constant current, so that, if anything happened to the circuits or the current, the indicator at once went to "danger." The cut-off switch was simply a switch by which the driver cut off the current from the instrument for the sake of economy when going into the shed at night; in the morning, when going out of the shed, he put it on again. In going out he passed over a number of energised bars which gave him the "off" indication.

The tapper switch was only necessary under present conditions of running. It was plain that Mr. Raven's system, or practically any system of cab-signalling, was intended only for main-line work, and not for shunting operations. That, however, did not mean that the engines equipped might not have to perform shunting operations, and, in doing these, they necessarily ignored anything which happened upon the cab-signalling apparatus; at the present day, therefore, it was necessary to provide some means whereby the driver could stop the bell from ringing before he started out on his journey. Although this was done, it did not constitute a full "off" signal, because the pointer of the visual indicator remained in the central position, and was not deflected, as it would be when any complete signal was obtained. Though Mr. Jones had suggested that the tapper switch might be used "illegally," the drivers did not, as a rule, tamper with apparatus, but had shown considerable interest in such appliances on their engines. With regard to cab-signalling affecting running time, the amount of line as yet equipped was so small that the effect could not be shown.

He could not see where Mr. Roberts would suggest placing the brushes if not on the engine frame, seeing that they had to be carried by the locomotive. The speaker concurred with regard to warning signals; he wished to indicate the very strong difference between such an apparatus as Mr. Raven's, in which control of the train was obtained throughout the whole of the distant signalling zone, and any apparatus which lost control of the train at the "distant" signal. He had already intimated that he regarded the canalisation of the line as the principal point. A driver running towards a number of signals, if the whole of the signals were within his line of vision, might select the right or the wrong one. Any system of signalling which left him to his own devices after he had passed the "distant" signal was, in the speaker's view, to that extent imperfect.

Mr. W. A. Stanier, who followed, stated that on the Great Western Railway last winter, since ramps had been fitted between Paddington and Reading, everyone at Paddington Station had been astonished at several of the trains arriving to time during fog. Drivers attributed their punctuality to the fact that they had the audible apparatus on the engine. With regard to the position of the ramp in short blocks, he did not know whether on the South-Eastern Railway they allowed "distant" signals for short blocks to overlap. He thought, however, when the "distant" signal for the block ahead was put on a "home" signal-post in cases of short blocks, and the running distance was at the minimum, it was usual to provide an intimation to the driver as early as possible. Immediately after the "distant" signal was considered to be the nearest position possible, because the "home" signal controlled up to the signal-post. The accumulator used on the Great Western system was no more than a 4-volt one, and he thought it could be seen from the drawing and photograph that the armature, at any rate, was robust enough to do the work required of it. He might mention that in one arrangement the Great Western Railway audible signalling apparatus was devised to operate without an accumulator; it was purely mechanical. He did not agree with Mr. Berry's suggestion that the driver should be required to repair a device on the road; on the Great Western Railway, at any rate, there was no time for that sort of thing. Mr. Pigg had spoken of the driver in regard to the position of the last signal. It was of far greater importance that the driver

should know the position of the signal ahead. Mr. Pigg had also stated that he did not think drivers would tamper with any apparatus; he and others were somewhat sceptical on the point.

Mr. Willox also replied very briefly to the discussion. He remarked that his paper contained a description of the control of trains without cab apparatus, and was of the nature of a foil to the other descriptions. He was greatly interested in cab-signalling apparatus. The Metropolitan did not consist only of electrical lines, and there were very fast trains running with ordinary signals. As soon as they could find a solution—which seemed as remote as a solution of the problem of rail corrugation—they would no doubt adopt the best system of signalling. Meantime, in London the density of traffic was extraordinary. On his own system, forty-two trains per hour were run over one line. Something, therefore, had to be done, and the train-stop with trigger was adopted. This had been most effective, and the signals had been arranged so as to give over-runs.

The Chairman then announced that the next meeting would be held on Friday, January 22, 1915. At that meeting a paper on "The Standardisation of Pipe Flanges and Flange Fittings," by Mr. Dewrance, would be read and discussed.

LITERATURE.

Industrial Chemistry for Engineering Students. By Henry K. Benson. Ph.D., Professor of Industrial Chemistry in the University of Washington. New York: The Macmillan Company. [Price 8s. net.]

An engineer who desires to become acquainted with the methods of preparing the materials with which he has to work, how they are varied or improved by ingenious manipulation, their mode of occurrence in Nature, or their chemical composition, would probably consult an encyclopædia or adopt some short cut for getting at the facts of which he is in search. We imagine that the purpose of Professor Benson's book is to present that kind of ready information in a convenient form and in a more systematised manner. There is no attempt to enter very thoroughly into the details of any particular department or specialised industry, but many useful facts are collected, general principles are presented, and not the least valuable portion consists in the large and excellent bibliographies attached to each chapter, enabling the student to follow up the inquiries which are here broached. By this means an index is furnished to monographs and to papers scattered through the Transactions of learned societies and trade journals that cannot but prove welcome and time-saving to those who want precise and accurate details of the latest and most thorough investigations.

Every engineer who is about to enter the profession must have acquired some acquaintance with the grammar of physics and chemistry. He has necessarily breathed the atmosphere of which such knowledge forms an essential part, and the author may be justified in assuming that his readers have acquired sufficient familiarity in interpreting chemical formulæ, and with the results of chemical analyses, to apply this knowledge in the pursuit of experimental research or the conduct of business. But supposing students to be armed with this knowledge and qualified by experience, it might have been prudent to have curtailed some of the elementary matter, in order to have had room to discuss the advanced in a more instructive manner. For instance, if one is writing on the chemistry of dye-stuffs, it seems hardly legitimate to refer the student to other works for an explanation of the diazo reaction or for information on the diazonium compounds. When treating of rubber, it is not satisfactory to be told of an artificial product resulting from reactions "which require fuller explanation than can be given in a brief discussion." There is no need to drag in the possibilities of synthetic rubber, since the process of manufacture and outcome are not in such an advanced state that the practical engineer is likely to be brought in contact with the product. It is not "a common material used in the various branches of engineering," and it is of these materials solely that the author proposed to treat. A superficial reference to many subjects, rather than a thorough and adequate treatment of any, somewhat depreciates the value of the treatise.

After a chapter on the general processes to which materials have to be submitted and the forms of apparatus for accomplishing definite mechanical results, as grinding, mixing, transportation, &c., the author discusses the composition of air and water, the uses to which these agents are put, the benefits they render to engineering science by their wide distribution, and some of the limitations arising from the presence of impurities. When treating of the air, we expected to see some reference to the effects of excessive atmospheric pressure on workmen in caissons and in similar necessary, but hazardous, industrial devices. An engineer can get on very well, as he did for many years, without knowing anything of argon, for instance, but to treat of the sanitary properties of air and to omit all reference to "decompression," and such matters, is not only to overlook a very important detail, but shows, as we think, evidence of disproportion. On the other hand, a specimen is given of a hygrometrical chart within the average range of temperature and difference of dry and wet bulb readings that seems entirely admirable. Such charts may be used in the textile industries more than is known, but those who have to interpolate from Glaisher's or similar tables will appreciate this graphical representation, which, no doubt, possesses quite sufficient accuracy.

The chapters on combustion, and on the related subjects of fuel, do not leave an altogether satisfactory impression. The author frankly admits that the text is an elaboration of lecture notes used in his class-rooms during the last eight years, and sufficient care does not seem to have been exercised in bringing these up to date. A good deal of work has been done of late on the chemistry of flame and combustion, giving rise to practical results that might very well have been incorporated here. More particularly improvements have been introduced into the processes of surface combustion, in which a homogeneous explosive mixture of gas and air is forced through the interstices of a porous refractory incandescent solid, resulting in an accelerated combustion and an increased development of heat. A more perfect combustion is ensured, combined with a local concentration and a rapid transmission of heat that are highly economical, while the mechanical arrangements are simpler than in the employment of recognised regenerative devices. The reference to regenerative furnaces here is slight, and might very well be elaborated.

With a chapter on lubrication, a large subject, here treated rather from the mechanical than the chemical point of view, Professor Benson passes to the actual process of manufacture in a certain number of typical cases. The manufacture of pig-iron and the commercial forms of iron and steel forms a fitting introduction to the subject of industrial alloys. Here the author again fails to present the results of modern research with the necessary lucidity and completeness—qualities that are of prime importance in compilations of this character. He declines to discuss the subject of eutectic alloys, and adopts his favourite device of referring the student to other works; but in any case the metallurgy of iron and steel, the physical properties of the many industrial alloys, and cognate questions, could not be dealt with adequately in the space at command.

Another class of engineering materials selected for examination consists of the clay products, or cement, concrete, and bricks. These secure a more ample treatment, and rightly, for the manufacture of cement, and the improvements introduced of late years illustrate the importance of a knowledge of chemistry in connection with this industry. The brickmaker should benefit no less from the employment of chemical research, though the field does not seem to offer many opportunities. On the whole this is one of the most satisfactory sections of the book. The chemical changes which occur in the manufacture and in the setting of cement might have been more fully treated, especially the chemical relations between lime, alumina, and silica. The principal defect, as it seems to us, is the failure to discuss the chemistry of colloids from an elementary standpoint. There are many curious properties, particularly in connection with plasticity, of which the colloidal theory offers an explanation, although, perhaps, it reveals as many difficulties as it explains. This may be the author's justification for not entering more fully into what may fairly be regarded as debatable matter. Where quantitative demonstration is wanting, he may fear to perplex and hamper the student by speaking with hesitation. The remaining sections refer to paints and varnishing materials, to electrical insulators, and to some employments of cellulose products. These chapters are, of course, suggestive rather than complete, but they should serve to interest the prospective engineer, and indicate the variety of technical knowledge that will prove useful in his career.

Mechanics of Particles and Rigid Bodies. By J. Prescott, M.A. London: Longmans, Green and Co. [Price 12s. 6d. net.]

This book is intended for students desiring a pass degree in British universities, but the author is not content to offer the minimum quantity that will exactly satisfy the curriculum demanded in the various mathematical schools. In many cases we may safely say that the average pass man does not pursue his subject so far, or so thoroughly, as the table of contents would imply. For instance, much of Newton's "Principia" is embodied in the dynamical portion—a feast usually reserved for honours men. But the author is well advised in offering more than the precise requirements; he does neither himself nor his readers justice in failing to follow a line of investigation to its legitimate end, or at least without indicating the reason for its introduction and showing whither it leads. Another excellent feature is the adoption of what Mr. Prescott calls a "utilitarian bias" that may recommend the treatise to the engineering student, and has determined the selection of examples. "Utilitarian" is a word that has surrounded itself with a special significance; we should have preferred to have said that the author has shown that mathematical science can, and should, be applied to the affairs of ordinary life. One is not tormented by the fanciful relations of a "rough board to a smooth plane," or "the coefficient of friction of a rough plane about a smooth pin." It is suggested that the numerical examples worked in the text will quicken into life the dead bones of inarticulate symbols and formulæ, investing with a fresh meaning the results of purely theoretical treatment. In this method of wise and practical teaching the author has the sanction of great names. Thomson and Tait have put on record that "nothing can be more fatal to progress than a too-evident reliance on mathematical symbols, for the student is only too apt to consider the formulæ, and not the fact, as the physical reality." One may go a little further and say that many students are quite content if they can reproduce a formula and use it, without any wish to master the physical fact underlying it. A complaint has long been made that many juggle with the symbols of the calculus and solve propositions by its aid without understanding its vital principles.

The contents of the volume now under notice naturally follow conventional lines; the arrangement alone offers scope for originality. Following the plan of most modern treatises, scalar notation is introduced at the outset, and due prominence is given to graphical methods. A good discussion is supplied on the means of obtaining centres of gravity, and moments of inertia of plane and solid figures. A rather lengthy chapter on elasticity is added, which, with one on potential and attractions, concludes the first section, devoted to statics. The selection is adequate and satisfactory on the grounds of variety and thoroughness. Doubtless stern necessity has compelled the omission or curtailment of much that would have been desirable and of assistance to the young student, but, of necessity, many attractive propositions must be pretermitted when covering a large area. Considering the scope of the book, the pupil may congratulate himself on the consecutiveness of thought and ordered arrangement that has permitted so much to be brought within definite limits.

In the second part the author attacks the subject of kinematics. He seems a little uncomfortable with Newton's "Three Laws of Force." But he does not think it necessary to ventilate at any length the objections, or the modifications, that have been urged from various quarters. From this it may be inferred that the author's point of view is rather that of the experienced teacher than the supporter of the purely academic aspect. This, as already indicated, is also shown by the fact that the teaching is more experimental than dogmatic. In this section rectilinear and curvilinear motion are dealt with in an attractive fashion, and generally the problem of central forces is adequately treated. The third part carries the general discussion a step further by discussing the dynamics of a rigid body. With a firm grasp of

TWIN PEAKS SERVICE RESERVOIR, SAN FRANCISCO.

(*For Description, see Page* 754.)

FIG. 1. TWIN PEAKS RESERVOIR, SAN FRANCISCO.

the earlier portions there should be little difficulty in following the author as he develops the equations of motion, or discusses the motion of a rigid body about a fixed axis. Impulses and initial motions are the subjects of another chapter, and an excursion is made into some problems connected with gyroscopic motion and precession. The character of the book will be indicated by these chapter titles, and as one notes the ease with which the experienced teacher removes many difficulties, there seems little reason for the universities to exclude the simpler applications of rigid dynamics from their scholarship examinations, and already, we believe, in some cases the restrictions are giving way.

INDUSTRIAL NOTES.

THE United States Commission on Industrial Relations have put before Congress their first annual report dealing with the year ended with October last. Among the causes making for unrest in the labour world, the following were cited, says the *Iron Trade Review*, Cleveland, Ohio:—

BY THE MEN.

Normal and healthy desire for better living conditions.
Protest against low wages, long hours, and insanitary and dangerous conditions existing in many industries.
Demand for industrial democracy and revolt against the suppression of organisation.
Unemployment.
Unjust distribution of the products of industry.
Unjust attitude of police and courts.
One law for the rich, another for the poor.
Immigration, and the consequent over-supply of labour.
Disregard of grievances.
Unfair competition from prison and other exploited labour.
The rapid pace of modern industry.
Arbitrary discharge of employees.
Black-listing of individual employees.
Exploitation of women and children in industry.
Promotion of violence by the use of "gunmen," spies, and provokers hired by employers.
Attempt to destroy unionism by the pretence of the "open shop."
Monopolisation of land and natural resources.
Suppression of free speech and right of peaceful assembly.

BY THE EMPLOYERS.

Normal and healthy desire for better living conditions.
Misunderstanding and prejudice; lack of conception that interests of both labour and capital are identical.
Agitation by politicians and irresponsible agitators.
Unemployment.
Unreasonable demands arising from strength of organisation.
Labour leaders who stir up trouble to keep themselves in office and to graft on employers.
Inefficiency of workers, resulting in ever-increasing cost of living.
Rapidly-increasing complexity of industry.
Sudden transition of a large number of foreigners from repression to freedom, which makes them an easy prey to labour agitators.
Universal craze to get rich quickly. Decay of old ideas of honesty and thrift. Misinformation in newspapers.
Too much organisation for combative purposes, instead of for co-operation.
Violence in labour troubles; sympathetic strikes; boycotting and picketing. Meddlesome and burdensome legislation
The "closed shop," which makes for labour monopoly; financial irresponsibility of labour unions.

The report for December, issued by the Steam-Engine Makers' Society, gives the following figures:—Membership, 17,400; branches, 169; capital, 137,000*l.*, equal to 7*l.* 19*s.* per member; expended in benefits, 820,000*l*; unemployed, 18, equal to 0.1 per cent.

The report for the month ended November 28, issued by the Associated Blacksmiths' and Iron-workers' Society, gives 48 as the number of members unemployed, equal to 0.4 per cent. of the total membership of 10,757. For the four weeks ended November 28 the income of the society was 1823*l.*, and the expenditure 1274*l.*

The question of the employment of Belgian refugee workmen at low wages, to the detriment of the British worker, was discussed last week at a meeting of the Manchester and Salford Trades and Labour Council.

The Chairman, Mr. Charles Kean, stated that they had present at the meeting two of their Belgian fellow-workers, Messrs. C. Mahlman and A. Theunissens, members of the Belgian Commission.

Mr. Mahlman gave interesting information, in the course of which he said that before the outbreak of war there were 250,000 organised trade-unionists in Belgium, and there were still 150,000 suffering from the dire results of the war. The mining, the metal, and all other trades were at a standstill. The coal-miners were working two days a fortnight, getting domestic coal only. Amongst the Belgian refugees in England there were a great many who were not trade-unionists, and who ought not to be aided by the Labour movement. German democratic organisations had asked the Belgian members to request the newspapers of neutral countries to state that the cruelties which had been reported as having taken place in Belgium were not true. International Labour members in Germany had promised to give assistance to the Belgian workers if they followed that course. The Belgian workers had refused with scorn, and had answered that "as Belgians they would not accept a penny from the men who had acted as the grave-diggers of their wives and children."

A meeting of the Coal Conciliation Board for the Federated Mining Districts in England and North Wales was held last week at the Westminster Palace Hotel, London, with a view to consider a dispute which has arisen on the district chairman's award for the West Yorkshire district, in regard to the minimum wage to be paid to men employed in the pits under the Minimum Wage Act. Mr. F. J. Jones, West Yorkshire (chairman), presided, with Mr. Stephen Walsh, M.P., Lancashire (vice-chairman). The wage dispute in the West Yorkshire coal-field is on similar lines to that which occurred in South Yorkshire early this year, and which caused the county strike of miners. The district chairman, Judge Amphlett, recently gave the men an advance of 4d. per day on the minimum wage. The owners paid the additional 4d., but refused to continue to pay the three advances of 5 per cent. which had been given by the Conciliation Board.

The effect of this decision is that the men receive an advance of 4d. per day under the district chairman's award, but are deprived of the three advances of 5 per cent., which are equal to 7½d. per day, and are thus 3½d. worse off per day.

The contention of the West Yorkshire coal-owners is that the advance given by Judge Amphlett is in substitution for the percentage advances given by the Conciliation Board. The miners' contention is that the percentage advances granted by the Conciliation Board are altogether distinct from the minimum fixed by the district chairman.

At the close of the sitting the joint secretaries, Sir Thomas Ratcliffe Ellis and Mr. Thomas Ashton, stated that there was no report. It may be added that the Board failed to come to any agreement on the disputed point. The Board met again on Friday last, the 18th inst., when it again failed to settle the minimum wages dispute in question.

Dr. Macnamara, Financial Secretary to the Admiralty, received last week at the Town Hall, Newcastle, a deputation of Labour leaders representing all departments of the shipyard trade. The deputation included Mr. Frank Smith (chairman) and Mr. Alex. Wilkie, M.P. (secretary), of the Shipwrights' Standing Committee, and Mr. John Hill, of the Boilermakers' Society.

Amongst the questions discussed was one in reference to the importation of unskilled labour into works doing Government contracts, and the unions suggested that there would be no difficulty in getting a sufficient number of skilled men if some inducement were offered by the firms concerned in the way of "subsistence money."

The question of demarcation was also dealt with, but upon this point there was complete agreement, the general desire being to forward Government orders as far as possible.

The question of "subsistence money" was referred to at length in the recently-issued monthly report of the Boilermakers' Society, and it is now part of the scheme which the Society is going to lay before the Shipbuilding Employers' Federation at an early date.

The case for the boilermakers is that "subsistence

money" is already being granted by a large number of firms in the country, and that, therefore, the Society is only going to place before the general body of employers a scheme which has already been endorsed by individual firms.

A good many firms have imported skilled labour, but there are difficulties concerning men who are brought long distances, and it is in respect of these that the question of "subsistence money" has been brought to the front.

The meeting was of an amicable character throughout, and there was full evidence of a desire on the part of all the trade unionists present to assist the Government to the utmost of their ability. We referred to this point in our leading article last week (see page 732 *ante*).

According to information which reaches this country from Holland, it is stated that the number of organised workers who were on active service in Germany on November 30 totalled 661,005, equal to about 31 per cent. of the organised workmen. Of those not called out, 300 000 were unemployed. The German Federation of Workmen had granted over 600,000*l.* for the relief of the unemployed, and 150,000*l.* for the assistance of women and children.

From information supplied by the High Commissioner for Australia, we take the following :—

At the end of the year 1913 there were 1838 factories in Queensland, as compared with 1790 for the previous year. The estimated number of hands employed was 42,363, as compared with 40,948 in the year 1912.

The salaries and wages paid in Queensland factories during the year 1913 was 14,183,539*l.*, as compared with 11,078,954*l.* for the previous year. The value of the output was 23,688,789*l.*, as compared with 18,798,904*l.* for the preceding year.

No increases have been provided for the public service of Queensland this year, but there will be no reductions in salaries. Increases had been arranged for all branches of the public service, but they had to be abandoned because of the war.

The Tasmanian Government is erecting a number of workmen's cottages in South Hobart. The houses, consisting of four and five rooms, will be built of wood on brick and concrete foundations, with iron roofs, and will be let by the Government at moderate rents.

Messrs. Cummins and Grant, who secured a contract for 78 miles of earth works on the Kalgoorlie-Port Augusta Railway, Western Australia, have entered into an agreement with the General Workers' Union for a minimum pay of 13s. 4d. per day, which is said to be 10d. higher than the Commonwealth rate of pay. Sundays and overtime will be paid at the rate of time and a half. Boarding-houses will be allowed a tariff not exceeding 25s. per week.

The amount of deposits in the Savings Bank of Queensland at the end of June was 9,350,998*l.*, an increase for the year of 1,137,882*l.* This is the largest increase that has been recorded in the history of the bank. In 1903-4 the number of savings bank depositors was 80,959, and the value of deposits was 3,741,967*l.*, an average of 46*l.* 4s. 5d. for each depositor. In 1913-14 the number of depositors was 176,961, the value of the deposits being 9,350,998*l.*, an average of 52*l.* 16s. 10d. This amount is 3s. 3d. per depositor greater than in 1912-13. During the year the depositors increased by 22,004.

Motor Ship. — The Brazil, built for the firm of Lorentzen and Co., Christiania, at the Aker yard, Christiania, and the first motor vessel built at these works, has just made a satisfactory trial-trip. She has two four-stroke motors of Burmeister and Wain's latest model, each with six cylinders. The cylinders are 500 mm. in diameter, with a 660-mm. stroke. The number of revolutions at full speed is 130, but they are supposed to work regularly with 60 revolutions. On the trial trip they developed together about 1500 horse-power, using 144 grammes of fuel per horse-power per hour, the guaranteed quantity being 190 grammes. Although badly trimmed, the Brazil made 11 nautical miles, and everything worked quite satisfactorily. Her oil-fuel capacity is large enough to last for 120 days.

The Society of Engineers (Incorporated).—The fifth annual general meeting of this Society was held at the offices of the Society, 17, Victoria-street, Westminster, on Monday, December 14, 1914. The Report of the Council, which was adopted, referred to the amendments that are being made in the articles and by-laws, and stated that the financial position of the Society was satisfactory. A list of members serving with the Allied Forces was included in the report. The scrutineers of the postal ballot reported that the following had been elected as Members of the Council and Officers for 1915 :—President : Mr. Norman Scorgie ; Vice-Presidents : Mr. Percy Griffith and Mr. Henry C. Adams ; Members of Council : Messrs. Henry Adams, C. T. Walrond, S. Cowper-Coles, B. H. M. Hewett, F. H. Hummel, G. A. Becks, F. L. Ball, W. B. Esson, G. O Case, and W. N. Twelvetrees ; Associate Member of Council : Mr. C. E. May ; Hon. Secretary and Hon. Treasurer : Mr. D. B. Butler.

EFFECT OF VACUUM IN STEAM-TURBINES.

To the Editor of Engineering.

Sir,—My attention has been called to the report of the discussion on Mr. Stoney's paper at Manchester in your issue of the 27th ult., and in which the following remarks are attributed to the writer :—

"In connection with the new Manchester scheme, he had taken the trouble to get out figures for working with an unlimited water supply, and also with cooling-towers. He found that for 90,000 kw. installed, the difference in working costs per annum would be 14,000*l.* *in favour of the towers.*"

This is the exact opposite of the remarks I contributed, which all went to indicate the costliness of cooling-towers *versus* an ample river or canal supply for condensing purposes.

Yours faithfully,
S. L. Pearce, Chief Engineer.
Manchester, December 22, 1914.

"THE INFLUENCE OF BANKS ON INDUSTRY."

To the Editor of Engineering.

Sir,—The industrial banking system, which has had an immense influence on Continental industry, had its origin in Denmark about 1865. The bank which introduced it was the "Privatbank" in Copenhagen, under the leadership of Mr. Tietgen, then a young man who had gained his banking experience in this country. He had tried hard to introduce the English system of current account deposits and cheques into Denmark, but only with scant success. Traders there, as in most other Continental countries, have to give long credit to their customers, and want every penny they possess for their own business. They expect to borrow money from their banker, and never dream of supplying him with unlimited funds, free of interest, for paying high dividends to his shareholders.

Mr. Tietgen had his first chance when an American company began to build tramways in Copenhagen, and had completed a part of the line, but were unable to find capital for the necessary extension. Mr. Tietgen, who was a financial genius and a man of great energy and prudence, took the matter up. He satisfied himself that the line would pay, employed the best experts he could get, saw that no unnecessary expense was incurred, and he found the capital by guaranteeing depositors 4 per cent. interest on permanent deposits in the bank. The business was a brilliant success, for the line never paid less than 10 per cent. per annum, which left a handsome surplus for the shareholders of the bank.

A large number of companies were subsequently financed in the same way, the capital being found partly from the bank deposits and partly by direct subscriptions from shareholders in the proposed new companies ; but no money was ever advanced for any company except after a thorough investigation, when the directors had satisfied themselves that the proposals were technically and financially sound, and the companies formed in this manner have invariably been successful.

It stands to reason that a well-managed bank is in a vastly better position to judge whether a project is sound or not than is a sanguine company promoter, a board of amateur directors, and a crowd of individual shareholders. The bank can further insist that any company it finances shall be efficiently managed by competent directors and officials, and that any money advanced shall be spent honestly and to the best advantage.

The present haphazard system of floating limited companies has probably cost this country more money than all its wars, including the present one. Why should not the great English banks step in and prevent this senseless waste, restore public confidence in limited companies, and at the same time benefit their shareholders to an extent little dreamt of at present.

The banks can get any amount of capital from depositors willing to give six months' notice of withdrawal by offering 4 per cent. interest on such deposits. The machinery required for investigating financial proposals would be similar to that now used by the Local Government Board for inquiring into the soundness of municipal works. The possible risk to the bank would, with an efficient staff of experts, be almost infinitesimal, and the advantage to investors, depositors, and to the shareholders of the bank would be enormous.

In Denmark this system has stood the test of fifty years' experience, and it has added enormously to the prosperity of that country. Germany began to adopt the Danish system twenty years later, and has found it equally profitable. If England adopts it at the present juncture, it will undoubtedly lead to most important results.

I am, Sir, yours faithfully,
C. T. Alfred Hanssen, Assoc. M. Inst. C.E.
300, Lordship-lane, East Dulwich, S.E.
December 18, 1914.

To the Editor of Engineering.

Sir,—The leading article in your issue of December 4, under the heading of "The Influence of Banks on Industry," appears from the correspondence which has followed to have aroused a sympathetic interest.

Curiously enough, however, it would appear from this correspondence that Government assistance is to be deprecated, and private initiative is to be relied upon for the establishment of the new industrial banks ; but it does not appear to be sufficiently realised by the writers of the letters that, as the article so pertinently points out, it is essential that the new methods should be brought into operation without delay, in order that the decline in trade which must necessarily follow on these disturbed times may be arrested as far as possible and the opportunities of new markets be exploited at the earliest possible moment.

Again, it is generally recognised that there is great reluctance among financiers at the present time to enter upon new ventures, but it is obvious from the large and steady increases of bank deposits that there is a large fund awaiting investment that could be tapped for the financing of the proposed new institutions, providing that the conditions under which they are to be established are such as will, to a large extent, assure reasonable security and a steady, if moderate, dividend. There is no doubt that the plan outlined in the article, whereby the Government takes an active holding in the institution, and during its preliminary strides lends it a moderate assistance, is certainly at the present time the best way to attract the large capital necessary for the proper establishment of such institutions as the proposed industrial banks.

I am, Sir, yours faithfully,
Ewell, Surrey, December 19, 1914. A. Percy.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Last Thursday morning the pig-iron market opened with a firm tone, and 1000 tons of Cleveland warrants were done at 53s. 8d. one month, and closing sellers quoted 53s. 5½d. cash, 53s. 8½d. one month, and 54s. 2d. three months. In the afternoon Cleveland warrants became a shade firmer, but only one lot changed hands at 53s. 4½d. five days. At the close the quotations were 53s. 6d. cash and 53s. 9d. one month sellers. On Friday morning the tone was again strong, and the business consisted of 1000 tons of Cleveland warrants at 54s. 1½d. and 54s. 2d. three months, with closing sellers at 53s. 7d. cash, 53s. 10d. one month, and 54s. 3d. three months. The afternoon session was quiet, but Cleveland warrants continued their upward movement. The turnover was only 500 tons at 54s. one month, and sellers' closing prices were called 53s. 8½d. cash, 53s. 11½d. one month, and 54s. 5d. three months. On Monday morning the market opened strongly, and although dealings only totalled 2000 tons of Cleveland warrants, another advance was marked. The business was at from 54s. 2d. to 54s. 4d. one month, and at 54s. 10d. three months, with sellers over at 54s. 1½d. cash, 54s. 4½d. one month, and 54s. 11d. three months. The tone continued strong in the afternoon, when one Cleveland warrant was done at 54s. 11½d. three months, and closing sellers named 54s. 3d. cash, 54s. 6d. one month, and 55s. three months. On Tuesday morning a decided reaction took place in Cleveland warrants, and after being done at 54s 7½d. one month, the price fell away to 54s. one month, and at the close sellers were only quoting 54s. 0½d. The dealings amounted to 6000 tons, and included business at 53s. 9d. cash, with sellers over at that figure. The afternoon session was dead idle, but Cleveland warrants were steady at 53s. 9d. cash, and 54s. one month sellers, with buyers naming 1½d. less in each case.

Sulphate of Ammonia.—During the past week or two a firmer tone has been exhibited in the sulphate of ammonia market, and the demand has improved considerably. The current price is round 11*l.* 17s. 6d. to 12*l.* per ton, Glasgow or Leith, for prompt lots, while for any forward parcels which are being asked for the quotation is about 12*l.* 7s. 6d. per ton ; but everything depends on the approximate dates when required, as sellers are not keen for forward business just now.

Scotch Steel Trade.—In the Scotch steel trade there is a steadily increasing demand for material of almost all kinds, and not only is this the case for the home market but export buyers are also more in evidence. Orders for ship-plates are more numerous, and the prospect of further shipbuilding contracts has strengthened the market considerably. Makers of black sheets are again busier, and a fairly healthy demand exists, with the result that activity is very general. Indeed, the improvement all round is such that the annual stoppage at the end of the year is likely to be cut very short, as not only is there much Government work to be pushed forward, but industrial activity is very much better and the outlook is fairly bright. Prices are very firm, and the following may be taken as the current rates :—Ship-plates, 7*l.* 5s. per ton ; boiler-plates, 7*l.* 10s. ; and angles, 7*l.* per ton ; all less the usual 5 per cent. for local delivery. The export trade, while showing a decided improvement, is not yet anything like back to its usual state, but each week seems to be a shade better than its predecessor, which gives hope for the future.

Malleable-Iron Trade.—The improvement in the West of Scotland malleable-iron trade has been well maintained this week, and better conditions are prevailing in the works. With a steady demand the prices continue very firm.

Scotch Pig-Iron Trade.—There has been no falling off in the demand for the ordinary qualities of Scotch pig-iron, and the recent advance made in prices has not even put any check to the desire of buyers to cover their present and near future requirements. Industrial conditions have been showing decided signs of improvement, and the inquiries for iron, &c., point to a largely increased consumption during the next few months. Prices all round continue firm, and the following are the market quotations for makers' (No. 1) iron : — Clyde, 69s. 6d. ; Calder, Gartsherrie, and Langloan, 70s. ; and Summerlee, 70s. 6d. (all shipped at Glasgow) ; Eglinton, 64s., and Glengarnock, 71s. (both

at Ardrossan); Shotts, 70s.; and Carron, 72s. 6d. (both at Leith). Hematite iron has been the subject of a heavy demand recently on the part of the steel-makers, and it is a general opinion that, as the latter are almost certainly on the eve of a big run of trade, the makers of hematite have good prospects of a spell of activity.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—Trade in house-coal has been somewhat crippled on account of the protracted shortage of empty wagons due to railway traffic congestion. So great was the pressure on the railway systems throughout the country that two southern railway companies refused, five days before Christmas, to accept any more traffic from South Yorkshire to London until after the expiration of the holiday period. A third company sent an intimation that they must decline further coal traffic until the congestion on their system was relieved, which practically came to the same thing. This serious development of affairs necessitated a greater restriction of output, and, as a result, prices have again advanced 3d. to 1s. on the top of the several advances of the preceding two or three weeks. The same drawback has resulted in a shortage of supplies of manufacturing fuel in the local industries at a time when record quantities are required to deal with a pressure of Government work. The people to suffer have, of course, been the firms engaged on "peace" products, as delay in armament-making had at all costs to be avoided. Hard steam values have accordingly advanced with household sorts. Shipments show a small but welcome expansion, a considerably bigger tonnage having been sent to the East Coast ports. Inland works have also taken larger supplies of gas fuel, there having been a general supplementing of contract requirements. Slacks have again improved. Weakness has disappeared from business in all qualities. Even the lower grades are showing a brisk tone. Big stocks accumulated at the pits a month ago have disappeared. Quotations:—Best branch hand-picked, 16s. 6d. to 17s. 6d.; Barnsley best Silkstone, 13s. 6d. to 14s. 6d.; Derbyshire best brights, 13s. 6d. to 14s. 6d.; Derbyshire house, 11s. to 12s. 6d.; best large nuts, 11s. to 12s.; small nuts, 9s. to 10s.; Yorkshire hards, 10s. to 11s.; Derbyshire hards, 9s. 6d. to 10s. 6d.; best slacks, 7s. to 8s.; seconds, 5s. to 6s.; smalls, 2s. to 3s.

Iron and Steel.—The close of 1914 witnesses a marked improvement in all classes of raw material. Though prices sagged during the quiet period in the finished trades which preceded the war, they are now, as for some weeks past, on the upward grade, and at the moment are appreciably higher than in December, 1913. Makers can show better order-books than for a good while past, and the improvement is expected to be of more than temporary duration. The only anxiety is as to supplies of ore, which are uncertain, owing to the risks of shipping. The attack by the German Fleet on the East Coast sent up hematite values several shillings on top of recent additions. West Coast hematite is quoted at 81s., East Coast at 72s. 6d. to 75s., Lincolnshire foundry at 59s., Lincolnshire forge at 57s. 6d., Derbyshire foundry at 56s. 6d., and Derbyshire forge at 53s. The quotations current at the end of December, 1913, afford an interesting comparison. They were:—West Coast hematites, 76s. 6d.; East Coast, 66s. 3d.; Lincolnshire foundry, 54s. 8d.; Lincolnshire forge, 53s. 8d.; Derbyshire foundry, 55s. 3d.; and Derbyshire forge, 52s. 6d. Bar iron is stronger, South Yorkshire crown bars being marked at 8*l.* 5s. Sheets are firm at 9*l.* 10s. The urgency of Government orders does not allow much respite in the heavy engineering trades. The armament houses are only resting Christmas Day and Boxing Day. The usual New Year holiday is to be dispensed with. The same applies to all steel-making concerns with Admiralty and War Office work on hand. This relates to the manufacture of guns, shells, armour, bayonets, rifle barrels, bullet-proof shields for aeroplanes and armoured motor-cars, camp-kitchens, motor-ambulances, and all kinds of entrenching and military engineering tools. Big orders are on hand for shipbuilders' forgings and castings, and ordinary trade in tool-steel, and mining machinery is expanding. Makers of agricultural implements and machinery parts are experiencing a quiet time, and many of them are devoting their resources to other purposes, notably the manufacture of parts for military automobiles. The steel billet section is steady. A stronger inquiry prevails for basic sorts.

BOOKS DEALING WITH THE USEFUL ARTS.—The Public Libraries Committee of the City and County of Newcastle-upon-Tyne have published a catalogue of books on the useful arts in the central libraries of the city. This catalogue, which runs to more than 200 pages, commences with a name index of authors. Then follow sections dealing with medicine, engineering, agriculture, domestic economy, communication and commerce, chemical technology, manufactures, and building. The engineering section fills 45 pages, and is again indexed under 18 subheads. We find here all the publications of the Engineering Standards Committee. Under steam-turbines there are 22 entries, under steam-boilers 26, under electric traction 17, under rolling stock 12, under automobiles 34, under aviation 23, and so on. The people of Newcastle are fortunate in having such an excellent assortment of technical books at their disposal, and their gratitude is due to their librarian, Mr. Basil Anderton, M.A., for this excellent and well-indexed catalogue. We hope his committee will aid his efforts by liberal grants for the purchase of technical books, for such publications often get out of date very rapidly. They have not the lasting value of good literature.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is not a great deal of business passing in pig-iron, but producers have now good order-books, and the output is being fully absorbed, due almost entirely to the very heavy home consumption. An undertone of confidence is noticeable, and the general situation must be described as satisfactory. An additional furnace on hematite has been started at the Thornaby works of Messrs. Whitwell, and a furnace has been damped down at the Jarrow works of Messrs. Palmer. The total number of blast-furnaces in operation on the North-East Coast now stands at 73. Of these, 36 are making Cleveland pig-iron, 26 are producing hematite, and 11 are manufacturing special irons. This week higher prices have been realised for Cleveland pig-iron than for fifteen months past. No. 3 g.m.b. has sold at 54s. 3d., and as much as 54s. 6d. has been asked. The quotation has now setted to 54s., at which figure several contracts have been made. No. 1 Cleveland is 56s.; No. 4 foundry, 53s. 6d.; No. 4 forge, 53s.; and mottled and white iron each 52s. 6d. East Coast hematite pig is moving steadily upward Possibly small odd lots of Nos. 1, 2, and 3 could still be bought from merchants at 70s., but makers have sold at 71s. 6d, and many of them now ask 72s. 6d. Foreign ore is almost unobtainable owing to scarcity of steamers, and many consumers complain of the small supplies coming to hand. Stocks are low, and unless substantial imports arrive shortly some works will be unable to continue fully employed. Market quotations are based on 23s. 6d. ex-ship Tees for Rubio of 50 per cent. quality. Freights Bilbao-Middlesbrough are 8s. 6d. Coke, as is usual at this season of the year, is firmer. Local demand is heavier. Durham beehive blast-furnace coke of average quality is fully 18s. delivered at Tees-side works.

Northern Shipbuilding Orders.—More orders for tonnage have been placed this week with North-East Coast builders. The Northumberland Shipbuilding Company have booked an order for a large cargo steamer for Messrs. Woods, Tyler and Brown, London, and also for a 7000-tons collier for Messrs. Cory and Co., of London. Messrs. Blumer and Co., Sunderland, are to build a cargo steamer for a Newcastle firm, and Messrs. Farrar, Groves and Co., London, have ordered two large steamers from Messrs. Richardson, Duck and Co., of Stockton-on-Tees.

Stocks and Shipments.—Stocks of Cleveland pig-iron in the public warrant stores now stand at 103,164 tons. Since the beginning of the month the stock has been reduced by 2330 tons. Shipments of pig-iron from the Tees are on only a very poor scale. To date this month they average 868 tons per working day, the total despatches being returned at 16,495 tons, 15,945 tons of which have gone from Middlesbrough and 550 tons from Skinningrove. To the same date last month the loadings were given at 44,621 tons, or a daily average of 2348 tons, and for the corresponding part of December a year ago the clearances reached 62,889 tons, or an average of 3309 tons per working day.

Manufactured Iron and Steel.—Very satisfactory accounts are given of all branches of the manufactured iron and steel trades. Producers have excellent order-books, and many firms are pressed for delivery. The holidays this year are being curtailed, works only closing from Thursday to Monday. Prices all round are very firm. Principal market quotations stand:—Common iron bars, 8*l.*; best bars, 8*l.* 7s. 6d.; best best bars, 8*l.* 15s.; packing iron, 6*l.* 5s.; iron ship-plates, 7*l.* 5s.; iron ship-angles, 8*l.*; iron ship-rivets, 8*l.* 17s. 6d.; iron girder-plates, 7*l.* 5s.; steel bars (basic), 7*l.* 10s.; steel bars (Siemens), 7*l.* 15s.; steel ship-plates, 7*l.* 10s.; steel ship-angles, 7*l.* 5s.; steel boiler-plates, 8*l.* 5s.; steel strip, 7*l.* 5s.; steel hoops, 8*l.*; steel joists, 7*l.* 2s. 6d.; cast-iron columns, 7*l.* 7s. 6d.; cast-iron railway chairs, 4*l.* 5s.; light iron rails, 7*l.* 15s.; heavy steel rails, 6*l.* 7s. 6d.; steel railway sleepers, 7*l.*—railway material net at works, and all other descriptions less 2½ per cent. discount; galvanised corrugated sheets, 24 gauge, in bundles, 14*l.* f.o.b. —less 4 per cent.

AUSTRALIAN TRADE.—Australia's exports (including bullion) to Germany for the years 1892-6 averaged 1,500,000*l.* per annum; for 1897-1901, 2,100,000*l.* per annum; 1902-6, 3,400,000*l.* per annum; and 1907-11, 6,900,000*l.* per annum. The exports to the United Kingdom for the same period averaged 23,000,000*l.*, 25,000,000*l.*, 25,000,000*l.*, and 33,400,000*l.* Of the iron and steel rails imported by Australia in 1912, 64 per cent. came from the United Kingdom, 9 per cent. from Belgium, 6 per cent. from Germany, and 16 per cent. from the United States. In 1907 the United Kingdom supplied 89 per cent. In 1899 the tonnage of vessels entered and cleared at the Commonwealth ports was 5,000,000; in 1912 it was 10,000,000. Seventy per cent. of Australia's United Kingdom and European shipping during 1912 was with the United Kingdom, 18 per cent. with Germany, 3 per cent. with France, and 4 per cent. with Belgium. Over 60 per cent. of Australia's total loans (or public debt) has been expended on railway and tramway construction and equipment. The British Trade Commissioner in Australia, in his report to the Board of Trade, says:—"No better method of extending trade relations can be conceived than by the visits to oversea and foreign markets of the younger partners in our great manufacturing firms. A visit from a number of manufacturers representative of British industries would form a fitting sequel to the recent visits of the Dominions' Royal Commission, the British Parliamentary Party, and the visit of the British Association for the Advancement of Science.

NOTES FROM THE SOUTH-WEST.

Cardiff.—There has been a good demand for all qualities of large and small coal in consequence of a pressure in loading steamers in dock and getting them away to sea before the holidays. In addition to vessels loading or waiting, a considerable number of vessels were due, and were expected over the week-end. Colliery owners have been quoting secondary Admiralty qualities, drys, and Monmouthshire coal with firmness; and it has been difficult to obtain the best Admiralty descriptions in consequence of large naval requirements. House coal, patent fuel, and coke have shown little change, but prices have been generally firm. The best Admiralty large has made 20s. to 21s.; best secondary qualities have brought 18s. 6d. to 19s. 6d.; other secondary qualities 17s. 9d. to 18s. 3d.; best bunker smalls, 11s. 3d. to 12s. 3d.; and cargo smalls, 9s. 6d. to 10s. per ton. The best household coal has been quoted at 19s. to 20s.; good households have made 17s. to 18s.; No. 3 Rhondda large has brought 13s. to 14s. 6d.; and No. 2 smalls have realised 8s. to 9s. per ton. Patent fuel has been quoted at 17s. to 18s. per ton. Special foundry coke has made 27s. to 31s.; good foundry coke, 20s. to 26s.; and furnace coke, 17s. 6d. to 19s. 6d. per ton. As regards iron ore, Rubio has been quoted at 19s. 9d. to 20s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Welsh Coal for France.—Tenders for Welsh coal have been submitted to the administration of the French State Railways. There has been little information available as to the result of these tenders, but it is understood that the offers made do not equal the requirements of the situation, which amount to 50,000 tons of large coal, 100,000 tons of smalls, and 50,000 tons of patent fuel, to be delivered over the next two months. Some orders appear to have been placed, but negotiations are still pending.

Dowlais.—The Dowlais steel works have been well employed, the finishing departments having even been working day and night. The blast-furnaces have also had a seven-day week, although some pig-iron has gone into stock. The Goat Mill has been engaged upon heavy steel rails, steel sleepers, steel squares, cogging steel, and small quantities of tin bar. The Big Mill has been occupied with tram-rails, fish-plates, gutter-iron, &c.

Newport.—The steam-coal trade has not been very active; but, upon the whole, prices have been well maintained, sellers being disposed to advance quotations for both large and smalls, in view of their order-books being well filled. House-coal, patent fuel, and coke have also shown steadiness. The best Newport black vein large has made 17s. 3d. to 17s. 6d. per ton; Western Valleys have brought 16s. 9d. to 17s.; and Eastern Valleys, 16s. to 16s. 6d. per ton.

Welsh Coal Exports.—The coal trade of the South Welsh ports appears to be improving, apart from Admiralty requirements, which are not included in the official returns. The exports from South Welsh ports in November showed, however, a decrease of 956,448 tons, the total for the month being 1,426,275 tons. The shipments of bunker coal for November were 321,917 tons, as compared with 387,231 tons.

BRITISH RAILS ABROAD.—The external demand for British rails has been scarcely maintained this year, the exports to November 30 having only amounted to 419,125 tons, as compared with 459,870 tons in the first eleven months of 1913, and 377,878 tons in the first eleven months of 1912.

THE LATE MR. DAVID BALFOUR.—We regret to have to announce the death of Mr. David Balfour, which ocurred at his residence, Myre Hall, Houghton-le-Spring, on Tuesday last, the 22nd inst. Mr. Balfour was a member of the Institution of Civil Engineers since April, 1889. He was the son of the late Mr. J. Balfour, manager of the London and Dundee Shipping Company. He was born at Dundee, in 1838, and exercised the profession of a civil engineer at Newcastle-on-Tyne. Mr. D. Balfour served his apprenticeship with Mr. John Fulton, late City Engineer of Dundee and Newcastle. He was appointed in the early 'sixties of last century engineer to the Sunderland and Houghton-le-Spring Highway Board; of late years he had acted for the Houghton-le-Spring Rural District Council. Mr. D. Balfour carried out many engineering works, including bridges, sewerage plant, water supply installations, tramways, railways, &c., in various parts of the county.

DANISH ENGINEERS AND THE UNITED STATES.—For a considerable number of years Danish engineers, with diplomas from the State Polytechnic College in Copenhagen, have gone to the United States or other parts of the world. The Danish Society of Engineers has recently looked into this matter, and it has transpired that out of 933 engineers who, during the years 1900-1912 (both included), passed the final examination of the above college, 10 per cent., or, to be accurate, 92 engineers, have gone to North America, and out of these 28 have subsequently returned to Denmark. The largest proportion is among "constructive engineers," of whom about 12 per cent. have gone to the United States, whilst the figure for "factory engineers" is only 4 per cent. All the electrical engineers have remained in America, whilst two-thirds of the mechanical engineers have returned. Out of six factory engineers, only one has returned; and of 64 constructive engineers, 47 have remained on the other side.

SERVICE RESERVOIR CONSTRUCTION.

By Professor E. R. Matthews, A.M. Inst. C.E., F.R.S.E., Chadwick Professor of Municipal Engineering in the University of London.

On page 751 we give a photographic view, and on this and the opposite page drawings of a number of service reservoirs which have, during recent years, been constructed in America, and which show that the trend of design in that country is departing from the lines which have hitherto obtained here. A study of these examples will show that ferro-concrete is being largely used for such structures in the United States, and apparently with much success.

Rectangular and Circular Reservoirs.—British engineers almost invariably adopt the rectangular reservoir, and American engineers the circular form. The circular reservoir has several advantages; some of these are as follow :—

1. No angles occur, so that the reservoir wall can be built without a joint. This is a great advantage, for when there is leakage it often occurs at the point where the walls join.

2. The circular form is well adapted to withstand external earth pressure.

3. Large circular reservoirs are cheaper to construct than rectangular ones.

One of the best examples that might be given of a reservoir of this type is that known as the "Twin Peaks" reservoir at San Francisco. This has been built in reinforced concrete, which is an excellent material to use in structures of this kind, as it has the following advantages :—

(*a*) There is a saving in first cost. (*b*) A reservoir built in this material occupies less space than one constructed in masonry or brickwork, or a combination of both. (*c*) It can more easily be made watertight. (*d*) It increases in strength with age. (*e*) There is less likely to be vegetation upon the face of the walls. (*f*) The cost of maintenance is practically nil.

San Francisco Reservoir.—The San Francisco reservoir is oval in plan, being 370 ft. by 285 ft. in area, and is divided into two parts by a reinforced-concrete dam (see Fig. 1, page 751). The reservoir is situated 750 ft. above the business section of the city, and is part of the high-pressure system for fire-extinguishing purposes established in consequence of the terrible fire of 1906. The depth of water allowed for is 27 ft., or a capacity of 11 million gallons. The buttresses of the dam are spaced at 9-ft. centres on both sides of the wall. They are 1 ft. in thickness, and 13 ft. wide at the base. Fig. 1 shows the reservoir on the day of the opening ceremony, with one half filled with water. The structure was designed by the city engineer, Mr. Shaughnessy.

Reservoir at Fort Riley.—Other circular or oval-shaped reservoirs constructed during recent years in reinforced concrete, in America, include that at Fort Riley, Kansas, which has a capacity of two million gallons. It is illustrated in Figs. 2 and 3, and is an interesting structure. The reservoir-wall is strengthened by the addition of buttresses, which are 18 in. in thickness and spaced at 12-ft. 6-in. centres. The reinforcement consists of ½-in. and ¾-in. round bars, spaced as shown in the section.

Reservoir at Lake Geneva, Wis.—The reservoir at Lake Geneva, Wis., is circular in plan, Figs. 4 and 5, and is constructed throughout of reinforced concrete. The roof is supported by 16-in. by 16-in. reinforced-concrete columns, which are reinforced by the insertion of four ¾-in. bars in each. The floor-slab is 6 in. in thickness, reinforced by ⅝-in. bars. The reservoir is 50 ft. in diameter, and the roof-slab is 8 in. in thickness, reinforced with ½-in. and ¾-in. bars.

Reservoir at Fort Wayne, Indiana.—The reservoir at Fort Wayne, Indiana, is a very interesting structure. It is oval in shape, and is divided into two parts by a reinforced-concrete dam 20 ft. in height. This wall is 3 ft. in thickness at the base and 1 ft. at the top. The reservoir is illustrated in Figs. 6 to 12. The old structure was lined with 4 in. of reinforced concrete, which was placed on top of the previous brick lining, this latter making a good foundation for it. The arrangement of the reinforcement is shown in the section, Fig. 8.

Division-walls in reinforced-concrete reservoirs need not, however, be so heavy in construction, but may, where upon a good concrete foundation, be as shown in Fig. 13, which represents a partition-wall in the Naval Academy Reservoir, Annapolis, Md. This wall is 11 ft. 8 in. in height, and is reinforced by the insertion of ½-in. and ¾-in. bars.

Reservoir at Albion, Mich.—A small circular reservoir, constructed in reinforced concrete at Albion, Mich., is shown in Fig. 14 This has a capacity of 100,000 gallons, and the design is admirably suited for a small reservoir or tank.

Water-Tight Reservoirs.—One of the problems which the water-works engineer has to solve is how to make and keep his reservoir water-tight. Reservoirs have been constructed in what appeared to be a substantial manner, and at a cost of thousands of pounds, and yet have never ceased to leak, and although frequent attempts have been made to remedy the leakage, these structures are still looked upon as a failure. There is probably no type of construction in which water-tightness is more likely to be assured than in reinforced concrete, provided that the work is properly executed, and expansion joints are inserted in suitable positions, both in the walls, floor, and roof of the reservoir; that suitable aggregate is used for the concrete; that a wet mixture is used; that the walls are not less than 5 in. in thickness, and are well reinforced, and that the depth of water in the reservoir does not exceed, say, 30 ft. If these conditions are complied with, there is no material so well adapted for use in the construction of service reservoirs. Where the water exceeds 25 ft. in depth, buttresses should be built at the back of the wall.

In America the usefulness of reinforced concrete for this purpose has been realised, and in much modern work of this class it has been adopted. Not only has it proved admirable for reservoirs, but a saving of 20 to 25 per cent. can be effected by adopting it, which is an important matter.

Saving by Using Reinforced Concrete.—A good illustration of the saving which may be effected by using reinforced concrete in the construction of a reservoir roof or covering may be given. All service reservoirs should be covered, if possible; and if they are situate on the immediate outskirts of a town, they must be covered, if the water is to remain clean and uncontaminated. Until recent years one of the principal methods adopted in this country for the covering of a reservoir was as shown in Figs. 15 and 16.

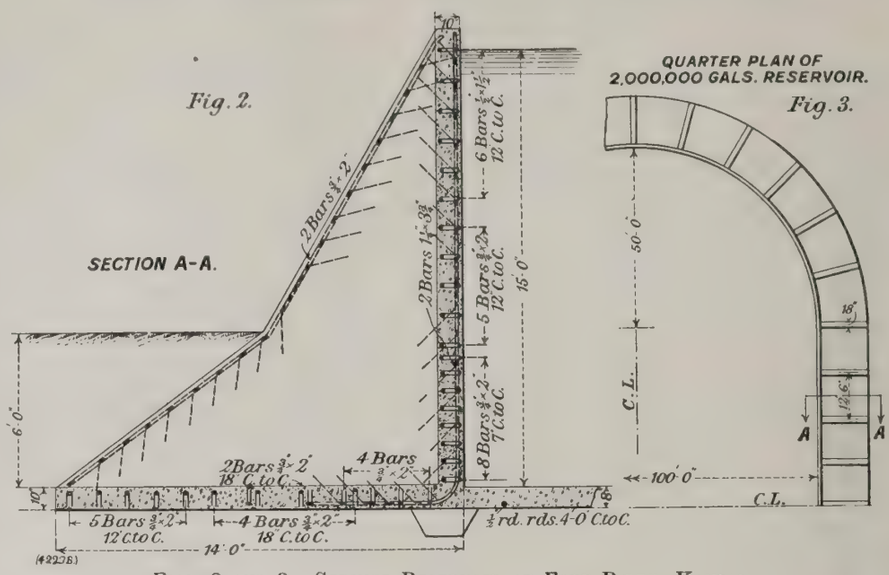
The disadvantages of this method of construction of the roof are :—(1) That it is too costly; (2) it is unnecessarily heavy; (3) it occupies too much space; (4) it is almost sure to be leaky, the leakage occurring where there is a minimum thickness of concrete—namely, immediately over the rolled-steel joists. Cement rendering might prevent the leakage, but it is doubtful.

In a reinforced-concrete roof the slab would probably in this case be 5 in. in thickness, and the reinforced-concrete beams supporting it, say, 16 in. by 8 in. in section. Quite 25 per cent. in cost would be saved by adopting reinforced concrete, and a water-tight job be ensured.

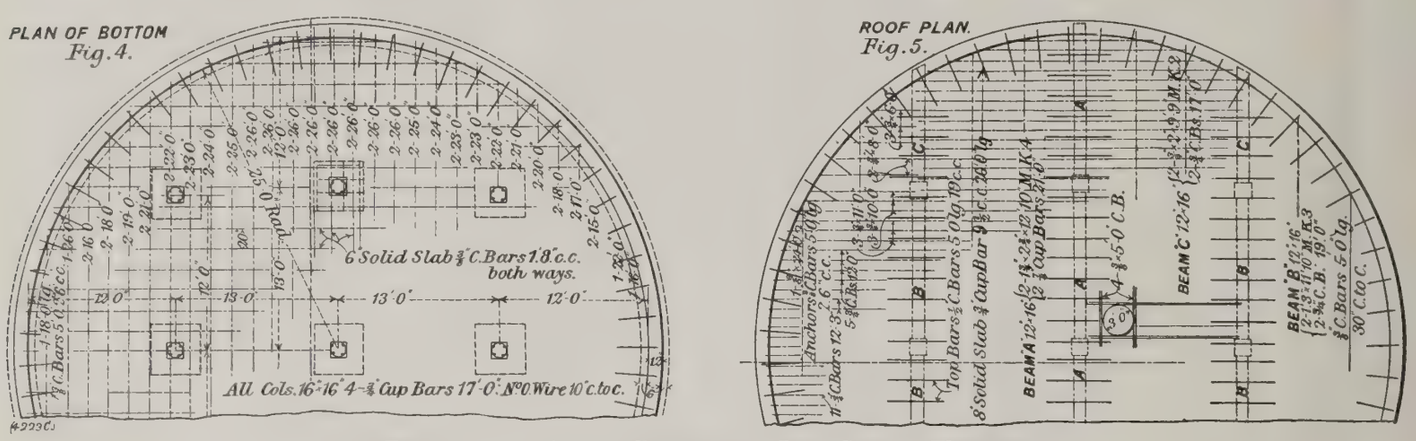
Reinforced-Concrete Walls.—The British practice is to build reservoir walls in mass concrete, and render the face with cement rendering 1 in. in thickness, or to line the reservoir with, say, blue Staffordshire bricks (see Fig. 17).

In America the walls are now usually built of reinforced concrete, which for a reservoir as shown in Fig. 17 would be about 7 in. in thickness. For a reservoir wall not exceeding 10 ft. in height the thickness should be 5 in. at top to 8 in. at bottom, and if 10 ft. to 15 ft. high, it should be from 8 in. to 10 in. thick at the bottom, according to the depth. In a deeper reservoir the top 6 ft. should be 5 in. thick, and the wall should be increased in thickness by 3 in. for every additional 6 ft. of its height. It is

FERRO-CONCRETE SERVICE RESERVOIRS.



Figs 2 and 3. Service Reservoir at Fort Riley, Kansas.


PLAN OF BOTTOM
Fig. 4.
6" Solid Slab ¾" C. Bars 18" c.c. both ways.
All Cols. 16"×16" 4-¾" Cap Bars 17'-0" No 0 Wire 10" c. to c.
ROOF PLAN.
Fig. 5.
8" Solid Slab ¾" Cap Bar 3'-0" c. to c.
BEAM A 12"×16"
BEAM B 12"×16"
BEAM C 12"×16"

Figs. 4 and 5. Service Reservoir at Lake Geneva, Wisconsin.

FERRO-CONCRETE SERVICE RESERVOIRS IN AMERICA.

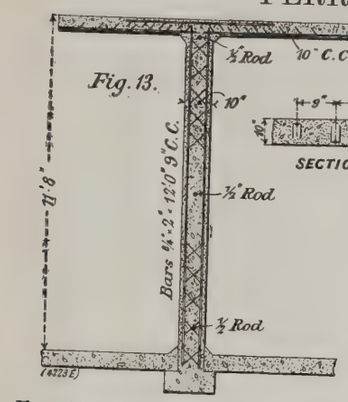


FIG. 13. DIVISION WALL IN THE ROYAL NAVAL ACADEMY RESERVOIR, ANNAPOLIS, MISSOURI.

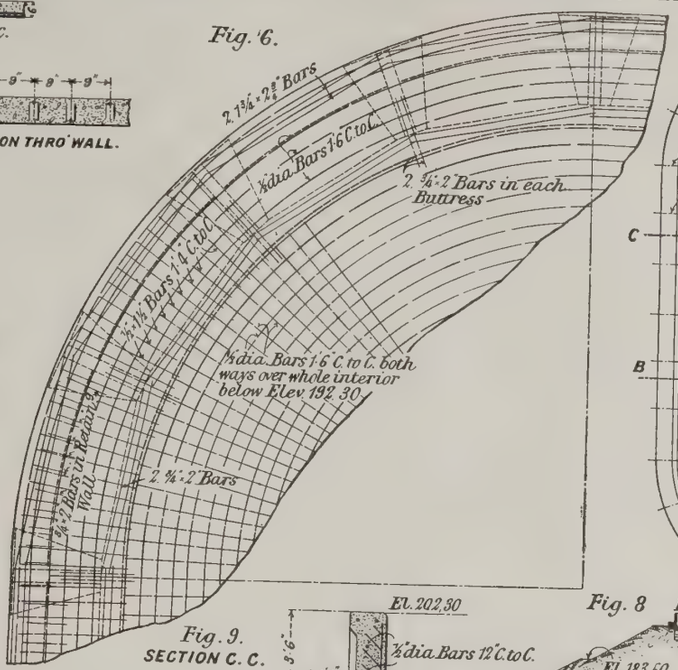
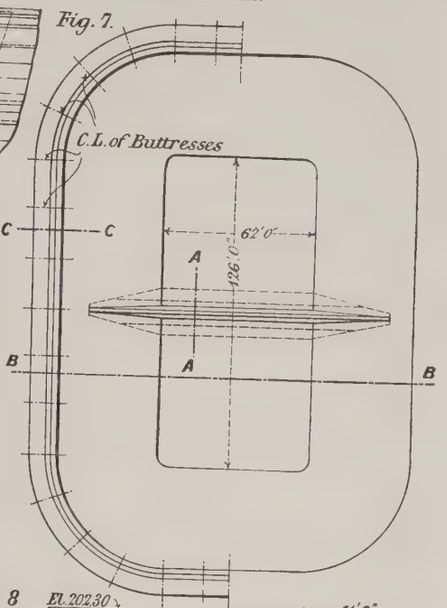


Fig. 6.
2 1¾"×2½" Bars
½ dia. Bars 1'6" C. to C.
2 ¾"×2" Bars in each Buttress
½ dia. Bars 1'6" C. to C. both ways over whole interior below Elev. 192.30
2 ¾"×2" Bars



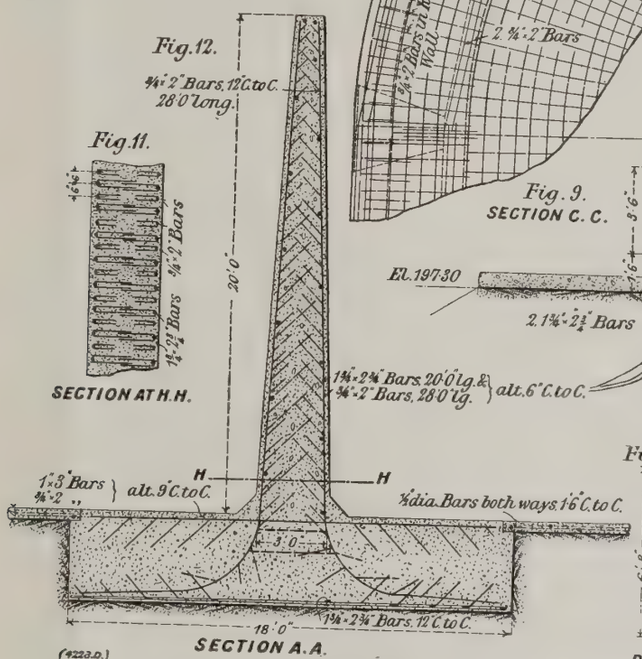
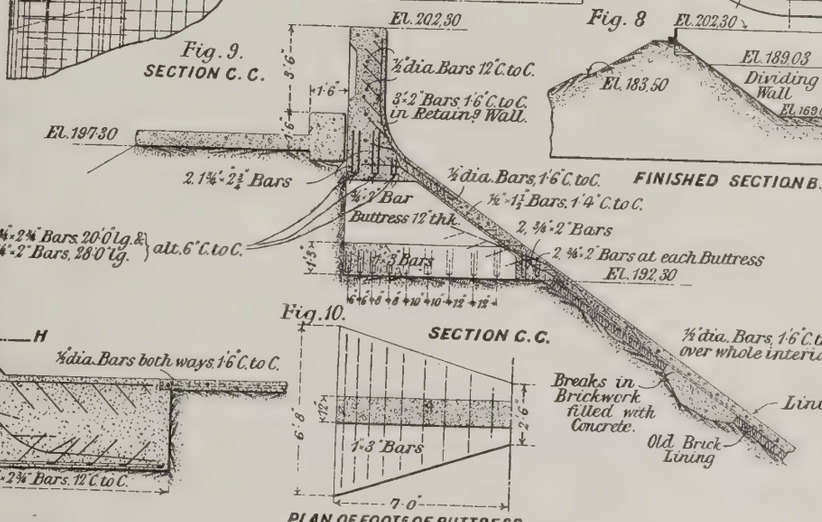
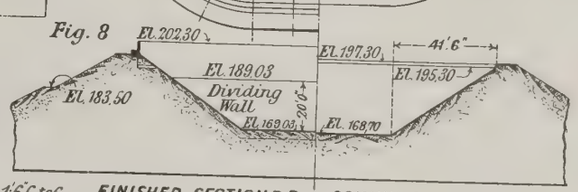


Fig. 12.
¾"×2" Bars, 12" C. to C. 28'0" long.
Fig. 11.
SECTION AT H.H.
20'0"
1¾"×2¾" Bars 20'0" lg. & ¾"×2" Bars, 28'0" lg. } alt. 6" C. to C.
1"×3" Bars ¾"×2" } alt. 9" C. to C.
H
H
½ dia. Bars both ways 1'6" C. to C.
3'0"
1¾"×2¾" Bars, 12" C. to C.
18'0"
SECTION A.A.





FIGS. 6 TO 12. SERVICE RESERVOIR AT FORT WAYNE, INDIANA.

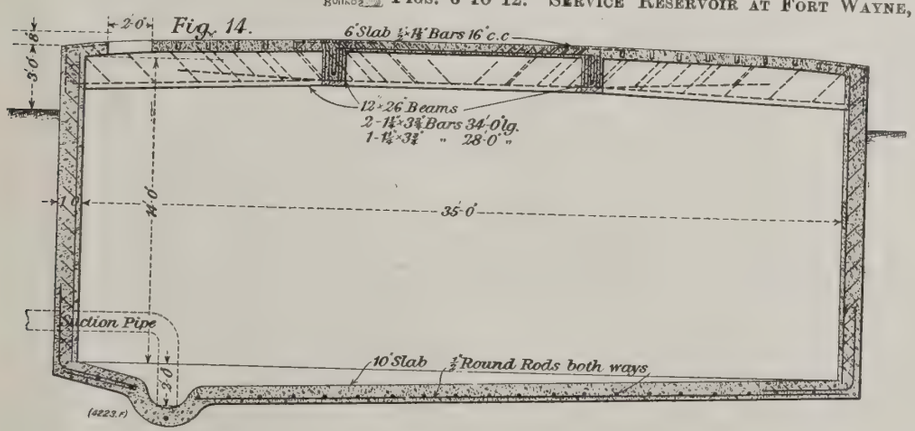
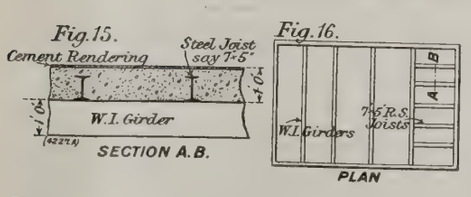


FIG. 14. SERVICE RESERVOIR AT ALBION, MICHIGAN.



FIGS. 15 AND 16. RESERVOIR CONCRETE ROOF.

FIG. 17. CONCRETE WALL OF RESERVOIR.

desirable to build counterforts, or buttresses, at the back of the wall if the reservoir is a deep one. By comparing the section shown in Fig. 17 with the examples of American reservoirs shown in Figs. 2 and 12, it will readily be seen that by using reinforced concrete there must have been effected a considerable saving.

Designing of Circular Reservoirs.—There is nothing complicated in the designing of a circular reservoir. Reservoirs are constructed under one of three conditions:—

(*a*) They are built entirely below ground. (*b*) Entirely out of ground. (*c*) Partly below ground.

In a reservoir wall the outward pressure of the water is resisted by the tension of the walls; no bending moments are produced. Where the reservoir is below ground, the inward pressure of the earth is resisted by direct compression in the walls.

In calculating the amount of reinforcement necessary to be inserted, allowance must be made for a number of steel horizontal rings being put in to take the whole tension at a small stress. The water pressure will vary from zero at water-level to a maximum of $W = \delta l$ at the base (see Fig. 18).

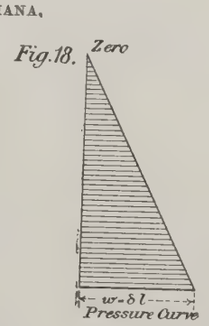


FIG. 18. PRESSURE CURVE. FIG. 19. JOINT.

w = pressure per unit area.
δ = weight of water per unit volume = 62.4 lb. per cub. ft.
l = depth of water.

The method of calculating the precise quantity of

steel that will be necessary if the reservoir is to be a water-tight structure is as follows :—

Let d = internal diameter of reservoir.
p = water pressure at any given depth.

Then the tension in a horizontal ring at a given depth will be :—

$$T = \frac{p\,d}{2}.*$$

So that at a depth of 20 ft. the pressure will be :—

$$p = 20 \times 62.4 = 1248 \text{ lb. per sq. ft.};$$

or we might have arrived at this approximately as follows :—

$$0.434 \times 20 \times 144 = 1250 \text{ lb. per sq. ft.}$$

Let us imagine a reservoir 40 ft. in diameter, and that this is cut up into horizontal slices or rings, each 1 ft. in depth. Then the tension in the ring at a depth of, say, 20 ft. will be :—

$$T = \frac{p\,d}{2}$$

$$= \frac{1248 \times 40}{2} = 24{,}960 \text{ lb.}$$

(This is the tensile stress on that 1 ft. in depth section.) At a stress of 12,000 lb. per sq. in. (which is the maximum stress which should be allowed in reservoir work, if we are to ensure water-tightness), the area of steel which will be required in this foot of the structure, the centre of gravity of which is 20 ft. below the surface of the water, will be :—

$$A = \frac{24.960}{12{,}000} = 2.08 \text{ sq. in.}$$

So that if two 1¼-in. horizontal rings are inserted in this 1-ft. section at 6-in. centres, that will be ample. And in this way the horizontal reinforcement that it will be necessary to insert at each section can be calculated. In addition to this horizontal reinforcement, however, it will be necessary to put in vertical bars ; these should not be more than 9 in. apart, and where the wall joins the floor of the reservoir additional steel will be required to strengthen the joint ; it is most necessary that the bars here should be hooked together, and that a fillet should be inserted, as shown in Fig. 19. Where the wall acts as a retaining-wall for earth as well as for water, vertical rods should be inserted at the back and front of the wall.

* "Reinforced-Concrete Design," by Faber and Bowie Arnold).

THE RUGGLES ROTARY DRIERS.

In a great many preparative processes it is necessary to drive off the moisture contained in materials of one kind and another, as, for instance, in the preparation of cement, of ore, of glass sand, granulated slag, kaolin, gypsum, peat, sewage, &c. In many of these cases the rotary drier or kiln has come into wide use. A form of rotary drier having numerous advantages over the usual rotary kiln is illustrated in Figs. 1 to 24, on page 758. This is known as the Ruggles drier. It is an American machine, for which the business in this country is in the hands of the Electro-Metals, Limited, 9½, Union-court, Old Broad-street, E.C., whose machines are manufactured in this country.

In Fig. 1 we give a general elevation of a large drier installation for treating ore at mines in Spain. In this instance the barrel of the machine is 75 ft. long, and the installation includes four cyclone dust separators for dealing with the exhaust leaving the drier, in order to reclaim the fine ore-dust carried out of the machine with the gases. The furnace is shown to the right of Fig. 1. This feeds the machine through a short brick-lined flue of medium diameter. At the same end of the drier and placed above it is an exhausting fan which draws the gases through the machine into an uptake, and finally delivers them into a duct, through which they pass to the cyclone separators. One of the chief features of the Ruggles driers is that the hot gases are passed down the barrel and back again, whereas in the ordinary rotary kiln they enter at one end and are discharged at the other. This gives the drier under notice a great advantage, as its efficiency is very much increased. The drier is composed of an inner barrel and an outer shell. The hot gases pass from the furnace, or other source of heat, into the inner barrel, down to the end of the drier, returning in the space between the inner and outer shells. By this means the outer shell is always at a comparatively low temperature, and the high radiation losses present in the ordinary rotary kiln are absent. The outer shell is at the hottest part seldom more than about 200 deg. Fahr., while the gases leave the drier at a temperature of about 100 deg. Fahr.

The construction of the barrel of one of these driers is shown in Figs. 2, 3, 4, &c. This is one of the standard patterns, being 35 ft. in length, and composed of plates ⅜ in. thick. The outer shell is 5 ft. 9 in. in diameter, built with circumferential lap-joints and longitudinal butt-joints. The inner barrel, or flue, is 2 ft. 6 in. in diameter, and is composed of two lengths lap-jointed. Half way down the shell there are six pairs of cast-iron radial braces, riveted both to the shell and flue. The flue is further supported from the shell by four sets of six braces. These braces, or arms, are bolted to lugs, and are an easy fit, so as to allow for a certain amount of longitudinal movement. The shell and flue are thus only rigidly connected at the centre, and longitudinal expansion and contraction under changes of temperature is unfettered. At the feed end (the left-hand end in Fig. 3) the flue is enlarged into a kind of socket, 3 ft. 2¼ in. in diameter. The flue conducting the gases from the furnace fits inside this end. The shell has eighteen internal longitudinal wings or flights, 6 in. wide, composed of $\frac{5}{16}$-in. plate, fixed to the shell-plating by small 2½-in. by 2½-in. by $\frac{5}{16}$-in. cleats. The wings are all set over in one direction, at an angle of 30 deg. to the radius. On the outside of the flue similar longitudinal wings are fastened by 2½-in. by 2½-in. by ⅜-in. cleats, the wings being 4 in. wide in this case, $\frac{5}{16}$ in. thick, and set radially. This arrangement will be clear from Figs. 3 and 4. At the feed end there are, further, eighteen specially-shaped wings or flights on the shell, 6 in. wide by $\frac{5}{16}$ in. thick, set at an angle of 45 deg. to the longitudinal wings. The drier is supported on two bearing-rings, or tyres, 7 ft. in diameter on the tread, which is 5 in. wide. These tyres are fastened to the shell by eighteen brackets. There is, further, surrounding the shell, a large spur-ring with a pitch circle of 6 ft. 10⅛ in. on one side, tapering to 6 ft. 9¾ in. in diameter on the other. This ring is of cast iron, in two segments, and has teeth 5 in. wide. The feed end of the drier is encased in a head, shown in Figs. 5 and 6. The drier is shown in dotted lines in Fig. 6, in position in the head, which embodies a chute for the material, and, above, an uptake leading to the fan trunk. The chute delivers the material fed in on to the spiral wings, by which it is carried up, and then dropped on the flue barrel. It is here held for a short time, and then allowed to fall, being again raised by the longitudinal wings on the outer shell. As the whole drier is on a slant of about 1 in 28, the material as it falls is gradually worked down the barrel to the discharge end. On the plate enclosing this end there are six pockets formed of ⅂-shaped castings riveted to the end plate as shown in Fig. 7. The centre of this discharge end is formed of the star-ribbed cone illustrated in Figs. 8 and 9. As the head rotates, material is picked up by the pockets and run into one of the partitions on this ribbed conical casting, and is then discharged through the mouthpiece shown at the end of the shell in Fig. 3.

The bearings and driving-gear for the standard Ruggles driers are shown in Figs. 12 to 24. The two bearings embody certain similar features. Figs. 23 and 24 illustrate the standard thrust-bearing ; Figs. 12 and 13 illustrate the standard driving-gear. It may be noted that while Fig. 1 shows the standard thrust-bearing in use, in the case of this drier, which is unusually long for a drier built on the Ruggles system, the driving-gear is separated from the second bearing. The standard drive embodies bevels of cast steel driving a cast-steel pinion with shrouded teeth meshing with the large spur-ring fixed to the shell. The rotating shell rests on four bearing-wheels with chilled and ground treads 5 in. wide by 18 in. in diameter. These wheels are arranged in two pairs in equalising arms (Figs. 20 to 22), the equalising arms being carried on a shaft supported in two bearings (Figs. 17 to 19). The latter are arranged with the necessary incline so that the bearing-wheel treads fit square to the tyre on the shell. The general arrangement of the drive and supports is shown in Figs. 12 and 13. The thrust-bearing embodies similarly equalised bearing-wheels set on the requisite incline, and in addition has two horizontal thrust-wheels 18¾ in. in diameter placed 2 ft. apart centre to centre, between the rims of which runs the tyre near the feed end of the machine. The thrust-wheels are carried in a frame shown, in Figs. 14 to 16, fixed across the bearing-frame. The wheels run on 2½-in. pins between steel washers ¼ in. thick.

From the above description of the Ruggles drier it will be clear that the material cannot pass from one end to the other without coming into intimate contact a number of times with the hot gases and with the hot surface of the internal flue. At the same time it does not come into contact with the gases until combustion has been completed and a large quantity of the heat has been given up by them. The risk of the too-early quenching of the flame and incomplete combustion is therefore avoided. By the time the gases reach the end of the internal flue they have already parted with most of their heat. Together with fresh air entering through the discharge-head, they are drawn back through the drier by the fan. The shrinkage in volume during the cooling of the gases is made up for by the admission of the additional air. The final temperature is so low that the efficiency of the driers works out in cases to from 75 to 88 per cent. of the heating value of the fuel. The final temperature of about 100 deg. Fahr. enables a fan to be used. Large fans run at comparatively low speeds are preferred, and this enables the output of the drier to be greatly increased, if for special reasons this should be necessary. The fan is coupled to the driving-gear, so that when the drier is out of use no hot gases can be drawn through the drier. Further, the adoption of a fan obviates the necessity of the high-discharge temperatures (500 deg. Fahr. or thereabouts) required to obtain the necessary draught with a stack, with which, of course, the output cannot be varied. With an initial temperature in both forms of about 1400 deg. Fahr., and a final temperature of 100 deg. Fahr. for the Ruggles drier, and of 500 deg. Fahr. for the stack method, the advantage in favour of the former is clear, to say nothing of the additional saving from the reduction of radiation losses, which, as noted above, are very large at the hot end of the ordinary rotary kiln.

The Ruggles system has been applied to driers for various purposes. In some cases the drier is mounted as a portable machine for use in road-making ; in others the heating agent may be steam, and the drier may be arranged internally, so that the steam or gases do not come into contact with the material being handled. We may mention that a machine of the size illustrated in Fig. 1, installed at Virginia, Minn., U.S.A., turns out about 40 tons of ore per hour, reducing the moisture percentage from 18 to 6. In addition to ores, cement, &c., these driers are adapted for dealing with coal, peat, and other substances for which comparatively low temperatures have to be used, and in special installations for dealing with fish scrap, &c.

NOTES FROM THE UNITED STATES.

Philadelphia, December 9.

The past week was the first normal week in the iron and steel industry for several months. Whether the activity was a spurt, or the beginning of a continuous broadening movement, it is impossible to say. Sales of considerably over 100,000 tons of rails are reported on domestic account, exclusive of important foreign orders, concerning which silence is observed. Inquiries for plates for the construction of five or six steamers are in hand. Mr. Schwab has thrown up the contract for the building of a large number of war-vessels. Inquiries for all manner of steel products have greatly multiplied. Bars, plates, and shapes are selling in large quantities as low as 1.05 dols. An Australian water-pipe company placed an order for 16,000 tons steel plates for earliest possible delivery. The United States Corporation has increased its output from 35 to 40 per cent. of capacity. A general improvement has set in. Tinplate is once more active, the largest recent order being for 400,000 boxes. Pig-iron has suddenly become quite active ; orders within ten days well exceed 250,000 tons of all kinds, in which low-grade iron for cast-pipe purposes figures largely. This activity in pig will probably continue until requirements for the larger consumers are safely covered—at least for the first quarter of the new year. Pig iron in Western markets has nominally advanced from 25 to 50 cents, but this does not affect the large interests, which are protected by options. Considerable export business is being done, which is not reported in the Press, but no munitions will be manufactured or exported in completed state, except, of course, ammunition and rifles and the like. While rails are active, other railroad material is ordered sparingly. There is great need of improvement, however, in general manufacturing circles.

The Gerard Life-Boat.—We have received from Mr. William J. Pitt, 10, Argyle-terrace, Plymouth, an illustrated pamphlet on the Gerard life-boat, from which we take the following dimensions and characteristics : — Length, 28 ft.; beam, 9 ft.; depth, 3 ft. 9 in.; material, steel plates, ⅛ in. thick ; draught when light, 7 in.; draught with 120 people, 1 ft. 9 in.; with 140 people, 2 ft. The boat can be built on the same dimensions to have sufficient buoyancy to float 200 people, when the draught would be 2 ft. 6 in., with a clear side of 1 ft. 3 in. The pamphlet illustrates a boat on roller-chocks ready for launching, and the boat being launched, the same carrying 120 men. It also illustrates stability trials, and the boat in two halves, floating separately to prove the buoyancy.

Contracts.—We are informed that since the outbreak of the war Messrs. United Water Softeners, Limited, the well-known makers of Lassen-Hjort and Permutit water-softening and purifying plants, have entered into contracts to erect over 100 installations, totalling several million gallons daily, for firms in the United Kingdom. Prominent among those who have placed orders for softening plants are the Admiralty (30,000 gallons per day), Vickers, Limited (14,000 gallons), Armstrong, Whitworth and Co. and Brunner Mond and Co. (500,000 gallons), the *Daily Chronicle* Paper Mills (240,000 gallons), Bickershaw Collieries (Ackers Whitley and Co.) (360,000 gallons), the North-Eastern Railway (96,000 gallons), British Portland Cement Manufacturers (12,000 gallons), Merryweather and Co. (8000 gallons), Curtis's and Harvey (19,000 gallons), Sir Joseph Lyons and Co. (24,000 gallons), Erith Oil Works (192,000 gallons), &c.

THE THERMAL AND MECHANICAL EFFICIENCY OF THE GAS-ENGINE.*

By A. VENNELL COSTER.

AT the present moment, when all our industries are affected either as regards men or material by the European war, and when the country's energies are being directed to capture German markets and German manufactures, it is imperative that we should remember that their commercial conquests have primarily and continuously received an impetus not only from their superior financial and industrial banking systems, but also from the enormous savings they have effected in production by the utilisation of waste gases and fuels for power purposes. They have not hesitated to persevere, in spite of initial blunders and costly experiments, knowing that the gas-engine can obtain a combined superior thermal and mechanical efficiency over every other prime mover, particularly when driven by these waste resources.

We are all agreed that in many fields of service on land and sea the steam-engine is still necessary and paramount, but in the progress of commerce the improved thermal and mechanical efficiencies of the gas-engine must be increasingly considered.

In a paper given before the Institution of Electrical Engineers, by Mr. C. E. Douglas, the choice between gas and steam was considered in relation to the economy obtained by each system at different loads. It will be noted that at full load the fuel consumption in pounds per kilowatt-hour is :—

	Lb.
Turbine steam-engine	2.6
Reciprocating steam-engine	3.1
Pressure producer-gas engine...	1.75
Suction producer-gas engine	1.5

and at half load :—

Turbine steam-engine	3.3
Reciprocating steam-engine	3.3
Pressure-producing gas-engine	2.35
Suction producer-gas engine	1.9

Thermal efficiency also must be considered in relation to stand-by losses. In a 500-horse-power gas-producer, the admission of air through a 1-in. diameter hole is sufficient to maintain combustion over a long week-end, the stand-by losses being at least 75 per cent. less than in a steam installation. Also the cost in wages involved in starting up a power-plant is very greatly reduced, as gas can be obtained in about a quarter of an hour sufficient to start the engine. The comparative costs of fuel for steam or gas-plants vary in different parts of the country and in different countries ; generally speaking, up to the present time the cost of fuel for gas-plants is higher in price than that required for steam boilers. But as the work of gas-producers becomes more general, and their charging and management is better understood, cheaper fuels will be used, so that the great thermal advantages of gas may be more fully realised. But where blast-furnace gas and coke-oven gas are available, or waste products that can be converted in a producer into gas, the advantages in favour of gas become enormous.

In Belgium, at the great works of Messrs. Cockerill and Co. near Liége, all their power is developed from blast-furnace gas, and allowing for an annual depreciation equal to 13 per cent. of the whole cost of the installation, with working hours per year 4380, corresponding to a load factor of 50 per cent., the total cost per kilowatt, including depreciation, equals 0.183d.

Before leaving this portion of our subject, I may give further examples of what has been effected in the iron and steel industry. In a blast-furnace of 250 tons per day capacity, and consuming 10 tons of coke per hour, the waste gas produced is sufficient to generate 10,000 brake horse-power by gas-engines. From this, 2500 brake horse-power are required for air supply, transport, lighting, &c., the remainder, equal to 7500 brake horse-power, being available for driving rolling-mills, or generating electric current which may be sold. In a coke oven of 200 tons per 24 hours' day capacity, requiring 10 tons of coal per hour, enough waste gas is generated to develop 1800 to 2000 brake horse-power in gas-engines ; and, further, by the utilisation of the waste coke (coke smalls) in a gas-producer a further 900 brake horse-power are obtained, so that altogether close upon 3000 brake horse-power are available continuously from this regenerative coke-oven plant. As you are aware, not only has the gas-producer fully a 10 per cent. better thermal efficiency than any type of steam-boiler extant, but also there is in the gas installation very little loss between the gas plant and the engine, however distant they may be apart ; the working pressure and resultant heat is generated only in the cylinders of the engine itself. The problem of the gas engineer is to utilise a larger proportion of the heat within the cylinder. The experience of the author's firm shows that on the average one-third to one-fourth of the total heat supplied per effective brake horse-power is lost in the external cooling medium or water-jacket—usually 27 per cent. ; whereas in the exhaust about 35 per cent. is lost, and 26 per cent. turned into actual work, the remainder being unaccounted for. Assuming a liberal consumption of heat per horse-power hour as 12,000 B.T.U., the exhaust carries off 4200 B.T.U., the water-jacket 3250 B.T.U., and the brake horse-power accounts for 3120 B.T.U. per hour. From these figures it can be seen that both the exhaust and jacket heats can be put to useful purposes, and assist in raising the thermal powers of the engines.

* Abstract of lecture delivered before the Rotherham T.I. Engineering Society, November 7, 1914.

Turning our attention to gas-engine design, the combustion-chamber of the gas-engine cylinder has attained its present excellence owing to patiently continued experiments resulting in the discovery of the laws of thermo-dynamics.

To-day we possess a much clearer grasp of the laws of combustion, and the extraordinary conditions in which heat is turned into work within the gas-engine cylinder. As already said, the extraordinary thermal advantage of this engine over the steam-engine lies in the fact that the fuel combustion actually takes place within the engine-cylinder. A large proportion of the heat is lost to the jacket and exhaust, and therefore it is desirable that the working cycle should be completed in such a manner so as to expose the working fluid to the least possible cooling surface, and that the exposure should be for the shortest possible time, and also that the mean temperature during exposure should be as low as possible. The ideal form of combustion-chamber is spherical, but it is practically impossible to maintain this form in the gas-engine, because the most economical ratio between cylinder diameter and piston stroke precludes this form. One has not to seek far for gas-engines in which little attempt has been made to restrict the cooling surfaces, which carry away too great a proportion of the heat of the gas. A time limit also must be imposed upon the inflammation and expansion of the gases. A slow-moving piston is most uneconomical, a minimum speed of 600 ft. per minute to a maximum of 900 ft. per minute being the usual limits, controlled by the weight of the moving parts and by the reciprocations per minute. A rapidly-moving piston assists in creating eddying currents throughout the burning gases, thereby attaining a thorough mixing of the gases and rapidity of combustion, and also reducing the relative importance of conduction losses through the cylinder-walls, and assisting in maintaining a higher pressure throughout the power stroke.

Thermal efficiency depends also upon the completeness of combustion within the cylinder. The curve of expansion upon the indicator-card lies above the adiabatic curve, which proves that, although the ignition may appear on the card instantaneously, after-burning invariably takes place, as can be easily proved by removing the exhaust-pipe ; when on the opening of the exhaust-valve, flames are projected from the engine-cylinder. This demonstrates that although ignition and combustion of the power charge may be as perfect as is possible, the fact remains that instantaneous combustion does not take place, but that through the whole course of the power stroke the gases are still burning and creating additional heat, raising the expansion-curve on the indication diagram, and continuing to burn after the opening of the exhaust-valve. This after-burning therefore adds somewhat to the loss of thermal efficiency in the gas-engine, and requires further patient research.

Imperfect combustion possibly arises from the specific heat of the combustible gases varying with their compression and expansion, and restraining them to a small extent from more perfect combustion until a lower stage of pressure and temperature is reached. Inflammation will not travel so rapidly through the more highly compressed gases, and this resistance is known to occur at the sparking points of the electrical ignition, for at higher compressions the fixed electrodes have to be brought closer together and at lower compressions further apart.

As the thermal efficiency is undoubtedly reduced by the coolness of the cylinder walls, we are driven to the conclusion that the hot gases influenced by these walls cannot instantaneously ignite under their, for the moment, existing pressure, but as this pressure decreases during the progress of the power stroke, this envelope of unburnt gases expands away from the walls, and is ultimately consumed along with the main body of incandescent flame, adding its share to the power area on the indicator-card. Now it must be remembered that these changes in specific heat, in density and temperature, all take place in a moment of time, making the investigation one of extreme difficulty.

But even if these theoretical arguments can be disproved, the physical fact of the preservation of the oil film, necessary for the lubrication of the piston, is substantial proof of their veracity. During the power stroke the explosion temperature ranges from about 3000 deg. Fahr. to 1600 deg. Fahr., and no one questions that oil, which, as a rule, carbonises at from 500 deg. Fahr. to 600 deg. Fahr., must inevitably be entirely consumed unless some extraordinary conditions exist adjacent to the cylinder walls to preserve it. The author thinks that the assumption is justified that the coolness of the walls on the one side, and the envelope of gases restrained from active combustion on the other, together assist in preserving the necessary oil-film, so that while the thermal efficiency may be somewhat reduced by this after-burning, the mechanical efficiency is very considerably improved.

The thermal efficiency of the gas-engine, considered in relation to actual horse-power, is about twice as good as that of the steam-engine. It would be even more than this but for the reason that the gas-engine of the Otto, or any, cycle requires a pump to deliver the power charge into the cylinder and then to compress it before the power stroke. The negative power necessary for this pump, whether the pump is internal or external to the engine cylinder, accounts almost wholly for this difference in efficiencies as between the gas and steam-engines. In a heat-engine, such as the gas-engine, the interposition of the pump stroke, within the cylinder and between the power strokes, greatly assists in restraining cumulative heat stresses and temperatures in the structure of the cylinder, breech-end, and water-jacket, and undoubtedly also assists in maintaining the necessary lubrication of the working parts.

Returning again to the subject of waste fuels, it will interest you to know that under actual working conditions the author's firm have obtained the following consumptions in their producers :—

	Per B.H.P. per Hour.
Coke breeze	1 lb.
Charcoal	1 ,,
Cotton-seed	2½ ,,
Bark refuse up to 50 per cent. moisture	4 ,,
Tan refuse	4 ,,
Peat	3 3 ,,
Lignite	1.75 ,,
Peat briquettes...	1.25 ,,

These figures, if corrected for indicated horse-power, will be about 15 per cent. better. The practice of gas engineers to give the brake horse-power, at the engine crank-shaft on the friction-brake, or other type of power-recorder, is being taken up more generally by steam-engine builders, and is the best method for determining the size of engine required, as it is based on the mechanical efficiency.

As a general rule, gas-engines using ordinary fuels are sold with a margin of 10 per cent. for overload. It is therefore important always carefully to estimate what the maximum overload or peak load may be, as it is found that sometimes a larger margin than 10 per cent. is required. The reputation of gas-engines often unjustifiably suffers from having to run constantly in an overloaded condition without relief. With a sufficient margin of power, applied common-sense, and some experience on the part of the attendants, the gas-engine will in all cases prove a trustworthy and economical servant, eliminating also the smoke nuisance, gas waste, costly chimneys, and all boiler, steam-pipe, and condenser troubles.

ROYAL NAVAL DIVISION PUBLIC SCHOOL BATTALION.—The Admiralty have given official permission for raising a battalion of 1000 men, which will be strictly limited to public school or university men, and who will serve together as a unit. Training is now going forward. Applicants should apply for further particulars to the Royal Naval Division, 6, 7, and 8, Old Bond-street, London, W.

RECORD IN WARSHIP CONSTRUCTION.—The Secretary of the Admiralty makes the following announcement :—An interesting record in ship construction has been established in the building, at Messrs. Cammell Laird and Co.'s yard at Birkenhead, of His Majesty's new light cruiser Caroline. Her keel was laid on January 28, 1914 ; she was launched on September 21, and delivered complete on December 17, after satisfactory trials on December 15, the contract date for delivery having been May 21, 1915.

PERSONAL.—Messrs. Stewart and Lloyd's manager in Johannesburg, Captain Bullock, has received honourable mention, the following telegram having been sent by General Smuts, Minister of Defence, to the British Staff Officer at Kimberley :—"December 5.—Please convey to Captain Bullock my congratulations on the splendid work which he and the motor squadron have performed in connection with the capture of General de Wet. Colonel Brits has assured me that without their efficient assistance the capture might not have been possible."

MICA IN THE UNITED STATES.—Bulletin 580 F of the United States Geological Survey, compiled by D. B. Sterrett, describes "Some Deposits of Mica in the United States," without claiming completeness. Of the two varieties of mica, muscovite (potassium mica) and phlogopite (magnesium mica), only the former is mined in the United States. The production of 1912 amounted to 845,483 lb. in partly-trimmed sheets, valued at 282,823 dols., and to 3266 short tons of scrap mica, valued at 49,703 dols., a total of 331,896 dols. ; the production of 1913 exceeded 400,000 dols. in value. The bulletin, a pamphlet of about seventy pages, briefly describes some noteworthy plants mainly from the standpoint of the geologist and miner ; the author had, in most cases, the assistance of the chief men on the spot.

THE INSTITUTE OF METALS.—The annual general meeting of the Institute of Metals will take place at the Institution of Mechanical Engineers, Westminster, S.W., on Thursday and Friday, March 18 and 19, 1915. The Council have selected a date towards the end of the week, as this may suit the convenience of a large number of country members. On account of the war the usual annual dinner will not take place next year. Members desirous of contributing papers at the annual general meeting, or of notes for the Journal, are asked—if they have not already done so—to advise the Secretary by return of post, without fail. The Council announce that the 1915 May lecture will be given by Sir J. J. Thomson, O.M., D.Sc., F.R.S. The time and place of the meeting will be announced later. The Council report that, notwithstanding the war, the membership of the Institute—assuming that the eleven candidates now to be balloted for are duly elected—is at the highest point it has ever reached. The exact figure, together with a full record of the progress of the Institute during the past year, will appear in the forthcoming report of the Council. Although the membership figures are satisfactory for 1914, it is expected that losses, particularly in the Continental membership list, will be appreciable during 1915, and it is therefore hoped that for the annual general meeting ballot a strong list of names will be sent in by the members.

THE RUGGLES ROTARY DRIER.

THE ELECTRO-METALS, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page 756.*)

Fig. 1.

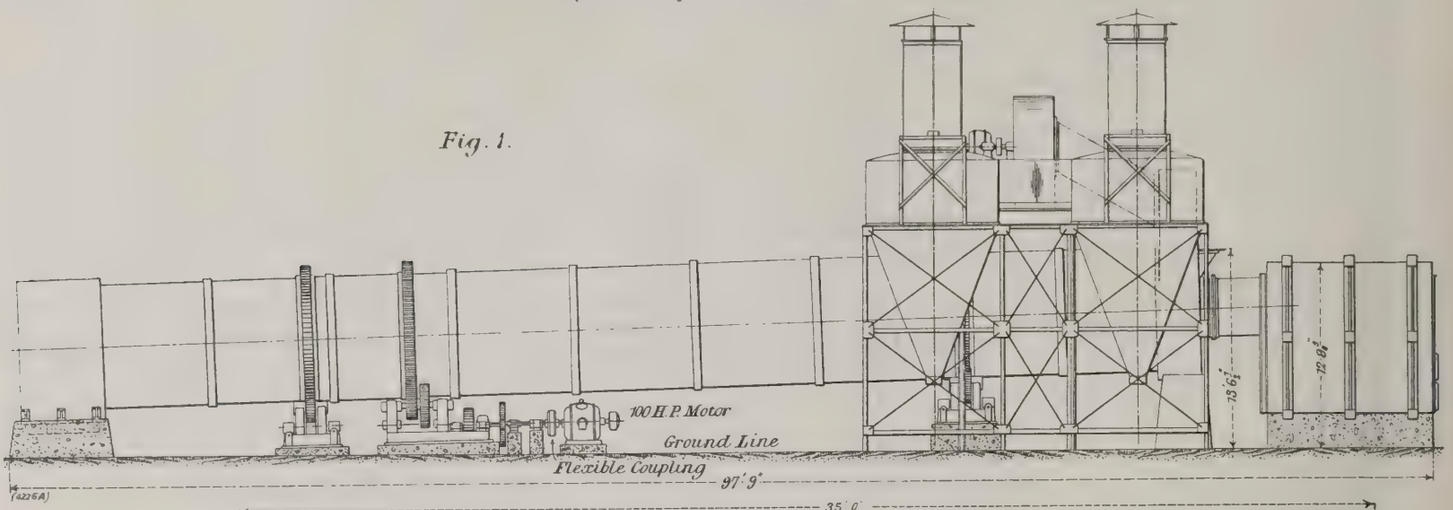


Fig. 2.

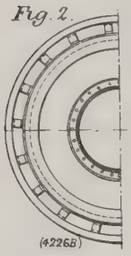
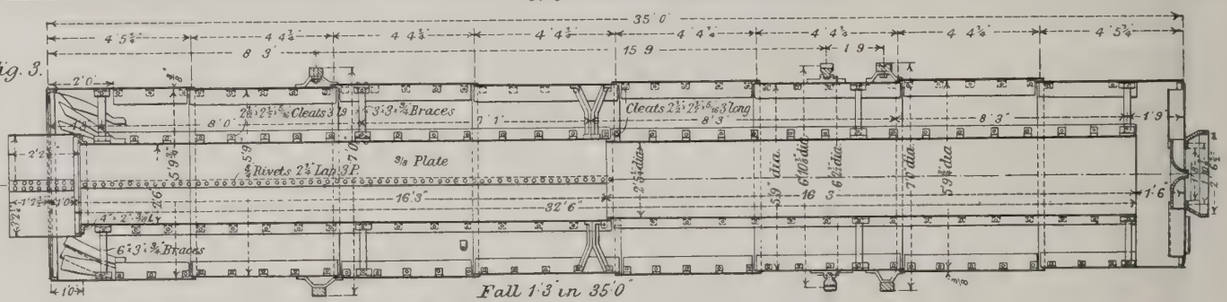


Fig. 3.



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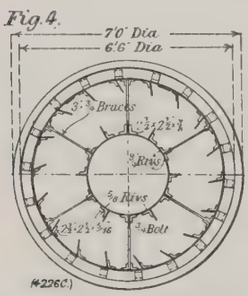

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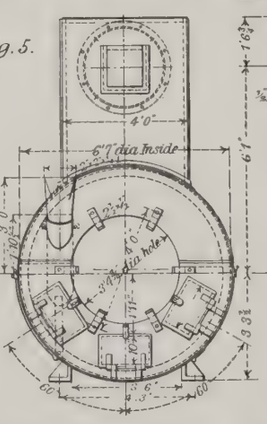

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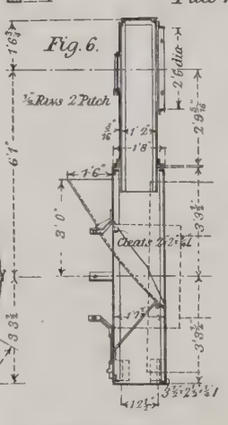

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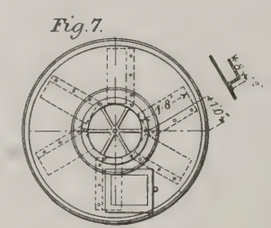

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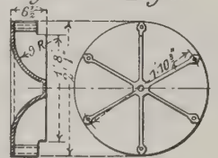

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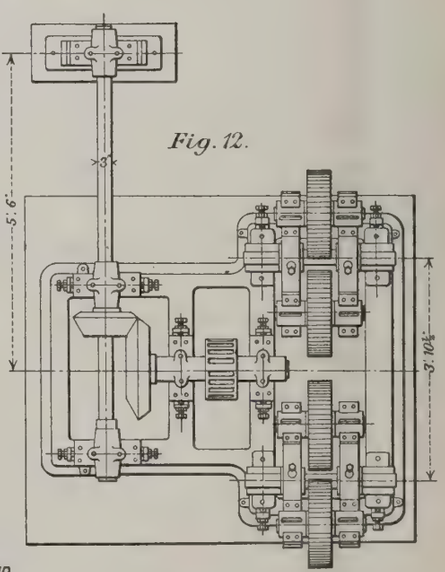

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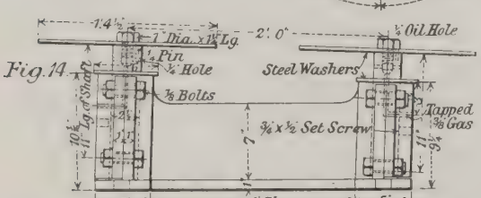

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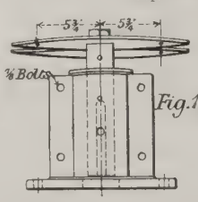

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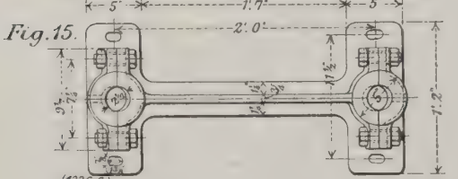

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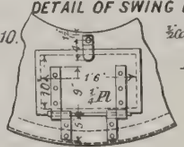

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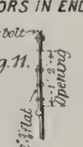

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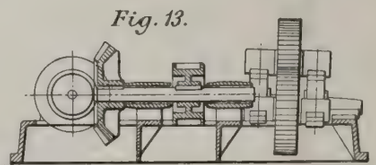

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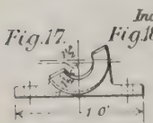

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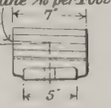

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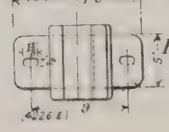

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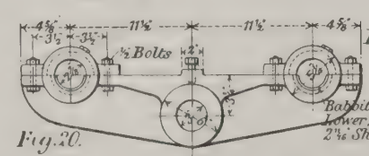

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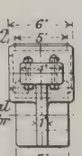

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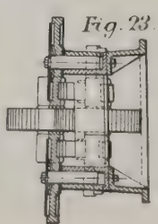

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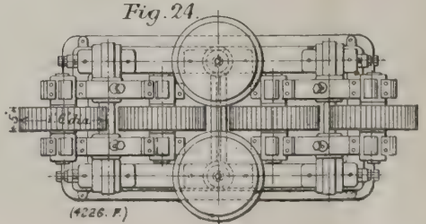

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ENGINEERING.

FRIDAY, DECEMBER 25, 1914.

METALLURGY AND THE WAR.

THERE are two aspects of the subject comprehended under the title "Metallurgy and the War" which are of especial interest at present. These may be summed up under the two words "manipulation" and "supply." Leaving the question of supply for the moment, we would like to say something about manipulation, and by manipulation we comprehend the whole of metallurgical knowledge and practice. Much has been said of the superior industrial methods of Germany as compared with those of this country, of the better education of her workers, and the better appreciation of co-ordinated knowledge by her manufacturers. It is not a new story. We have all heard it, and are, perhaps, a little weary of hearing it. It appears in all discussions on British and German methods, and duly cropped up at the last meeting of the Birmingham Metallurgical Society, with which we wish to deal in a moment. We have now no intention of arguing about this German superiority. But a reflection in connection with it is permissible under our present heading. Modern war being based on engineering, success or failure in this war is going to be largely determined by the right use of metals, and we ask the preachers of Germany's technological superiority if they believe that this country is going to stand second to any other in this matter. If they do not, they must admit that our metallurgical knowledge and practice cannot be seriously wanting if they are successfully able to meet what can only be described as the supreme test. In war—in this war above all—second-rate materials and second-rate methods spell failure, and as that word has no place in our expectations, it is clear that we are confident that our materials are not inferior to those of any other country.

We have plenty to learn from Germany. In certain aspects of manufacture and commerce she is pre-eminent. But continual depreciation of Great Britain, as compared with her, is neither very helpful nor very true. It is useful to remember at times that Germany is a larger country than this, and that we cannot do all the work in the world. Further, German methods are not British methods, nor German ways British ways. The practice of one country cannot profitably be transferred bodily to another. The amazing industrial development of Germany may have been helped by learned investigations into the rate of decrease of thickness, with time, of the layer of paint on the back door. We do not know. It is quite certain, however, that similar meticulous researches would be no help to British industry. To do justice to this country in these comparisons between our manufacturing methods and those of Germany, it is necessary to remember that the whole points of view of the two nations are different. The reason our manufacturers do not act like those of Germany is because they *cannot*. The reason German manufacturers do not act like ours is also because they *cannot*. A nation can only express itself in its own way; and while a wise nation will learn all it can from its neighbours, it will not seek to thrust itself into the procrustean mould of an alien constitution. In many ways German methods are superior to ours. If they are superior at bottom and on a broad survey, the world is to learn.

In our sermon we are getting rather away from the Birmingham Metallurgical Society, which is the proper subject of this article. The meeting with which we wish to deal was held at the White Horse Hotel, Congreve-street, Birmingham, on the 17th inst., and took the form of a discussion on metallurgy and the war. In great part the proceedings were confined to consideration of questions of the supply of metals, which we have already mentioned as a second interesting aspect of this question. Much has been said in the daily Press and elsewhere during the last few months about the shortage, or the coming shortage, of various materials in Germany, and it has been suggested that economic pressure due to such shortage will ultimately end the war. It is a difficult question, and one that no one can venture to dogmatise on, but it is interesting to have the opinion of one who knows so much of German commerce as Professor Ashley, of Birmingham University, who was present at the meeting, and who gave it as his opinion that economic stress would not end this war, which would be determined by military considerations. None the less, as Professor Ashley himself showed, lack of certain materials and, of special interest from our present point of view, lack especially of certain metals, were likely to be important factors. It is true, of course, that not only Germany, but we ourselves may be short of certain metals—we are short of certain metals now—but the German shortage is likely to be more serious than ours, and less possible to deal with.

Before going on to give some of the figures in reference to the metal trades, which were quoted at the meeting, we would like to refer to a general aspect of the discussion. Some of the speakers—indeed, the majority of the speakers—referring to the German superiority question, had a good deal to say about the German control of the spelter industry and of various other industries concerned with some of the less common metals. Professor Ashley referred to the Metallgesellschaft of Frankfort-on-Main, which, he stated, practically controlled the minor metal trades of the world. One can have no quarrel with Germany over this kind of matter. It is allowable business enterprise. But if the idea is to criticise the commercial men of this country for not doing the thing themselves, it is necessary to point out that again there are two sides to the question. Great Britain has not got all the capital in the world, and, as we have already said, she cannot do all the work in the world. It is further pertinent to remember that this type of enterprise is not looked upon with particular favour in this country, and certainly is not encouraged by our political constitution.

Be one's conclusions what they may on the question of cornering metal markets, it is certain, now a state of war has supervened, that Germany's position is worse than ours. What our position would be without the Navy is another question, but one that fortunately need not be discussed. Professor Ashley had something to say about Germany's present position. In iron and steel, he stated, she could be looked upon as self-contained, but the same thing was far from being true of copper. She had reached the position of second copper consumer in the world, standing second only to the United States, and consuming about half as much again as this country. Her consumption was about one-quarter of the world's output, and very little of it was her own production. In 1902 she used 100,000 tons, which for the last time was a little less than the British consumption. In 1912 she used 230,000 tons, of which she produced only about one-tenth herself, extracting about one-quarter. She was thus dependent on imports for nine-tenths of her consumption, and of this fourteen-fifteenths came from the United States, and the rest from England and Australia. We had no information about her available stocks at the beginning of the war, but last May she had only 8000 tons, and there was nothing to show that this figure had been seriously increased in the succeeding months. These facts clearly suggested that, under present conditions, her position might become very serious.

Other references, but less detailed, were made to Germany's position by Professor T. Turner, who was in the chair. He thought Germany was likely to suffer from a scarcity of both tin and aluminium. Our own position could be looked on as quite reasonably satisfactory. Copper the previous week ruled at 56*l.* a ton, and tin 148*l.* a ton, both these prices being lower than those of two years ago. Lead was 19*l.* and spelter 27*l.*, both rather high, but not abnormally so. Cleveland pig was 52*s.* a ton, and silver 23*d.* an ounce—one of the lowest prices he remembered. There had been considerable shrinkage in our trade, but Germany had suffered at least as much. Our comparatively satisfactory position must again be put down to the Navy, as we were no longer the producers of metals we were in the past. In the important matter of gold, we were especially well off, as some two-thirds of the world's production came from the British Empire. Silver was not largely produced in the Empire, but, as Professor Turner pointed out, there was no great demand for the metal at present, and consequently our supplies were more than sufficient. In iron and steel we, with our

Allies, were fairly well self-contained, with the exception of some special ores. We, however, had the chief supplies of manganese, a fact which might be of importance if the war went on long enough. We also had chromium and tungsten.

Going on to speak of spelter, Professor Turner pointed out that the chief supplies came from the United States, Belgium, and Silesia. We, however, manufactured some 70,000 tons a year in this country, which was sufficient for war purposes, but not for those of general trade. Apart from the ores in this country, the Empire includes the important deposits at Broken Hill, and it was to be hoped that the war would lead to a considerable increase in the number of our plants. In this connection Mr. C. H. Barwell stated that the Silesian mines were largely worked out, and that ore was now shipped from Broken Hill to Silesia. Mr. F. Johnson also dealt with the point. In his opinion only a small proportion of the Broken Hill concentrate could be dealt with in this country at present. To take up the work on a large scale would require some time, and to deal with it all would probably require a capital expenditure of five or six millions. Professor Turner also referred to tin, nickel, and aluminium. Tin was only manufactured to a moderate extent from English ores now, but the British Empire occupied an important position. Nickel was manufactured in moderate quantities in Birmingham and South Wales, but our chief source of supply was the United States. The ores, however, were largely obtained from the British Empire. Aluminium was largely made here, and we could draw on the United States for any shortage.

Some interesting information in reference to the less common metals was given at the meeting. One speaker pointed out that cerium, an important material for the manufacture of incandescent mantles, and for the igniters which were being used to a large extent at the front, was not manufactured at all in this country. We had access to the ores, but so far had done nothing. The whole of the cerium alloys were made in Germany. Tungsten was another metal of which we had ample supplies of ore from Australia, but had left the reduction too much to Germany. As illustrating the resources of the Empire it was interesting to note that there were also important tungsten deposits in Rhodesia. These could not at present be worked owing to lack of transport facilities. There was also vanadium in Rhodesia. It would certainly be satisfactory to learn that some attempt is to be made to deal at home with some of these rarer ores which the Empire can send to us. There appears to be something like a crisis in the country over the supply of magnesium. One speaker stated that the ordinary price was about 5s. a pound. This had recently risen to 30s. a pound, and on the day he was speaking his firm had bought 6 lb. at 2*l*. a pound. He was able to add that he had recently tested a sample of magnesium made in this country, and found it in every way equal, if not superior, to the German product.

THE FLEXURE OF ECCENTRICALLY-LOADED COLUMNS.

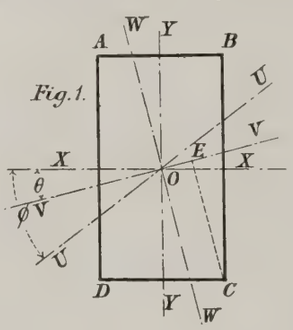
The regulations of the London County Council, which stipulate that in the case of eccentrically-loaded struts the bending stress due to this eccentricity shall be computed and added to the stress due to direct loading, have drawn attention to the existence of a curious and dangerous pitfall or trap in the theory of beams bent in other than in a principal plane. The usual and the correct method of treating a bending moment of this kind is to resolve it into two bending moments parallel to each of the principal planes of the section. The stresses due to each of these components are computed separately, and the resultant stress at any point is the algebraic sum of the two component stresses thus found. The following fundamentally wrong method has, however, recently been advocated, and has, we understand, been accepted by certain Metropolitan borough surveyors. Take, for example, a rectangular section such as A B C D, Fig. 1, and let a bending moment, M, be applied in the plane of W O W. Then some draughtsmen have assumed that when the beam bends under the action of this moment its neutral axis will be represented by the line V O V perpendicular to W O W, and that, if I^1 denote the moment of inertia of the section with respect to this line, the maximum stress at the corner C will be given by the relation—

$$p = \frac{M \cdot EC}{I^1}.$$

In practice the value of I^1 has in many cases been measured from the ellipse of inertia which has been computed for the British standard sections by Mr. Max am Ende. The assumption that, in cases of the kind in question, the neutral axis is perpendicular to the plane of the bending moment is in point of fact totally erroneous, and involves an error on the danger side, which in certain actual practical examples is as much as 30 per cent. The real neutral axis of the beam in such a case is represented by the line U O U drawn at an angle ϕ, such that

$$\tan \phi = \frac{I_1}{I_2} \cdot \tan \theta,$$

where I_1 and I_2 denote the principal moments of inertia of the section. The inaccuracy of the assumption made is perhaps best seen from such an example as that shown in Fig. 2, which is intended to represent a rectangular section bent in such a way that the neutral axis is the diagonal B D. Then the whole of the area A B D is in compression, and the whole of the area D C B in tension. The resultant of all the fibre stresses above the line B D lies obviously at some point R



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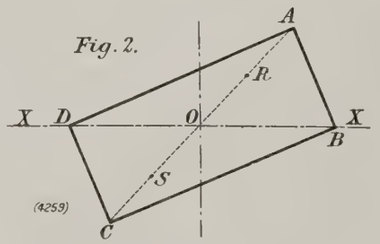


Fig. 2.

(4259)

on the line A O, whilst the resultant of all the fibre stresses below D B is at S on the line O C. The two resultants at R and S form a couple which balances the couple producing the bending. Since, however, a couple can only balance another couple when the two are in the same plane, the bending moment which gives rise to the neutral axis D B must be in the plane of A C, and is not therefore at right angles to X O X. In other words, in the case of a rectangular section, if a bending moment is applied in the plane of one diagonal, the corresponding neutral axis is the other diagonal. It follows from the foregoing that the common practice of reckoning the section modulus of, say, a 4-in. by 4-in. by ½-in. angle as practically equal to the section modulus of 4 in. by 4 in. by ½ in. T is illegitimate. This assumption is, however, very common, and the section moduli of angles given in the usual section tables have been calculated on this basis. The error is by no means negligible. Take, for example, a 4-in. by 4-in. by ½-in. angle. The section modulus tabulated for this in the tables is 1.93, and the stress caused by a bending moment M acting parallel to one leg is quite commonly taken as given by the relation—

$$p = \frac{M}{1.93} = 0.519\ M.$$

The actual maximum stress caused by such a moment is, however, 0.657 M. This can be shown as follows:—The table in question gives the moment of inertia I of such a section about an axis parallel to one of the flanges as 5.46, and the position of the centre of gravity as 1.17 in. from the outer face of each leg. The area of the section is tabulated as 3.749 in., and the least radius of gyration as 0.77 in., this being about an axis cutting the flanges at an angle of 45 deg. Hence one of the principal moments of inertia I_2, say, is

$$3.749 \times (0.77)^2 = 2.2228,$$

and the other, I_1, about an axis bisecting the angle between the flanges, is given by the relation—

$$I_1 = 2\ I - I_2 = 2 \times 5.46 - 2.223 = 8.697.$$

A line perpendicular to the plane of the bending moment makes an angle of 45 deg. with the principal axis of the section. Hence the true position of the neutral axis is obtained from the relation already given, viz.:—

$$\tan \phi = \frac{I_1}{I_2} \tan \theta = \frac{8.697}{2.2228} = 3.913.$$

The stress will be a maximum at that point of the section which is most distant from the true neutral axis. By drawing a full-size section, and scaling it, this point is found to be at a distance $y_1 = 2.53$ in. from one principal axis, and $y_2 = 1.42$ in. from the other principal axis. Resolving the applied bending moment parallel to the principal axes, each component is equal to 0.707 M. Hence the actual maximum stress on the section is given by the relation—

$$\begin{aligned} p &= 0.707\ M \left(\frac{y_1}{I_1} + \frac{y_2}{I_2}\right). \\ &= 0.707\ M \left(\frac{2.53}{8.697} + \frac{1.42}{2.2228}\right) \\ &= 0.657\ M. \end{aligned}$$

The stress thus found is therefore about 27 per cent. greater than when found by the inaccurate method frequently used.

THE MINERAL WEALTH OF SPITZBERGEN.

From being a neglected no-man's country, in which the world took but the scantiest interest, Spitzbergen has in a very short span of years become a land in which a number of big and smaller Powers are anxious to secure possession. It is her coal deposits which first and foremost have exercised this magnetic influence, next comes her unprecedented wealth of marble, and it is quite possible that the future may have further important geological discoveries in store for the world, inasmuch as Spitzbergen's formations are singularly manifold and varied. Her coal deposits are generally found in the tertiary formations, and a Norwegian engineer, Mr. Karl Bay, estimates the coal deposits on an area covering only 5 square miles within this formation, located between Green Harbour and Advent Bay, on the south side of the Ice Firth, in the two layers so far known there, to contain about 1,000,000,000 tons. This large tertiary formation extends from Bell Sound and Ice Firth to the Stor Firth, on the eastern shore of West Spitzbergen, but in addition there are a couple of smaller tertiary formations at King's Bay and Forland Sound. Coal, however, has also been found by the Swedes in Klaas Billen Bay. Along the whole of Green Harbour's east side, in the tertiary formations, two beds, as already mentioned, have been found; but there is reason to believe that there is a third. As a typical profile, Mr. Bay mentions one east of the whaling station, Green Harbour, where the upper bed consists of 95 cm. pure coal, then some 17 cm. clay-slate, and 30 cm. coal-slate, and, finally, a layer of 38 cm. pure coal; in another place the upper coal layer measures 70 cm. pure coal, the intermediates 80 cm., and the bottom coal layer 30 cm. pure coal. In a third place, at Advent Bay, there are two intermediate strata of an aggregate thickness of 60 cm., whilst the three coal layers have an aggregate thickness of 1.30 metres. This was the first deposit worked, but it was discontinued, probably because the harbour accommodation was inadequate.

Most of the coal deposits at King's Bay are pure coal, without any intervening strata, the thickness being 1.5 metres, the gradient being moderate, from 10 to 30 per cent. All these coal layers are sharply defined, and the covering strata are firm, and stand well after the breaking of the coal. The average thickness of the coal layers may be put at 1 metre, fully, or about the same as the English average. Four analyses showed a coke production from 54 to 60 per cent., and 37 to 44 per cent. gaseous contents. The percentage of ash is somewhat low—3.8 to 5.6 per cent.; the percentage of water at air-drying, 3 to 4 per cent., at 100 deg. Cent., 1.5 per cent.; heating capacity, 12,000 B.Th.U., consequently moderately high.

The coal is not particularly suited for gas works; but on account of its heating capacity and low percentage of ashes it is excellent steam coal. It is free from dust and breaks in good-sized squares when worked.

All reports place the Spitzbergen coal very high. Only one coal-mining company has, so far, established what may be termed rational working at Spitzbergen—viz., the Arctic Coal Company, in Advent Bay, which commenced operations in the year 1906. The pit mouth is about 1 km. from the harbour and 200 metres above the level of the sea. The coal has a thickness of 1.10 metres, and the quality has always been excellent. The working is very easy, there being no water in the mines, on account of the frozen ground; there is no development of gas, and the coal gives no dust; the temperature keeps at a couple of degrees Centigrade below freezing point throughout the year. The health of the miners has so far been excellent, and there has been no lack of hands. On time work a man is paid 6s. 6d. per day, 1s. 7d. being deducted for board and lodging; on piece work he can earn as much as double that wage. There is a railway down to the quay, which has a length of 200 metres. The company shipped 25,000 tons of coal in 1911, and 40,000 tons in 1912 and 1913. Modern cargo-steamers take only forty-eight hours from Ice Firth to Northern Norway, where it is considered advisable to arrange for large dépôts.

Besides coal, Spitzbergen is excessively rich in marble, located in a cluster of islands at the bottom of King's Bay. It is claimed for these deposits that they are absolutely unique, the islands simply consisting of nothing but marble of the most varying colours and kinds. The solid marble rock goes, so to speak, right to the surface, being only covered with a layer 1 to 2 metres thick of loose stuff caused by the frost, and the conditions for shipping are simply ideal, the greater part of the shore being a firm, steep coast, 1 to 2 metres high, with deep water immediately outside. The country rises gradually from the coast, and several streams, with some elevated lakes further inland, yield a sufficiency of water. So far, about forty varieties of marble have been worked, some of them are entirely new in colouring, and the extent of the deposits seems simply inexhaustible. The marble is found in three formation groups—Devon, Breccia, and Carbon—all of which go right to the coast, and the transport on shore is of very small amount. Some three years ago Marble Island was surveyed and examined by several leading experts, and since then further examining work has been going on. A number of installations so as to facilitate shipping, &c., have been carried out, and diamond borings show solid, first-class marble to a depth of 100 metres. Further back marble ridges rise to a height of from 100 to 300 metres, a formation not known anywhere else. Working is now being carried on in a systematic manner.

THE RAILWAYS OF NEW ZEALAND.

THE annual report of the Government railways of New Zealand for the year ending March 31, 1914, has recently come to hand, together with two rather interesting documents relating respectively to the past and future of that system. The annual report is compiled, for the first time, by Mr. E. H. Hiley, who replaced Mr. T. Ronayne as general manager in October, 1913. Mr. Ronayne, who then retired, had occupied that post since 1895. The annual report is supplemented by a summary of the development of the railways during that period. In addition, there have been issued an independent report, by Mr. J. H. Lowe, on the condition of the railways at the time of Mr. Ronayne's retirement, and a statement on future requirements by the new general manager.

The figures given in Mr. Ronayne's summary show a really remarkable expansion. In the period in question, the total revenue, for instance, has increased no less than 247 per cent., in spite of reductions in rates and fares equivalent to 350,000*l.* per annum, as compared with those ruling in 1895. In many ways the Government of New Zealand has been lavish in its concessions to the patrons of its railways. The list of these is far too lengthy to enumerate, but it may be stated that it includes reductions in ordinary and season-tickets, week-end tickets, cheap rates to young people travelling to work, to religious bodies, sports teams, &c., cartage of luggage, reductions in excess rates, concessions on parcels, dairy produce, honey, vegetables, coal, live stock, frozen meat, wool, lime, &c. It is evident, however, that this generosity has gone somewhat too far, and the policy has of recent years had to undergo some readjustment in view of the increased price of labour, &c. At the same time it has of late years become evident that the 3 per cent. policy adopted in 1897 did not provide sufficient net revenue. It was decided in 1897 that any balance beyond a 3 per cent. return on capital invested should be returned to the public in the form of concessions. We have frequently expressed the opinion that this figure was placed too low. In 1909 it was found advisable to raise the figure to $3\frac{3}{4}$ per cent., and in 1910 to 4 per cent. During the whole of Mr. Ronayne's *régime*, in spite of all the unprofitable services demanded by the Government, the railway system produced the stipulated interest on invested capital. That it has failed to do so in the last year under review is neither due to fault of his, or of his successor. The cause appears rather to have been in unforeseen circumstances, including a small-pox epidemic, serious labour troubles, and an unfavourable season resulting in heavy floods. All these contributed to the interference with normal traffic, so that the net result for the year is a return of only 3.33 per cent. on the capital of 34,980,576*l.*, invested in this system of 2863 miles worked.

The gross revenue for the year under notice stood at 4,043,328*l.*, and the expenditure being 2,880,323*l.*, the working ratio was 71.24 per cent. This is an increase of no less than 3.11 per cent. on the previous year, and brings the figure up to a rather high standard. The expenditure, which has increased during the year, has been swollen by advances to the staff and by additional train services. At the same time it should be noted that a number of improvements to open lines are constantly being paid for out of revenue, so that the standard of the system is higher than the capital cost would indicate. Such improvements embrace extensions to signalling, siding accommodation, new wharves, duplication, new tablet stations, and so on, including, therefore, items which might reasonably be charged to capital. The total amount thus spent to the date of the report appears to have been close on half a million sterling. The system appears to have been well kept up on the whole.

The report by Mr. J. H. Lowe goes into the question of increased expenditure in maintenance, and concludes that the expansion in this direction has been inevitable, owing to the demands of labour and the higher requirements of the public. Mr. Lowe, being a civil engineer, conducted his examination of the railways from that particular point of view. He is consequently somewhat at variance with the recent policy of the New Zealand railways as regards the conduct of traffic. The late general manager rightly, we believe, concentrated a good deal of effort on the question of economically handling the freight traffic in large train-loads. To this end, the standard of the permanent way was gradually raised, and 70-lb., and even 100-lb., rails were introduced on main lines in place of the earlier 53-lb. and 56-lb. sections. Wooden bridges have been replaced by steel, and, concurrently, the average tractive power of the locomotives has been increased from 6528 lb. to 12,989 lb. In 1895 the heaviest locomotive weighed 63 tons; to-day the largest on the system weighs 94 tons. Mr. Lowe's report raises the old question of the permanent way *versus* the locomotive. Mr. Ronayne and, we are pleased to see, Mr. Hiley believe in making both equal partners in the good work. While Mr. Lowe advocates no further increase in train-loads, but rather the running of more frequent trains in order to save the permanent way from heavy loads, which will involve still further expenditure on betterments, Mr. Ronayne and Mr. Hiley both hold the recent policy of the railways to be correct and capable of still further economic development.

It is not unnatural that Mr. Hiley should take this view, having relinquished, in order to take up his present appointment, a position on the one railway in England which has gone minutely into this point with eminent advantage. Mr. Hiley's statement with regard to the future needs of the system mostly bear on this subject. He reviews the present condition of the system from the broad view of economic and progressive operation, and all his suggested changes are proposed with a view to enabling the officials to keep in closer touch with the public requirements, and the improved loading of trains. Not overlooking what has already been done in these respects, the present general manager advocates the appointment of certain new officials so as to free others from routine work and make it possible for them to keep in closer touch with actual operation. At the same time expenditure on urgent works is proposed to the amount of 3,250,000*l.* The proposals are mostly concerned with improvements to stations and station yards, under which heading two items of respectively 450,000*l.* and 480,000*l.* are proposed for alterations and extensions at Auckland and Wellington, and 320,000*l.* at Christchurch. The work of duplication which has occupied attention of late years, Mr. Hiley thinks, should be continued, and he has allotted a sum of 485,000*l.* to this class of work. Two other interesting proposals bear directly on the big-train-load question. One has reference to grade reductions, and one to the purchase of powerful Garrett locomotives.

With regard to grade reductions, some work of this character has already been done in the neighbourhood of Auckland, at a cost of 92,000*l.* The full benefit of this, however, will not be secured until some further work on the same 45-mile section is taken in hand in order to reduce the maximum grade thereon from 1 in 40 to 1 in 100. The work involved will, it is estimated, cost about 150,000*l.*, making a total for this improvement of 242,000*l.* The advantage, however, will be appreciable, since with the same class of engine the possible loads will be increased from 162 to 494 tons. This is an improvement on the trunk line, which has only been completed in recent years, between Auckland and Wellington. On another section of this line, about 40 miles further south, there is a grade of 1 in 43, which restricts the train-load at present to 209 tons. This it is also proposed to reduce to 1 in 100, rendering loads of 494 tons possible from Auckland to Te Kuiti. Still nearer the Southern end of the North Island, there are grades of 1 in 44 at Greatford and Kakariki. These can be reduced at a cost of about 50,000*l.* to 1 in 70, permitting an increase of train-load from 209 to 355 tons. For a distance of 100 miles between the two last-mentioned sections there are ruling grades of 1 in 50, the reduction of which could only be undertaken at a cost which must at present be regarded as prohibitive. Still nearer Wellington there are ruling grades in one direction of 1 in 53, and in the other of 1 in 35. These, it is stated, it will be possible to reduce, but it is not proposed to take the work in hand at once, owing to other proposals of a more urgent nature.

Another interesting suggestion concerns the reconstruction of the Wairarapa line, on which there are severe gradients, the worst being one of nearly three miles in length at 1 in 15, well known as the Rimutaka incline. The actual paying load handled per engine on this incline is only 20 tons, involving much waste of time in marshalling at the top and bottom of the bank. This incline it is proposed in the near future to cut out.

For some time the State Railway locomotive stock has been constructed either in the Government shops at Addington and Hillside, or at contract shops at Thames. The expansion of the railways in the North Island has made it desirable to erect Government shops for the building of locomotives somewhere on that system. The point suggested is Newmarket, on the outskirts of Auckland. One argument in favour of this proposal is that for every engine built in the South Island for use in the North, the sum of 380*l.* is expended in packing and re-erection, while the delay involved is about 28 days. Sea freight has to be found in addition, so that for fifty-four locomotives transferred from the South to the North Island in the past seven years a sum of no less than 71,000*l.* has been required to cover these items. With the introduction of heavier engines for the North Island system, these costs would naturally increase.

Mr. Hiley's statement covers so large a field that we can touch only upon a few features of it. It reveals an enthusiastic desire to establish the system upon the soundest basis, not stinting expenditure if business will be stimulated thereby. At the same time the general manager is careful to let it be known that the system should not be committed to expense by political parties. He points out that at present the construction of lines is

decided upon without consultation with the Railway Department; that the work is placed in the hands of the Public Works Department and that the line is handed over, without stock and often with unsuitable grades and alignment, to the railways, which are given no opportunity beforehand of preparing a statement of probable revenue, cost of working, &c. In place of this unsatisfactory practice, M. Hiley asks for the introduction of the Victorian system. In Victoria there is a non-party Parliamentary Standing Committee on Railways. When a new line is proposed it is considered by this Committee, which calls for estimates for construction and working, with probable traffic and revenue. After consideration of these reports the Committee recommends to Parliament whether the line shall be built or not. A similar system might be adopted in other Australasian States with advantage.

AIRCRAFT IN WARFARE: THE DAWN OF THE FOURTH ARM.—No. XVI.*

By Frederick William Lanchester, M. Inst. C.E.

The Fourth Arm in Peace Time.

The problems connected with the maintenance of the Fourth Arm in time of peace are numerous, and present difficulties which will certainly be found to increase as the numerical strength of the Arm is augmented. It is not easy to form any real conception of what the future may have in store in the direction of numbers, but as a matter of pure guesswork it is difficult to believe that, sooner or later, the *personnel* of the Flying Corps will not reach or exceed 1 per cent. of the total strength of all Arms. Thus a considerable part of the work formerly allotted to cavalry will in the future be assigned to the new Arm, and the cavalry ordinarily represents numerically 6 per cent. of the total forces. Again, the guns will require the assistance of aircraft, probably one or more machines being attached to each battery. Beyond this there will be fighting-machines of different denominations. Taking everything into consideration, the suggested 1 per cent. does not look like an over-estimate; it is probably too low. Assuming, however, 1 per cent. as a basis, the numbers are sufficiently formidable. Thus, for the British regulars on home service prior to the outbreak of war, the number of the *personnel* would need to be about 1200 or 1300 men (combatants), and, allowing for machines out of commission, a total of some 700 or 800 machines. In the case of the large Continental armies—say, the French—with over 700,000 men (peace footing), the *personnel* of the flying corps would require to be 7000 combatant strength, representing a total of about 4000 machines.†

The peace training of these vast numbers of flying-men would represent an organisation of immense proportions, especially if the writer's anticipations in such matters as aeronautical tactics, formation flying, &c., come to be realised. The multiplicity of flight-grounds, training-schools, workshops, sheds, &c., with the necessary staff of instructors, mechanics, and other non-combatant members of the organisation, will render the whole matter a very big undertaking.

In view of the probable magnitude of the business, it is to be feared that the question of peace-time casualties in the Flying Corps is going to become an extremely serious and important matter. It is quite certain that everything possible must be done to minimise the dangers of military flying in peace time. This looks like a self-evident proposition, but it is not. The writer has frequently passed comment on the seriously defective nature of some of the existing flight-grounds, and has found himself met by the argument that since the men will have to alight upon pasture land, or even ploughed fields, when on service, it is best that they should have plenty of experience of rough ground when at home; further, that it is necessary to test the strength of the machines by using them in peace time under service conditions. So far as the machine is concerned, this kind of argument is altogether unsound. If the *type* is one that has been thoroughly tested in the first instance before adoption, and if the machines are properly inspected during manufacture, they will be far more reliable in the battlefield if they have not been knocked about by rough treatment over bad ground in peace-time flying. Testing to destruction is good in its way, but the particular article so tested must not be subsequently used. With regard to the men themselves, the argument that a bad ground is better than a good one is almost as gravely at fault. One hundred alightings on a good ground (with a fair surface and without obstructions) will carry less risk than, say, 20 or 30 on a poor or bad ground, and the man who has made his 100 alightings, with, if we wish, *imaginary* obstacles, is a better man than the one who has only done his 20 or 30, especially if the latter is disabled or dead. A man who practices jumping uses a light lath, which will do him no injury if he fails, in spite of the fact that his object may be to join a club of harriers and jump a five-bar gate.

A somewhat knotty point is that of the duration of the service life of an aeroplane. So far no definition has been generally accepted. The truth is that any machine may become "superannuated" either owing to *depreciation* or to *obsolescence*. In the former case it is the number of miles covered that will be the determining factor, coupled, perhaps, with other data relating to its history; in the latter it is the age of the machine which determines its unfitness for service, considered, of course, in relation to the advance that has been made in the art of construction since the date of building. Thus a machine may be unfit for service either because it is, according to some accepted definition, *worn out* and incapable of repair, or because it is *obsolete in design*. In some cases obsolescence may be *absolute*, as when a design is so out of date that by comparison with the best available it is to be considered unsafe or uneconomical; in this case it is only fit to be destroyed; or its obsolescence may be *relative*, as when it is outclassed by the machines of corresponding type in the service of some neighbouring Power; in this case it is fit to be sold out of the Service or to be transferred to some distant part of the Empire, where competition is not equally severe. The questions of depreciation and obsolescence and the disposal of condemned machines have not yet received due consideration. In a recent case of a machine which fell to earth, owing to a structural failure, an elaborate investigation was made, and certain recommendations resulted; but it was impossible to assign any satisfactory and definite reason for the failure. Broadly, at the time the machine was built it may be said that the knowledge of aeroplane construction accumulated from one year to the next was sufficient to determine the obsolescence of any machine in that period; *the machine on which the post-mortem investigation took place was approximately two years old.*

The foregoing may be taken as no more than samples of the many questions that have to be faced before the training of army pilots and aeroplane gunners and signallers can be attempted in the thousands, or tens of thousands, for which the warfare of the future may call. Without adequate consideration of these questions, coupled with appropriate measures, progress in the direction of increase of numbers and the practical development of aeroplane tactics on a large scale would be most seriously handicapped.

Present Position. British Superiority.

The reports as to the performance of the aircraft, and more particularly the aeroplanes, of the different belligerent armies are at present very meagre and incomplete. However, it would appear from the observations of those best qualified to judge that the British machines are by no means backward, and in many important respects are superior both to those of the enemy and to those of our Allies. The main features in which we at present possess ascendancy are more especially those in which the flying capacity of the machine, rather than its more essentially fighting quality, is concerned. Thus superiority may be claimed for the British aeroplanes: firstly, as being better *aerodynamically*—that is to say, for given horse-power and weight they possess a greater speed and climbing power; secondly, they are more stable—in fact, our present-day machines are definitely automatically or *inherently* stable; thirdly, they have a higher factor of safety than any of their Continental rivals and are far more robust as to alighting gear; and, fourthly, they are more weather-proof. In short, they are better fitted to service conditions. Beyond this, the latest model turned out by the Royal Aircraft Factory is by far the fastest machine in the world, being some ten or twenty miles per hour faster than anything that the Continent can show. On the other hand, on the outbreak of hostilities we found ourselves without a thoroughly satisfactory fighting or gun-carrying type of machine—it is one matter to be able to mount a gun on an aeroplane, and quite another to design and construct machines expressly for that purpose. It is, indeed, doubtful whether any really satisfactory gun-carrying aeroplane existed at all; but it is in any case precisely in this direction that our own air service has found itself most lacking. In brief, it may fairly and undoubtedly be claimed that so far as the reconnaissance machine is concerned, the British aircraft are more than able to hold their own with those of the other European nations.

In the main the "proprietary" machines built by private firms have lacked the all-round qualities of those turned out by the Government factory, or under contract to the Royal Aircraft Factory specification. In some cases they have failed from a constructional standpoint; under the exacting conditions of service the alighting chassis have sometimes proved inadequate; in other cases the weather-proof qualities of the "proprietary" machines have been found deficient. These defects have shown themselves amongst British-built machines, but also some of the best known of the French makes have failed, or at least are reported to have cut a very sorry figure when submitted to the rigorous test of service conditions in real warfare. Possibly it was not anticipated (as it appears is the case) that machines would be required to remain permanently in the open night and day, shelter being the exception rather than the rule. It is under these conditions that our own Aircraft Factory machines have exhibited an unrivalled robustness of constitution. On behalf of the "proprietary" makes of machine, however, it must be said that some of the most notable of the exploits performed by the Naval Air Service (such as the raids on Düsseldorf and Friedrichshafen) have been performed by such machines,* which appears to show that, merely from the point of view of flying, they are fully worthy of the Service and a credit to their designers and constructors.

Causes which have Contributed to British Ascendancy.

The position of the British in the matter of military aeronautics—more particularly aviation—to-day, which, subject to the limitations stated, may properly be described as "ascendancy," is not to be attributed to any one definite cause; the results achieved in the field have been contributed to both by the *personnel* of our Flying Corps and Naval Air Service, and by the sound qualities of the machines employed. In view of the peace-time exploits of the airmen of the three leading Western Powers, in which it may fairly be said that honours have been divided, it would appear that, without belittling the magnificent performance and daring of our flying men, it is in the matter of material — *i.e.*, actual machines, &c.—that our superiority is most marked.†

In discussing the influences which have led to the development of the present-day types of service machine it must be borne in mind that these influences have been at work in the factories of the private firms engaged equally with the Government factory at Farnborough. There has in

* This is the final article of the series. The first appeared in our issue of September 4, and the remainder have appeared in successive issues, with the exception of the issue of December 11.

† The fact should not be lost sight of that Great Britain may require to regulate the strength of her Flying Corps by that of her neighbours rather than by the strength of her own Army.

* The execution of these somewhat sensational feats of arms by naval airmen must not be taken to mean that they could not have been performed equally well by members of the Royal Flying Corps, but rather that the latter are fully occupied by their regular daily work of military reconnaissance, and are actually no more than numerically sufficient for the needs of our Army in the field. In the Navy, the routine or "business" employment of aircraft (more especially aeroplanes) is not yet understood; the efficient patrolling by aircraft of the seas in which a state of war exists—the North Sea, in the present instance—should be considered by the Air Department of the Admiralty to be its most important duty; this will require the systematic employment of a considerable fleet of aeroplanes, which should, if possible, be machines of 16 or 18 hours' capacity and at least capable of 80 miles per hour. The large airship, until recently in contemplation for this duty, is, in the writer's opinion, a hopeless proposition, the key-note in matters of military or naval advancement is *mobility*, and again *mobility*, and always *mobility*.

† In time of peace the opportunities for public demonstration accorded to Service machines are limited.

the past been little or no secrecy in connection with the Royal Aircraft Factory—private builders and the designers attached to private firms have virtually had the "run of the place," and all assistance that has been possible has been rendered them; so much so that on more than one occasion features due to the Government staff have made their first appearance on "proprietary" makes of machine. In brief, there has been no attempt to deprive the private firms of any of the information available.

The main factors that have contributed to the production of the machines of outstanding merit, which are upholding our reputation in the field to-day, are unquestionably the greater scientific knowledge possessed by our designers, and the conspicuous ability shown by the staff of the Royal Aircraft Factory in making practical use and application of the latest and best information at their disposal, and in their own full-scale experimental work and study of the many practical problems outside the range of purely scientific research. The machinery set up by the Government for dealing with a new and difficult question of the greatest national importance, has, so far as its allotted scope is concerned, worked with singular smoothness and with undeniable effect. In brief, we have the Royal Aircraft Factory, which may be regarded as the headquarters of the national sources of production, and in itself of the character of an experimental or pioneer department rather than a national manufactory. Behind this we have the Advisory Committee for Aeronautics, a body whose functions are mainly concerned with scientific and technical questions, and at the disposal of the Advisory Committee a large and growing department forming part of the National Physical Laboratory. In addition to this, there exists the Naval side, consisting of constructional works and dépôt at Aldershot, which has taken over in its entirety the Dirigible (Balloon) section of the work. The secretarial headquarters of the Advisory Committee is permanently located at the National Physical Laboratory, the Director of the latter, Dr. R. T. Glazebrook, F.R.S., being the Chairman of the Committee under the presidency of Lord Rayleigh, O.M., F.R.S., and the Army being represented by the Director-General of Military Aeronautics, Major-General Sir David Henderson, K.C.B., the Navy by the Director of the Air Department of the Admiralty, Captain Murray F. Sueter, and the Royal Aircraft Factory by the Superintendent, Mr. Mervyn O'Gorman, C.B. In a sense the Advisory Committee may be said to act as a "clearing-house" for information, inasmuch as its functions are to ensure, on the one hand, that the information obtained from the work done at the National Physical Laboratory, and collected from other sources, is duly made available to the Royal Aircraft Factory and the Services, and, on the other hand, to hear and dispose of the difficulties and demands of the said parties. This may be a matter either of tendering immediate advice or of appropriately employing the resources of the National Physical Laboratory, or requisitioning any such other assistance as may be deemed expedient. The work is carried out in the main on the basis of an annual programme framed on a sufficiently elastic basis to allow of all possible contingencies being dealt with. In addition to the foregoing, the Committee receive and publish a considerable number of new investigations, also abstracts of most of the work of importance done on the Continent; in these latter respects the work accomplished by the Committee can be best judged from a perusal of the Annual Report presented to Parliament.* It is by these means that those responsible for the design, specification, and construction of our aircraft, whether military or naval, have been, and are, kept fully informed of all that concerns them from both technical and scientific standpoints, and have been able to employ the somewhat limited resources granted them by the Treasury to the best possible advantage. Beyond this the staff of the Royal Aircraft Factory includes men of exceptional resource and ability who have proved themselves again and again more than competent in the execution of the duties entrusted to their care. It is impossible in this connection to pass over without mention the great loss which the factory (and the country, it may be said), has suffered in the death of Mr. E. T. Busk, who recently lost his life in the execution of his duties, being burnt to death in mid-air whilst personally carrying out investigations of an experimental character. Mr. Busk combined with exceptional ability as an experimenter a very thorough knowledge of his work; he was largely responsible for the design and construction of many instruments and appliances which have proved of the greatest service in the development of the present-day machine.

There are many of the less-informed members of the public who believe that the flying-machine has been developed, and is to-day being designed, by empirical methods, and that the scientific man has had nothing to do with it, except, perhaps, late in the day, to give plausible explanations of the "whys and wherefores." Nothing is further from the truth. The work relating to the design and construction of the modern aeroplane is quite as much the result of careful and scientific calculation, in fact, rather more so, than in the case of shipbuilding. All matters connected with the flying properties of a machine, whether it be lifting power, propulsion, or stability, are amenable to rigorous scientific treatment, and are as carefully founded on scale-model and wind-channel experiment as the analogous problems in ship design.

In scientific work connected with flight (as pointed out by the writer in his recent James Forrest Lecture), the work that has been done in this country is far in advance of that done on the Continent; more especially is this the case in connection with stability: it is fair to take it that the advantageous position in which Britain finds herself to-day in the matter of aircraft is legitimately to be regarded as a reflection of this fact. No one acquainted with the history of the development of our Service machines can have the slightest doubt as to the truth of this statement.

Maintenance of British Superiority.

The maintenance of the present superiority of the British reconnaissance machine and the development of different types, and, in short, the building up and consolidation of the Aeronautical Arm, both as to quality and quantity, in order to ensure our capacity to hold our own with the other great Powers, is a task of national importance, and, as such, one of the first magnitude. In order that our Aeronautical Arm may be raised and maintained as a whole at the necessary high degree of efficiency, more will be needed than merely the technical superiority of our machines; many other questions of vital consequence will require to be adequately dealt with. However, the basis of strength lies in possessing the right machines in adequate numerical strength. Hence there must be no relaxation of effort; we must retain our technical ascendancy by every means in our power.

There is much to be said at the outset in favour of the exercise of greater secrecy in the matter of technical information. At present a great deal of work of an important character is done at the public expense which is of the utmost value to the aeronautical constructor, and forthwith it is given complete publicity; one has only to glance through any one of the annual reports of the Advisory Committee to realise the extent to which this is the case. There is, it is true, also a great deal of work which is not published, being considered as of a confidential character. The question arises whether the main body of the work, or, at least, some of the more important sections, should not be held back, and treated as confidential for a certain period, possibly one complete year, in order to give our own designers a twelve months' lead. The difficulties in the way of any such scheme are, firstly, that, to be effective, the first twelve months' output of any new design would require to be met as output from the Government factory; the conditions issued with designs and specifications for tenders, though nominally intended to ensure secrecy, can never be really effective.

In the second place, in the case of a branch of Governmental activity as little understood by the public as that of aeronautical construction, the public and Parliament expect to see something for their money, and for those entrusted with aeronautical development to have shrunk from publicity would have been equivalent to committing suicide. In spite of any disadvantage which may have resulted from publicity in the past, the net result has been highly satisfactory. It is quite probable, however, that the Continental Powers have somewhat underrated the importance of the work that had been done in this country, and have taken no particular pains to follow or study that work. Certain it is that, technically, the Continental nations are, without being aware of the fact, some way behind us in aeroplane design. The writer is disposed to think that, all things considered, it will be found advisable in the future to restrict publication somewhat, and considerably to strengthen the Aircraft Factory, to enable full control to be exercised over new models, and otherwise to take steps to ensure secrecy where, in the national interest, it may be deemed wise.

Government *versus* Private Manufacture.

In every problem of production in quantity, otherwise that which is termed "manufacture," the essence of true economy is *continuity*. The whole of the organisation of a modern factory is based on the work in progress being of the nature of a "flow," rather than a succession of jerks. In actual practice it is only in the case of certain industries in which the goods manufactured are not liable to change from year to year, and in which the demand is not of a fluctuating character, that the "flow" can be maintained under ideal conditions—that is to say, with perfect uniformity. In other cases fluctuations are inevitable; changes in design necessitated by the stress of competition and the advance of knowledge prevent the condition of perfect *continuity* from being realised. Under these conditions a not inconsiderable part of the duties of the organisation is that concerned with negotiating the necessary irregularities and changes. The work still is dealt with on the theory that it remains a flow, but it is actually a succession of batches, the flow being comparable to that of a river subject to seasonal fluctuations, periods of flood alternating with periods of slack. The system of organisation requires to be framed to deal with the consequent unavoidable breakages of continuity, and it is the business of the works and engineering staff so to regulate the progress of work that the resulting disorganisation is minimised, and the economy of production is not too seriously impaired. The possibilities of the situation, so far as the management staff is concerned, are very much circumscribed by considerations of finance and the exigencies of the market. These latter questions are, or should be, dominated by the prevision of the directorate; they are matters governed by the *policy* of the company, for which the board of directors (directly or through their managing director) should be definitely responsible. The *policy* thus includes such questions as the market or markets to be attacked; the quantities and dates at which it is estimated sales can be effected; the financial needs, whether it be for building or plant extensions or for stock-in-trade, and the provision of, or the raising of, the necessary finance.

In brief, in a well-managed concern the Board may be said to control that which is in military parlance the strategy of the company, whilst the management staff look after the tactics. Clearly, just as in military affairs, success must depend very largely upon the strategic scheme being accommodated to the tactical resources, and the tactical work being skilfully adapted to the strategic scheme.

Now, in the case of a Government factory, there is no real board of directors. The financial side is controlled by the Treasury, whose interests are not concerned with the prosperity of the concern in the least degree; it is equally satisfactory from a Treasury standpoint whether the "grant" can be reduced by the most arbitrary and expensive "cheeseparing," or whether it is done by legitimate and proper means—by the exercise of true economy. The result is that anyone acquainted with the working of Government manufacturing institutions could cite innumerable cases of gross extravagance resulting from so-called Treasury economy. Again, there is no one to formulate in advance a proper manufacturing programme with the least assurance that there will be the means available in order to carry it to a successful conclusion; even iron-work of a part-finished structure has been known to be denied the wherewithal for a coat of paint! The cast-iron system of closing the programme at the termination of each financial year without carry forward is destructive of good management. Thus the position of a Government factory is equivalent to that of an army with no Minister of War, no strategic scheme, and a capricious and fitful transport and supply. The larger institutions, such as dockyards, &c., represent a national interest of sufficient magnitude to escape some of the disadvantages of Govern-

* Reports 1909-10, 1910-11, 1911-12, and 1912-13, at present published.

ment control, but here the circumstances are exceptional.

Manufacturing by private firms under contract, therefore, has considerable advantages; but even here the want of regularity in the placing out of orders is not conducive to high economy; a private firm, however, is able to work in one job with another and execute a Government contract in lieu of other work for which there may happen to be a lull in the demand. This is especially the case in war time, when (as at the present moment) a large proportion of our engineering works and factories, having little demand for their regular products, are mainly occupied in turning out munitions of war. Whatever the state of preparedness may be before war is declared, it is almost certain that the needs of the country, whether for aeroplanes, guns, or other items of armament, will be increased many times during the period of hostilities. The employment of private enterprise under these conditions is clearly desirable, and may be looked upon as imperative.

Once admit the above, the propriety of widely utilising the ordinary manufacturing resources of the country during peace time follows as a corollary, for it is only by this means that these resources can be brought promptly into operation when the need arises. A firm which has once executed contracts for any given article is always in a better position than one to whom the work is new; this is true in any case, but is more especially so where the preparations for manufacture involve the duplication of gauges, tool outfits, &c.

When work is done by contract it is absolutely necessary that it should be first *standardised* in every detail. The rigid methods of gauging and viewing which have definitely to be adopted when aeroplanes (or other implements of war) are being manufactured to Government specification and contract render anything in the way of ambiguity or alteration during manufacture intolerable. Therefore, whatever be the relative merits or demerits of private and Government manufacture, the former can only properly be resorted to for work which has passed its experimental stage, and has been finally standardised in every detail. This involves, in the case of anything so progressive as an aeroplane, that the Government will of necessity carry the manufacture of every new design up to a certain point; we may say up to that point at which it has become, after due tests and trials, an officially accepted type. This is almost exactly the position as it has come about: the Royal Aircraft Factory is directly responsible for the initial development of every new model (with the exception of some few "proprietary" types which have been taken into service); the only difficulty at present is that the resources of the factory are not sufficient fully to cope with even this preliminary work, and, in consequence, private enterprise is being called upon to do more than ought to be the case: the standardisation is having to be effected whilst manufacture is under weigh.

In view of the present position and the enormous development which may be anticipated in the course of the next few years, it will, in the writer's opinion, be necessary very greatly to strengthen and increase the establishment of the Aircraft Factory in the near future.

Future Maintenance of British Supremacy. Continuity of Policy.

The supremacy of British aircraft can only be maintained by the adoption of a thoroughly progressive constructional policy, guided constantly by the most recent scientific discovery and research, and by utilising to the full information and experience gained in the Services. The day is past when technique or craftsmanship in any direction can be permanently bottled, and the trade or craft in question monopolised by any one nation, as was at one time the case. Under present-day conditions the lead can only be obtained and held by mobility and progress in which the motive power is derived by the combination of brains, energy, and material resources. The most that can be hoped is to obtain a lead of two or three years in advance of other nations, and to keep it. The task is not beyond the power of the country; we have both the men and the money, and an Empire whose preservation demands that nothing shall be left to chance.

The key to the whole situation lies in the proper organisation and control of the manufacturing resources of the Government (as at present represented by the Royal Aircraft Factory) involving, firstly, a clear conception of the duties of the factory as being the birthplace of new types and the nursery for their development, and as the headquarters of full-scale experiment work (as distinct from laboratory experiment); that is to say, tests and investigations engineering in character, or those in which actual flying is involved. The deficiencies at present existing are due, firstly, to the fact that the Treasury has too much control over the Factory, and the Factory not enough control over the Treasury; secondly, there is no one upon whom definitely devolves the duty of initiating any departure in advance of immediate requirements; thirdly, the resources of the factory have been insufficient for the needs of the Services; it has been necessary to send out drawings and specifications to contractors before the designs have been standardised or even thoroughly established, with all the little attendant difficulties in the matter of minor alterations, ambiguities as to gauging, &c.; also with the loss of any real pretentions to secrecy. Lastly, there is a tendency to divorce the aircraft development of the two Services—the Army and Navy; this the writer considers to be bad. The main supplies of established types may certainly be obtained by the two Services from independent sources or from different contractors, but to separate the experimental or developmental phase of construction appears to have nothing to commend it.

The deficiencies of the present *régime*, such as they are, in no way reflect adversely on the existing staff and *personnel* of the Royal Aircraft Factory as it stands; in fact, it is undeniably greatly to the credit of all concerned that so much has been done. It is, however, hard to say who is supposed to be responsible for supplying initiative. That initiative has not been lacking is evident, but it is an open question whether anyone could have been accused of neglect of duty if the factory had never developed or constructed a solitary machine.

Actually that which is lacking is something analogous to a directorate, a Board whose existence would ensure continuity of policy, and whose members would be definitely responsible for the sufficiency of the constructional programme so far as its developmental side is concerned, and for securing the needed Treasury support.

A Board of Aeronautical Construction.

The duties adumbrated in the preceding paragraph would be best deputed to a Board of Aeronautical Construction in which both Army and Navy are represented by the responsible heads respectively of the two branches of the Arm—namely, the Director-General of Military Aeronautics and the Director of the Air Department of the Admiralty, in addition to a strong civilian contingent selected for their eminence or attainments in such directions as aeronautical or mechanical engineering, manufacturing, naval architecture, business management (organisation), finance, &c., and including the Superintendent of the Factory. In view of the fact that the future of the new Arm has yet to be determined, and in view of the vital importance of this future, it would seem desirable that certain Cabinet Ministers, such as the Minister of War and the First Lord of the Admiralty, should *ex officio* be members of the Board. This may possibly appear to be giving unnecessary importance to the idea, but it must be remembered that the existing Arms of the Services, during the earlier stages of their history, were considered of sufficient importance for the most minute and detailed attention of kings and princes, and the new Arm might almost claim as its right similar solicitude from those on whom the burden of office has fallen.

The duties and functions of the proposed Board would be in nowise limited to the aircraft themselves, but would extend to aircraft and counter-aircraft armament, and, further, to all questions of *matériel* ancillary to the employment of aircraft in the Services, including aeroplane vessels or ships.

The duties and constitution of the Advisory Committee for Aeronautics would remain as at present, being in no way affected. In some few cases it is possible that questions touching the work done at the Royal Aircraft Factory would be referred to the new Board in place of the Advisory Committee.

The arrangements regulating the Board in the matter of expenditure would need to be on a basis compatible with the responsibilities; a refusal or a cutting down by the Treasury of the requisitions by the Board, either annual or supplementary, should be rendered next to impossible. It would suffice for the purpose if, in case of such eventuality, it were made incumbent upon the civilian section of the Board to resign *en bloc*. Parliament and the public would thus be advised that something had gone wrong with the "machine." To create this position it is only necessary for a public statement to be made by a responsible Minister of the Crown that the Board has at its disposal whatever funds it deems necessary; this is virtually the footing on which the present Advisory Committee is placed.

The alternative to the creation of a Board, such as suggested in the present article, would be an extension of the powers of the Advisory Committee. The present functions of that Committee are strictly advisory; and they are, to all intents and purposes, confined to the scientific and technical side of the subject; the *personnel* of the Committee also has obviously been chosen on the basis of this being the intention. The Committee expends no money directly, but controls grants on account of aeronautics so far as relating to research work and the like. It would be impossible without destroying the whole intention and character of the Committee, to assign to it those duties in relation to the national programme of aeronautical construction for which the writer is advocating the formation of a Board of Aeronautical Construction; hence any such change may be regarded as out of the question.

Conclusion.

The present article being the last of the series, a few words are due by way of conclusion. In the preparation of these articles it has been the writer's endeavour to give some account of the possibilities of the future in military and naval aeronautics, so far as present knowledge permits of reasoned forecast. Various digressions have been made—always related to the main subject; also a few speculative incursions into the unknown have been ventured. There still remains much ground, however, which has not been traversed or attempted.*

It is the writer's present impression that, so far, the most optimistic amongst those in the Services who have made a study of military aeronautics scarcely begin to realise the full meaning and importance of the subject from the national standpoint; and if the present work does no more than rouse those interested to a broader realisation of the possibilities of the future, it will not have been in vain.

The teachings of modern history have shown that in warfare *speed* is the talisman of success; whatever the task may be, the man who can do the most in a given time wins. Sometimes, more especially in civil life, speed gives an advantage proportional only to itself, as in the output of an automatic machine-tool; similarly in war—in rapidity of gunfire, for example—the same is approximately true. When, however, speed spells mobility, and becomes the *means of concentration*, then its value is immeasurably enhanced, in that it becomes the factor controlling the numbers brought into action, and so commands the potential might of the n-square law. In the presence of an enemy we find in speed once more a decisive virtue, in that it gives the option of accepting or declining battle, a power which, if persistently exercised, may enable a small force to wear down an enemy many times its numerical strength. And still once more in reconnaissance, where the gleaning of information is concerned, speed becomes a deity; in such work seconds count as minutes and minutes as hours.

The world has scarcely yet acquired a true sense of proportion in these things; the bald facts are well known, but their significance is only slowly receiving recognition. As a fighting asset, where, for example, is the super-Dreadnought, with its 22 knots, in the face of a modern battle-cruiser, with 28 or 29 knots at command? Ship for ship, the battleship has on paper possibly some 50 per cent. greater fighting value; numbers of guns and inches thickness of armour can be expressed in figures, and appeal to even the dullest imagina-

* The possible employment of aircraft in connection with transport, for example:

tion—in other words, they "count;" but the overwhelming strategic and tactical value of speed is intangible, it does not figure on paper, and so fails to attract its due *meed* of appreciation. In exactly the same manner, the potential military value of aeronautics has never yet received a tithe of the recognition due. Impossible as it must seem, *the very fact of speed* was for long regarded by our military "experts" as something undesirable. The authorities even asked for and purchased a number of slow-flying machines, and it was not until experience was gained at the military trials and during the manœuvres of a few years ago, that the most elementary facts began to be understood. Then the interesting spectacle was witnessed of machines incapable of over 40 miles per hour or thereabouts, being sent out to reconnoitre in a 35 miles per hour wind. As well might a man be sent with a wheel-barrow. Experiences of this character have virtually killed the once advocates of slow flying, and to-day the doctrine of speed in flight is thoroughly established, both from the technical and military standpoints; but the question remains, Are we as enlightened in other directions? The answer is *doubtfully* in the affirmative, but we may at least believe that those who to-day have the responsibility and conduct of the defence of the Empire, and those who will follow, will cultivate and exercise mental flexibility to a degree unwonted in the past. They will not condemn, after the manner of their predecessors, the bicycle because it will not travel cross-country like a horse, or the aeroplane because it will not stand at "attention." The lesson has been learnt: a new engine of war differs from a human being in that its enumerated virtues are to be reckoned by the things that it does rather than amongst those which it does not.

McKEEN SWITCHING LOCOMOTIVE.—The McKeen Motor-Car Company, of Omaha, Neb., U.S.A., has recently turned out a 300 horse-power gasoline shunting-engine, for use by the Motley County Railway between Roaring Springs Junction, on the Quanah, Acme, and Pacific Railway, and Matador, Texas. The locomotive has a tractive effort of 12,000 lb. at a speed of 6 miles per hour. The engine is of the 0-4-2 type, the driving-wheels being 42 in. in diameter. The engine has cast-steel frames, the spring rigging being equalised. The gasoline engine is a six-cylinder motor placed transversely between the frames, the cylinders being 11 in. in diameter, with a 15-in. stroke. It is fitted with water circulation round the cylinder-heads and valves, with tungsten-steel valves and various other standard features of the McKeen cars. It has air reversing-gear, two 5-in. air-compressor being attached to the engine crank-shaft, while there is an auxiliary air-compressor in the cab for emergency service. The extremities of the main and rear driving-axles have outside counterbalanced crank discs connected by coupling-rods. Power transmission is pneumatically operated. A sprocket on the engine crank-shaft drives, by means of Morse chain transmission, a sleeve working free on the main driving-axle. By clutch the drive is then transmitted to the axle by gears, or direct. The rigid wheel-base of the locomotive is 12 ft. long, and length over the couplers 23 ft. The height from the rail to top of the exhaust-pipe is 13 ft. 3 in. The gauge is 4 ft. 8½ in., and the frames are 6 ft. 9⅛ in. centre to centre. The driver's position is in the middle of the cab, from which a clear view all round may be obtained.

A NEW MANGANESE STEEL.—We read in the *Iron Age* that an improvement in manganese-steel alloys has been patented in the United States (No. 1,113,539, October 13, 1914) by Messrs. William Campbell, John H. Hall and Henry M. Howe. It is said to possess the characteristic hardness of "the regular manganese steel;" but as it contains a lower amount of manganese, it is of cheaper production. Commercial manganese steel, adds our contemporary, contains from 11 to 14 per cent. of manganese, and hitherto any attempts to produce a steel lower in manganese than 10 to 11 per cent. has tended to make a metal as brittle as glass and unfit for commercial use. The inventors have discovered that a certain critical relation exists between the percentage of manganese and the percentage of carbon. They proportion the carbon content in accordance with this relation, and thus a steel may be obtained containing from 6 to 9 per cent. of manganese, or as low as 5 per cent.; this latter percentage is the lowest which can be worked to. The inventors state that the metal, having an amount of manganese less than 9 per cent., and somewhat more than 5 per cent., should contain carbon, other than graphite, between, or not materially exceeding, the following limits:—1.075 − 0.04 of the percentage of manganese as the lower limit, and 1.075 + $\frac{1}{10}$ of the percentage of manganese as the higher one. For example, for an 8 per cent. manganese steel the carbon content would be between $1.075 - (0.04 \times 8) = 0.755$ and $(1.075 + \frac{8}{10}) = 1.342$ per cent. The particular amount of carbon present is controlled within these limits according to the degree of ductility required of the product. The ingredients are preferably brought together in a molten state, as is usually the custom with manganese steel, and in the above proportions. After casting, the metal is properly water-toughened.

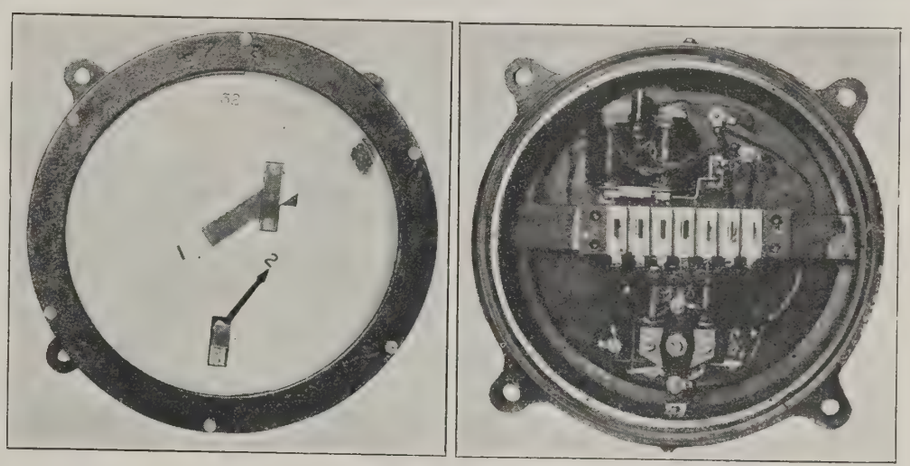
AUDIBLE AND OTHER CAB-SIGNALS ON BRITISH RAILWAYS.*

AUDIBLE SIGNALLING ON RAILWAY TRAINS IN MOTION.

By W. C. ACFIELD, Member, Signal Superintendent, Midland Railway, Derby.

To convey a signal or indication from a given position on a railway to an engine or vehicle travelling at a high rate of speed along the said railroad is one of the problems that has occupied the attention of inventors and others from the earliest days of steam-traction up to the present time, but for many years little or no progress was made towards a solution, as it was proved beyond doubt that a mechanical arrangement could not stand the shock to which two portions of mechanism are subjected at the moment of impact when trains exceeded a speed of 30 miles per hour. One of the greatest difficulties to be overcome in mechanical appliances is so to design the apparatus that it will fail on the side of safety, and at the same time render the giving of a false "clear" signal or indication impossible.

Another very important point is the ease of application and attachment to the engines or rolling-stock of railways over which, particularly in the United Kingdom, the trains of one company require to pass over and on to various other companies' lines in their progress to their respective destinations. Each year more and more through communication is introduced in the present-day system of enabling the travelling public to pursue their journey without having to change from one company's train to another, and, with the interchange running of trains from one part of the country to another, the problem of fitting all engines with similar apparatus becomes a necessity. It is a well-known fact that, in the past, very considerable opposition was offered by the locomotive engineers to any signalling appliances being fixed on the engine foot-plate, but it is only fair to say that to-day the locomotive engineers are more willing for apparatus to be installed on



FIGS. A AND B TWO-ROUTE INDICATOR ON CAB OF NORTH-EASTERN LOCOMOTIVE.

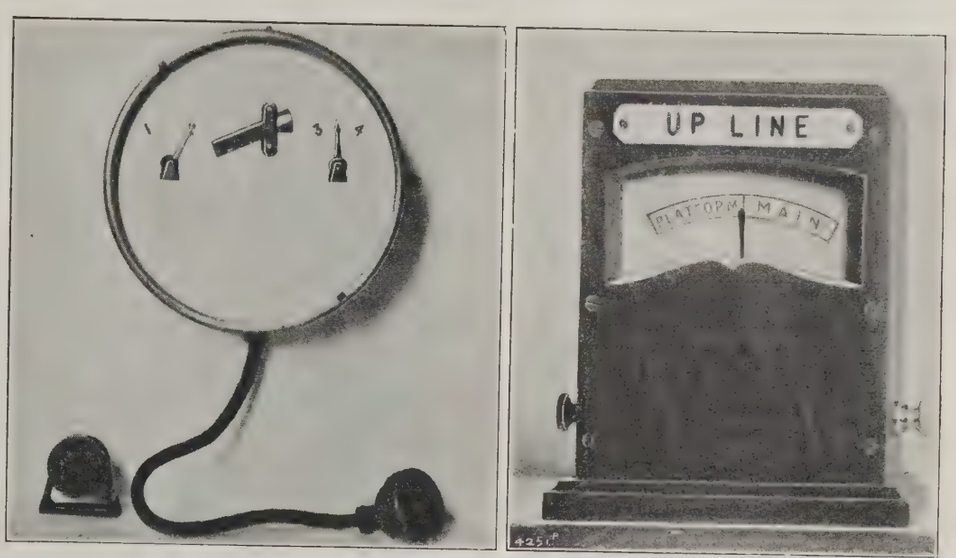


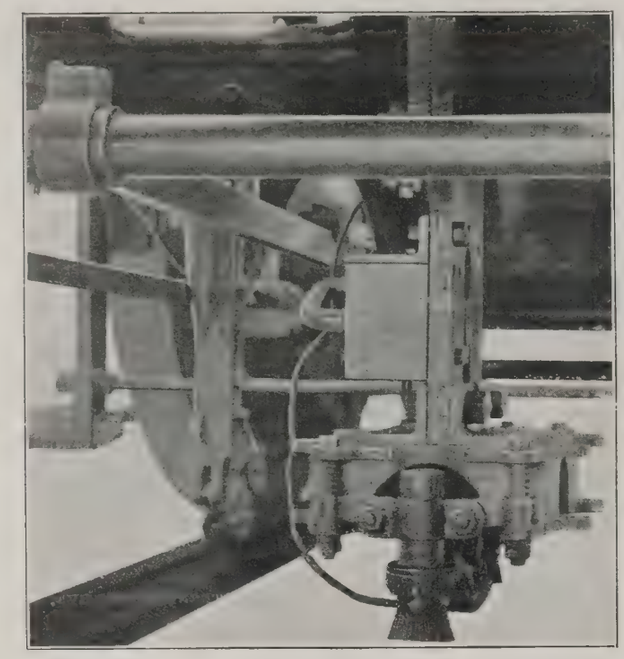
FIG. C. FOUR-ROUTE INDICATOR. FIG. D. CABIN INDICATOR.

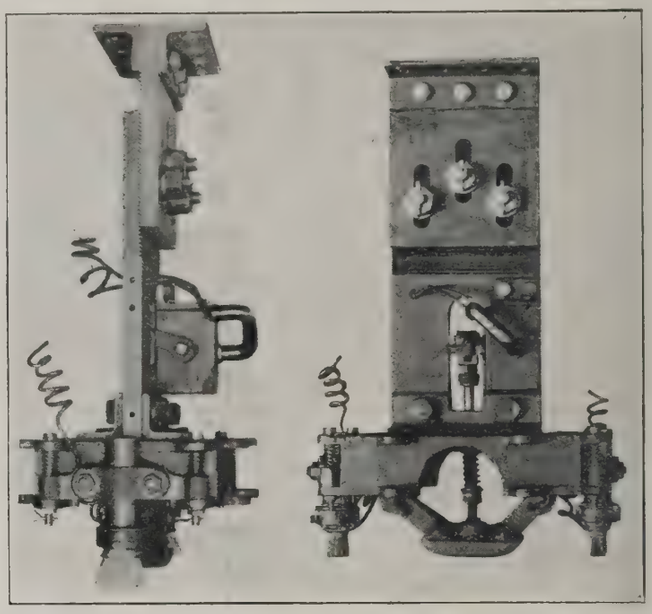
FIG. E. INSULATED TRACK BAR; NORTH-EASTERN RAILWAY.

* Five brief papers by Mr. W. C. Acfield, Member, Midland Railway; Mr. Leon P. Lewis, Caledonian Railway; Mr. Vincent L. Raven, Member, North-Eastern Railway; Mr. W. A. Stanier, Member, Great Western Railway; and Mr. W. Willox, Metropolitan Railway. Read before the Institution of Mechanical Engineers, December 18, 1914.

engines for the purpose of making trials, with the object of arriving at a solution of the problem before the railways generally.

The essential requirements of apparatus for signalling either the rolling-stock or permanent way, being operated entirely on the wireless inductive principle. So far, however, it has not been considered desirable to publish any results of the experiments.





Figs. F, G, and H. Collecting Brushes and Shoe for Cab-Signalling on North Eastern Locomotive.

on railway trains in motion may be briefly laid down as follow:—

(*a*) Warning to engine-drivers of train approaching signals either at "danger" or "clear."

(*b*) Distinctive sounds for "danger" and "clear" signals.

(*c*) Absence of apparatus operated by the force of impact.

(*d*) Gradual application of train-brake in the event of a "danger" signal being received, and means of liberating the brake on the part of the engine-driver.

(*e*) Apparatus, in the event of the failure of any part, should give a "danger" signal.

(*f*) Elimination of movable ramps operated by signalmen by mechanical means.

(*g*) Impossibility of signals being in contrary position to the position of the levers in the signal-box working the same.

Such an apparatus is known now as "cab-signalling," and in the early stages of the working-out of such devices it was deemed imperative that, in addition to audible signals being given, an indication should also be displayed on the foot-plate, but to-day it is almost unanimously considered undesirable to give the engineman anything liable to distract his attention from keeping a proper look-out.

Sirens appear to be the most desirable form of warning as a "danger" signal, operated either by steam or by air-brake, and a bell for the "clear" signals. An attempt has been made in some systems to provide clockwork recording apparatus working in connection with cab-signalling devices, with the object of showing definitely and placing on record each time the apparatus is operated when a signal is passed at "danger;" this, no doubt, is an ideal system, but, it is suggested, of not much actual value, as an immense amount of work would be entailed in checking these records, which would doubtless necessitate an increase in the staff of the department responsible.

Again, in some systems it has been suggested that apparatus be sealed up, with the result that, when a train has run past a signal, a seal is to be broken, and before the apparatus can be re-set the brake has to be released and the apparatus re-sealed by the guard or some responsible person before the train can proceed on its journey. Such rigid working would, of necessity, be the means of seriously delaying the traffic on busy lines of railway, and would cause the traffic to be held up to such an extent as to render correct time-keeping in running impossible. The Midland Railway has not adopted any cab-signalling device up to the present time; but has experimented with the combined automatic train-control and audible-signal system, as used on the Great Western Railway, on a branch line, for which two engines only have been fitted with the apparatus, and so far the experiments have proved satisfactory.

The Midland Railway has this year made some experiments with a new invention called the "railophone," an invention of Mr. H. Von Kramer for giving an automatic warning in the engine-cab. This apparatus differs from anything hitherto brought out. It is primarily intended for use in connection with "distant" signals, and, unlike the automatic train control mentioned, has no physical connection or contact with

Figs. I and K. Track-Bars on North-Eastern Railway. Fig. L. Signal and Switch.

Automatic Signalling on Trains.

By Leon P. Lewis, of the Signal Superintendent's Office, Caledonian Railway, Glasgow.

Before considering any particular method of railway train signalling, it is desirable to mention the main principles on which any safe system of railway signalling must be based.

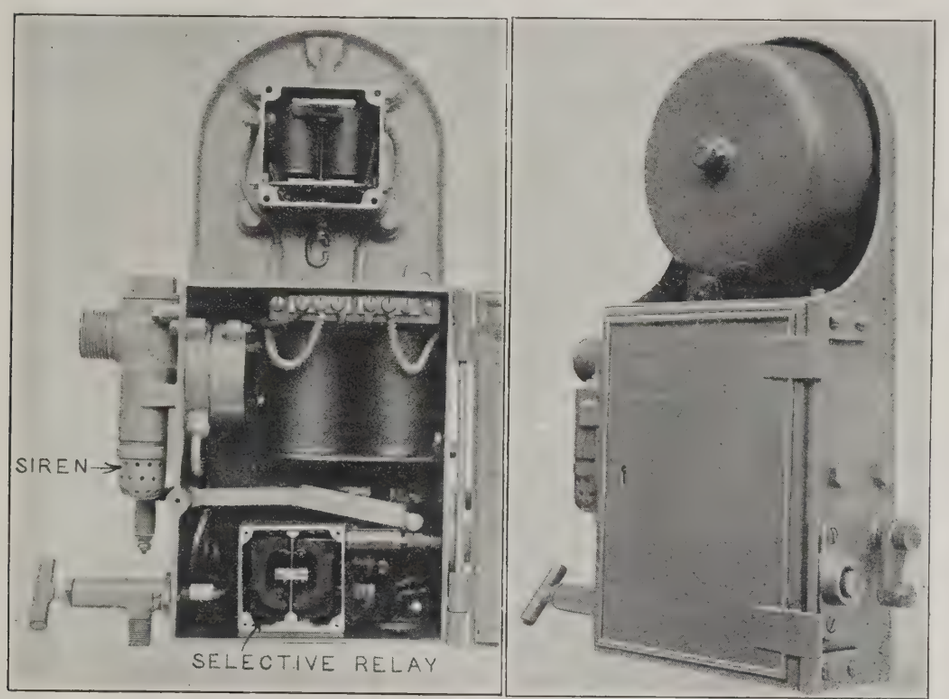
Principles of Railway Signalling.—The most important principles are:—That an adequate interval of space must be maintained between following trains, and at junctions between crossing or converging trains; also, in cases where trains are operated over one single line of rails in both directions, an adequate interval of space must be maintained between trains approaching from opposite directions. Another very important principle is that, as far as possible, any failure of apparatus should indicate "danger," or, in other words, any failure should be on the side of safety. All schemes and regulations should be designed or drafted with the idea of ensuring that at least two mistakes shall be made before any accident is possible. It is generally with the object of reducing the liability to make mistakes by the men engaged in the actual control or operation of trains that most automatic train-signalling devices have been brought forward.

The basic principle of the "space interval" is very

efficiently carried out by the ordinary electric block telegraph system and code of regulations, aided by the semaphore signals erected by the side of the railway for giving instructions to the enginemen. In carrying out this system, two classes of operators are responsible for the safety of the traffic: (1) the signal-operators; and (2) the enginemen. The signal-operators must know the positions of all trains occupying the sections under their control, and, with this knowledge, must exhibit signals giving permission for a train to proceed, or ordering a train to come to a state of rest.

*"Stop" and "Proceed" Indications.**—It should be noted that no system of signalling can be satisfactory unless it can convey separate indications for "stop" and "proceed." The mere absence of a "stop" indication must not be taken as permission to proceed. For the successful operation of trains at speed, an efficient system of route-indicating at junctions must be provided in addition to the "stop" and "proceed" indications; also shunting movements between main lines and sidings must be conducted with the aid of signals. When the providing of a "stop" signal is considered, it is quite obvious that with a train going at high speed it is necessary to give the order to stop at a point some distance away from that point at which the order must be obeyed to the extent of the train being in a state of rest. It is therefore necessary to give a preliminary warning order of "caution," or "be prepared to stop at a point ahead." The distance between the point where the warning is given and the order "dead stop" must be obeyed depends on the retarding forces at the command of the enginemen, and this can only be found by experiment. In practice, a distance of from 600 to 1200 yards is allowed, which depends on the gradient of the line, &c., but it should be remembered that, under ordinary conditions, with outdoor signals, the warning signal can be seen for some considerable distance before the train arrives at it.

The usual signalling practice in Great Britain is to use outdoor visual signals, supplemented by audible signals when atmospheric conditions render the visual signals difficult to read. The common practice in foggy weather is to place detonators on the rail a few yards before the warning signal, but when the signal is at "clear" no detonators are in position on the rail. The explosion of the detonator should not be regarded as a signal—it should only be taken as being a means of attracting the enginemen's attention to the outdoor visual signal. In addition to the difficulty of observing ordinary outdoor signals in bad weather, cases have happened of enginemen misreading signals, and also of signals being overlooked. With a view to preventing such occurrences, a great many suggestions have been made and experiments carried out. Some few have passed the paper stage, and of these but very few have survived the experimental stage.



FIGS. M AND N. SIGNALLING APPARATUS ON CAB; GREAT WESTERN RAILWAY.

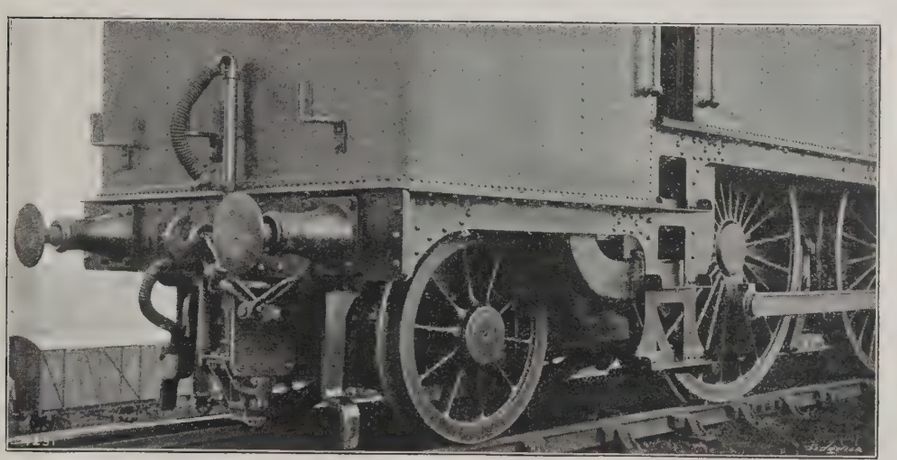


FIG. O. COLLECTING SHOE FOR CAB-SIGNALLING; GREAT WESTERN RAILWAY.

Automatic Feeding of Detonators.—Some of the most modest ideas have been developed for the purpose of placing the detonators automatically on the rails when the train is required to stop. When these are placed near the signal-box they are generally successful, but if they are placed near the "warning" signal, difficulties not easy of solution are encountered. Many inventors were of the opinion that it was only necessary to connect their devices either to the operating-gear of the "warning" signal, or to make a connection to the wire working that signal, whereas in practice the signal-wire and gear has enough to do to ensure the correct working of the signal without the added duty of operating such devices.

It is possible to provide independent connections from the signal-box to the apparatus, but this adds complications, and such are not desirable. One or two devices have been developed with the object of overcoming this difficulty, and they employ electricity to explode a detonator cartridge, on the train passing over a treadle, should the "warning" signal not be in the "clear" position. In one device the pressure due to the explosion is used to bring the next cartridge into position for service. There have also been a very great number of devices brought forward which are designed to sound a large gong by the side of the line when a train approaches a signal in the "danger" position, but no one of these has been very favourably received.

Railway-Cab Signals.—From quite early days in the history of railways, inventors have given much time and thought to the problem of giving some sort of indication on the engine itself, with the object of compelling the driver's attention. Many engineers have strongly opposed all such devices, because they have been regarded as relieving the enginemen from the duty of keeping a keen look-out. The enginemen have many things to observe in addition to the outdoor fixed signals, such as workmen on the line, signals indicating permanent-way slacks, and emergency conditions generally. Recognising this objection, several devices have been thought out which only check the driver, should the engine overrun an outdoor signal in the "stop" position; with such devices no indication is given when passing a signal in the "clear" position. Devices of this description are very useful, but they are of little assistance to the driver; they cannot appreciably assist in the operation of traffic, because a driver must disobey a signal before any indication is given.

Warning Signal on Engine.—Other ideas have been with the object of displacing the usual fog-signalling detonators, and they indicate on the engine the position of the "warning" signal. This is a very useful thing to do, as the apparatus is in constant use, and gives the warning irrespective of the state of the weather; thus the critical period between the calling out of the fog-signalmen and their actual attendance at the signals is eliminated. Some of these schemes attempt to follow fog-signalling practice very closely, in that no indication is given when the signal is at "clear;" others, again, make provision for a positive "clear" indication in addition to the "danger" indication. More ambitious inventors have designed their apparatus with a view to indicating on the engine both "warning" and "stop" signals, and in addition have further provided route-indications. These devices are intended to displace all outdoor running signals, only leaving purely shunting signals to be of the outdoor visual type. When considering schemes of this description, it is necessary to remember that the present outdoor signals not only serve the purpose of running indicators, they also perform the very important function of position-markers. Landmarks of some description must be provided to mark the spot beyond which a train must not proceed in order to avoid danger. It is only necessary to mention the fouling points of junction, and the limits of block sections to bring to mind this important duty of the outdoor signals. It is quite possible to provide various indicators on the engine to inform the driver of such positions, but these must necessarily add considerably to the complexity of the apparatus, and it is most unlikely that any such devices can compete with outdoor visual landmarks in the matter of convenience or cost.

In attacking the problem of communicating with a moving train, most of the early inventors employed a crank or lever fixed either by the side of the line or in the 4-ft. space, which operated in conjunction with the outdoor signal, so arranged that with the signal at "danger" the lever projected upwards, and so came in contact with a corresponding crank on the engine. When the signal was moved to "clear," then the crank at the same time moved to a position in which it did not come in contact with the crank on the engine. The crank on the engine was usually connected to a bell, or to a steam-whistle, and in some cases it was intended to shut off the steam in addition. Most of these devices were found to be unsuitable, because either the contacts were placed in an unsuitable position, or the fittings on the railway were such that the free working of the outdoor signal was imperilled, or, if these objections were partially removed, the articles employed did not possess the requisite mechanical strength to withstand the impact between the moving part on the engine and the stationary part on the railway.

Requirements of Automatic Signalling.—Before any mechanical device can be made generally suitable for railway service, the following requirements must be met:

1. The standard loading and structure gauges must be recognised.

2. The moving parts on the engine must have the smallest possible inertia.

3. The portion on the railway must be sufficiently strong to withstand the impacts received in service, and yet must be such that it can easily be operated at a considerable distance from the signal-box.

4. The apparatus must serve for engines running either chimney first or tender first.

5. It should be suitable for working over single lines where trains run in both directions over one pair of rails.

In practice there can be little objection taken to devices which are fixed in the 4-ft. space, and which do not project more than 3 in. or 4 in. above rail-level. If these devices are to be fitted on lines over which snow-ploughs operate in winter, then the height above rail-level must be curtailed, to allow the plough to be run over the apparatus without coming in contact with it. Projections by the side of the line are open to more objection, unless they are close to the rail, and do not rise above rail-level. A projection above the engine would meet with less objection, but apparatus designed for overhead

* The author writes that he deals with the subject from a theoretical point of view, and purposely omits references to "distant," "home," and "starting" signals. He endeavours to use terms which have a generally understood meaning irrespective of the technical terms in use.

operation would naturally be more costly to install than apparatus for fixing on the ground-level.

The inertia of the moving parts on the engine needs careful attention, and in order to reduce this as much as possible the actual work to be performed by this article should be little.

It is impossible for a series of cranks and rods connected to a large steam-valve to give satisfaction, and several of the early experimenters recognised this in their designs by giving the part on the engine nothing more to do than to release a trip connection, thereby releasing a weight, or its equivalent, to perform the duty of sounding a bell, or opening a small valve, which in turn controlled the indicating apparatus fixed in the cab of the engine. After the automatic air-brake was in general service most experimenters caused the trip to admit air into the vacuum-pipe or release air from the Westinghouse air-pipe, according to the system in use. With the compressed-air type the outrush of air was used to sound a whistle. The air-brake provided an attractive means of stopping a train automatically should it overrun a "stop" signal; but a recent collision has demonstrated that the air-brake cannot be invariably relied upon for stopping a train. A very common idea for reducing the impact is the use of an inclined plane to lift the portion on the engine. This is an admirable idea, provided it is not required to be operated by a signal wire. If the device must be worked by wire, then the moving part must be properly counterbalanced to drag back the wire on its being released by the signalman; at the same time it is essential that the apparatus shall work freely. Where cranks are used for contact-making, unless they are very substantially designed, they either bend or break in service. If they are made so strong as to be practically unbreakable in use, then there is a considerable risk of the portion on the engine being swept off. Most designs also suffer from the impossibility of the driver knowing when his apparatus has become defective, thereby giving a false sense of security.

Several schemes have been brought forward which actually depend on a portion fixed on the engine breaking in the event of an engine overrunning a "stop" signal. A specially-shaped piece of wood supporting a weight on being broken gives the required indication of a signal passed at "danger," or a glass tube which is attached to the air-pipe of the brake apparatus on being broken applies the brakes.

These and similar devices are well worth trial to ascertain the most suitable position, &c., as there certainly should be a considerable field of service for a device which only checks a driver if a signal is passed at "danger." Past experience seems to suggest that, apart from some simple device such as just mentioned, it is not likely that a purely mechanical system of signalling on moving trains can be designed suitable for general railway service.

Electrical Automatic Signalling.—The use of electricity in some manner, however, appears to give promise of a successful scheme being possible, and for many years experiments have been made to discover an electrical or an electro-mechanical solution of the problem. With electrical devices it is essential to scrutinise closely all the details, to be certain that in all circumstances, should any part of the apparatus fail in service, a false "clear" indication shall not be possible. Most electrical systems employ ramps of various lengths and in various numbers, depending on the scope of the device. There is no difficulty in designing a good working insulated ramp, as with electrical ramps no movement of the ramp is required. The portion on the engine at the most has to open or close electric contacts, which need possess little inertia. Where brushes are used for making contact with the ramp, there is some difficulty likely to be experienced in maintaining them in such a condition that they will clean the ramp, and ensure a good electrical contact in all weathers; and if the brush is intended to operate a "danger" indication, there will be the risk of a defective brush failing to perform this important duty, and it is hardly possible to provide a detector to inform the driver when his brush has failed. Some device which can be relied on to inform the driver should the contacts not be in working order is necessary so far as the indication of danger is concerned.

The general principle of operation of most of these devices is as follows:—On the engine current is provided, either from a battery or dynamo, which, under normal conditions, maintains either the indication "clear" or, preferably, a neutral indication. When the engine passes over a ramp, or other device of similar construction, the current which maintains the normal indication is either interrupted or the apparatus is short-circuited, thereby causing the normal indication to disappear and "danger" to be exhibited in its place. Should, however, the "clear" indication require to be exhibited, it is necessary that a current be picked up by the brushes, or their equivalent, which either suppresses or covers the "danger" indication.

For interrupting the normal current on the engine, either a small wheel, which rotates on passing over the equivalent of a ramp, or else a skid, which rises when passing over a ramp, seem to be serviceable ideas, as, should either the wheel or skid be torn off in service, the current would still be interrupted and the "danger" indication exhibited. With a system of this sort, it will be observed that the "danger" indication is always given on passing a ramp, unless the ramp is connected to a source of power, which power is under the control of the signalman.

Electrical devices are subject to failures caused by troubles which cannot be discovered quite so readily as mechanical failures, and electrical apparatus installed on a locomotive is subjected to a considerable amount of vibration, and this necessitates a careful inspection of all fittings, batteries, and connections, to detect either breakages or parts getting out of adjustment. With electrical schemes, route-indicating simply resolves itself into adding more ramps on the railway and contacts on the engine, the particular ramp electrified giving the required indication. With skids or brushes no difficulty is experienced in designing them for running the engine in both directions, but some devices require different contacts, which are set by the reversing gear on the engine.

To make the device suitable for single-line working, it is necessary to arrange that an engine passing a ramp intended for the "up" direction shall not indicate "danger" if the engine is passing in the "down" direction. This can most conveniently be done by employing polarised relays or magnets on the engine, so that the polarity is changed in accordance with the direction of running authorised for the train. Attempts have been made to give continuous indications on the engine by employing a continous cable which conveys a high-frequency alternating current; the portion on the engine consists of a detector operated by induction. Whilst such a device may be a scientific possibility, it is doubtful if such is likely to prove commercially successful in the near future.

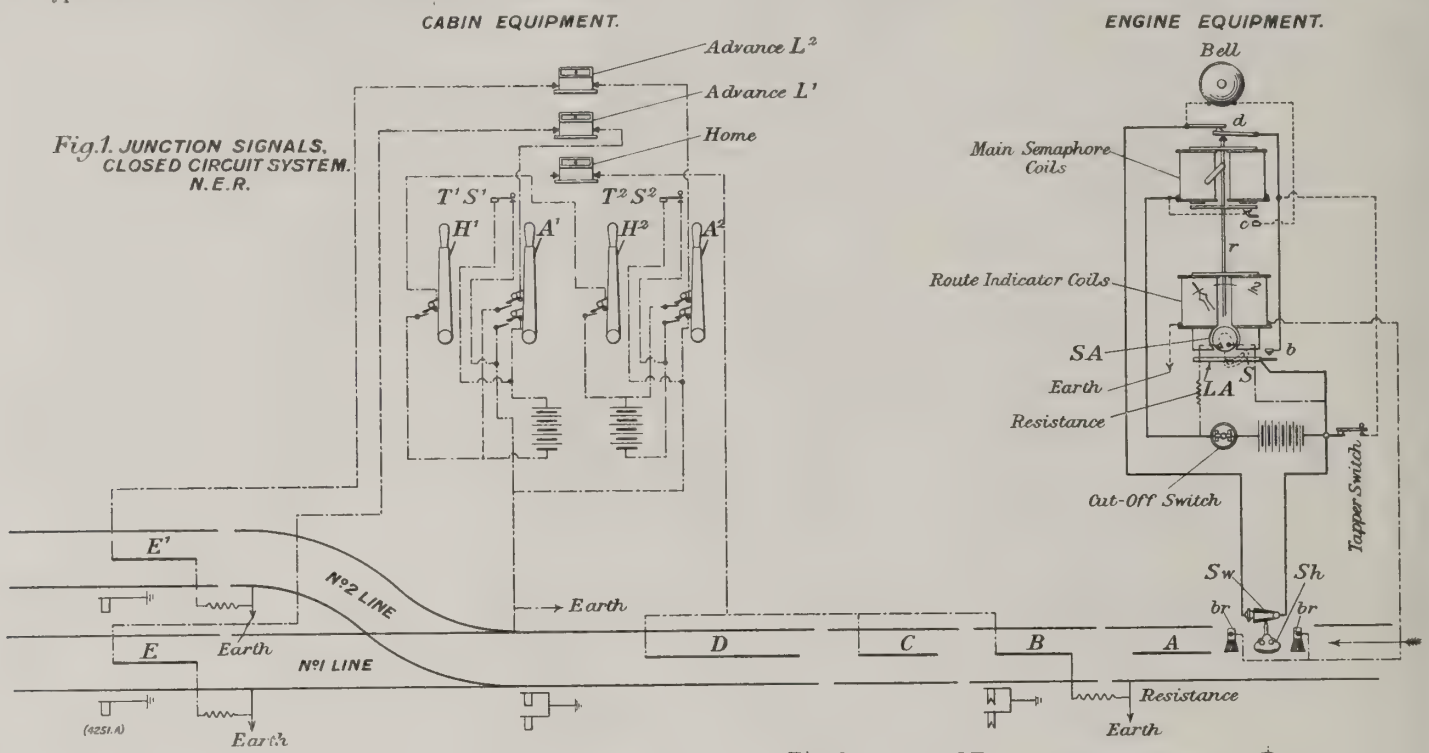


Fig. 1. JUNCTION SIGNALS, CLOSED CIRCUIT SYSTEM. N.E.R.

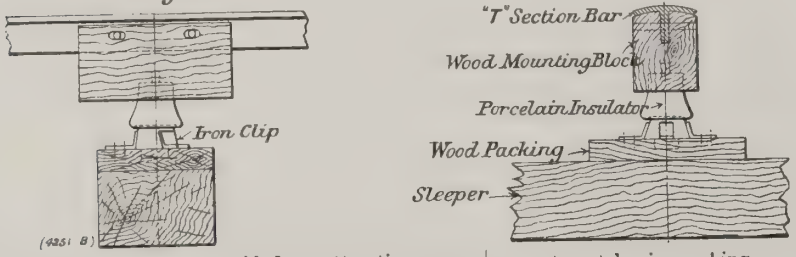


Fig. 2. METHOD OF MOUNTING CONTACT BAR.

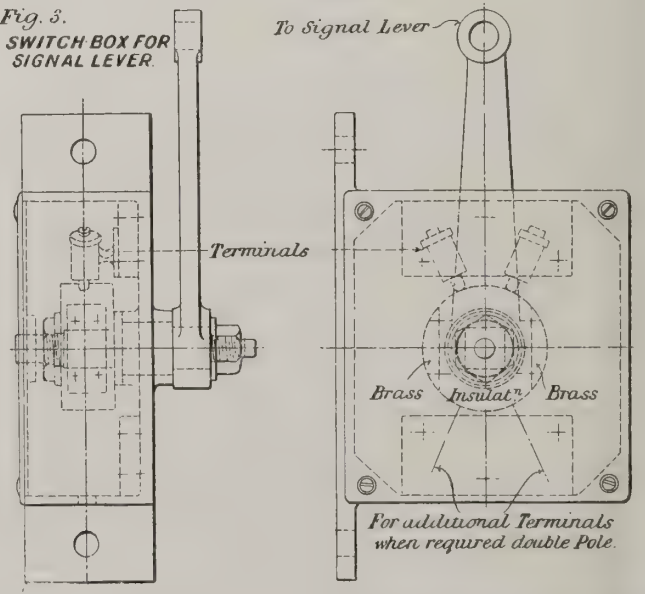


Fig. 3. SWITCH BOX FOR SIGNAL LEVER.

Electrical System of Cab-Signalling.

By Vincent L. Raven, Member, Chief Mechanical Engineer, North-Eastern Railway, Darlington.

This system, designed by the author, has been in actual use on the Richmond branch of the North-Eastern Railway for over two years, and also on that part of the North-Eastern Railway Company's main line which is situated between Durham and Bensham, and during the whole of that time the arrangement has given every satisfaction; on no occasion has the "danger" signal ever been omitted to be given. The apparatus is fitted to thirty-six locomotives.

The main objects of the system are:—

1. To advise the driver of his approach to a signalling zone where signals are to be looked for.

2. To give the driver the necessary information with regard to the position of the signals controlling his

further advance, and to prevent him from mistaking other signals for his own.

3. To retain control of the driver by the cab-signals until he has passed the last signal-controlling entrance into the section ahead.

As is well known, the three principal signals are placed in the order of "distant," "home," and "advance." The "distant" signal is not a "stop" signal, but indicates whether the "home" is at "danger" or not. The "home" and "advance" signals are "stop" signals when they are at "danger."

In some systems of cab-signalling the designers have only arranged to give the engine-men a warning at the "distant" signal, leaving the driver to distinguish the positions of the "home" and "advance" signals from the road signals only. It has happened that drivers, after leaving the "distant" signal at "danger," have seen a "home" signal "off," and have mistaken this for their own, and serious consequences have followed. In the case of the present design, however, only those signals which are applicable to the driver are indicated, and therefore the chance of taking the wrong "home" or "advance" signal is entirely obviated.

From the following description and drawings the indications given to the driver and the method of operation of this system can be fully discerned :—

Indications Provided.—The system comprises visual and audible indicators, and the apparatus is electrically operated.

The visual indicators on the engine consist of a small semaphore, with which is combined one or two small pointers capable of being deflected to indicate numbers painted on the dial. The semaphore arm, together with the operation of the small pointer, indicates "condition" signals, and the small pointer, by the number indicated on the dial, also gives the "route" indication.

The audible indicator is an electric bell, which is separate from the visual apparatus.

Production of Signals on Engine.—The engine circuits are brought into operation by the movement given to a metallic shoe linked to a small switch when passing over metallic bars placed in suitable positions on the track, and currents are collected from the bars by insulated steel-wire brushes brushing lightly but firmly over the bars as the engine passes over them. The shoe and the brushes are carried on one bracket, which is insulated from the engine-frame. The metallic bars on the line are mounted on insulators.

Method of Operation.—On page 765, Figs. A, B, and C, are shown two forms of the apparatus as already made and in use. As will be seen, the only difference in the indicating arrangements is that one has two route-indicator pointers, and the other has only one route-indicator pointer. One route-indicator pointer is sufficient for a two-way diverging junction, and two pointers are only required for three-way or four-way junctions.

With regard to the audible bell signal, Fig. 1, page 768, serves to illustrate what takes place during the passage of a train up to a two-way diverging junction. The semaphore and the bell are directly operated by a battery carried on the engine. The route-indicators are directly operated by currents established by the signalman in the operation of the ordinary levers of the "stop" line signals. These currents also indirectly operate the semaphore and bell.

Fig. 1 is a diagram showing the complete cabin equipment for a two-way diverging junction, together with the circuits on an engine approaching the junction. $S h$ is the shoe, and $S w$ the switch controlling the engine circuits, and $b r$ are two insulated steel-wire brushes, which pick up current from the cabin batteries under certain conditions by contact with the bars B, C, D, E, and E^1, all of which are connected with the cabin equipment by line wires. The bar A is not connected with the cabin equipment, and current is not picked up by the brushes $b r$, $b r$, from this bar.

Leaving the technical side for a time, assume that a train is travelling in the direction shown by the arrow. When the shoe $S h$ passes on to the bar A, the semaphore arm will immediately rise to the "danger" position, and the route-indicator pointer takes up the central position between the Nos. 1 and 2, Fig. A, page 765. The bell will begin to ring as soon as the shoe $S h$ has passed over the bar. These indications continue until the engine arrives at the bar B.

If the line signals are at "danger," as shown in Fig. 1, the switch $S w$ is broken by the lifting of the shoe $S h$ as soon as the latter runs on the bar. The bell stops ringing whilst the switch $S w$ is broken, but the semaphore arm remains at "danger." The brushes $b r$, $b r$ run over bar B at the same time as the shoe $S h$, but as bar B is not energised when the line signals are at "danger," they have no effect. As soon as the shoe $S h$ is clear of the bar the switch $S w$ is made again, and the bell recommences to ring. When passing over bar C, the same action takes place. If the engine is stopped at the "home" signal, the shoe and brushes are resting on bar D. In this position the semaphore arm remains at "danger" and the bell is silent.

Suppose now that the "home" and "advance" line signals for No. 1 line are lowered for the train to go forward. The small semaphore arm is lowered to "off," and the route-indicator pointer is deflected to No. 1 on the indicator, and remains there. These indications remain when the engine passes off bar D, whilst passing over bar E, and until it arrives at the bar A of the next signalling point.

If the "home" and "advance" line signals for No. 2 line had been lowered, the route-indicator pointer would have been deflected to No. 2 on the indicator, and the semaphore arm would have been actuated as described. Suppose, now, that the signalman had desired to draw the train forward to "advance" No. 1, instead of sending it right away. The engine is standing with the brushes $b r$, $b r$, and the shoe $S h$ on bar D. The signalman lowers the "home" signal and then taps the small switch $T^1 S^1$ several times. This has the effect of lowering and raising the small semaphore arm on the engine, and calls the driver's attention and gives him to understand that he is only being drawn forward to the "advance." It is thus a cautionary signal entirely distinct from the "off" signal, just described. The small semaphore remains at "danger," and when the engine moves off the bar D, the bell recommences to ring. These indications continue until the engine comes to a stand on bar E. (It may be mentioned that, when the small semaphore is being worked up and down by the signalman using the key $T^1 S^1$ in the cabin, the route-indicator pointer is being moved alternately to No. 1 or No. 2, and to the centre position as the semaphore arm is "off" or "on" respectively.)

Suppose, now, it is desired to despatch the engine standing at No. 1 "advance" line signal. The small semaphore arm is at "danger" and the bell is silent. The signalman lowers the "advance" signal No. 1 by the lever A^1 in the cabin, and the small semaphore arm on the engine is immediately lowered to "off," and the route-indicator pointer deflected to 1 on the dial of the indicator. As described before, these indications remain until the engine arrives at the bar A of the next signalling section. If the "calling-on" actions just described had been made for No. 2 line instead of No. 1, the only difference in the indications given on the engine would have been the actuation of the route-indicator pointer to No. 2 instead of to No. 1 on the dial of the indicator.

Assume, now, that the "home" and "advance" signals for No. 1 line have been lowered before the engine arrives at bar A. On passing over A the small semaphore arm on the engine rises to the "danger" position, the route-indicator pointer takes up the central position and the bell begins to ring, and these indications continue until the engine arrives at bar B. Whilst passing over B the small semaphore arm is lowered to "off," the route-indicator pointer is deflected to No. 1 on the dial of the indicator, and the bell then ceases to ring. These indications are continued whilst the engine is passing over the subsequent bars C, D, E, and until it arrives at the bar A of the next signalling section. This constitutes the "off" signal ; if the signalman had prepared No. 2 line for the engine by lowering the "home" and "advance" signal, No. 2, the route-indicator pointer would have been deflected to No. 2 on the dial of the indicator, but the operation of the semaphore arm and the stopping of the bell would have been precisely the same.

Assume, now, that the engine, on passing over B, has obtained the "off" signal, as just described, for either No. 1 or No. 2 lines, and that an emergency arises at or near the signal-cabin, or elsewhere, which renders it necessary to stop the engine at the "home" signals, if possible. Under ordinary circumstances the signalman would throw his "home" and "advance" line signals to "danger" immediately. This action on his part, with the line signals, ensures a "danger" signal being given either at bar C, or D, or E, according to the position of the engine when the line signals are put to "danger." It is not necessary that both the "home" and the "advance" should go to "danger" to give this emergency "danger" signal on the engine. Either of them alone is sufficient to ensure this being done at either bar C or D, and the "advance" line signal at "danger" ensures the emergency signal being given at bar E, or E^1, as the case may be.

Finally, assume that the engine has passed over a bar B with the line signals at "danger," and before it has reached bar C the signalman has lowered the line signals. The small semaphore arm is at "danger," and the route-indicator pointer in the central position, and the bell ringing. On passing over bar C the complete "off" signal will be obtained—that is, the semaphore arm will be lowered, the route-indicator pointer deflected to No. 1 or No. 2 on the dial of the indicator, as the case may be, and the bell stopped precisely as in the case where the "off" signal was assumed to be obtained at bar B.

Summary of Indications.—Considering the descriptions of the operations, it will be seen that :—

1. The natural action of the bar A upon the engine circuits constitutes a signal warning the driver of his approach to a signalling point—that is, it is a "warning" signal indicating locality of position.

2. The continuance of the "warning" signal constitutes a "danger" condition relating to the "stop" signals for the signalling point which is being approached. The bar A is situated at a distance of about 150 yards from the bar B, and the "warning" signal is, therefore, of short duration only if the "stop" signals are "off."

3. The stopping of the "warning" signal by the return of the small semaphore arm to the "off" position, the stopping of the bell, and the receipt of a "route indication," constitute the "off" signal, which, since it can only be given when all the main-line signals are "off," and then only by the direct intention of the signalman, gives the fullest possible information with regard to the condition of the line.

4. An indication given at the first signalling-bar B can be reversed during the passage of the train from B over the subsequent bars to the "advance" signal. That is to say, an emergency "danger" signal can be given after an "off" indication has been given, or an "off" signal can be given after an "on" signal has been given. The number of points at which these reversals can be obtained is only limited by the number of intermediate bars C. The number of bars so employed is, of course, optional.

5. The "off" signal can be given when a train is standing at either the "home" or "advance" signals equally as well as when travelling. When a train is given the "off" signal at the "advance," the bars B, C and D are not energised.

6. The apparatus is capable of giving cautionary "calling-on" signals, as well as the "off" and "on."

7. The "distant" line signal plays no part in the working of the system as described and is superfluous. The system, however, can be worked in connection with a line "distant" signal.

8. As described, the route indications for a two-way diverging junction have only been referred to. The engine indicator can be made to provide route-indications for three-way or four-way junctions, as shown on page 765. For a three-way or four-way junction the bars B, C and D are duplicated, as is the line wire, &c.

9. An examination of Fig. 1, page 768, shows that an indicator is provided in the signal-cabin, by which the signalman is informed of the condition of the electrical signalling apparatus on the line which he controls. Fig. D, page 765, shows the type of indicator employed. The resistances are for the purpose of obtaining readable deflections of the cabin indicators as economically as possible. It forms a high-resistance shunt on the engine circuit when the brushes are on an energised bar, and does not interfere with the signals given on the engine from the signal-cabin.

10. The route-indications are conventional, by numbers commencing from the left. Line-signals are always erected relatively to each other, at diverging junctions, as the lines are to each other. Hence the convention is in accordance with the positions of the signals and the lines they control.

11. Currents are sent to the bars by the operation of switches connected and working with the levers operating the "stop" signals, "home" and "advance," and the signalman can, therefore, only give the "off" indications by intention. It will be noticed that the complete "off" signal can only be given at bars B, C, or D, by pulling off the "home" and "advance" levers, but that at bar E or E^1 the "off" signal can be given by pulling off "advance" signal 1 or 2 respectively, alone. Moreover, the pulling off of either "advance" signal alone does not energise the bars B, C, or D, so that given, say, an engine standing at "advance" No. 1 and a train passing from B to D, the latter will receive no indication other than "danger," should the signalman, at the time, lower the "advance" signal No. 1 for the train standing there to proceed. The "advances" Nos. 1 and 2 are entirely independent of the working of the "homes" Nos. 1 and 2 respectively, but the operation of the latter without the "advances" will give no "off" indication at the bars B, C, or D.

12. Whilst in Fig. 1 (page 768) the bar is shown at the line "distant" signal, there is no reason why it and bar A should not be put at any further distance from the signal-cabin which the exigencies of the service render necessary. At present drivers can ordinarily see the "distant" signal some distance before they reach it, and have that much greater distance to get their trains under control if required. The bars A and B can be set at any point equivalent to such sighting distances.

Circuit Arrangements and Design of Indicator.—Referring to Fig. 1, the circuit arrangements and the design of the indicator will be seen to be simple. As already indicated, the bars A, B, C, D, E, &c., act mechanically on the shoe $S h$ to actuate the semaphore and its auxiliary, the bell, and electrically, by currents set in operation by the signalman, through the brushes $b r$, $b r$, to actuate the route-indicator, and indirectly the semaphore and bell. The opening of the switch $S w$ causes the armature of the main semaphore coil to be released, raising the arm to "danger," and mechanically releasing the route-indicator pointer from its deflected position. At the same time the contact c is made, and contact d broken. These alterations of the contact c and d divert the current through the bell as soon as the switch $S w$ is closed by the shoe $S h$ passing off the bar A. The armature of the main semaphore coil cannot be raised by the closing of $S w$, because the circuit is now broken at d. Hence the bell continues to ring, and the semaphore arm remains at "danger" until further action takes place.

The route-indicator has two armatures; one is a shuttle-wound armature S A, capable of turning between the poles and carrying the pointer at the front of the dial; the other is an ordinary lifting armature L A. The shuttle-wound armature is polarised by a special circuit supplied from the engine battery as shown. The lifting armature closes the contact b, which completes a circuit through the main semaphore coils. The shuttle-wound armature carries a slotted sector S, having depressions at each end. In the slot rides a freely-pivoted rod, which, when the sector follows the deflection of the armature, drops into one or other of the depressions, and locks the armature, pointer, &c., in the deflected position. The sector and armature are mechanically released by the dropping of the armature of the main semaphore coils, through the rod r.

When the engine passes on to the bar B—the small semaphore arm being at "danger," the bell ringing, and the route-indicator pointer in the central position—when the "stop" signals are off for, say, No. 1 line, a current passes from B, by $b r$ and $b r$, through the route-indicator coils to the engine-frame and earth. The following actions take place in the indicators :—

1. The route-indicator pointer is deflected to No. 1 on the indicator-dial, and locked.

2. The lifting-armature is raised for the time the current is passing through the route-indicator coils, and closes the contact b.

3. The closing of b sends a current through the main semaphore-coils, which raises the armature, and breaks the contact c, and also makes the contact d.

4. The breaking of contact c stops the bell. The making of contact d provides another path for a current through the main semaphore coils than that by b, which is broken as soon as the brushes $b r$, $b r$ have passed off the bar B.

Hence the semaphore indication is restored to what it was before the engine passed over bar A.

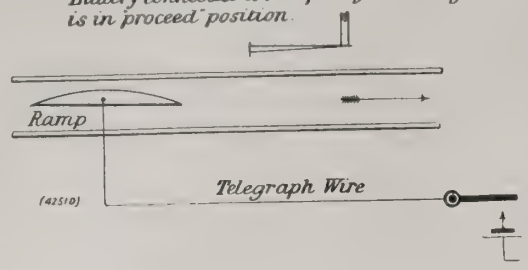
In passing over subsequent energised bars, the action of the switch S w is neutralised by the closing of the contact b, and no change takes place in the indication. Should the engine pass over an unenergised bar after passing over B, it is obvious that the neutralising of the effect of the mechanical opening of the switch S w, by the shoe S h, would not take place, and indications similar to those obtained at bar A would be received. This is the basis of the emergency "danger" signal, previously referred to, the de-energising of the bars being effected by putting one or both "stop" signals to "danger."

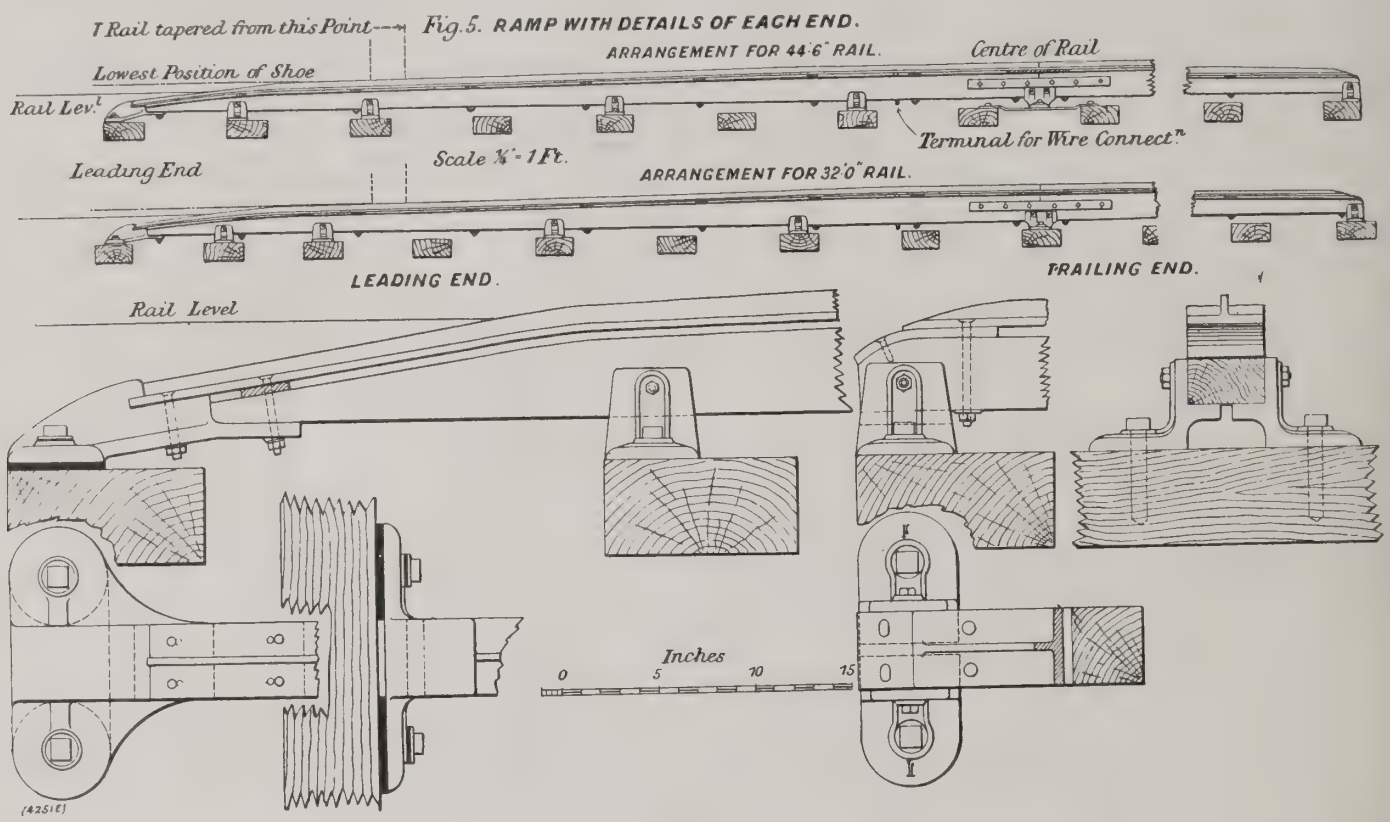
The line equipment by which the bars are energised when required is simple. Movement of the signal-levers in the ordinary operation of the signals to the "off" position closes switches connecting the batteries in the cabin with the line wires. Of the latter there are three; one goes to the "distant" signal, and is connected to the three bars B, C, D. One of the others goes to the "advance" signal for No. 1 line, and the other to one position on the engine. Details of the bracket carrying the brushes and shoe, together with the switchbox, are also shown.

Switches in Cabins.—The form of switch used on the

DIAGRAM OF RAMP & CONNECTIONS.
LINE CIRCUIT, G.W.R.

Fig. 4. *Battery connected to ramp only when signal is in proceed position.*





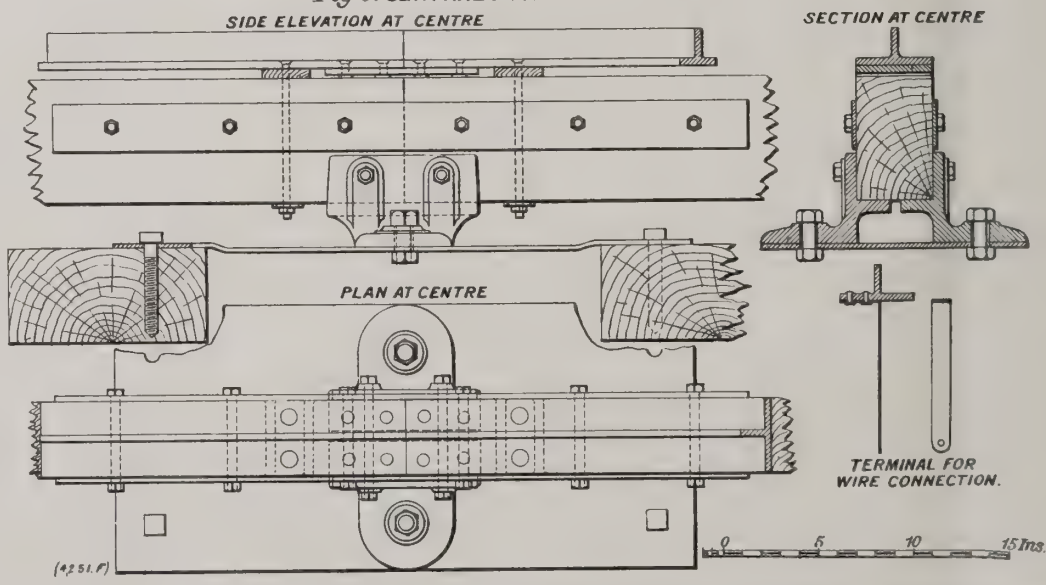
the "advance" for No. 2 line. In each case the line wire is connected to the bar. Each of the line wires is provided with an indicator in the cabin, by which the signalman can see whether the bar is energised when he expects it is so. A small deflection only is given for this, the current being limited by the resistances connected to the bars B, E, and E^1. This resistance in no way interferes with the giving of the indications on the engine. A much greater deflection is obtained on the cabin indicators at the moment the brushes $b r$, $b r$ of an engine are on an energised bar, and this, if looked out for, is to some extent an assurance that the apparatus is in order, and that the requisite indications are being duly given.

The cabin circuits are easily followed. H^1 and A^1 are the levers for the "home" and "advance" line signals for No. 1 line, and H^2 and A^2 are similiar levers for No. 2 line. The circuit set up by the operation of the "home" signal-lever is not complete until the corresponding "advance" has been operated. On the other hand, the operation of either "advance" is sufficient to give an indication at the "advance" bar. Hence an "off" indication cannot be given at the bars B, C, or D unless both "stop" signals are "off"—which corresponds to the arrangements necessary to lower a "distant" line signal under ordinary interlocking—but such an "off" signal can be given at the "advance" without in any way interfering with the necessity for giving "danger" signals at the rear. The small tapper switches $T^1 S^1$, and $T^2 S^2$ enable the "calling on" signal previously mentioned to be given. Their normal position is open, as shown; when closed they simply intermittently take the place of the switch closed by the "advance" lever when the "off" signal is being given. As will be readily seen by the diagram, Fig. 1 (page 768), the direction of the currents to the line wire for B, C, D is different when H^2 and A^2 are operated, to what it is when H^1 and A^1 are operated, and the reversal of the route-indication numbers follows.

Collecting Apparatus: Track Bars.—Figs. I and K, page 766, show a bar A, Fig. 1. Bar B, in the distance, is faintly visible in Fig. I, page 766. A bar corresponding to D, or E, or E^1, is shown in Fig. E, on page 765. These bars are of steel, of T section, mounted on wood blocks and porcelain insulators, as seen clearly in Fig. 2, page 768. The form of insulator is shown, and it is fixed to the sleepers by clips.

Brushes on Engines.—The brushes and shoe carried on the engine are shown on page 766, Figs. F, G, and H, in

Fig 5. CENTRAL PORTION OF RAMP.



signal levers in cabins is shown by Fig. 3, page 768, and Fig. L, page 766, shows one such switch connected to the disk at a road-crossing, where the disk is used for both lines. The same form of switch is used in connection with the lifting-shoe on the engine.

Conclusion.—A consideration of the description of the apparatus will show how fully the system meets the conditions found to be necessary in the introductory examination of the requirements. Further consideration will show that it is adaptable in many other ways than those mentioned. It may be used partially or wholly, as described, where the conditions of service require less than on fully-developed railways. It is capable of being adapted to show signals for "distant," "home," and "advance" signals where the present outdoor system is to be retained, or it may be adapted to work with the present "distant" signal only. It is capable of adaptation to single-line working, and lends itself easily to the provision of records of the "condition" signals obtained at each signalling point, should such records be considered desirable. It is also capable of acting as a means of indicating points at which temporary speed restrictions are imposed. It is hardly necessary to point out that the design of the apparatus is such as to give the fullest possible indication of failure of the equipment. The normal operating position of the semaphore-arm is maintained by a continuous current, any interruption of which places the semaphore-arm to "danger," and inability to restore the arm to the normal running position is proof of such failure.

The arrangements by which the "warning" and "danger" signals are given by the mechanical raising of the shoe obviate the necessity for relying upon the making of electrical contact with the bars of the track for the giving of these signals, and any failure to make such contact has only the result of causing "off" signals to be missed, and so does not in any way result in dangerous action. The apparatus is self-testing during the whole time it is in operation.

Combined Automatic Train-Control and Audible Signal System in Use on the Great Western Railway.

By W. A. Stanier, Member, Assistant Manager, Great Western Railway Locomotive Works, Swindon.

For some years it had been felt on the Great Western Railway that the system of calling up fogmen, and the use of detonators for warning trains, was unwieldy, and led to many delays that might be avoided, but at the same time it was felt that to supersede it, any device proposed must provide the following features:—

1. An audible warning on the foot-plate of the engine,

THE T.-S.SS. "CIUDAD DE BUENOS AIRES" AND "CIUDAD DE MONTE VIDEO."

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(*For Description, see Page* 745.)

FIG. 8. THE "CIUDAD DE BUENOS AIRES" ON TRIAL.

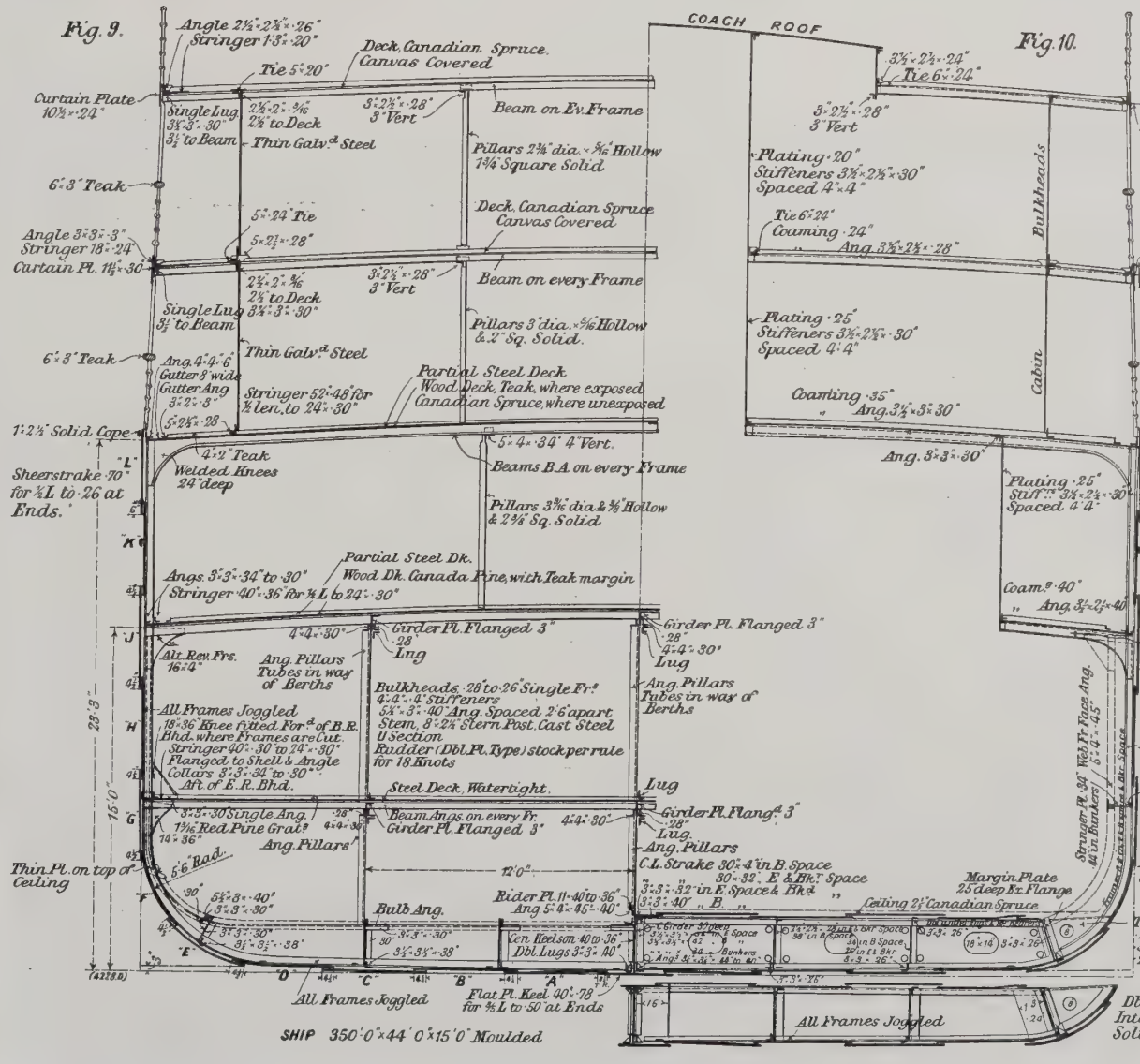
Fig. 9.
Angle 2½"×2¾"×36"
Stringer 13"×20"
Deck, Canadian Spruce. Canvas Covered
Tie 5"×20"
Curtain Plate 10½"×24"
Single Lug 3¾"×3"×30" 3½" to Beam
2½"×2"×⅜ 2½" to Deck
Thin Galv.d Steel
3"×2½"×28" 3" Vert
Beam on Ev. Frame
Pillars 2¾" dia.×⅝" Hollow 1¾" Square Solid
6"×3" Teak
5"×24" Tie
5"×2½"×28"
Deck, Canadian Spruce Canvas Covered
Angle 3"×3"×3" Stringer 18"×24"
Curtain Pl. 11½"×30
2½"×2"×⅜ 2½" to Deck
3"×2½"×28" 3" Vert
Beam on every Frame
Single Lug 3½" to Beam
3¼"×3"×30"
Pillars 3" dia.×⅝" Hollow & 2" Sq. Solid.
6"×3" Teak
Thin Galv.d Steel
Ang. 4"×4"×6 Gutter 8" wide Gutter Ang 3"×2"×3"
Stringer 52"×48" for ⅜ len. to 24"×30"
Partial Steel Deck Wood Deck, Teak, where exposed Canadian Spruce, where unexposed
1"×2¼" Solid Cope
5"×4"×34" 4" Vert.
4"×2" Teak
Welded Knees 24" deep
Beams B.A. on every Frame
Sheerstrake 70" for ¾L to 26 at Ends.
Pillars 3⅜" dia. & ⅜" Hollow & 2⅜" Sq. Solid
Partial Steel Dk. Wood Dk. Canada Pine, with Teak margin
Angs. 3"×3"×34" to 30"
Stringer 40"×36" for ¾L to 24"×30"
4"×4"×30"
Girder Pl. Flanged 3" 28"
Lug
Alt. Rev. Frs. 16"×4"
Ang. Pillars Tubes in way of Berths
All Frames Joggled
18"×36" Knee fitted For.d of B.E. Bhd. where Frames are Cut.
Stringer 40"×30" to 24"×30" Flanged to Shell & Angle Collars 3"×3"×30" to 30" Aft. of E.R. Bhd.
Bulkheads 28" to 26" Single Fr.e 4"×4"×4" Stiffeners 5"×3"×40" Ang. Spaced 2'6" apart
Stem 8"×2½" Stern Post, Cast Steel U Section
Rudder (Dbl. Pl. Type) stock per rule for 18 Knots
Steel Deck, Watertight.
3"×3"×30" Single Ang. 1¾" Red Pine Grat.g 14"×36"
Ang. Pillars
Beam Angs. on every Fr.
Girder Pl. Flanged 3"
Thin Pl. on top of Ceiling
5'6" Rad.
12'0"
Bulb Ang.
Rider Pl. 11"×40" to 36" Ang. 5"×4"×45"×40"
Cen. Keelson 40" to 36" Dbl. Lugs 3"×3"×40"
Flat Pl. Keel 40"×78" for ¾L to 50' at Ends
All Frames Joggled
SHIP 350'0"×44'0"×15'0" Moulded
28'3"
15'0"
Fig. 10.
COACH ROOF
3½"×2½"×24" Tie 6"×24"
3"×2½"×28" 3" Vert
BOAT DECK
6" Tumble Home
Plating 20" Stiffeners 3½"×2½"×30" Spaced 4"×4"
Bulkheads
Tie 6"×24" Coaming 24" Ang. 3½"×2½"×28"
3" Tumble Home
PROMENADE DECK
Plating 25" Stiffeners 3½"×2½"×30" Spaced 4'4"
Cabin
Coaming 35" Ang. 3½"×3"×30"
AWNING DECK
Ang. 3"×3"×30"
Plating 25" Stiff.rs 3½"×2½"×30" Spaced 4'4"
Coam.g 40" Ang. 3½"×2½"×40"
UPPER DECK
4½"×3"×28" Every Fr.
Webs 1'2" deep
All Frames Joggled
3"×3"×34"
Stringer Pl. 30" Web Fr. Face Ang. 64 in Bunkers
Double Bott. in way of Solid Floors
Margin Plate 25" deep Fr. Flange
Ceiling 2½" Canadian Spruce
Tank Side Brackets 26" in E Space 34" " B " 26" " Bhr "
Dbl. Bottom at Frs Intermediate betw.n Solid Floors.
All Frames Joggled

FIG. 9. HALF SECTION BEFORE AND ABAFT MACHINERY SPACE.

FIG. 10. MIDSHIP HALF SECTION SHOWING CELLULAR DOUBLE BOTTOM.

(*To Face Page* 744.)

THE T.S.SS. "CIUDAD DE BUENOS AIRES" AND "CIUDAD DE MONTE VIDEO."

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(*For Description, see Page* 745.)

FIG. 11. DINING-SALOON, LOOKING AFT.

FIG. 12. DINING-SALOON, LOOKING FORWARD.

FIG. 13. VIEW ON AWNING-DECK, LOOKING FORWARD.

FIG. 14. VIEW ON PROMENADE-DECK, LOOKING AFT.

THE TWIN-SCREW GEARED-TURBINE-DRIVEN STEAMERS "CI

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(For Descripti

Fig. 1. **PROFILE.**

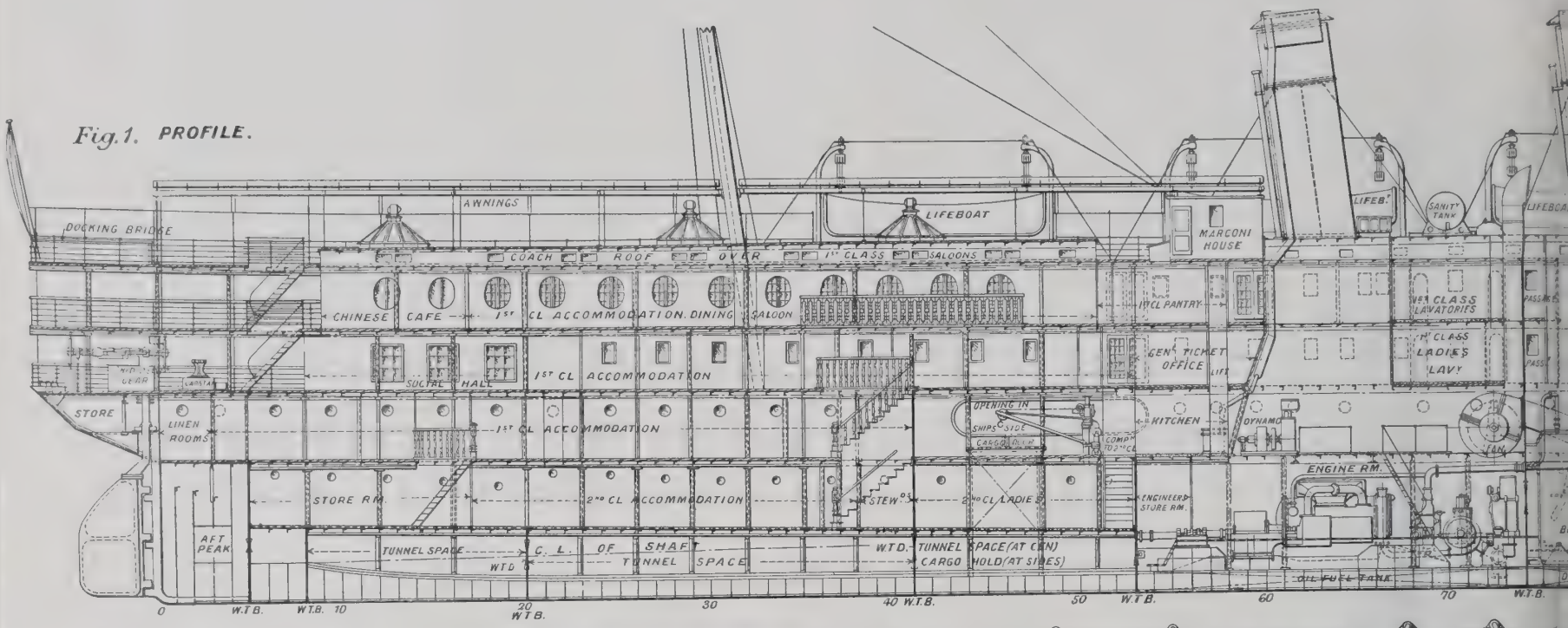
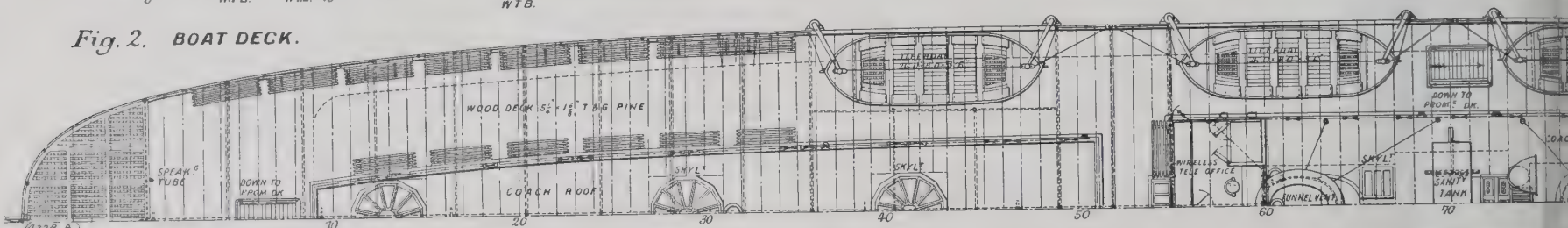


Fig. 2. **BOAT DECK.**



(9228. A.)

Fig. 4. **PROMENADE DECK.**

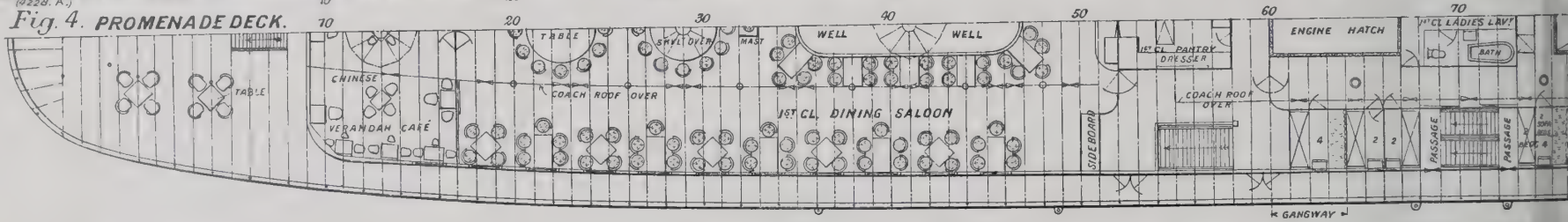


Fig. 5. **AWNING DECK.**

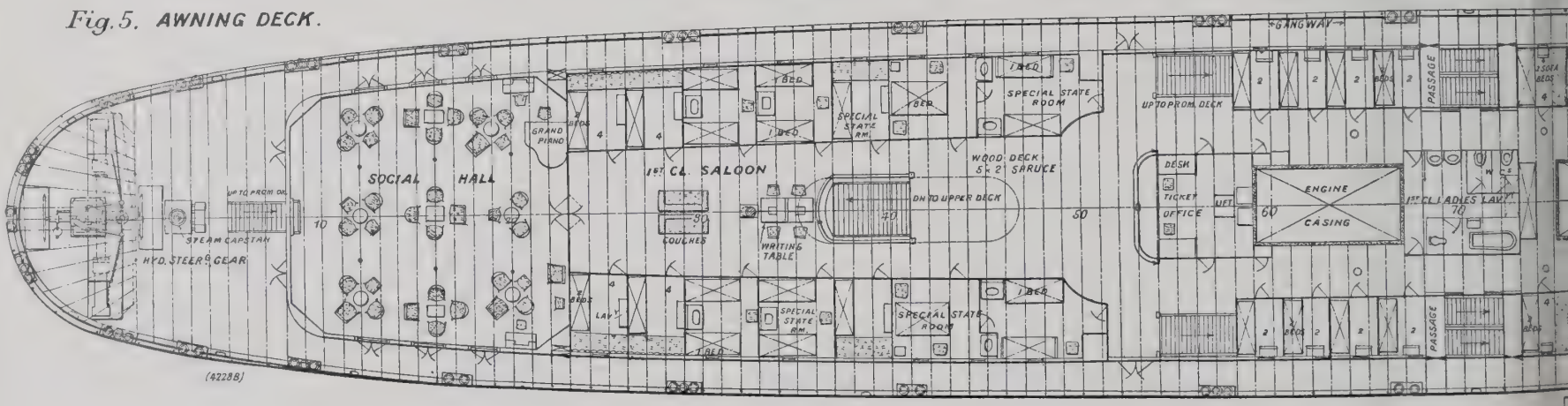


Fig. 6. **UPPER DECK.**

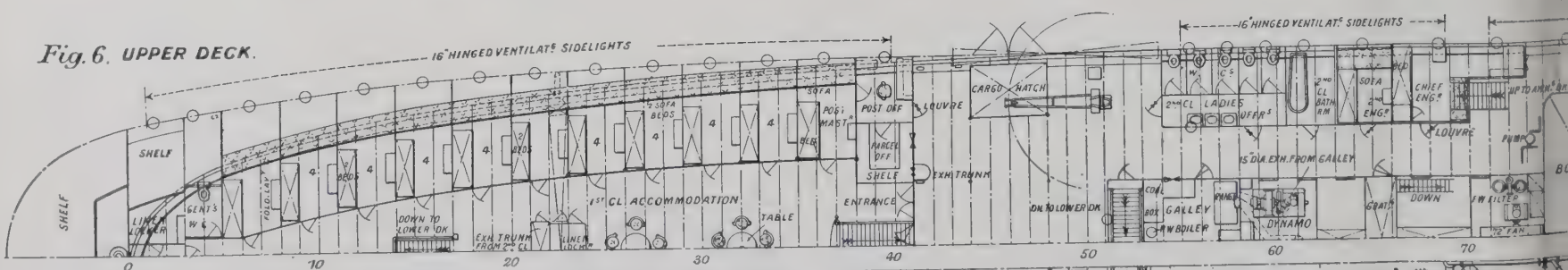
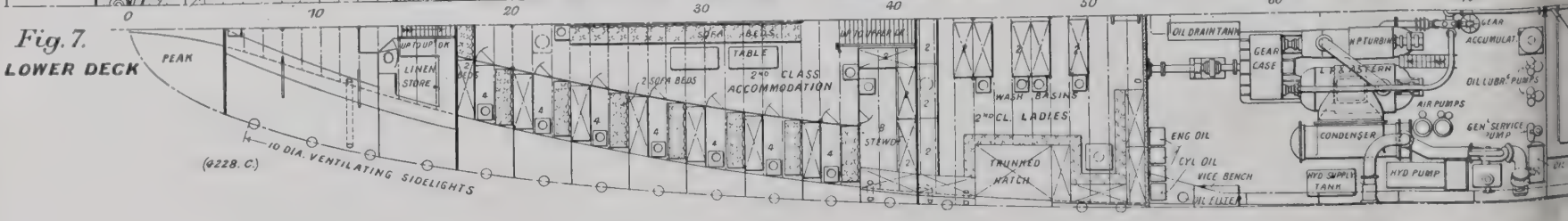


Fig. 7.
LOWER DECK



)AD DE BUENOS AIRES" AND "CIUDAD DE MONTE VIDEO."

ÓR THE ARGENTINE NAVIGATION COMPANY (NICOLAS MIHANOVICH), LIMITED.

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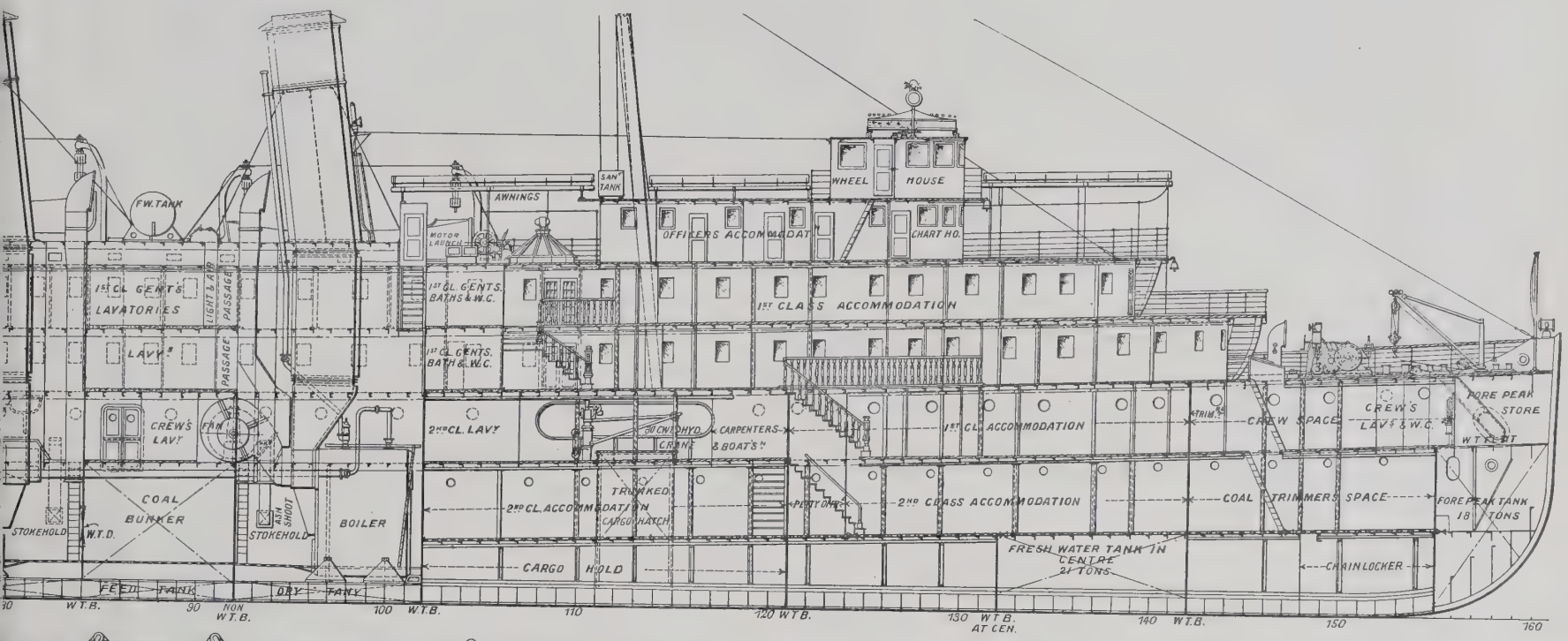


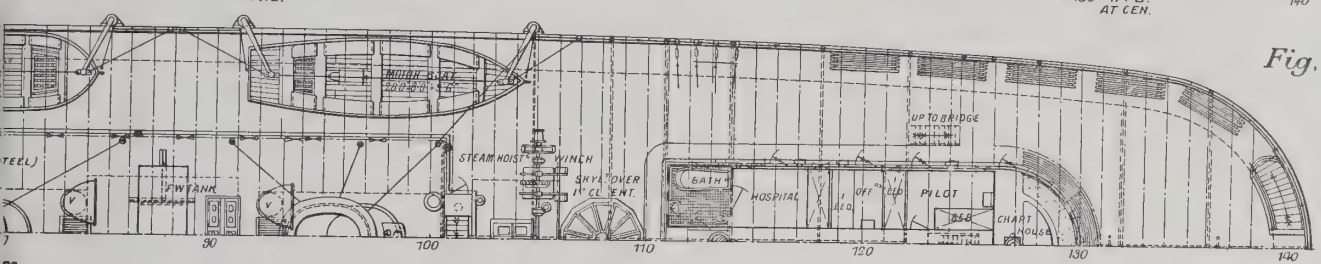
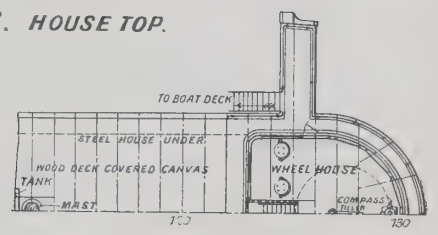
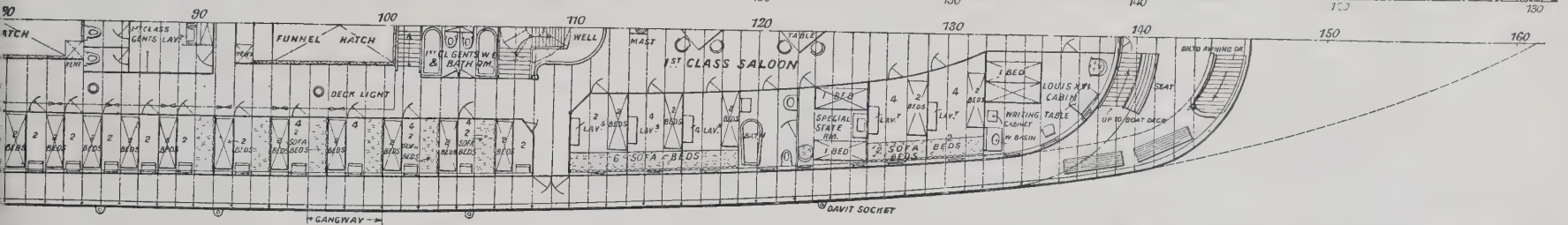
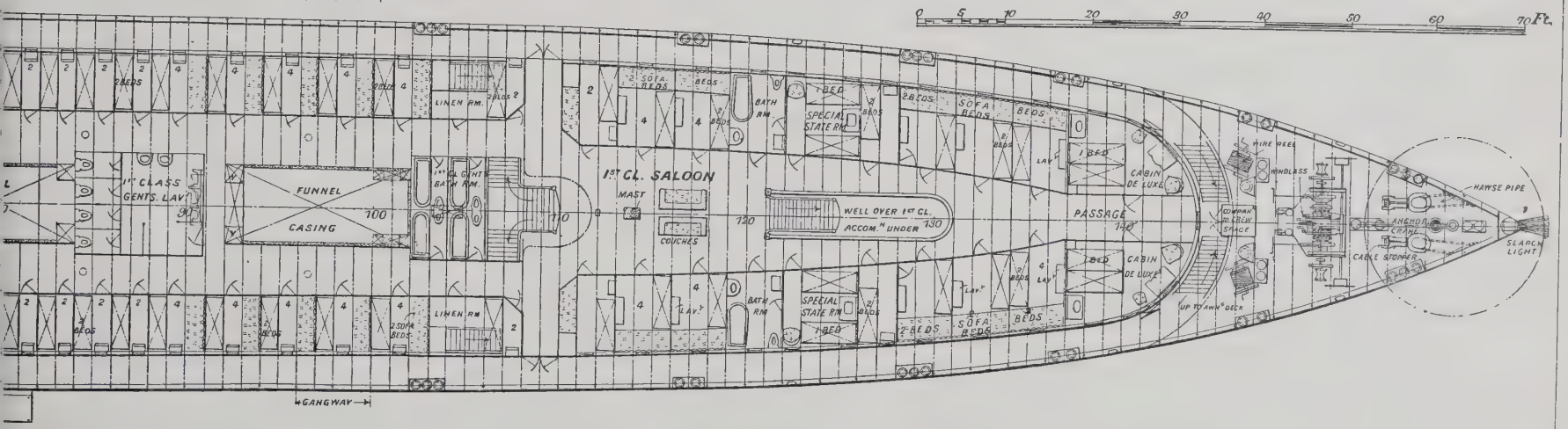
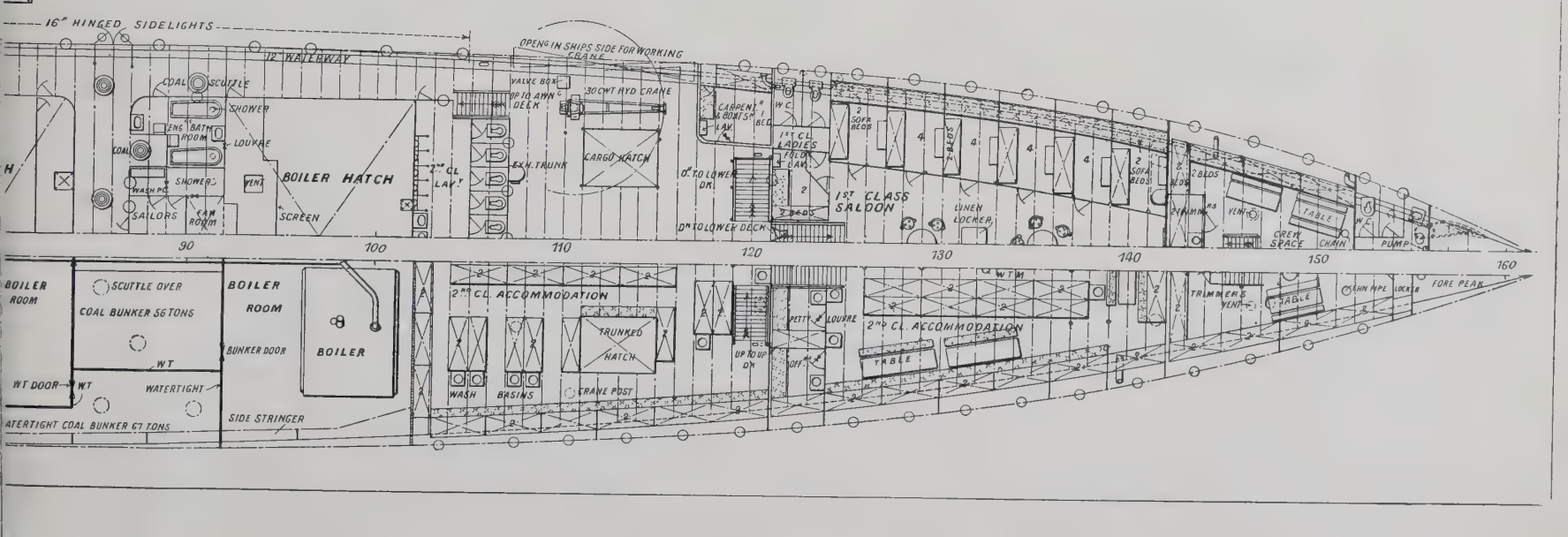


Fig. 3. **HOUSE TOP.**









THE T.-S.SS. "CIUDAD DE BUENOS AIRES" AND "CIUDAD DE MONTE VIDEO."

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(*For Description, see Page* 745.)

FIG. 15 CHINESE TEA-ROOM.

FIG. 16. CHINESE TEA-ROOM.

FIG. 17. SOCIAL HALL.

FIG. 18. ONE OF THE SPECIAL STATE-ROOMS.

GENERAL ARRANGEMENT OF GEARED-TURBINE MACHINERY OF THE T.-S.SS. "CIUDAD DE BUENOS AIRES" AND "CIUDAD DE MONTE VIDEO."

CONSTRUCTED BY MESSRS. CAMMELL LAIRD AND CO., LIMITED, BIRKENHEAD.

(*For Description, see Page* 745.)

Fig. 19.

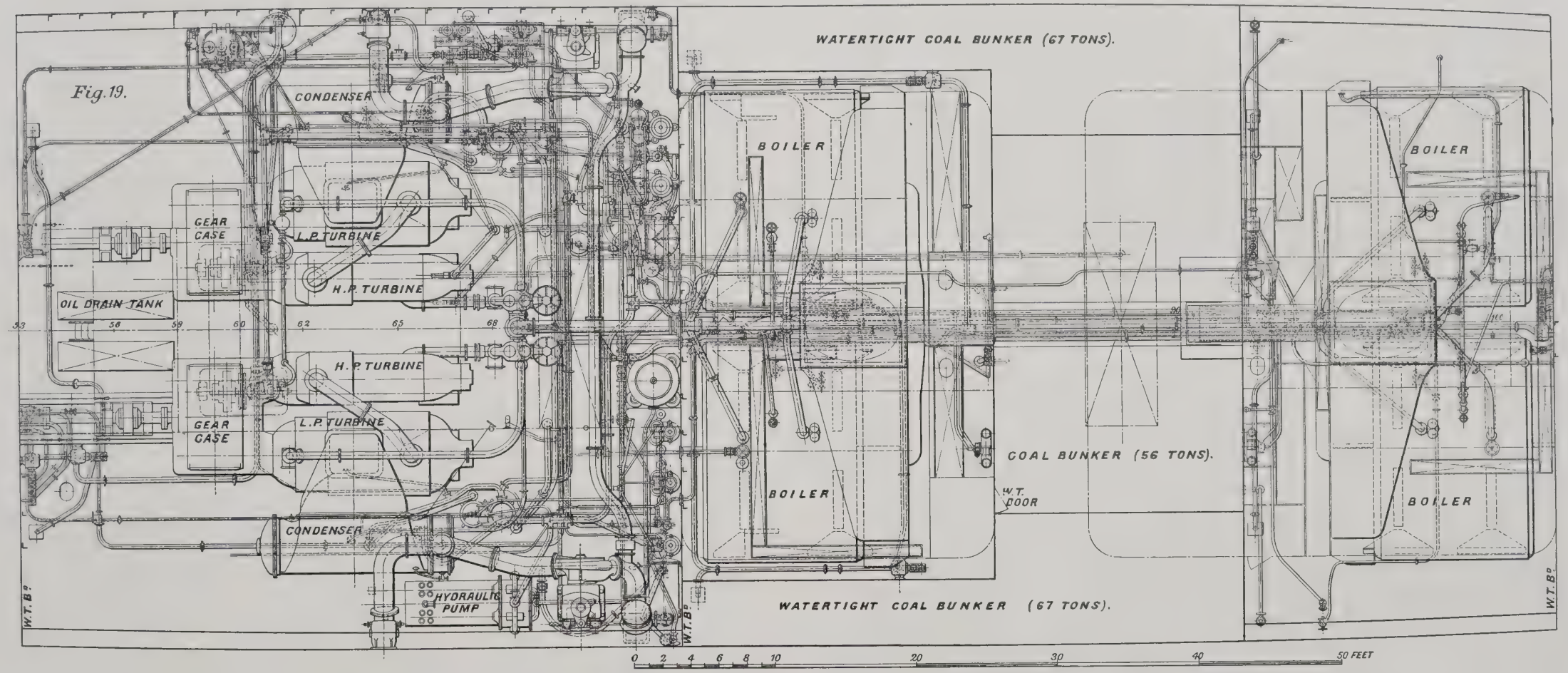


Fig. 20. SECTION AT FRAME 58 LOOKING FORWARD.

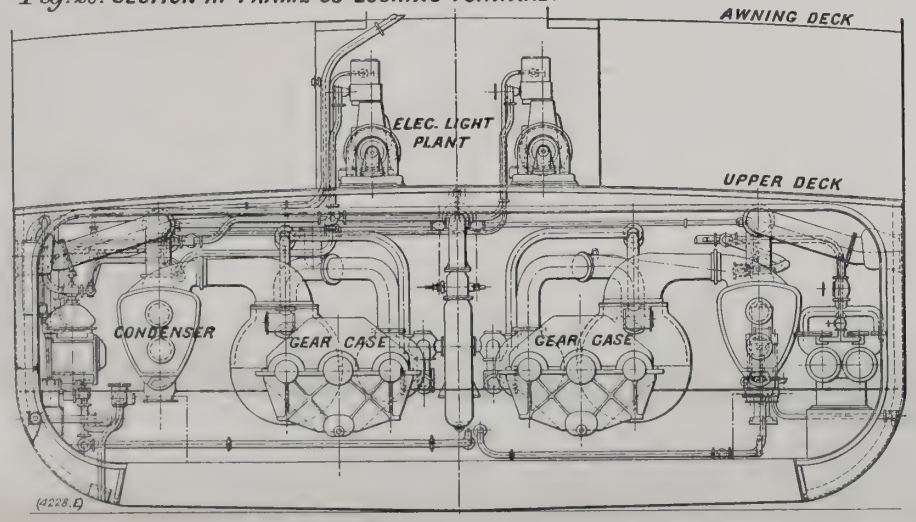
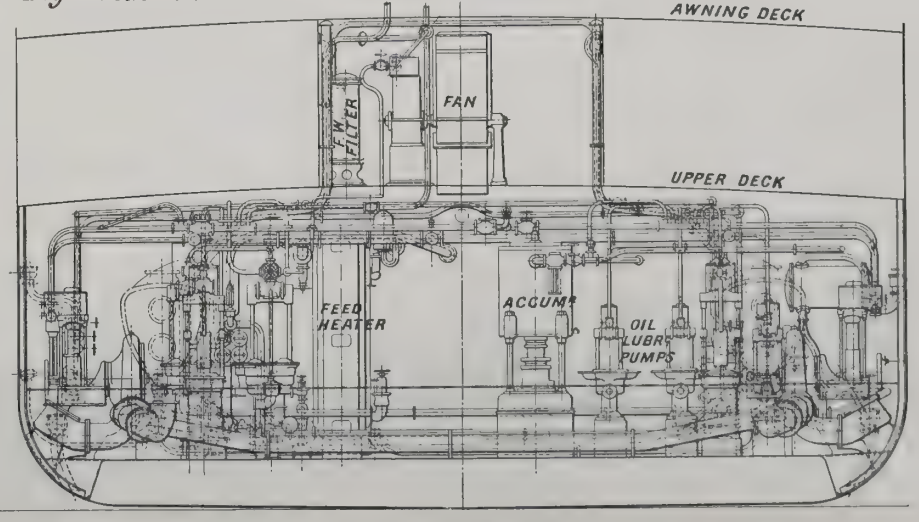


Fig. 21. SECTION AT FRAME 70 LOOKING FORWARD.



(*To Face Page* 745.)

to indicate to the engineman the position of the signal he is approaching.

2. The warning must be separate and distinctive for "stop" or "danger" position and the "proceed" or "all-right" position of the signal.

7. Latterly it has been decided that in the event of the signal being at "danger" the brake must automatically be applied.

About the year 1905 some of the Great Western engineers devised an audible signal for the locomotive cab, which, after a certain amount of experimenting, was considered to be simple enough and certain enough to warrant a more extended trial. It was agreed to equip certain branch lines with the apparatus, and, as a result, the system has had certain improvements, and its use has been considerably extended. This device met the foregoing requirements, as follow :—

1. A bell and a whistle or siren on the foot-plate of the engine.

2. A whistle or siren sounded for "stop" or "danger" and a bell for "proceed" or "all right."

3. The "stop" or "danger" signal is not dependent on any electric connection to sound, and the failure of any electric connections does not prevent it sounding.

Fig. 6. PLUNGER, SWITCH AND BELL ON ENGINE.

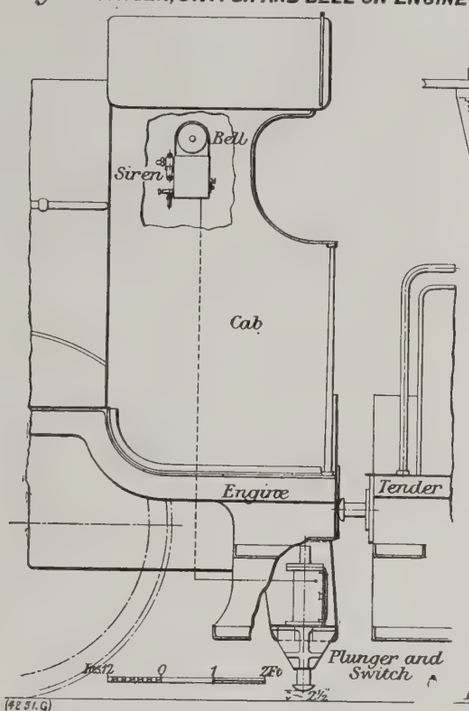
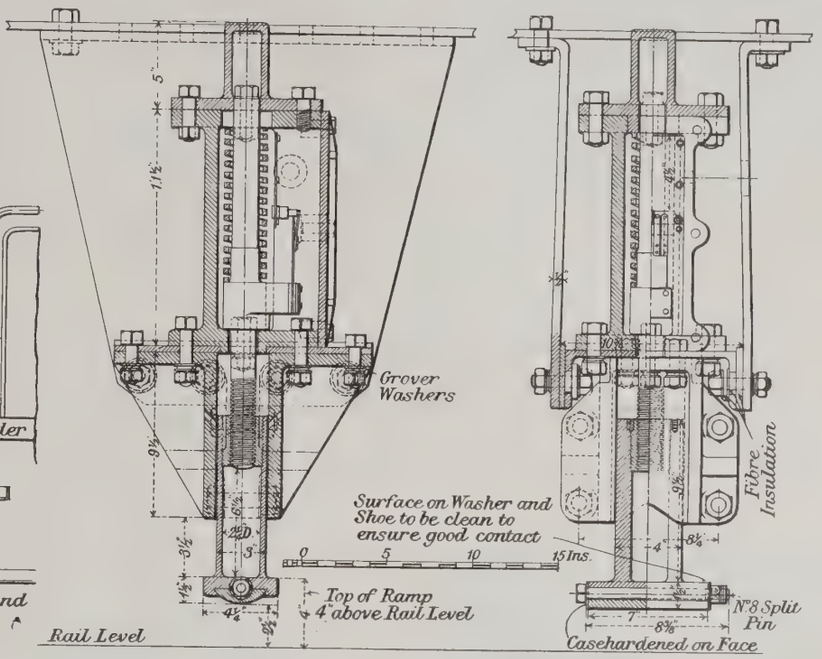


Fig. 7. DETAILS OF PLUNGER AND SWITCH.


Grover Washers
Surface on Washer and Shoe to be clean to ensure good contact
Top of Ramp 4" above Rail Level
Fibre Insulation
N°8 Split Pin
Casehardened on Face

SIMPLIFIED DIAGRAMS, SHOWING CIRCUITS IN SYSTEM OF COMBINED AUTOMATIC TRAIN-CONTROL & AUDIBLE SIGNALS.

Electro-Magnet Controlling Brake Valve and Siren.

Fig. 8.

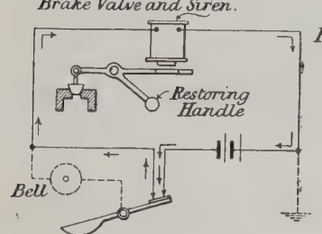


FIG. 8. *Local Engine Circuit. Normal.*
Local circuit closed; electro-magnet energised; brake-valve and siren closed.

Fig. 9.

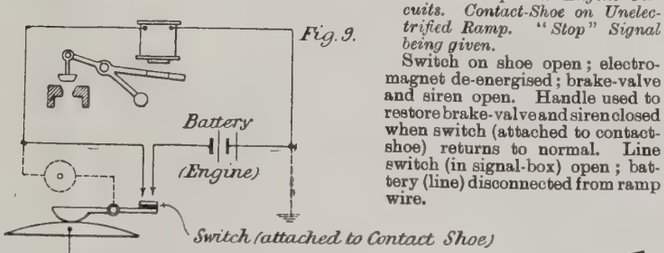


FIG. 9. *Ramp and Engine Circuits. Contact-Shoe on Unelectrified Ramp. "Stop" Signal being given.*
Switch on shoe open; electro-magnet de-energised; brake-valve and siren open. Handle used to restore brake-valve and siren closed when switch (attached to contact-shoe) returns to normal. Line switch (in signal-box) open; battery (line) disconnected from ramp wire.

Fig. 10.

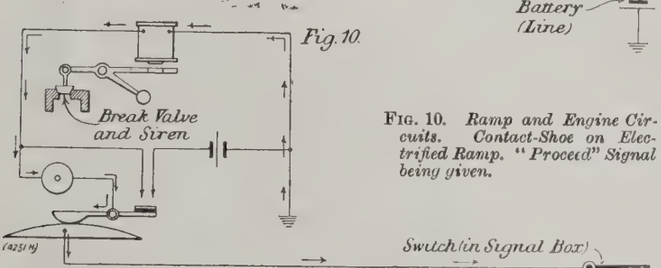
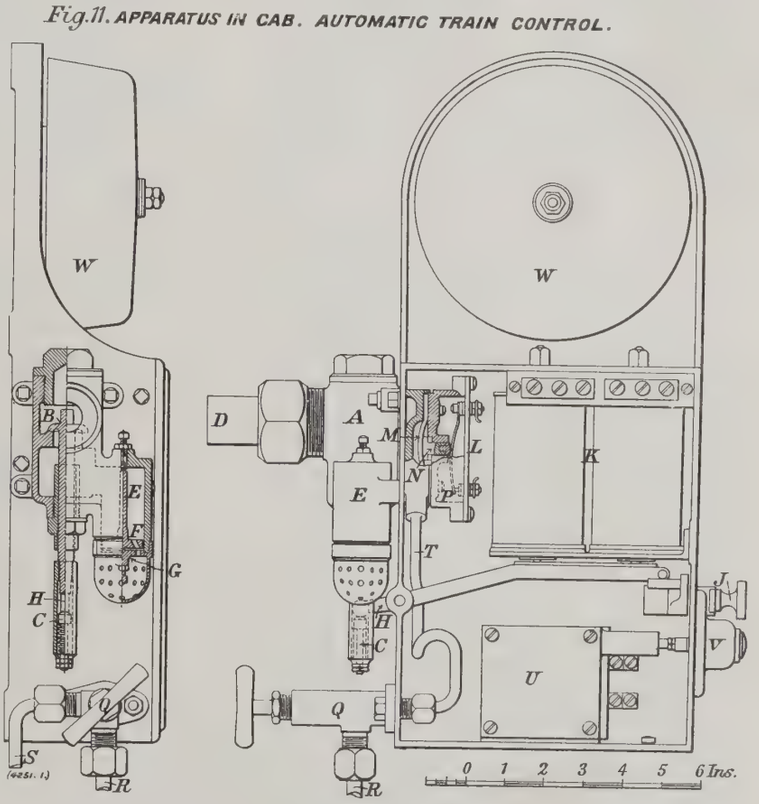


FIG. 10. *Ramp and Engine Circuits. Contact-Shoe on Electrified Ramp. "Proceed" Signal being given.*
Local circuit broken, as in Fig. 9; line circuit complete, as shown by arrows; bell ringing; and electro-magnet maintained energised by line current from battery (line).

Fig. 11. APPARATUS IN CAB. AUTOMATIC TRAIN CONTROL.



A. Air-valve chamber.
B. Air-valve.
C. Spring buffer between air-valve and armature lever controlling same.
D. Brake-pipe connection.
E. Siren.
F. Revolving disc for siren.
G. Fixed pivot-plate for siren.
H. Armature lever.
J. Re-setting lever for armature.
K. Electromagnets.
L. Automatic steam-switch.
M. Rubber insertion diaphragm.
N. Plunger for closing switch.
P. Switch.
Q. Valve for steam-heating shoe, and connection to automatic steam-switch.
R. Steam-inlet.
S. Connection to contact-shoe.
T. Connection to automatic steam-switch.
U. Polarised relay.
V. Brake-push for bell.
W. Bell.

NOTE.—Re-setting lever is shown in position occupied when lifted to re-set armature.

3. The "stop" or "danger" warning must be independent of any electric connections either on the line or the engine, and must be given even if the electric connections fail.

4. Each signal must be acknowledged by the engineman in some tangible way.

5. It must be possible to apply it to any engine, and to any line, whether single or double.

6. There should be no moving parts on the line.

4. The engineman acknowledges either signal by a definite movement to re-set the device.

5. The apparatus is in the centre of the track, so that it makes no difference which way the engine is running.

6. The ramp in the centre of the track is a fixture.

7. When the "stop" or "danger" signal is given on passing over the ramp, a valve automatically opens in the train-pipe, which admits air through a siren, and applies the brakes, thus pulling up the train.

The apparatus consists of a fixed ramp in the centre of the track, about 400 yards before the "distant" signal is reached, except where the "distant" signal is a lower arm on a "stop" signal, when it is fixed at a spot just after the "stop" signal is passed. This ramp is connected to the lever in the signal-box controlling this particular "distant" signal by means of an electric wire and switch with a battery in the circuit, Fig. 4, page 770.

The ramp consists of a 4-in. by 2-in. inverted T-section steel bar, about 40 ft. to 60 ft. long, sloped at each end for about 20 ft., and about 4 in. above rail-level in the centre, Fig. 5. It is laid on the skew 1½ in. each side of the centre line, so as not to wear a groove in the shoe of the plunger on the engine, and to assist in clearing it, and the shoe which rubs on it, of anything, such as frost or snow, which tends to insulate them from one another. It is mounted on timbers that are fixed to the sleepers with cast-iron shoes. The rails adjacent to the ramp are bonded, to ensure a good earth return through the engine. At first the steel T section was insulated from the timber, but this was found unnecessary after trial, the timber alone being found quite satisfactory. The ramp has now at its front end a cast-iron wedge-piece which carries the slope down to sleeper level. This has only recently been added, as it was found that the water-scoop on the engine tender, if left down, was sufficiently low to get under the steel ramp and rip it up. The bottom of the water-scoop, when down, is 1 in. below rail-level.

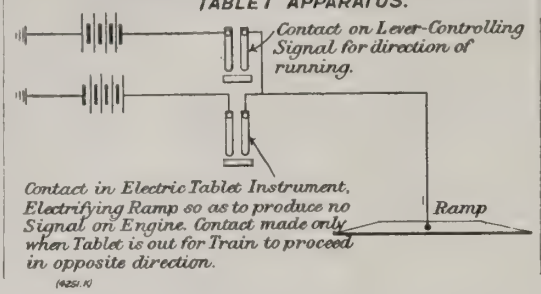
In the signal-box is a switch connected to the ramp by means of a telegraph wire and with a battery of about eighteen Leclanché cells in the circuit, with an earth return. This switch is attached to the lever controlling the "distant" signal, so that when the lever is placed in the "proceed" position, the electric battery is connected to the ramp, and when the lever is placed so that the signal is in the "stop" position, the battery is cut out from the ramp. The ramp is therefore electrified when the signal is at "proceed," and dead when the signal is at "stop." The ramp is therefore dead in the event of the battery failing or of the wiring or connections becoming faulty.

The apparatus on the engine comprised a contact-shoe, an electric bell, and an electrically-controlled whistle in the early arrangement, but in the present arrangement it consists of a siren and brake-valve, and an automatic steam-switch, Fig. 6, page 771. The contact-shoe (Fig. 7) is fixed in the centre line of the engine, usually under the drag-box, and projects to within 2½ in. above rail level, in which position it is held by gravity, assisted by a spring. It is capable of being raised vertically, and, being in line with the ramp, it is lifted 1½ in. whenever a ramp is passed over. This lift of 1½ in. is utilised for effectively opening a switch attached to the contact-shoe (although ½ in. is sufficient for this).

The switch is connected with the electrically-controlled brake valve and siren in such a way that whenever it is opened, except as hereafter described, air is admitted through the siren and brake-valve to the train-pipe, sounding the siren and applying the brakes on the train, Figs. 8 and 9. This happens when an engine passes over an unelectrified ramp. The driver can stop the siren sounding, and stop the application of the brakes by raising a handle provided for the purpose, and thus acknowledges the audible "stop" or "danger" signal given by the siren. Should the signal be in the "proceed" or "all right" position, Fig. 10, the switch connected to the lever in the signal-box working this signal is closed, and the ramp is electrified, so that when the engine passes over the ramp, the shoe picks up the current, closing a secondary circuit on the engine which prevents the brake-valve from opening, and at the same time causes the bell on the engine to ring. This audible "all-right" signal continues until the engineman presses a push-button on the side of the cab apparatus, thus acknowledging the signal, and by breaking the bell circuit stops the bell ringing.

The cab apparatus, Figs. M and N, page 767, consists of a box mounted on the side of the cab close to the engineman. It contains an electromagnet, energised from a small accumulator on the engine, which holds up an armature. The armature is integral with the lever that controls the brake-valve and siren. Close to it is a steam-switch. Its object is to cut out automatically the electric battery on the engine, so that when the engine is not in steam the circuit is open, and waste of current is prevented. It is arranged with a diaphragm, which is set to move with about 40 lb. of steam pressure, and when it moves it joins up the circuit in the engine. A selective or polarised relay controls the secondary circuit, Fig. 11, page 771, which circuit is used for ringing the bell mounted at the top of the box, and which gives the "all-right" signal. This selective or polarised relay is also used when the apparatus is installed on single lines. When a train is going in one direction on a single line it is necessary that the ramps controlling signals in the opposite direction should give no signal. This is effected by electrifying these ramps with a current of opposite polarity. The means for doing this is controlled by the electric staff or tablet apparatus, Fig. 12.

Fig. 12. DIAGRAM OF WIRING ON SINGLE LINE RAILWAY, SHOWING ASSOCIATION WITH TRAIN TABLET APPARATUS.


Contact on Lever-Controlling Signal for direction of running.
Contact in Electric Tablet Instrument, Electrifying Ramp so as to produce no Signal on Engine. Contact made only when Tablet is out for Train to proceed in opposite direction.
Ramp
(4251.K)

The apparatus on the engine is always tested as the engine leaves the locomotive-shed, as a short ramp is fixed alongside the outgoing signal for the locomotive-yard, so that the engineman satisfies himself that the device is all right before he gets to his train. The device has proved so satisfactory in service that about 180 miles and ninety engines up to the present have been equipped, and its use is rapidly being extended.

The Interstate Commerce Commission of the U.S.A., when visiting this country in 1908, reported on their return:—"Of the cab-signal devices in use on English railways, and forming the chief object of the Committee's investigations, only one—namely, that of the Great Western Railway—is believed to be worthy of consideration." Colonel Sir H. A. Yorke, speaking at the discussion on a paper given by Mr. A. T. Blackall, the Great Western Railway signal engineer, before the Institution of Civil Engineers in February, 1911, said with regard to audible cab-signalling:—"All that had been done on the Great Western Railway was exceedingly satisfactory. He agreed that it had the advantage of distinguishing the "distant" signal by night as well as by day, which was a point to which he attached a good deal of importance. No failure had taken place in which a "clear" or "all-right" signal had been given when a "stop" or "danger" signal should have been given.

The experiment on the Fairford branch, 22 miles of single line, was carried out with the full approval of the Board of Trade, subject to a report in six months' time. It has been working satisfactorily since 1906, and the automatic application of the brake when the signal is at "danger" removes practically the last objection to it from an operating standpoint. These remarks have been compiled with considerable assistance from the Great Western Railway signal engineers, to whom the author's best thanks are due.

Fig. 13 TRAIN-STOP FIXED IN POSITION. METROPOLITAN RAILWAY.

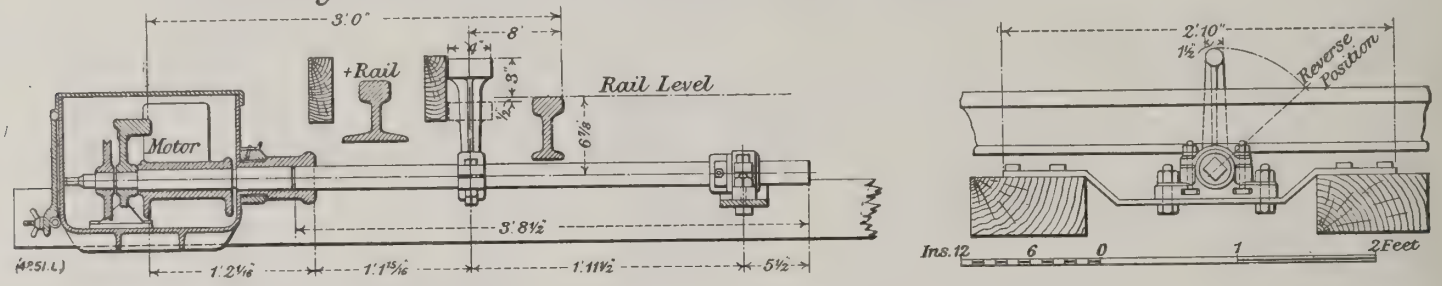


Fig. 14 GENERAL ARRANGEMENT OF "TRAIN-STOP," SHOWING THE CONTROLLING MOTOR. PRAED STREET TO ALDGATE PATTERN. METROPOLITAN RAILWAY.

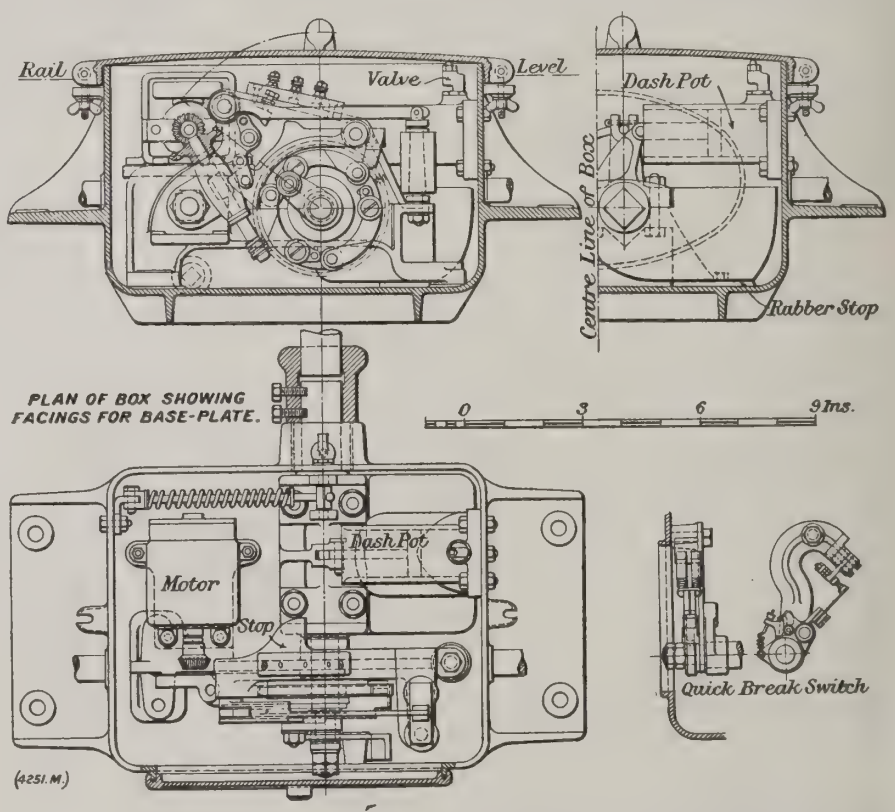
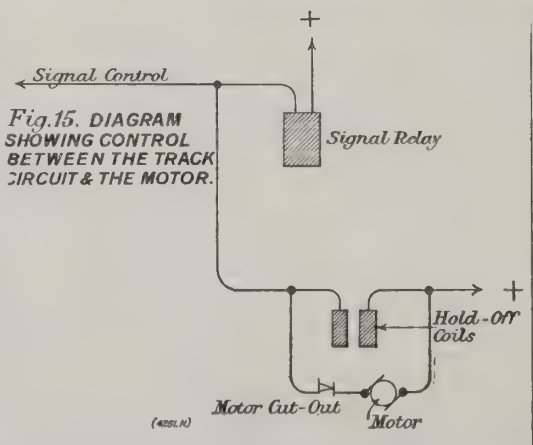


Fig. 15. DIAGRAM SHOWING CONTROL BETWEEN THE TRACK CIRCUIT & THE MOTOR.



SIGNALLING ON RAILWAY TRAINS IN MOTION.

By W. WILLOX, Engineer, Metropolitan Railway, London.

Twenty-seven miles of the Metropolitan Railway are electrified, and 23½ miles are governed automatically by track-circuits. The rest of the Metropolitan Railway has ordinary lock-and-block signalling, with a number of sections automatically controlled by track-circuits.

The system of signalling in use on the electrified portion of the Metropolitan Railway is all electric automatic, and this signalling requires no visual indication in the driver's cab. There is, however, a control on the driver by means of what are called "train-stops," which

are placed at every "stop" signal. The train-stop is a device which is controlled by the track-circuit in exactly the same manner as the signals, and consists of a short vertical arm which is held vertically in its normal position and is lowered to the "clear" position by means of the track-circuit acting through a motor at the same time as the signal goes to "clear." There is a trigger fitted on the leading motor coach or electric locomotive which would engage with the train-stop in its normal position and so be deflected backwards. When this occurs, it applies the emergency brake on the train and simultaneously opens the power circuit, thus braking the train and cutting off the current. In this way, if a driver passes a signal at "danger," his train is automatically brought to a stand and cannot be started again until the trigger is replaced in the vertical position. As showing the effect of these train-stops, it may be mentioned that a train weighing 200 tons, running at a speed of 25 miles per hour on the level, is brought to a stand in less than its own length.

It should be mentioned that these train-stops, although they come to a "clear" position at the same time as the signals, are controlled by the track-circuit independently of the signals, so that if by any accident the signal should remain at the "clear" position instead of going to "danger," the train-stop would still go to the vertical position, and thus come into action if the train went past the signal.

The control for the train-stop mechanism is complete when the respective track-section is unoccupied, and is in shunt with the signal control. After the train-stop motor has finished its work—that is, bringing the train-stop arm to the "clear" or inoperative position—the motor circuit is opened automatically by means of the motor control. The train-stop is then held in the "clear" position electrically by means of a clutch (as shown on plan). The motor only operates for the actual clearing, and the clutch arrangement reduces the power for holding at "clear" to an almost negligible quantity, $\frac{1}{10}$ ampere. When the power circuit is broken, the only moving part of the apparatus is the train-stop arm and shaft, the motor remaining stationary, this being effected by the clutch mechanism. The voltage of operation is 60, and the power required for clearing about 30 watts, the time taken being five to six seconds.

Fig. 13, page 772, shows the general arrangement of the train-stop and controlling-motor at rail level, and Fig. 14 is a plan of the train-stop showing the controlling motor. Fig. 15 is a diagram of the wiring between the track circuit and the motor, showing how it is controlled.

With regard to the reliability of the train-stops described, the results are most satisfactory, as there have been many cases of drivers running past the signal, either through carelessness or some failure of the apparatus, being pulled up by the train-stops.

As to its usefulness, it is relied on to such an extent that fog-signalling in some cases has been dispensed with. Further, it has been possible to shorten the signal-sections, and this shortening has only been agreed to by the Board of Trade on condition that train-stops are provided. The Board of Trade also requires that all "stop" signals on the electrified lines shall be fitted with the train-stop apparatus.

ROYAL INSTITUTION.—Professor Charles Scott Sherrington, M.D., LL.D., D Sc., F.R.S, new Fullerian Professor of Physiology at the Royal Institution, will deliver a course of six lectures at the Institution on "Muscle in the Service of Nerve," on Tuesdays, January 19 and 26, and February 2, 9, 16, and 23, 1915. Lecture hour, 3 o'clock.

THE P. AND O.—At the close of September, this year, the Peninsular and Oriental Steam Navigation Company owned sixty-seven steamers having an aggregate displacement of 550,407 tons, and fitted, or to be fitted, with engines working up to an aggregate of 588,000 horse-power. The company has ten steamers on its books with a displacement of upwards of 10,000 tons each. Two of four steamers now building will have a registered tonnage of 15,620 tons each; they are at present unnamed. Two other steamers, which are also building—the Kashmir and the Kalyan—will have a displacement of 9000 tons each, and will be fitted with engines working up to 9000 indicated horse-power. The company maintains a branch service to Australia *via* the Cape, and seven steamers are employed upon the line. Altogether, the company's fleet, either building or in service, represents, with auxiliary vessels, an aggregate displacement of 554,855 tons. Messrs. Rennoldson and Co., of South Shields, are building for the company a steamer with a displacement of 1000 tons to trade in the Malay Archipelago; she will enter into service early next year. Immediately war was declared against Germany and Austria, the Lords of the Admiralty commandeered nearly half the company's fleet, or upwards of 200,000 tons. The company's fleet stood in the books at the close of September, this year, at 3,299,546*l.*, as compared with 3,375,991*l.*, at the close of September, 1913; the amount written off for depreciation in 1913-14 was 450,036*l.* Payments on account for new ships had also been made at the close of September, this year, to the amount of 1,386,230*l.* Steam tenders, launches, and lighters stood in the books at the close of September, this year, at 107,657*l.*; coal, naval and victualling stores at 104,954*l.*; and graving docks, workshops, machinery, wharves, buildings, land, moorings, &c., at 374,550*l.* Traffic receipts, less certain charges, amounted in 1913-14 to 3,455,605*l.*; on the other hand, navigating and general ships' charges—coal, victualling, port dues, stores, repairs, Suez Canal dues, &c.—amounted for the year to 2,355,209*l.*

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information concerning these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Canada: The Commercial Intelligence Branch of the Board of Trade is notified by the Toronto Commissioner of Works that tenders are invited by the Toronto Department of Works for the construction of the bridge and retaining-wall required for the Rosedale section of the Bloor-street viaduct. The length of the bridge is approximately 580 ft., and of the retaining-wall 170 ft. Tenders will be received by the Chairman of the Board of Control, City Hall, Toronto, but no date for the receipt of tenders is mentioned. A cash deposit, or a marked cheque for 2½ per cent. of the value of the offer, made payable to the order of the City Treasurer, must accompany each tender.

Australia: A firm in Melbourne, claiming an extensive machinery-importing business, makes inquiry for the names of United Kingdom manufacturers who may desire to appoint agents for the sale of steam-turbines, Diesel oil-engines, high-speed steam-engines, centrifugal and plunger pumps, fans, blowers, and air-compressors. An engineer in Melbourne, claiming over twenty-five years' experience, wishes to secure the representation of United Kingdom manufacturers of any machinery and electrical goods. United Kingdom manufacturers of the above-mentioned goods may obtain the names and addresses of the inquirers on application to the Commercial Intelligence Branch. Further communications regarding the inquiries should be addressed to H.M. Trade Commissioner for Australia, Commerce House, Melbourne. A firm, established in Australia for over thirty years, is desirous of obtaining agencies for United Kingdom manufacturers of the following:—Telphers, gas-work installations, electric cranes, wheels and axles, and locomotives. Communications regarding these inquiries should be addressed to the Official Secretary, Office of the High Commissioner for Australia, 72, Victoria-street, London, S.W. H.M. Trade Commissioner for Australia reports that tenders will be received by the Victorian Railway Commissioners for the supply and delivery of the following:—(1) Up to 11 a.m. on February 10, 1915, for three air-cooled petrol-engine sets, for railway-inspection cars; (2) up to 11 a.m. on February 17, 1915, for a carpet-beating and cleaning machine for railway-carriage shelter-shed. Sealed tenders will be received up to the dates mentioned, by the Secretary to the Railway Commissioners, at the same address. A preliminary deposit of ½ per cent. of the total amount of the offer is required in each case. Local representation is necessary. H.M. Trade Commissioner also reports that tenders are invited by the Melbourne City Corporation for the supply and erection of a 5000-kw. turbo-alternator, with exciter and condensing plant. Copies of the specification, with conditions and forms of tender, may be obtained, on payment of 1*l.* 1s. each, from the London agents for the Corporation, Messrs. McIlwraith, McEacharn and Co., Billiter-square Buildings, E.C. Sealed tenders, accompanied by a deposit of 2½ per cent. of the amount of the offer, will be received, up to noon on January 15, 1915, by the Chairman, Electric Supply Committee, Town Hall, Melbourne.

Russia: H.M. Consul-General reports that an agent in Moscow wishes to secure the representation of United Kingdom manufacturers of sawing and wood-working machinery, metal-working lathes, paper-making machinery (for writing-paper), steam-turbines, gas-generators, and gas-generating motors.

Portugal: The *Diario do Governo*, Lisbon, publishes the text of a contract, dated October 28, between the Ministério do Fomento and the Companhia Hidro-Eléctrica do Varosa for the construction and working for a period of seventy-five years of an electric railway, 12 km. (about 7½ miles) long, from Lamego to the left bank of the Douro. Work must be commenced within thirty days from the date of the contract and completed within two years.

Spain: The *Gaceta de Madrid* publishes a notice to the effect that tenders will be received at the Dirección General de Obras Públicas, Madrid, up to noon on February 12, 1915, for the construction and working, for a period of ninety-nine years, of a secondary railway from Matico to Azbarren. The cost of construction is estimated at 2,291,720 pesetas (about 88,000*l.*), on which interest not exceeding 5 per cent. per annum will be guaranteed by the State. A deposit of 10 per cent. of the foregoing amount will be required to qualify any tender. The minimum rolling-stock required to work the line will be two locomotives, two passenger coaches, ten covered and thirty open goods wagons. An option on the concession is held by the Compañia de los Ferrocarriles de Santander à Bilbao. Work on the line must be commenced within three months from the date of the award of the concession, and completed in two years. The *Gaceta* also notifies that tenders will be opened by the municipal authorities at Valladolid on December 22 for the carrying out of drainage works at that town, at an estimated cost of 390,380 pesetas (about 15,000*l.*). Although the two foregoing contracts will probably be awarded to Spanish firms, nevertheless the carrying out of the works may involve the purchase of material outside Spain. The *Gaceta* further publishes a Royal Decree authorising the Ministerio de Fomento to present to the Cortes a Bill authorising the construction of the Balaguer-Camarasa section of the international railway between Lérida and Saint-Girons, *via* the Noguera-Pallaresa Valley. The same *Gaceta* also contains a Royal Decree authorising the Ministerio de Fomento to make arrangements for the acquisition, by public tender, of four electric cranes for the port of Valencia, at a total estimated cost of 188,000 pesetas (about 7200*l.*). The same *Gaceta* further publishes a Decree authorising the Ministerio de Fomento to carry out drainage works in connection with the Castilian Canal project, at an estimated cost of 4,664,621 pesetas (about 179,400*l.*). The Ministerio will acquire by public tender the necessary materials for the execution of the works, such as cement, hydraulic lime, metal-work, &c.

Colombia: The *Diario Oficial*, Bogatá, publishes a Decree authorising the Colombian Government, as soon as the financial circumstances of the Republic will permit, to make arrangements for the construction of a railway from the port of Barrancabermeja to the town of Chiquinquira, *via* El Tablazo, on the River Sogamoso; a branch line will also be constructed from El Tablazo to Bucaramanga.

The same Decree also authorises the construction of a railway from Tunja, passing through the Departments of Boyacá and Santander to the River Magdalena.

BRITISH POPULATION.—Although emigration was on a gradually-increasing scale in 1911-12, 1912-13, and 1913-14, the emigration movement exerted scarcely any effect upon the growth of British population. This is shown by the annexed table, illustrating the number of emigrants in each of the ten years ending with 1913-14 inclusive, and the gradual expansion of our home population during that period:—

Year.	Emigrants.	Home Population.
1904-5	271,435	42,610,920
1905-6	262,077	42,980,188
1906-7	325,137	43,360,331
1907-8	395,680	43,736,942
1908-9	263,199	44,122,777
1909-10	288,761	44,518,264
1910-11	307,848	44,914,591
1911-12	454,527	45,298,573
1912-13	467,666	45,665,423
1913-14	469,640	46,026,463

The aggregate emigration in the last ten years was, accordingly, 3,505,970, while the growth of population was 3,415,543. The emigration which now takes place is practically wholly derived from Great Britain, the population of Ireland having fallen off in the last ten years 23,754. As regards the destinations of our emigrants, they are much more restricted than formerly to British Colonies, while they have shown no progress to the United States. In 1904 emigration to Canada absorbed 69,681 persons; in 1913 the corresponding total had risen to 196,278. There were 13,910 emigrants to Australia and New Zealand in 1904; in 1913 the total had expanded to 77,934. The attractions of the Cape and Natal do not appear to have exerted a greater effect in 1913 than in 1904; last year 25,855 persons proceeded to British South Africa, while in 1904 the corresponding number was 26,818. The United States obtained 146,445 British emigrants in 1904; in 1913 the total had declined to 129,169.

THE BRITISH FIRE-PREVENTION COMMITTEE AND THE WAR.—Like many other technical and scientific institutions, the British Fire-Prevention Committee has been largely engaged during the past three months on work connected with the war emergency. In the first place, its well-known series of "fire warnings" has been extended to meet the special circumstances of the present time, and thus the "warning" has been issued dealing with the necessary fire precautions in military hospitals, the distribution of which at the request of the authorities already exceeds 10,000. Abbreviated French and Flemish translations are provided in the form of short notices for Belgian wounded. To meet the fire danger resultant from the great influx of refugees, many of whom were not conversant either with the English open fire, gas-lighting, or electricity, a special "warning" was issued for refugee homes and hostels, and this was also published in French and Flemish. Here, again, considerable issues are being made on the requirements of the authorities, one public department alone absorbing 5000 copies. The British Fire-Prevention Committee, having a number of distinguished surveyors among its membership and subscribers, also organised a special fire-survey force, which is doing a considerable amount of survey work in connection with Government establishments, and particularly in connection with hospitals for the wounded. The force comprises no less than 70 fire-surveyors, and it is interesting to note that the two seniors of the fire surveyors are Mr. Leslie Vigers (Past-President of the Surveyors' Institution) and Mr. George T. Bullock (Past-President of the Junior Institution of Engineers). Further, to meet the emergency of the depletion of actual fire brigade and watching staffs, a special Fire Service was formed, with the Earl of Londesborough as honorary commandant. This comprises 300 fire-brigade officers, patrol men, and firemen, divided into sections available for mobilisation at forty-eight hours' notice. Some of the sections can be equipped with steam fire-engines kindly lent by large estate owners. Mobilisation of a section to take up duty in any locality is carried out in forty-eight hours, but a patrol was recently mobilised in eighteen hours. Besides this, the Committee has also formed a technical inquiry office, to which the Government departments, local authorities, and other corporations bring many questions and inquiries to be dealt with, and by a system of decentralisation most of these technical inquiries can be dealt with in forty-eight hours. Whilst doing this special work the Committee still conducts its ordinary routine operations.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 8d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the date of sealing is given.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

GUNS AND EXPLOSIVES.

6082/14. Societe Anonyme John Cockerill, Seraing, and E. Ternstrom, Jemeppe-s/M., Belgium. Cupolas for Ordnance. [7 *Figs.*] March 10, 1914.—This invention relates to armoured cupolas of the kind illustrated in a prior Specification, No. 1466, of 1907, and wherein the gun is represented as having formed around the barrel an obturator or gas-check which does not constitute the mounting of the gun, the said obturator having a spherical surface the axis of which is coincident with the axis upon which the vertical movements of the gun takes place, and which fits into a corresponding spherical bed on the inner side of the hood, around the port or embrasure through which the gun is fired. The object of the present invention is to arrange the spherical joint and gas-check, so that notwithstanding that the hood may be injured locally, or even displaced within certain limits, the laying of the gun and the tightness of the gas-check will not be affected, and to this end the

Fig. 1.

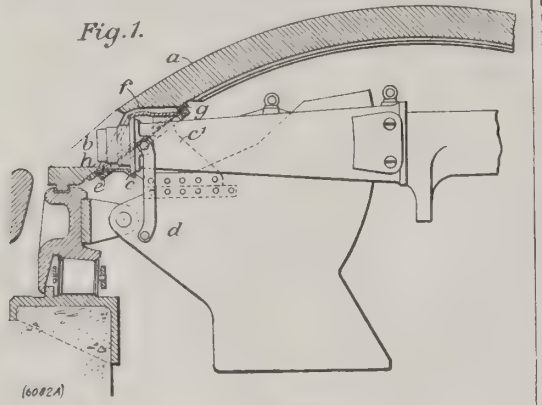
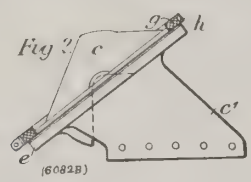


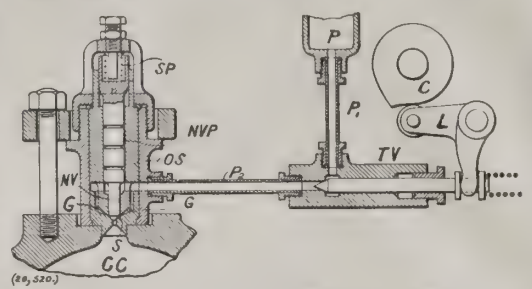
Fig. 2.



invention consists in arranging the spherical gas-check entirely distinct from the hood. *a* indicates a hood or cap, *b* the port or embrasure therein, and *c* the spherical bed of the joint, which is provided with arms or brackets c^1 designed to be secured to the gun-mounting *d*. This spherical bed *c*, which is of wrought metal, is provided with a flange *e* which approximately corresponds with the internal surface of the hood around the embrasure; but in order to prevent gas from the muzzle of a gun or from a shell bursting close to the port *b*, returning through the space *f* around the outside of the bed into the interior of the cupola, an annular packing *g* of elastic material is inserted between the hood and the flange *e*. The flange *e* is in the form of a ring which is screwed on to the bed *c*, and which serves to clamp the packing-ring *g* against the interior of the hood *a*, the packing-ring being advantageously surrounded by a band or clip *h*. (*Accepted September* 16, 1914.)

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

20,520/13. K. I. Crossley, Manchester, and W. Le. P. Webb, Hale. Internal-Combustion Engines. [5 *Figs.*] September 11, 1913.—This invention relates to improving the methods by means of which the supply of oil fuel is controlled in that type of internal-combustion engine in which the spray of oil fuel is injected by itself under pressure into the combustion-chamber of the engine. The improvements are applicable to any type of engine working on either the two or four-stroke cycles, and to engines having any desired degree of compression, and to engines in which the oil-spray is injected at any desired period in the cycle. The invention consists in the use, in conjunction with an oil-sprayer in which the oil fuel under pressure acts on the annular portion of a piston needle-valve in the sprayer, thus lifting the piston needle-valve outwardly off its seat, and thereby enabling the oil to pass through the sprayer and to be sprayed by itself without the admixture of air into the combustion-chamber, of a separate timing-valve, opened and closed by suitable mechanical means, arranged in such a manner as to control the times at which it is opened and closed, and thereby to definitely control the exact times at which the said piston needle-valve opens and closes, and thereby to definitely control the exact times when the spraying of oil into the combustion-chamber begins and ends. The drawing shows an oil-sprayer O S constructed according to Specification No. 20,758, of 1911, and connected by means of an oil-pipe P^2 to a timing-valve TV. The piston needle-valve in the oil-sprayer in the figure is shown with a needle-valve piston N V P, a needle-valve N V, and seat S. The oil passes to the seat of the needle-valve by means of the grooves G, G, which in a plan view would be preferably arranged spirally or tangentially. When oil under pressure is admitted to the sprayer through the oil-pipe P^2, the pressure acts on the annular underside of the needle-valve piston N V P and lifts



the needle-valve N V off its seat against the pressure of the spring S P which normally retains the valve on its seat. The oil in passing down the spiral or tangential grooves issues into the combustion-chamber C C in the form of a whirling cloud of oil spray. The timing-valve T V, which controls the supply of oil to the oil-sprayer O S, is operated by means of a cam C and lever L. As soon as the timing-valve is lifted off its seat by the cam, the oil (under pressure from a pump or accumulator at P) passes along the oil-pipes P^1 and P^2 and issues as spray into the combustion-chamber C C. As soon as the timing-valve T V closes, the pressure under the needle-valve piston N V P is reduced, and the needle-valve N V also closes and prevents further oil entering the combustion-chamber. (*Sealed December* 3, 1914).

RAILWAYS AND TRAMWAYS

2642/14. The Metropolitan Carriage, Wagon and Finance Company, Limited, and E. Squires, Birmingham. Brake-Shoes. [7 *Figs.*] February 2, 1914.—This invention has reference to means for securing certain kinds of brake-shoes to brake-blocks. In the well-known type of brake-shoe and brake-block to which this invention applies, the curved brake-shoe is adapted to fit against the curved face of the brake-block, and there is removably secured by means of a tapered key which has a head at the top and is driven down between the side cheeks of the brake-block and through a central loop-like lug on the back of the brake-shoe, this key being curved to bear against the curved back face of the brake-block. According to this invention, means for securing together a brake-shoe and brake-block of the type herein referred to, comprises a key formed with an extra or second limb which is adapted to be struck to drive the key up or down into position. According to this invention, the upper part of the key A is continued down-

Fig. 1.

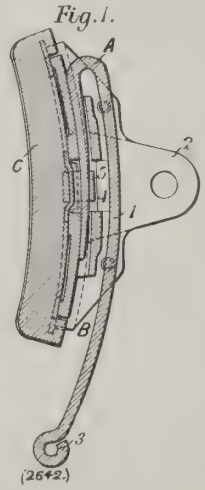
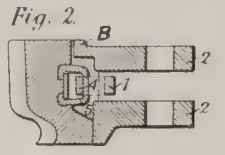


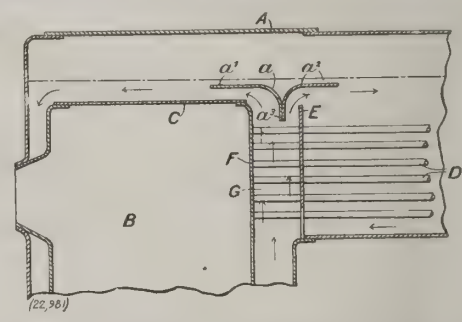
Fig. 2.



wardly as an extra limb 1, called the striking limb, between the two side cheeks 2 of the brake-block B, this limb 1 being made preferably so as to project below the bottom end of the brake-shoe C. The lower end of this limb 1 is formed as an eye 3, or as a hook, or is otherwise shaped so as to be engaged by a bar, or the like, which can be struck by a hammer to drive the key up or down into position. The key can be readily removed by the lower end of the striking limb 1 being struck upwardly, thereby driving up the whole key until the tapered limb 4 has been driven out of the back lug 5 of the shoe C, so that the latter can then be removed and the key A can meanwhile be held up in position by grasping the lower part of the striking limb 1, and in a similar manner, after the new brake-shoe has been placed in position, the key can be driven down through the back lug 5 of the brake-shoe into its proper position by any convenient tool being engaged with the lower end 3 of the striking limb 1, and then being struck by a hammer, such a tool, for instance, a round bar, may be employed and inserted crosswise in the eye 3 of the striking limb 1, and then can be struck by a hammer, and thus drive the key up or down into position. (*Accepted October* 7, 1914.)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

22,981/13, Circulators, Limited, and H. Schofield, London. Steam-Generators. [2 *Figs.*] October 11, 1913.—This invention has reference to steam-generators, and relates to circulating devices for improving the circulation in a longitudinal direction, both in the body of the boiler and also in the region of the combustion-chamber. According to this invention, a circulator is provided for throwing a powerful current over the crown of the furnace or combustion-chamber, said circulator comprising a bent or wing-plate having its upper part extended considerably in a horizontal direction beyond the top or mouth of the circulating space. Now the main object of this invention is to provide an arrangement applicable to boilers having vertical circulation spaces. A is the shell of the boiler; B is the fire-box or furnace thereof, or the combustion-chamber in the case of a Scotch boiler, C being the crown thereof; D are the small tubes by which the smoke and gases pass through the boiler to the smoke-box D^1; E is a vertical partition or false tube-plate, arranged parallel to the main tube-plate F, so as to form a vertical circulation space G. All the foregoing parts are as in known arrangements. The deflector or wing-plate for throwing the water over the top C of the combustion chamber is shown at *a*. The top part or horizontal portion a^1 of this deflector is extended considerably forward beyond the top of the circulation-space



parallel (or approximately so) with the furnace-crown C, so that the space between the two forms a wide, flat discharge nozzle, or ejector, as it were. From this the water is projected very forcibly in a horizontal direction along the plate C, in a stream which is powerful enough to resist the disturbing action of any steam that may be generated in it as it flows over the plate. a^2 is a similar wing-plate or curved deflector, arranged at the front of the combustion-chamber back-to-back with regard to the first-mentioned wing deflector *a*, and having its top or horizontal portion extended forward in the opposite direction to the portion a^1 of the plate *a*. Thus the parts *a*, a^1, and a^2 form a double-wing or V-shaped device. It will be seen that the lower edge or angle portion of the device, where the plates *a* and a^2 meet back-to-back (as at a^3) is much nearer to the plate E than to the plate F, and that the vertical distance between a^1 and C (that is to say, the height of the aforesaid nozzle) is considerably less than the distance between F and a^3. That is to say, the inlet for the water entering the device from the space G is considerably wider than the outlet over the furnace-crown. In this way the action of the rising current in space G is concentrated or reinforced at the nozzle, and a more effective and energetic discharge is produced over the tube-plate. The wing-plates or deflectors may be fixed in position in any convenient way—for instance, by means of brackets or hangers secured to some of the stay-bars of the boiler. (*Accepted September* 30, 1914.)

TEXTILE MACHINERY.

27,808/13. J. L. Rushton, Bolton. Thread-Guides. [15 *Figs.*] December 3, 1913.—This invention relates to improvements in thread-guides employed in machines for winding and gassing yarns. According thereto, the upper guide is dispensed with, and one guide only is employed, such guide having a shank of reverse taper held in a spring clip formed on a metal plate secured to the ordinary traverse guide-bar by a screw and spring clip formed by bending the plate to fit over the traverse-bar. *a* designates the usual traverse-bar or rod; *b* the metal plate, bent to form a spring clip which fits over the traverse-bar *a*, and is

Fig 1.

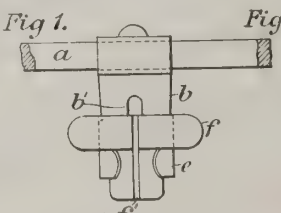
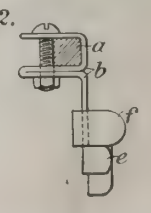


Fig. 2.



secured by a screw and nut. On this metal plate *b* is formed a spring clip *e*, the plate being slotted at b^1 to give the required resilience to the clip. The spring clip *e* embraces and holds in position the thread-guide *f*, which is specially shaped, having a shank of the reverse taper to that of the ordinary pot eye, so that the wings of the spring clip *e* are first forced aside and then close on the reduced taper of the shank, and so hold the guide *f* firmly in position. The piece *f* may be of earthenware, metal, or other material, and is slotted at f^1 for the passage of the thread on its way to the bobbin, the usual upper guide being dispensed with, and the piece *f* being the only guide employed. (*Accepted September* 30, 1914.)

THE END OF THE NINETY-EIGHTH VOLUME.

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